Onslow Marine Support Base

Stage 2 Capital Dredging

Ecological Site Investigation

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WA Marine Pty Ltd t/as O2 Marine
ACN 168 014 819
Originating Office – Busselton
Suite 5 5/18 Griffin Drive, Dunsborough WA 6281
PO Box 1370 Dunsborough WA 6281
T 1300 739 449| F 61 7 3339 7222 | info@o2marine.com.au

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Name	Email Address
Andrew Natta	andrew.natta@omsb.com.au

Executive Summary

Onslow Marine Support Base Pty Ltd (OMSB) is planning to modify and extend the harbour approach channel, turning circle and berth pocket as part of Stage 2 of the Onslow Marine Support Base Project (herein the OMSB Project). The proposed capital dredging will enable offshore supply vessels to access the newly-constructed OMSB land-backed wharf infrastructure within the Beadon Creek Maritime Facility.

Capital dredging proposed includes a turning basin and channel to a declared depth of - 6.0 m CD and a berth pocket to -8.0mCD. The total volume of dredging is anticipated to be 930,000 m^3 and it is expected that dredging will be undertaken using a medium-sized cutter suction dredge (CSD) over a period of approximately eight months. Dredge material is proposed to be disposed of onshore within a dredge material management area (DMMA) located on surplus land owned freehold by the Shire of Ashburton (SoA) adjacent to the Onslow Airport. During dredging, the dredge spoil area will be dewatered to the intertidal flats between the DMMA and the western tributary of Beadon Creek.

A desktop assessment and field survey have been undertaken to characterise the ecological environment, identify the risk/significance of OMSB Project activities on the ecological environment and identify mitigation or management measures that may potentially reduce the impacts associated with the OMSB Project to support referral of the OMSB Project to the EPA under section 38 (Part IV) of the Environmental Protection Act (1986). The following four key environmental factors are assessed:

- Benthic Communities and Habitat (BCH);
- Marine Fauna;
- Flora and Vegetation; and
- Terrestrial Fauna.

A summary of the risk assessment is provided below.

Benthic Communities and Habitats

Project Risks

The OMSB Project will entail a range of activities that have the potential for impacts to intertidal BCH from:

- Construction of the DMMA;
- Dredging of the turning circle;
- Installation of pipeline route Option B;
- Dewatering of dredge material from the DMMA;
- Sedimentation from dredging and dewatering; and
- Modification of the bathymetry altering hydrodynamic patterns in Beadon Creek.

Capital dredging is the aspect of the OMSB Project with the greatest potential for causing loss or structural change to subtidal BCH. The dredging program will result in the direct removal of BCH and generating elevated levels of suspended sediment concentrations (SSC) and sedimentation which can affect the functional processes of BCH and cause mortality.

Assessment of Significance

The predicted *irreversible loss* of BCH and *recoverable impacts* from the OMSB Project is shown in **Table 1**. Key findings of the assessment are detailed below.

Permanent loss of intertidal BCH will occur from construction of the DMMA and dredging of the turning circle. The proposed DMMA overlies 2.4 ha (0.2%) of algal mat BCH within LAU 0A. Dredging to widen the turning circle will result in the direct removal of 0.8 ha (<0.1%) of tidal lagoon comprised of abundant burrowing ocypodid fiddler crabs (i.e. species of *Uca*). The bioturbated mud flat community of the tidal lagoon is well represented both locally and regionally.

Two options are proposed for the dredge discharge pipe route. The proposed route for Option A is predominantly terrestrial while pipeline route Option B extends along Beadon Creek and up the western tributary crossing the broad intertidal flats adjacent to Onslow Road. Option B results in potential *irreversible loss* of <0.1% mangrove, samphire/bioturbated mudflat and algal mat BCH within LAU 0A.

Discharge of supernatant water from the DMMA is expected to pool as it free-flows over the intertidal zone back towards the creek, which may cause a temporary shift in the intertidal community due to perpetual inundation and subsequent changes to the salinity gradient. The specifics of the potential impact are not well understood and may have possible temporary beneficial consequences. However, any impacts on intertidal BCH from dewatering are expected to recover once the salinity gradients are re-established following completion of OMSB Project dewatering activities. A precautionary approach has been applied to predict the *recoverable loss* of 1.3 ha (0.2%) of mangrove, 0.4 ha (<0.1%) of samphire/bioturbated mudflat and 8.5 ha (0.8%) of algal mat within the predicted flow-path.

Impacts to intertidal BCH from elevated sedimentation generated during dredging or dewatering activities are not predicted if activities are managed appropriately. Modelling indicates the proposed modifications to the bathymetry at the mouth of Beadon Creek is unlikely to change the hydrodynamics which could impact intertidal BCH.

A dredge plume impact assessment was undertaken to develop predictions of the Zone of High Impact (ZoHI), Zone of Moderate Impact (ZoMI) and Zone of Influence (ZoI). Separate zones of impact were created based on SSC and sedimentation tolerance limits for coral and seagrass. The SSC dredge plume ZoHI represents the predicted area of *irreversible loss* and the ZoMI represents the predicted *recoverable impacts* on BCH. The impact zones for sedimentation are more localised and occur within the extent of area predicted in SSC dredge model outputs. No areas mapped as coral habitat occur within the ZoHI or ZoMI for “best-case” or “worst-case” model outputs.

Dredging of the approach channel within nearshore waters of Onslow will result in the permanent loss of 21 ha (0.2%) of BCH mapped as seagrass/macroalgae/filter feeder within LAU 1G. The ‘best case’ and ‘worst case’ ZoHI and ZoMI for SSC are predominantly located over BCH mapped as ‘Moderate cover (5-10%) seagrass/macroalgae/filter feeders’ which occur in LAU 1 G and LAU 1C between Sunset Beach (i.e. Onslow back beach) and Third Creek. These plumes also cover a small nearshore area mapped as ‘Low cover macroalgae and filter feeder’ habitat. It is noted that model outputs depict the cumulative extent of plumes generated during dredging activities undertaken in winter, summer and transitional periods, although dredging is only proposed for a period of 13 weeks. Therefore, the potential impacts will be significantly reduced once a proposed dredge schedule can be confirmed. Review of the potential impacts to the ecological integrity and biodiversity of nearshore Onslow subtidal BCH indicates they are likely to be more resistant and/or resilient to the impacts of dredging than conservatively predicted. The rationale for this assumption is evaluated within the report.

No historical loss has been previously recorded within LAU 1G, so cumulative loss of BCH is limited to loss predicted for the OMSB Project. The ‘worst case’ loss predicts an undetectable proportional increase in cumulative loss for mangroves and bioturbated mud flat/ samphire BCH in LAU 0A, and a minor increase (0.3%) for algal mat and Seagrass/Macroalgae/Filter Feeder BCH in LAU 0A and LAU 1C, respectively. The additional loss of BCH is likely to be within the range of error inherent in mapping BCH.

Table 1 Predicted *recoverable impacts* and *irreversible loss* of BCH from the OMSB Project

LAU	BCH	Recoverable Impacts		Irreversible Loss	
		Best Case	Worst Case	Best Case	Worst Case
LAU 0A	Mangrove	1.3 ha (0.2%)		0.1 (<0.1%)	
	Bioturbated mudflats/ samphire	0.4 ha (<0.1%)		0.8 (<0.1%)	
	Algal Mat	8.5 ha (0.8%)		2.4 (0.2%)	
LAU 1G	Seagrass, Macroalgae, Filter Feeder	838 ha (8.2%)	975 ha (9.5%)	391 ha (3.8%)	459 ha (4.5%)
	Seagrass, Macroalgae, Filter Feeder	109 ha (8.3%)	71 ha (5.4%)	58 ha (4.4%)	96 ha (7.3%)
LAU 1C	Seagrass, Macroalgae, Filter Feeder	157 ha (2.6%)	236 ha (3.9%)	5 ha (0.1%)	18.5 ha (0.3%)
	Seagrass, Macroalgae, Filter Feeder	46 ha (1.4%)	102 ha (3.2%)	-	-

Marine Fauna

Project Risks

The OMSB Project will entail a range of activities that have the potential for significant impacts to marine fauna as a consequence of:

- Underwater noise emissions;
- Habitat modification;
- Human presence at sensitive sites;
- Change in hydrological regime;
- Increased turbidity;
- Nutrient pollution;
- Vessel strike;
- Dredge entrainment;
- Chemical leaks or spills;
- Entanglement or ingestion of debris;
- Artificial light spill; and
- Invasive species.

Assessment of Significance

Assessment of potential impacts from proposed OMSB Project activities determined that significant impact to marine fauna is unlikely. Although several species of high conservation status are likely to be present in or near the area at some-time during OMSB Project activities, significant impacts to marine fauna are not predicted because:

- populations are not restricted to the Project area.
- critical habitats are not identified for these species in the OMSB Project area.
- the extent of potential impact does not encroach areas where high abundance has been recorded within the Onslow region.
- The nature of the potential impact is within likely to be within the natural extreme environmental conditions that these species have historically adapted to many risks from the

OMSB Project already occur to some extent within a busy working harbour such as the Beadon Creek Maritime Facility;

- Potential impacts from the scale of proposed activities do not threaten species populations or distributions; and
- Any impacts to these species arising from the OMSB Project are manageable through the incorporation of appropriate mitigation measures.

The spatial and temporal variability of faunal assemblages in the region prior to the commencement of commercial trawling is not known although the biodiversity of the nearshore area is comprised of an assemblage adapted to harsh physical environmental conditions and frequent anthropogenic and natural disturbances such as trawling activities, warm water temperatures and cyclonic conditions. This is reflected in life-history characteristics that indicate species can either move from the disturbance area or recover quickly in the unlikely event they are impacted by the proposed dredging activities. Therefore, dredging is unlikely to significantly impact the abundance and distribution of marina fauna species.

Flora and Vegetation

Project Risks

Direct removal of flora and vegetation for the DMMA and pipeline route.

Assessment of Significance

A total of 15.8 ha of vegetation will be required to be cleared for the construction of the DMMA. Habitat to be cleared is predominantly comprised (14.6 ha) of good condition inland dune system scattered *Acacia* and *Hakea* shrubland over hummock grassland (*Troidia*) and Tussock grassland (*Cenchrus ciliaris*), which is the most common habitat type locally and regionally. A small area (1.1 ha) of degraded tidal creek bare mudflat with scattered low samphire shrubs and claypan low samphire shrubs (<0.1 ha) occurs within an open stormwater drain at the north boundary of the proposed DMMA. Approximately 0.3 ha vegetation will be required to be temporarily cleared for the duration of construction works for the pipeline route Option A and <0.1 ha will be required to be cleared for pipeline route Option B.

Vegetation associations recorded within the OMSB Project area are not listed as a Threatened Ecological Communities under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), as Environmentally Sensitive Areas under the EP Act, or as Priority Ecological Communities by Department of Biodiversity, Conservation or Attractions.

The vegetation unit 'claypan', ranked as High conservation significance in Biota (2013), occurs within the OMSB Project area. A small area (<0.1 ha) of "degraded" claypan comprised of samphire shrubland was found within the open stormwater drain. In accordance with Biota (2013) this vegetation unit may contain numerous poorly recognised samphire species which are difficult to determine, and potentially contains the P3 flora species Dwarf Desert Spike-rush (*Eleocharis papillosa*), which is also listed as '*Vulnerable*' under the EPBC Act (Biota 2010b). The condition of the vegetation unit was ranked as "degraded" due to frequent vehicle tracks and dumped rubbish.

The Dwarf Desert Spike-rush was listed under the EPBC Act on the basis that it was known from only eight populations in the Northern Territory, some of which were under threat from weed invasions and it was considered the area and extent had declined. However, current records from the species indicate *E. papillosa* has a considerably broader distribution, from Northern Territory, South Australia and Western Australia. It is likely that this species has been poorly collected due to its small size and ephemeral nature. It has been recorded from two locations approximately 16 km south of the OMSB Project area within tidally influenced creeks. It is considered it may occur throughout the claypan samphire shrublands vegetation unit.

The review of the distribution of this species, small area (<0.1 ha) of claypan habitat proposed to be impacted by OMSB Project activities and the potential occurrence of this species within that small area of habitat indicates that the proposed activities are unlikely to have a significant effect on *E. papillosa*.

Desktop review and field assessment determined six introduced species have been previously recorded within and adjacent to the OMSB Project area. Three introduced species (Kapok, Buffel, Caltrop) were commonly found during all three previous surveys and are expected to be encountered during any works undertaken onsite. In addition, Verano was found in proximity to the border of the proposed pipeline route and DMMA. Whilst these species may be common and widespread, they are considered significant environmental weeds and are identified for control. Mesquite and Athel pine are listed as Declared Plants under the ARRP Act 1976, although they are considered less likely to occur in the OMSB Project area. Mesquite was not observed during the field survey but if present, will likely be found within the wet depressions of the natural stormwater drain at the DMMA. Athel pine has typically only been found closer to the Onslow townsite. Management actions will be developed in an OMSB Project management plan to minimise the spread of weeds through implementation of weed management practices during construction works.

Terrestrial Fauna

Project Risks

Direct removal of fauna habitat for the DMMA and pipeline route.

Assessment of Significance

Due to the small area which could potentially be affected by the proposed activities and the widespread local and regional representation of these habitats, any potential impacts from OMSB Project activities is not considered to be of elevated conservation significance. The beach and dune system and the dominant fauna habitat in the OMSB Project area, shrubland of *Acacia* species over Hummock grassland, provide simple habitat given a moderate habitat value.

None of the habitats present in the OMSB Project area are listed as Threatened Ecological Communities. The small area (<0.1 ha) of "degraded" claypan comprised of samphire shrubland found within the open stormwater drain afforded a High conservation significance is expected to provide an inhospitable environment for many species due to offering very little protection and prey availability. Mangrove communities lining Beadon Creek are provided conservation significance. Bird and bat species restricted to mangrove habitats are generally a subset of the more diverse mangrove fauna present in the Kimberley. The potential impacts to mangroves from OMSB Project activities is unlikely to have significant effect on the populations of mangrove dependant fauna. However, the potential impacts to mangrove dedicated fauna may be reduced through the selection of unvegetated areas along the Beadon Creek tributary for the crossing of the Option B pipeline and inspection of any mangrove trees prior to removal.

Review of fauna species likely to occur within the OMSB Project area potentially impacted by the proposed activities include a small number of amphibian, reptiles and mammal species, and a comparably high number of bird species which includes resident and migratory species. The proposed development is not expected to significantly affect populations of fauna species in the area as only a small proportion of local habitat suitable for the taxa would be cleared relative to the distribution of that habitat and fauna species in the wider region.

The proposed development is not expected to affect the conservation status of Migratory species, as only a small proportion of local habitat suitable for the taxa would be cleared relative to their distribution in the wider region (Biota 2010d). Additionally, migratory waterbirds are known to feed and roost close to industrial areas in many parts of the world, and appear unaffected by lights, noise and other human interaction. Previous projects where significant land-based reclamation has occurred

(Gladstone, Brisbane, Fremantle and Port Hedland) would indicate the creation of large reclamation ponds and flooded expansive tidal flats, where material is placed by pumping of a slurry, has the potential to attract shorebirds (feeding and roosting). It is plausible that onshore disposal and dewatering activities onto nearby intertidal flats will provide preferable foraging and roosting habitat for migratory species and may need to be managed during the OMSB Project duration. The Eastern Reef Egret and Rainbow Bee-eater probably breed locally (ENV 2011). Habitat containing any breeding colonies is likely to be absent from the study area.

The state listed Specially Protected Peregrine Falcon (*Falco peregrinus*) is the only non-migratory bird species 'moderately' likely to occur within or immediately adjacent to the OMSB Project area, possibly within the home range of this species from other locations. Peregrine Falcons prefer cliff faces as nesting sites and a lack of cliffs in the Project area indicates no potential impacts on this species would be expected.

The list of threatened terrestrial species 'moderately' likely to occur within or immediately adjacent to the OMSB Project area includes one reptile, the Keeled Slider (*Lerista planiventralis* subsp. *Maryani*), and three mammals: Northern Quoll (*Dasyurus hallucatus*), Lakeland Downs Short-tailed Mouse, (*Leggadina lakedownensis*) and the Little Northern Freetail-bat (*Mormopterus loriae cobourgensis*). The proposed pipeline route is unlikely to impact habitat of conservation significant species if clearing of native vegetation is minimised through orientating the pipeline along existing roads, tracks and highly disturbed areas adjacent to roads and tracks. Potential risks to the Little Northern Freetail-Bat would be reduced if disturbance of mangrove trees was minimised.

Potential impacts on subterranean fauna are expected to be negligible. No subterranean fauna records were returned in the database searches, no troglofauna were collected from surveys undertaken at the Wheatstone site and two stygofauna species with widespread distributions were recorded from only two locations. Therefore, a diverse or significant subterranean community is unlikely to occur in the study area or in the immediate surrounds.

Acronyms and Abbreviations

Acronyms/Abbreviation	Description
ALA	Atlas of Living Australia
ANSIA	Ashburton North Strategic Industrial Area
ARRP Act	Agriculture and Related Resources Protection Act 1976
BCH	Benthic Communities and Habitats
BIA	Biologically Important Area
BPPH	Benthic Primary Producer Habitat
CSD	Cutter-suction dredge
DBCA	Department of Biodiversity, Conservation and Attractions
DMMA	Dredge Material Management Area
DoE	Department of Environment
DoT	Department of Transport
EIS	Environmental Impact Statement
EP Act	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ERMP	Environmental Review and Management Program
EVNT	Endangered, Vulnerable and Near Threatened
Ha	hectares
IBRA	Interim Biogeographic Regionalisation for Australia
IUCN	International Union for Conservation of Nature and Natural Resources
LAU	Loss Assessment Unit
LIA	Light Industrial Area
LNG	Liquified Natural Gas
MOF	Materials Offloading Facility
MVG	Major Vegetation Groups
MVS	Major Vegetation Sub-groups
NVIS	National Vegetation Information System
OMSB	Onslow Marine Support Base
OPMF	Onslow Prawn Managed Fishery
OZCAM	Online Zoological Collections of Australian Museums
PECs	Priority Ecological Communities
PMST	Protected Matters Search Tool
SoA	Shire of Ashburton
SSC	Suspended Sediment Concentrations
TECs	Threatened ecological communities
TC	Tropical Cyclone
WAFIC	Western Australian Fishing Industrial Council
WAMSI	Western Australian Marine Science Institution

Acronyms/Abbreviation	Description
WC Act	*Wildlife Conservation Act 1950*
WONS	Weeds of National Significance
ZoHI	Zone of High Impact
ZoI	Zone of Influence
ZoMI	Zone of Moderate Impact

Table of Contents

Figures

Plates

Tables

Appendices

1. Introduction

1.1. Project Overview

Onslow Marine Support Base Pty Ltd (OMSB) is planning to modify and extend the harbour approach channel, turning circle and berth pocket as part of Stage 2 of the Onslow Marine Support Base Project (herein the OMSB Project). The proposed capital dredging will enable offshore supply vessels to access the newly-constructed OMSB land-backed wharf infrastructure within the Beadon Creek Maritime Facility.

Capital dredging proposed includes a turning basin and channel to a declared depth of - 6.0 m CD and a berth pocket to -8.0mCD. The total volume of dredging is anticipated to be 930,000 m^3 and it is expected that dredging will be undertaken using a medium-sized cutter suction dredge (CSD) over a period of approximately eight months. Current schedule has operations planned to commence in November 2017, subject to planning and approvals.

Dredge material is proposed to be disposed of onshore within a dredge material management area (DMMA) located on surplus land owned freehold by the Shire of Ashburton (SoA) adjacent to the Onslow Airport. During dredging, the dredge spoil area will be dewatered to the intertidal flats between the DMMA and the western tributary of Beadon Creek.

Key characteristics of the OMSB Project are summarised in **Table 1-1**.The proposed capital dredging area and spoil disposal locations are shown in **Figure 1-1**.

Table 1-1 Key characteristics of the OMSB Project (Stage 2)

Element	Location	Proposed Extent
Physical Elements		
Approach Channel	Figure 1-1	Harbour approach channel (HAC) dredge area of 32 ha, with a target depth of -6.0 m CD, width of 55 metres (m) and length of 2 km. Direct removal of 21 ha of nearshore subtidal benthic communities and habitat (BCH) from within the HAC dredge area.
Turning Basin	Figure 1-1	Turning basin dredge area of 2 ha, with a target depth of -6.0 m CD and a diameter of 143 m.
Berth Pocket	Figure 1-1	Berth pocket dredge area of 3 ha, with a target depth of -8.0 m CD.
Dredge Material Management Area (DMMA)	Figure 1-1	Onshore spoil disposal area of 44 ha. Clearing of no more than 16.2 ha of native vegetation within the onshore spoil disposal area.
Channel Navigation Markers	Unspecified.	Floating (i.e. moored) channel navigation markers (approximately 15) will be installed within the development areas as required. No removal of BCH is required.
Dredge Material Disposal Pipeline	Figure 1-1 (Two Options Proposed)	Two (2) pipeline route options are proposed: Pipeline Route Option A – 450 mm diameter pipeline installed within a 50 m wide pipeline route corridor. Pipeline confined to existing tracks and road reserve. Clearing of 0.2 ha of native vegetation is expected within the pipeline corridor. Pipeline Route Option B – 450 mm diameter pipeline installed within a 50 m wide pipeline route corridor. Pipeline confined to Beadon Creek and intertidal flats adjacent to Beadon Creek. Clearing of <0.1 ha of native vegetation is expected within the pipeline corridor. Potential direct loss of 0.1 ha of BCH within the pipeline corridor.

Element	Location	Proposed Extent
Operational Elements		
Capital Dredging – Approach Channel	Figure 1-1	Capital dredging of 758,000 m³ of marine sediment from within the harbour approach channel dredge area to target depth of -6.0 m CD.
Capital Dredging – Turning Basin	Figure 1-1	Capital dredging of 86,500 m³ of marine sediment from within the Turning Basin dredge area to target depth of -6.0 m CD.
Capital Dredging – Berth Pocket	Figure 1-1	Capital dredging of 85,500 m³ of marine sediment from within the Berth Pocket dredge area to target depth of -8.0 m CD.
Dredge Material Disposal Pipeline	Figure 1-1	Two pipeline route options are proposed: Pipeline Route Option A – Temporary installation of 450 mm diameter onshore pipeline and booster stations within the pipeline corridor to transport dredge material from floating pipeline to DMMA. Pipeline Route Option B – Temporary installation of 450 mm diameter floating pipeline and booster stations within the pipeline corridor to transport dredge material to an onshore pipeline connection and subsequently to the DMMA.
Onshore Spoil Disposal to DMMA	Figure 1-1	Disposal of approximately 930,000 m³ of clean, uncontaminated marine sediment to the DMMA.
Onshore Spoil Disposal Dewatering	Figure 1-1	Controlled discharge of approximately 21 megalitres (ML) per day of dredge spoil return water to the adjacent intertidal catchment of Beadon Creek.
Channel Navigation Markers	Unspecified	Floating (i.e. moored) channel navigation markers will be installed within the development areas as required.
Vessel Operations	Figure 1-1	Increase in vessel traffic up to approximately 700 vessels per annum to/from the existing OMSB land-backed wharf within the Beadon Creek Maritime Facility, via the HAC, Turning Basin and Berth Pocket.

Figure 1-1 **OMSB Stage 2 Proposal area, including proposed capital dredging area and spoil disposal location**

1.2. Study Area

Onslow

The area around Onslow is the traditional home to the Thalanyji People. The Thalanyji cultural tradition is associated with the rainbow serpent Burra Balanyji that created underground tunnels in the area which link all of the water bodies around Onslow (WAPC, 2011).

The location of the OMSB Project within the Onslow region is shown in **Figure 1-2**. Onslow is located 1386 km north of Perth and 360 km south of Karratha. It was founded in 1883 and gazetted in 1885, as a port at the mouth of the Ashburton River. However, due to repeated cyclone damage and subsequent flooding/silting of the Ashburton River, the townsite was moved in 1925 to its current location, 18 km northeast of Old Onslow, to take advantage of the deeper waters of Beadon Creek. The town's dominant purpose has been as a residential base and service centre for the workforce employed at Onslow Salt, with the solar salt fields encompassing a large area surrounding the Beadon Creek tidal embayment. Pastoralism, fishing and tourism have also supported the town (SoA 2016).

The Onslow Airport is owned and operated by the Shire of Ashburton (SoA) and is located approximately three kilometres south of the Onslow town site. The airport underwent significant upgrades in 2015 to cater for the construction of the Macedon and Wheatstone Projects. The proposed DMMA is immediately north of Onslow airport adjacent to the western tributary of Beadon Creek, and Onslow Road forms the western boundary.

The Macedon and Wheatstone Projects are Liquified Natural Gas (LNG) plants located at the Ashburton North Strategic Industrial Area (ANSIA) approximately 12 km southwest of Onslow. The Port of Ashburton is a multiuser port providing support for the Macedon and Wheatstone Projects LNG developments and other planned industrial activities in the area. Offshore loadout facilities for the Onslow Salt Facility are located to the west of Onslow in the Port of Onslow. The Port of Ashburton and the Port of Onslow share a common port boundary. The Roller oilfield occurs in shallow coastal waters to the west of Onslow (WAPC, 2011).

Beadon Creek Maritime Facility

The Beadon Creek Maritime Facility was developed in 1964 and is managed by the Department of Transport (DoT). The facility is located approximately 550 m south of the entrance to Beadon Creek and is used as a harbour for both recreational and commercial activities, although it has recently transformed from a small facility supporting local and charter fishing activities into a significant facility now providing support to the myriad of industrial and commercial activities associated with the growing offshore oil and gas industry in the region. The Beadon Creek Maritime Facility covers an area of 15.29 ha and includes ~260 m wharf face, mooring berths, cyclone moorings, public service wharf, public boat ramp, diesel fuelling facilities, public car park and fish cleaning facilities (GHD, 2014).

In 2014, the DoT developed a land use framework to upgrade the facilities in Beadon Creek to support the growing demand for industrial, commercial and recreational facilities (GHD 2014). The DoT gained relevant environmental approvals to undertake capital dredging of approximately 55,000 m^3 to form a new berth pocket and turning basin immediately west of the existing channel, with the material to be used to create an additional land-backed wharf area and preliminary development for a community boating precinct immediately north of the existing lots (Oceanica, 2014). The OMSB leased Lot 13 from the DoT and commenced capital dredging and construction of the land-backed wharf in 2016 on behalf of the DoT as part of Stage 1 of the OMSB Project, with the intention of creating a maritime support base to service increasing onshore and offshore demands.

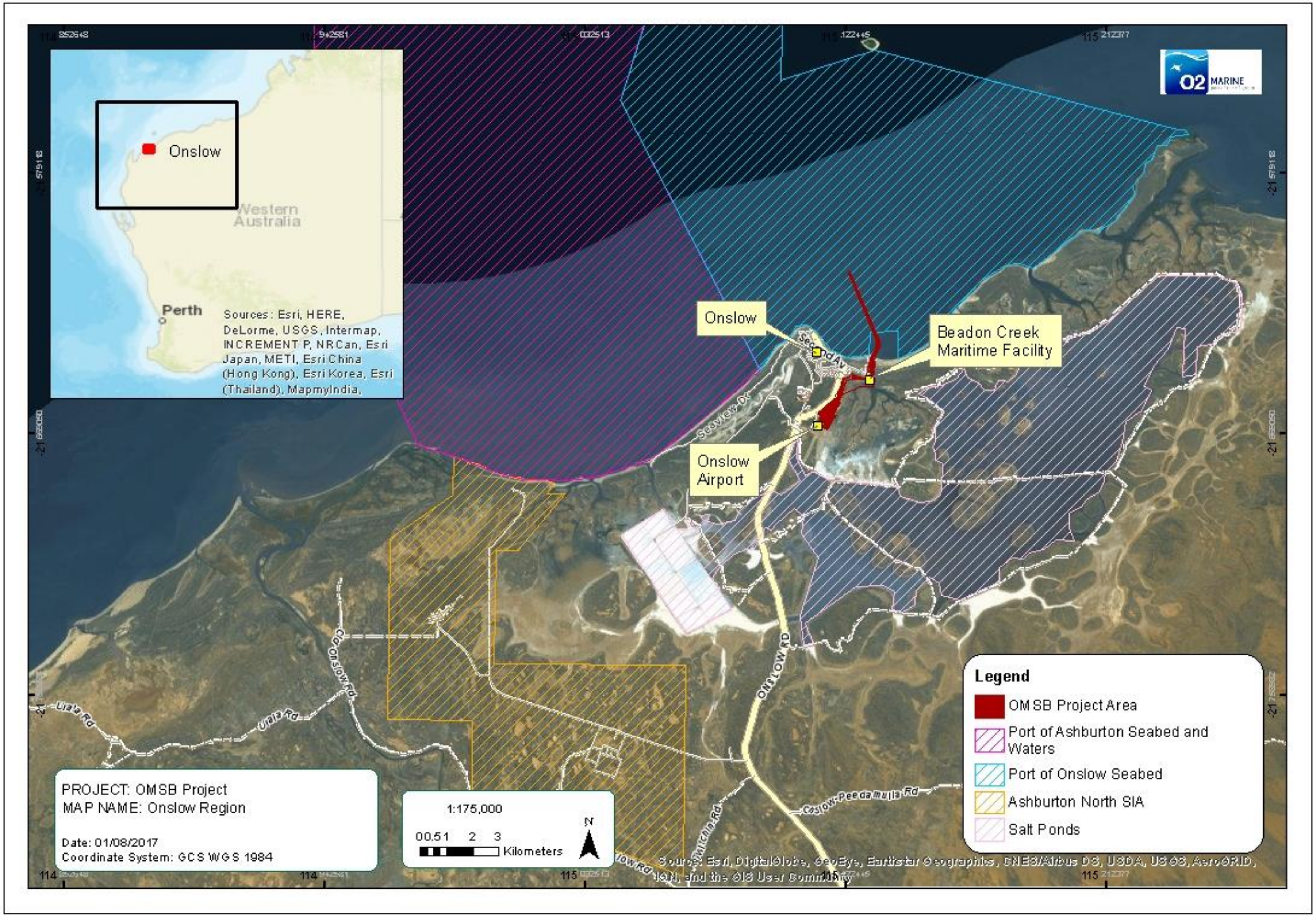

Figure 1-2 The OMSB Project location and developed areas in the Onslow region

1.3. Environmental Assessment Guidance

The Environmental Protection Authority (EPA) adopts a framework of environmental factors, environmental objectives, and guidance material as the basis for decisions on the environmental acceptability of proposals and schemes. The environmental factors segment and characterise key components of the environment within a project footprint to provide a systematic approach to organising environmental information for environmental impact assessment. This report has been prepared to characterise the key characteristics of the following specific environmental factors:

- Benthic Communities and Habitat
- Marine Fauna
- Flora and Vegetation
- Terrestrial Fauna.

The following EPA policies and guidance have been consulted in the evaluation of which environmental factors may potentially be impacted by the proposed project:

- EPA (2016a). *Environmental Factor Guideline: Benthic Communities and Habitats*, EPA, Western Australia;
- EPA (2016b). *Technical Guidance – Protection of Benthic Communities and Habitats*, EPA, Western Australia;
- EPA (2016c). *Technical Guidance – Environmental Impact Assessment of Marine Dredging Proposals*, EPA, Western Australia.
- EPA (2016d). *Environmental Factor Guideline: Marine Fauna*, EPA, Western Australia;
- EPA (2016e). *Environmental Factor Guideline: Flora and Vegetation*, EPA, Western Australia;
- EPA (2016f). *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment*, EPA, Western Australia;
- EPA (2016g). *Environmental Factor Guideline: Terrestrial Fauna*, EPA, Western Australia; and
- EPA (2016h). *Technical Guidance – Terrestrial Fauna Surveys*, EPA, Western Australia

1.4. Study Objectives

This document has been prepared by O2 Marine on behalf of OMSB to demonstrate that the key ecological characteristics of the environment have been adequately assessed to support referral of the OMSB Project to the EPA under section 38 (Part IV) of the *Environmental Protection Act 1986* (EP Act).

The key ecological characteristics of the environment are covered by the following four environmental factors:

- Benthic Communities and Habitat
- Marine Fauna
- Flora and Vegetation
- Terrestrial Fauna.

A desktop assessment and field survey have been undertaken to characterise the ecological environment, identify the risk/significance of OMSB Project activities on the ecological environment and identify mitigation or management measures that may potentially reduce the impacts associated with the OMSB Project. A description of the findings of an assessment for each of the four environmental factors is provided in the following sections of the report.

2. Benthic Communities and Habitat

The Environmental Protection Authority (EPA) has developed technical guidance for the protection of Benthic Communities and Habitats (BCH) in recognition of the important role these community and habitat types play in maintaining the integrity of marine ecosystems and for the supply of ecological services. Benthic communities and their associated habitats are important for the maintenance of biological diversity by providing structural complexity, refuge for vulnerable life stages and a varied and increased food supply. The EPAs objective for the factor BCH is *"to protect benthic communities and habitats so that biological diversity and ecological integrity are maintained"*.

This report describes the BCH within the area of the OMSB Project using desktop investigations and ground-truth field surveys. The information collated is used to provide an assessment of the potential effects of project activities on BCH and recommendations for mitigating these effects. Environmental impact assessment and management requires investigation of the extent, severity and duration of the project activities. Also assessed are the cumulative effects when the impacts associated with this proposal are added to historical and proposed impacts from other sources in the region.

The BCH which are considered in this report comprise:

- Mixed species mangrove communities;
- Upper intertidal mud flats supporting samphire communities;
- Cyanobacterial algal mats;
- Subtidal coral communities; and
- Seagrass, macroalgae and filter feeder communities.

The assessment process for BCH was informed by the EPA technical guidance documents for the Protection of Benthic Communities and Habitats (EPA, 2016a) and Environmental Impact Assessment of Marine Dredging (EPA, 2016b).

2.1. Method

2.1.1. Desktop Assessment

Desktop review of previous relevant surveys of intertidal and subtidal habitats from the region revealed a substantial amount of fieldwork and data analyses have been undertaken in the OMSB Project area to define both the types of BCH that occur and their approximate distribution. The following studies were reviewed:

- Onslow Salt ERMP Volume 2 Technical Appendix C Report on the Biological Environments near Onslow, Western Australia (Paling, 1990)
- Roller Oilfield Development CER – Appendix 2 Intertidal Habitats of the Onslow to Tubridgi Point coast and Locker Island (LEC, 1991a)
- Roller Oilfield Development CER – Appendix 3 Underwater Surveys of Roller Oilfield (LEC, 1991b)
- Final Guidance No. 1 Guidance Statement for protection of tropical arid zone mangroves along the Pilbara coastline. (EPA, 2001)
- Wheatstone Project Draft EIS/ERMP Technical Appendices N7 Baseline Coral Community Description (URS, 2010a)
- Wheatstone Project Draft EIS/ERMP Technical Appendices N11 Survey of Intertidal Habitats off Onslow, WA (URS, 2010b)
- Wheatstone Project Draft EIS/ERMP Technical Appendices N12 Survey of Subtidal Habitats off Onslow, WA (URS, 2010c)
- Wheatstone Project Draft EIS/ERMP Technical Appendices N15 Benthic Primary Producer (Seagrass and Macroalgae) Habitats of the Wheatstone Project Area (URS, 2010d)

- Wheatstone Project State of the Marine Environment Baseline Report (Chevron, 2013)
- Wheatstone Project Mid-term State of the Marine Environment Report (Chevron, 2015)
- Wheatstone Project First Post-Development State of the Marine Environment Report (Chevron, 2017)

2.1.2. Field Assessment

A ground truth survey in the intertidal area at the back dune from the LIA, comprising the area between LIA and the proposed DMMA to provide an overview of the current range and distribution of intertidal habitats potentially impacted from onshore disposal activities relative to previous detailed mapping of this area. A similar survey was also undertaken in the intertidal area of the turning circle proposed to be dredged on the eastern side of the bank to determine whether intertidal BCH are present. The areas that were assessed by the ground-truth surveys along the proposed pipeline route and the DMMA are shown in **Figure 2-1**, which includes both intertidal BCH and terrestrial flora and vegetation. The results for the terrestrial flora and vegetation of the pipeline route and DMMA is provided in **Section 4.1.2.**

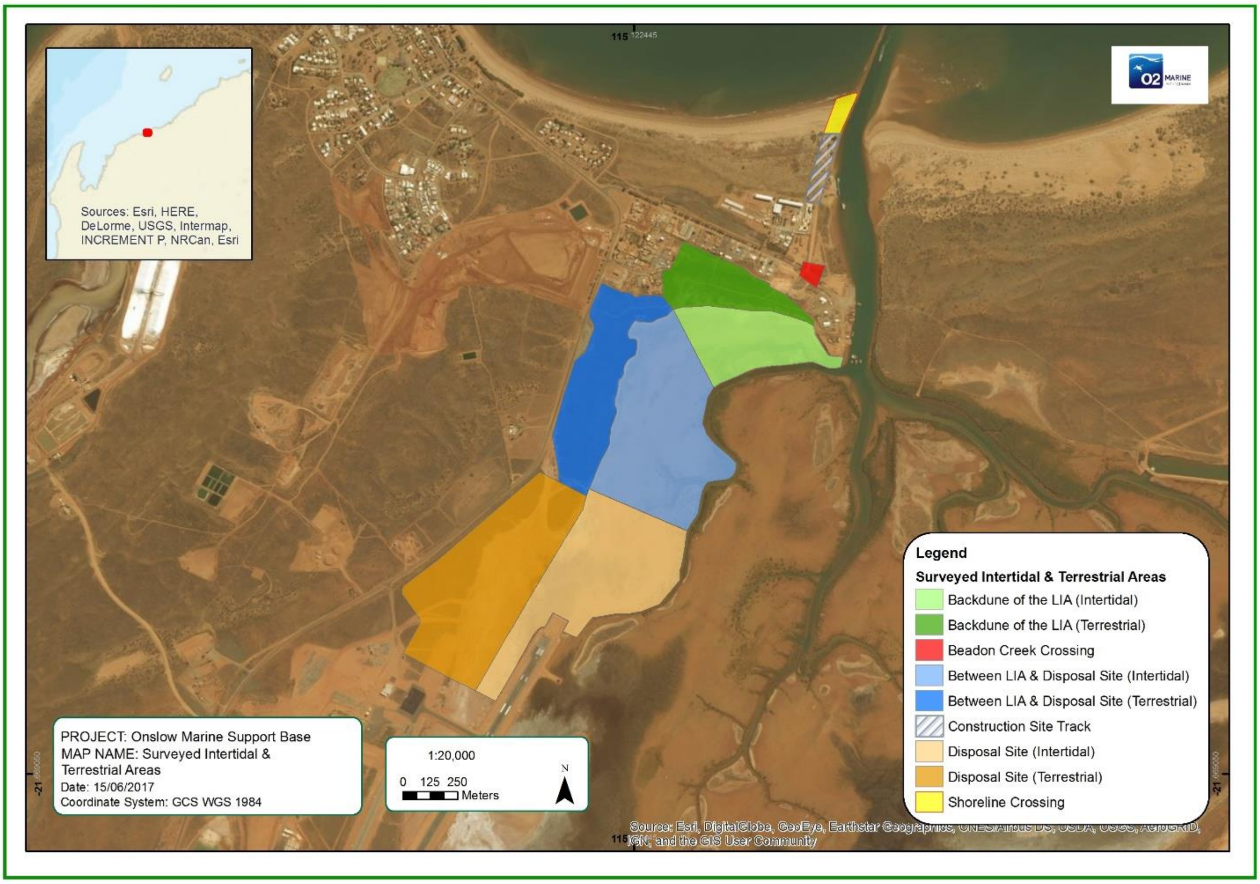

Figure 2-1 **Intertidal and Terrestrial areas surveyed during the field assessment**

A subtidal ground-truth survey was undertaken on 19 March 2017 of nearshore areas previously mapped as seagrass BCH that could potentially be impacted during the proposed dredging activities. The surveyed area spans ~7.5 km of coastline, from Town Beach to 3rd Creek, and ~2.5 km offshore. A 1 km cell grid was overlaid onto the survey area prior to the field investigation to identify potential site locations at the intersection point of each cell. A total of 30 sites were surveyed during the field assessment using drop camera transects drifting for a duration of 5 minutes. The locations of the sites surveyed are presented in **Figure 2-1** with the results. The video feed from the towed camera was displayed in real time with an overlay showing the vessel position, transect identification and time. Video footage was recorded on a hard disk drive and backed up on a laptop computer. Digital still images were also collected from each site. The live video feed was used to undertake qualitative classification of BCH by marine scientists onboard using the scheme shown in **Table 2-1** and observation of other general comments. The classifications and videos were reviewed by an experienced observer after completion of the survey. Benthic drop camera field records are provided in **Appendix A**. Benthic habitat mapping involved review of the dominant characteristics of the BCH recorded during the survey and classifying into six distinct habitat classes shown in **Table 2-4** based on substrate type, total biotic cover and dominant BCH type.

Benthic habitat mapping results from the First Post Development State of the Marine Environment Report (Chevron 2017) for non-coral were reviewed and reclassified into classes which correlate very closely with categories used in the field assessment to compare the results from separate investigations. The maps from Chevron (2017) show the cover estimates for seagrass, macroalgae and filter feeder habitat separately. The results presented in each map were combined to provide the total biotic cover and the dominant BCH type, although information on the substrate type was not able to be obtained from the data. The results from Chevron (2017) covers a broader survey area and more diverse habitat types over the West Pilbara region and therefore resulted in a total of 10 classes which are presented in **Table 2-5**.

Table 2-1 Habitat classifications used to record benthic habitat features during the field assessment

Physical Factors		Biological Factors	
Relief	**Substrate Type**	**Percent Cover**	**Dominant Benthic Habitat**
Flat	Sand	Bare (<1%)	Macroalgae
Gentle slope	Silt	Sparse (1-3%)	Seagrass
Steep slope	Mud	Low (3-10%)	Non-coral benthic invertebrates
Vertical wall	Gravel	Medium (5-25%)	Hard corals
Macro-ripples	Rubble	High (25-75%)	Soft corals
	Sand with shell	Dense (>75%)	Unvegetated
	Silt with shell		
	Reef low profile		
	Reef High profile		
	Limestone pavement		
	Boulders		

2.1.3. Benthic Habitat Mapping

Benthic habitat mapping was undertaken to identify the location of habitats and sensitive receptors to characterise the local marine environment, inform predictions, detection of dredging related impacts and focus monitoring and management actions.

Intertidal BCH has been interpreted through interrogation of aerial imagery provided from the DoT, review of previous survey information and notes recorded from the field assessment. Intertidal habitat mapping has been prepared through review of existing maps, review of the abundance and distribution of these habitats since these maps were generated and results from the field assessment.

Subtidal habitat maps have been prepared through extensive review of existing information collected within the area and the results of the field ground-truth survey. The information considered in mapping the distribution of BCH includes baseline survey results from the Wheatstone Project EIS/ERMP, monitoring results and mapping presented in the State of the Marine Environment Reports for the Wheatstone Project, survey results undertaken by (Paling, 1990) and the results recorded in the field assessment ground-truth survey.

2.2. Desktop Assessment Results

2.2.1. Intertidal Habitats

The tidal embayment of the OMSB Project area is broad and flat with narrow mangrove fringed creeks backed by extensive mudflats. The distribution of habitat types within the tidal embayment is a landward progression from tidal creek, mangroves, samphire and bioturbated high tidal mud flat, algal mat covered high tidal flat, salt flat to hinterland margin.

The intertidal habitats occurring within the OMSB Project area are sandy beaches, sand bars and shoals at the mouth of tidal creeks, rocky shores, lagoon flats, mangroves and a large tidal mud flat unit which contains the habitats of bioturbated mud flats with samphire communities, algal mats and supratidal salt flats. Mangroves, samphire communities and algal mats have been considered in defining the BCH within the OMSB Project area.

Mangrove Communities

Mangroves typically occur between the high neap-tide (1.8 m CD) and spring-tide (2.5 m CD) levels mostly associated with river mouth and tidal creek systems where they form a nearly continuous ribbon of vegetation fringing the creek channels (i.e. 10-20 m wide). More expansive mangrove areas are found at Coolgra Point where a far greater area and diversity of habitats exist that are suitable for mangrove colonisation (URS, 2010b). These mangroves are protected and partially isolated from the sea by barrier dune systems. The relationship between the tidal elevation and frequency and duration of tidal inundation establishes salinity gradients across the mangrove zone that influences both the occurrence of the different mangrove species (due to differing salinity tolerance limits) and the mangrove community structure.

Six of the seven mangrove species recorded in the Pilbara region occur within the Onslow area (Paling, 1990, LEC 1991a; URS 2010a). The six mangrove species are:

- *Avicennia marina* – grey mangrove
- *Rhizophora stylosa* – spotted-leaved red mangrove
- *Bruguiera exaristata* – ribbed mangrove
- *Ceriops australis* – spurred mangrove[1]
- *Aegialitis annulata* – club mangrove
- *Aegiceras corniculatum* – river mangrove

The six species represent four families: Avicenniaceae (*Avicennia marina*), Rhizophoraceae (*R. stylosa*, *B. exaristata, C. australis*), Plumbaginaceae (*A. annulata*), Myrsinaceae (*A. corniculatum*).

The typical assemblage structure and distribution of mangrove species in the Onslow area is shown in **Table 2-2**. Whilst the area supports a wide distribution of mangrove systems, in this report mangroves within the Beadon Creek system are the focus of the assessment of potential impact from dredging and onshore disposal within and adjacent to the creek. Typical of Pilbara coastal region mangrove communities, *A. marina* is the most widespread and abundant species within mangrove associations in Beadon Creek (Paling, 1990; LEC, 1991a; Semeniuk, 1993; URS, 2010b). It occurs both as monospecific and mixed assemblages in a range of structural forms (e.g. dense forest to open shrubland) with growth forms typically reflecting a salinity gradient. *Rhizophora stylosa* is the next most common species forming dense stands in the muddy protected

[1] Many historical records of this species have been classified as *Ceriops tagal*

environment lining the seaward part of the creeks subject to regular tidal inundation. *Ceriops australis* and *A. corniculatum* are much less common, with *C. australis* typically occurring with *A. marina* to form open scrub along the landward margin of the mangrove zone and *A. corniculatum* forming a narrow band along the shallow areas of gently sloping banks. The other two species known from the Onslow area *Bruguiera exaristata* and *A. annulata* have not been reported within Beadon Creek (URS, 2010b).

Consistent with these findings, (Paling, 1990) noted *A. marina* was the dominant mangrove with small pockets of *R. stylosa* lining Beadon Creek as a discontinuous band and occasional trees of *C. australis* present at the landward mangal edge. (Paling, 1990) estimated 134.67 ha of mangroves occur along the edges of Beadon Creek.

Table 2-2 Mangrove species, structure and extent within the Onslow area

Mangrove	Assemblage Structure	Extent/Occurrence
Avicennia marina	Typically, tall/dense monospecific or mixed assemblage on the seaward margin & low/open monospecific or mixed assemblage towards the landward margin	Widespread and abundant across mangrove systems
Rhizophora stylosa	Dense mostly monospecific stands lining lower reaches of the creeks	Widespread & common, although most extensive stands occur at Coolgra Point & Ashburton Delta
Bruguiera exaristata	Minor species amongst dense *A. marina* dominated tall shrubland	Limited to two isolated stands (10-15 trees) at Coolgra Point & Ashburton Delta
Ceriops australis	Forms open scrub with *A. marina* along landward margin of the mangrove zone	Moderate distribution & occurrence within larger creeks (i.e. Beadon Creek), Coolgra Point & Ashburton Delta
Aegialitis annulata	Forms understory species to A. marina dominated tall shrubland	Limited and uncommon within large creeks West of Onslow, Coolgra Point & Ashburton Delta
Aegiceras corniculatum	Narrow band on shallower tidal creek slopes of prograding banks	Common in parts of the Ashburton Delta & uncommon within larger creeks (i.e. Beadon Creek) & Coolgra Point

Upper Intertidal Mud Flats Supporting Samphire Communities

Throughout the West Pilbara coastal region, landward of the mangroves there are large areas of high tidal mud flats commonly extending to the hinterland margin and often interspersed with supratidal salt flats, cheniers and limestone ridges. These high tidal mud flat areas are not inundated by daily tides. There are two habitat types on the high tidal mud flats:

- Bioturbated mud flats, devoid of macro-vegetation but heavily worked over by burrowing crabs
- Samphire flats, dominated by halophytic shrubs but with some crab burrows

Boundaries between these mud flat types are not always discrete and are not easily mapped. Typically, an area of bioturbated mud flat occurs immediately behind (landward of) the mangrove zone, while samphire flats extend landward of the bioturbated mud flat to the hinterland margin. In many areas patches of samphire plants also occur amongst the low open mangrove scrubs.

URS (2010b) describes the vegetation communities generally found in the Onslow region on the samphire flats as dominated by two samphire species, *Tecticornia halocnemoides* and *T. pruinosa*, and other species commonly found included *Muellerolimon salicorniaceum*, *Frankenia ambita*, *Neobassia astrocarpa*, *Hemichroa diandra* and the perennial grass *Sporobolus virginicus* (marine couch). Paling (1990) recorded

Sueda arbusculoides amongst mangrove trees and at the landward edge of the mangrove community and *Halosarcia auriculataipruinosa* high on the mud flats of creeks within the area (including Beadon Creek).

Cyanobacterial Algal Mats

At locations on the Onslow coastline where expansive mud flats extend further landward of the high tidal mud flat habitats described above, areas of algal mats (also referred to as cyanobacterial mats) frequently occur (URS 2010b). Within the Beadon Creek area Paling (1990) recorded a total area of 453.76 ha of algal mat. The algal mats examined were made up almost exclusively of *Microcoleus chthonoplastes*, a blue green algae (cyanobacterium) which is also a major constituent of algal mats in the Dampier region, and has been shown to fix nitrogen in significant quantities (Paling, 1990). Another cyanobacterium, *Oscillatoria* sp., was noted in one sample but this was very rare.

The algal mats vary from a sheet form, to a pustular crinkled form. In the most commonly observed sheet form, the mat is generally 5 to 10 mm thick and could be easily rolled and peeled back from the mud flat surface. At higher elevations the mat have been observed to be broken and peeled back due to desiccation and wind (URS, 2010b). Where the algal mats retain moisture, they take on a dark colouring and texture that makes them readily identifiable from a distance. Six hours after a high spring tide (2.2 m), large areas of mat were overlain with water which had remained after the tide had receded. This ponding was also visible from the air 16 hours after a high spring tide on mats at Beadon Creek (Paling, 1990).

Supratidal Salt Flats

Supratidal mudflats in the Pilbara region are highly saline and are referred to here as salt flats. They do not provide habitat for marine invertebrate fauna although are part of the drainage catchments of the mangrove ecosystem. Salt flats are located where the high tidal mudflats extend landward from algal mat habitats. These flats are inundated only on rare occasions by either extreme sea level events or by freshwater during flood periods. There are no burrowing crabs or marine invertebrates living in this zone and are predominantly devoid of vegetation (URS, 2010b).

Rocky Shore

Short, narrow, sloping intertidal limestone ramps occur along small stretches along the sandy Onslow coast. These beach rock outcrops are presumed to be either Holocene beach rock or Pleistocene limestone. At Beadon Point an intertidal exposure of limestone formed a wide rock platform with a moderately well-developed rocky shore fauna and flora (URS, 2010b). There was no upper littoral rock bench so that part of the rocky shore community was missing. Instead there was a steep beach slope in the upper littoral zone with a narrow, muddy sand flat at the base. The inner rock platform was covered in mud and populated only by a low muddy turf alga with very little invertebrate fauna. The outer mid littoral and lower littoral rock platform had a moderately diverse invertebrate fauna and there was moderate, patchy growth of leafy algae and low seagrass. Some shallow lower littoral pools had small but numerous coral colonies. A limestone rock outcrop in the mid to upper tidal zone was recorded along the north-western shoreline of Coolgra Point which is partially covered in mud with moderately dense mangrove growth. The invertebrate fauna observed at this location was a diverse, mixed assemblage of mangrove and rocky shore species (URS, 2010b).

Sandy Beaches

Sandy beaches in the area have been recorded to be remarkably consistent in profile, sediment characteristics and fauna. The beaches comprise fine, well sorted sand on a near-horizontal supratidal ramp and steep intertidal beach slope. Except for a transient escarpment 20-40 cm high cut into the upper slope by a previous high tide, the slope from the upper to lower intertidal zones is very consistent. The only noted bioturbation was from occasional ghost crab burrows. The sand comprises medium to coarse-grained calcareous sands and shelly sands which is widespread along the coastline. The fauna of the seaward beach slopes is extremely limited. Similarly, the fauna on sand bars and shoals at the mouths of tidal creeks in the area are extremely restricted (URS, 2010b).

2.2.2. Subtidal Habitats

Comprehensive surveys of subtidal habitats in the Onslow region have recently been undertaken for baseline and monitoring programs completed for the Wheatstone development which entailed a large-scale capital dredging project. The data gathered during the Wheatstone project has provided a wealth of useful information on the BCH types present in the region and highlights the spatial and temporal variability in the distribution, abundance and diversity of these BCH. Detailed examination of this information is useful for informing the assessment of the potential environmental impacts from the proposed project in Beadon Creek.

The complex topography of the nearshore seafloor in the West Pilbara region provides habitat for a variety of benthic biota. The seabed is predominantly comprised of soft sediment substrate which supports a low cover of sessile benthic biota. There is a gradation of silty sands from inshore to the 10 m isobath to sandy gravels seaward of the 10 m isobath. The silty sand habitat was found to support a lower density of sessile invertebrates than the gravels offshore (URS, 2010c).

Habitats shown to support sessile benthic biota with greater than 10% cover are generally restricted to the fringes of islands, small shoals and rock outcrops along the 10 m isobath, or areas of shallow hard pavement. Corals are sparsely distributed and are only found around island fringes and on shallow subtidal shoals. Macroalgae tend to occur on shallow hard pavement that surround most islands in the region whilst filter feeders (sponges, sea whips and sea fans) occur on deeper water hard pavement. Seagrasses are sparsely distributed throughout the area and tend to be associated with shallow protected nearshore waters (<10 m CD). The distribution of the major biotic groups was mapped for the Wheatstone Project EIS/ERMP to provide the basis for impact assessment of the effect of the marine construction activities and these major groups are shown in **Figure 2-2** (URS, 2010c).

Coral Communities

In the Onslow region, coral communities have been found on biogenic reefs and rocks fringing islands of the area. Biogenic reefs are primarily associated with the ecosystem unit between 10-20 m depth, which includes fringing reefs surrounding offshore islands. The other coral communities present in the area do not form reefs but are found on exposed hard substrate and are typically in the shallower nearshore waters to 10 m depth, an area that is characterised by a ridge of scattered patch shoals. The reefs fringing the islands (e.g. Ashburton Island) have been recorded to support a moderate, but variable, percent coral cover. Shoals within this zone typically support a diverse and healthy coral community. Hydroids, gorgonians, sponges and macroalgae are also present at these locations. Closer to shore, the shoals and exposed pavements have a low coral cover (i.e. <10%). However, Ward Reef, Roller Shoal and Glennie Patches, between the nearshore reefs and the chain of shoals along the 10 m isobath, have been recorded to support a moderate to high coral cover (URS, 2010c).

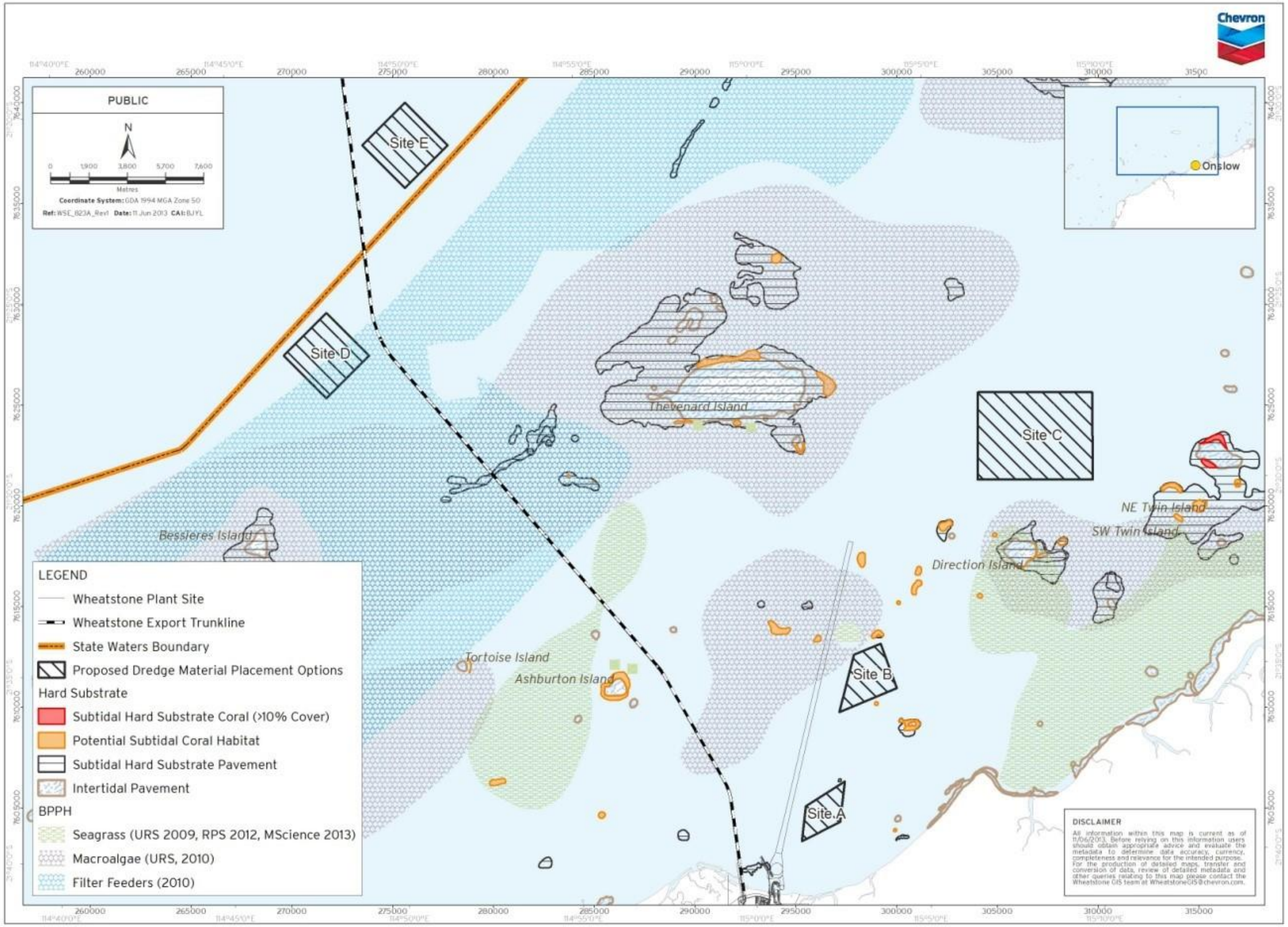

Figure 2-2 **Subtidal benthic habitat map for the Onslow region (Chevron, 2013)**

Coral monitoring was undertaken between April 2009 and May 2015 prior to, during and post the Wheatstone Project dredging program to assess changes in coral cover from baseline to three months post dredging activity. The areas mapped for 'potential' subtidal coral habitat changed very little between baseline, mid-term and the first post-development survey. However, the coral community composition recorded within these locations changed considerably through time since the initial baseline surveys in response to widespread natural disturbance events associated with anomalous water temperatures and cyclones. In 2009 coral cover was high, with a mean cover among survey reefs of 45% (range 29% to 68%) (Chevron, 2013). Hard coral cover declined considerably between April 2009 and September 2011 in response to above-average sea temperatures in summer 2010/2011 that caused widespread mass coral bleaching and subsequent coral mortality, as well as damage resulting from TC Carlos in February 2011. Relative coral cover declined by up to 97% at monitored reef formations resulting in an average coral cover of 6% (Chevron, 2013). Sea temperatures were again elevated during February and March 2013 causing mass bleaching of most of the remaining corals and resulting in further decline in coral cover at most sites between the final Baseline survey in March 2013 and the first dredge monitoring survey in May 2013. Reefs located further to the East and West used as reference reefs for the Wheatstone Project were less impacted by the bleaching event in 2010/2011, although suffered greater mortality following the event in February/March 2013 (Chevron, 2015). The low percent coral cover across monitored reef formations remained relatively stable during the dredging program, with cover recorded in May 2015 across monitored reef formations ranging from <1% to 16%. Average coral cover on nearshore reefs such as Ward Reef, Roller shoals and Locker Island ranged between 2% and 4% (Chevron, 2017).

The decline in coral cover between 2009 and 2013 was largely attributable to the loss of the dominant Acroporidae corals (i.e. *Acropora* and *Montipora*), and to a lesser extent Pocilloporidae, Agariciidae and Merulinidae coral families. The previous high coral cover on the reef was replaced by turf algae and sediment and the default dominant taxa across reefs shifted to Faviidae and Poritidae corals more tolerant to thermal bleaching warm sea temperatures (Chevron, 2013). Benthic cover on reef formations since this event has remained relatively stable. However, the cover of corals from the Acroporidae family, particularly the genus *Acropora*, appear to have increased on some reefs between 10-20 m within the region during the dredging program through growth of recent recruits (Chevron, 2017).

Seagrass, Macroalgae and Filter Feeder Communities

Paling, (1990) investigated the benthic communities for the Onslow Salt ERMP dredge channel from East of Ward Reef to 750 m offshore. The benthic habitat was described as very fine bioturbated mud with small macroalgae (0.05 to 0.4 m) and the occasional hydrozoans, starfish (Asteroideae) and ascideans. Bottom vegetation varied from bare mud to a light covering of macroalgae all of which was attached to small (5 cm) shells. The algae most commonly, present were phaeophytes (*Padina*, *Glossophora, Spatoglossum*) rhodophytes (*Laurencia*, *Amphiroa*, *Asparagopsis*), and chlorophytes (*Hailmeda, Caulerpa*). Approximately 1 km offshore and 4 m depth the turbidity of the water was very high and prevented evaluation of benthic epifauna on the muddy bottom. The sediment changed to a bare muddy sand with rare patches of the seagrass *Halophila decipiens* closer inshore. The green algae *Caulerpa geminata* was commonly seen on small low profile rocky outcrops (<0.5 m wide) and the sandy bottom adjacent to them. Small coral, phaeophytes and sponges commonly occurred on larger low-profile rock outcrops (1 m wide). Nearshore surveys opposite Four Mile Creek, Middle Creek and Hooleys Creek recorded predominantly bare rippled sand with a low density of sponges, bryozoans and macroalgae to approximately 800 m (Paling, 1990).

Benthic habitats of the region were also extensively surveyed during the baseline period for the Wheatstone Project EIS/ERMP between November 2008 and September 2009 using a remotely operated camera across some 352 transects in the project area. Most of the survey area comprised soft sediment substrate dominated with infauna although relatively few epifaunal species were observed. Soft sediments were typically comprised of sands and silts within the 10 m isobath and gravel seaward of the 10 m isobath. A higher density of benthic infauna was typically associated with gravels further offshore. Sessile non-coral invertebrates recorded during these surveys included macroalgae, seagrass and filter feeders (sponges, ascidians and hydroids). However, these habitats are rarely described as homogenous and were typically characterised by patches of different community types (URS, 2010c).

Macroalgae are generally restricted to hard substratum in subtidal and lower intertidal areas. Macroalgae occur in tidal pools in occasional outcrops of beach rock along the mainland shoreline, and more extensively on shallow subtidal platforms and flats surrounding the offshore islands. Limestone reefs and platforms provide habitat for more extensive development of mixed algal and seagrass beds, whilst sparse cover of macroalgae was present at most sites attached to small rocks and shell fragments which permitted colonisation of areas largely dominated by soft substratum. These areas are generally dominated by brown macroalgae (*Sporochnus, Padina, Sargassum, Dictyopteris*) and large red algae (*Asparagopsis*), with green algae (*Halimeda, Caulerpa*) forming a smaller component, often in shallower (lower intertidal and shallow subtidal) water. The greatest macroalgae coverage was near Thevenard Island and the Mangrove Islands, typically on subtidal limestone platforms, with localised lower abundances present at numerous shoals and islands (URS, 2010c).

Seagrasses were absent at most sites during surveys undertaken in both summer 2008 and winter 2009. The distribution of seagrasses is sparsely distributed in small patches within larger areas of suitable substrate, with the plants usually occupying areas of only a few square meters or tens of square meters that are not continuous patches. Four species of the seagrass genus *Halophila* were recorded: *H. spinulosa*, *H. ovalis, H. minor* and *H. decipiens* in December 2008. Seagrass cover tended to be low. Low cover (<10%) areas of seagrass were found south-west of Thevenard Island and northeast of Onslow. Seagrass northeast of Onslow was lower in August 2009 than December 2008, although seagrass genera *Syringodium* and *Halodule* were discovered that were not identified from other locations during previous surveys (Chevron, 2013). The largest known meadow of seagrasses in the Pilbara is a patch of *Cymodocea angustata* at Mary Anne Reef, east of Onslow, that has several hundred hectares of 30% to 50% cover at a depth of 2-3 m (URS, 2010d).

Sessile filter feeders are common on the sand veneered pavement that dominates the inner shelf and are one of the largest BCH units present (URS, 2010c). The greatest density of filter feeders generally occurred at >10 m depth. Filter feeder taxa identified included sponges, gorgonians, bryozoans, ascidians and soft corals. Hard corals were also relatively common in these areas (Chevron, 2013).

Habitat maps were prepared using the habitat classification results from the surveys to identify the existing and potential areas of benthic primary producer habitat (BPPH). The objective of characterising BCH during baseline investigations for the Wheatstone Project was focussed on identifying areas of BPPH with >10% cover. Large areas of substrate had <10% biota cover and were categorised according to their predominant sediment type, although sparse foliose macroalgae were often present. Sites with the potential for macroalgae, seagrass, and filter feeders at >10% cover were categorised. Statistical analysis and a kriging process were then applied to produce interpolated distribution maps for these communities (**Figure 2-2**). Although seagrass areas dominated by *Halophila* are generally difficult to map because this genus is temporally variable and cover is usually low, the dugong tracking study undertaken in 2012 showing dugong activity at Coolgra Point, Thevenard, Direction and Ashburton Islands provided evidence that seagrass habitat boundaries were relatively accurate with respect to the distribution of benthic biota and low seagrass cover (<1%) during the baseline investigations (**Figure 2-3**).

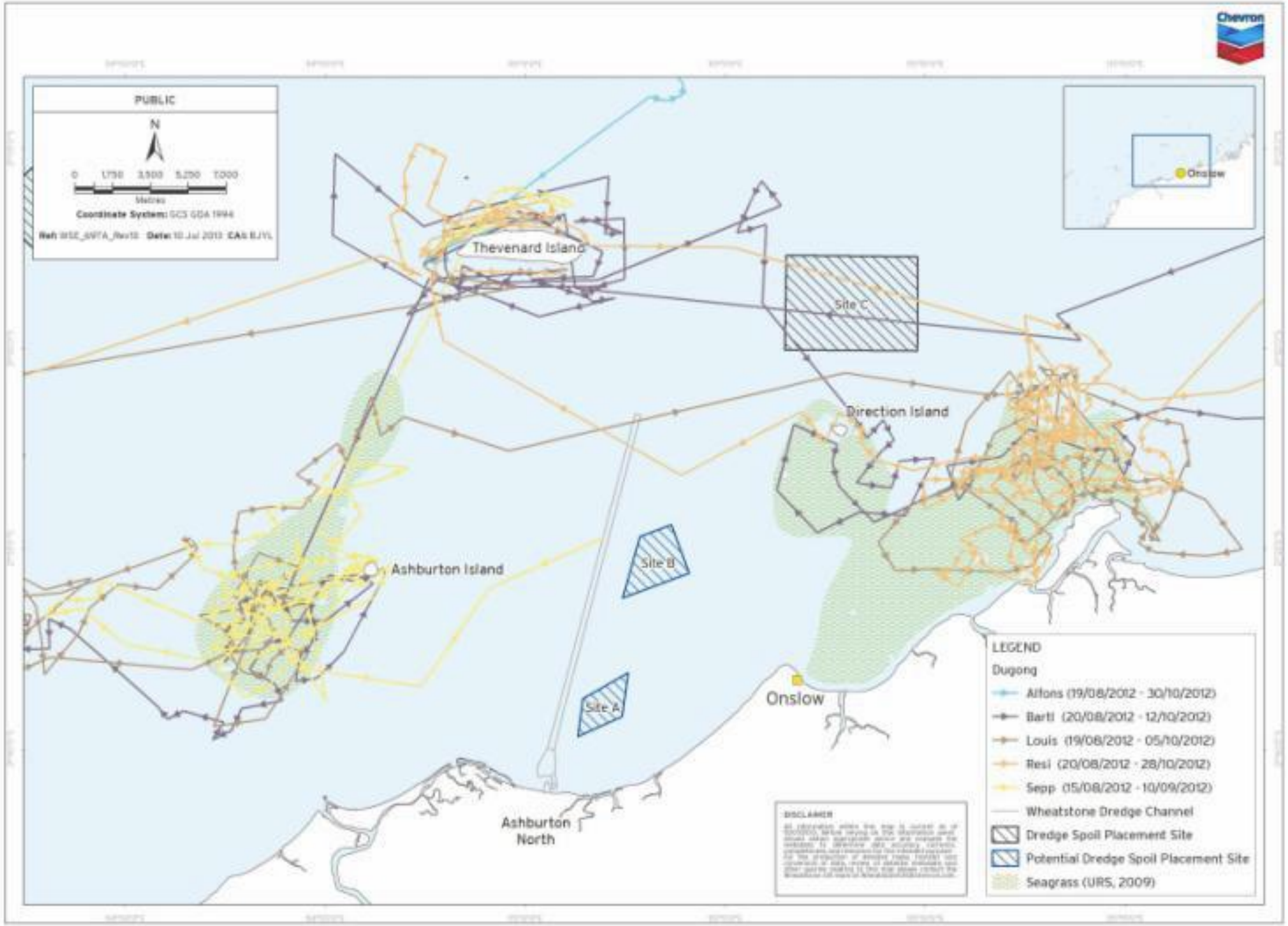

Figure 2-3 **Satellite dugong tracking data August 2012 (Chevron, 2013)**

Review of habitat mapping within the State of the Marine Environment Reports prepared during the mid-term and post the dredging program for the Wheatstone Project within the nearshore area (<10 m) determined that BCH is much more widespread than initially identified in the map (Chevron 2015). Most of the habitat within the nearshore area between the Ashburton River and Coolgra Point is composed of occasional filter feeder and macroalgae from <1% to 2% cover with sparse to moderate bioturbation of the substrate. Filter feeders recorded typically included bryozoans, hydroids, ascidians, sponges and gorgonians. Macroalgae recorded included short tufting and foliose algae and genera listed were *Udotea*, *Sargassum* and *Halimeda*. Seagrasses were recorded in transects west of Beadon Point to Coolgra Point although the abundance and diversity was typically greater between Third Creek to Coolgra Point. Seagrass cover of 10-25% with dense patches of 50-75% were recorded within this area consisting of *H. decipiens*, *H. spinulosa*, *Halodule* and *Syringodium*. In comparison, *Halophila* seagrass identified in patches within transects from west of Beadon Point to Third Creek contributed to a typically low total biotic cover with filter feeder and macroalgae of <2% (URS, 2010c). These findings support those of (Paling, 1990) who recorded very low cover of seagrass, macroalgae and filter feeder habitat offshore from Beadon Point. Small areas (i.e. 5 m^2) of isolated outcrops, rubble and pavement covered in sand are regularly encountered within the coastal zone from the Ashburton River to Coolgra Point which typically comprise higher cover and diversity of BCH including hard corals, typically *Turbinaria* although includes massive and encrusting Poritidae, Acroporidae, Faviidae and Mussidae, as well as crinoids, sea pens, sea whips and sea stars.

Sampling units within mapped areas of macroalgae, seagrass, and filter feeder habitat were created in 2011 to monitor the change in percent cover estimates of BCH at baseline, during and post dredging for the Wheatstone Project. Data were collected in early summer to coincide with the predicted peak period of seagrass cover and biomass in nearshore water of the survey area (Chevron, 2015). In general, marked spatial differences in cover among zones was evident at baseline, midterm and post-development surveys for some but not all non-coral habitat types

Baseline surveys indicated that the nearshore seafloor between reef areas is primarily composed of soft substratum with only occasional sparse patches of seagrass, as well as pavement with a sand veneer where moderate levels of macroalgae and occasional seagrasses or filter feeders occurred. The cover of seagrass and filter feeders was typically low (<5%), although localised areas of high cover were recorded with maximum cover within cells reaching 53% for macroalgae, 11.6% for seagrass and 9% for filter feeders. Complex temporal/spatial changes in seagrass cover were observed within and between baseline years in 2011 and 2012. An increase in seagrass cover from September to December 2011 was recorded from offshore transects near Ashburton Island, although nearshore transects northeast of Onslow recorded declines in seagrass cover during the same period. This pattern was reversed in 2012 with a decrease in seagrass cover from September to December in offshore sites and an increase in nearshore sites. However, seagrass was typically more abundant in December than September. Seagrass composition also changed between 2011 and 2012, with *H. minor* recorded as the most common species in 2011 and *H. spinulosa*, *H. decipiens* and *H. ovalis* the most common species in 2012. Only three seeds were collected during baseline sampling and above and below ground biomass was spatially variable in both years. Macroalgae and filter feeder cover did not vary greatly between September and December 2012 although spatial variability was high within and between sampling units (Chevron, 2013).

Little difference in the mean percent cover of macroalgae, seagrass and filter feeders was recorded between December 2012 and the mid-point of the dredging program in December 2014. Despite no clear change apparent for any benthic habitat type, the 17 surveyed cells within the nearshore area northeast of Onslow typically recorded a positive change for macroalgae (12 cells) and a negative change for seagrass and filter feeders (10 & 11 cells, respectively). The composition of benthic types, particularly seagrass species present, varied within fixed repeated cells reflecting the temporally dynamic nature of seagrass in the area. The dominant seagrass *H. spinulosa* in 2012 was four times the biomass of *H. ovalis* and *H. decipiens*, although *H. ovalis* was the most widespread species in 2014 (Chevron, 2015).

The mean percent cover of seagrass and macroalgae post dredging in December 2015 declined compared to cover recorded in December 2012 and 2014. This was possibly due to the passing of TC Olwyn which was shown to remove seagrass from an area near Thevenard Island during March 2015 although seagrass communities should have recovered by December (Vanderklift et al. 2017a). However, the cover of filter feeders was higher compared to previous surveys. Of the 14 cells surveyed in 2015 within the nearshore area northeast of Onslow, a negative change was recorded from 11 cells for macroalgae and 14 cells for seagrass, whilst nine cells recorded a positive change for filter feeders. Negative changes recorded could not be attributed to dredging activities as the patterns of cover were not correlated with distance from the dredging (i.e. variable patterns recorded among sites directly adjacent to dredging and at reference sites), indicating natural variable influences on the cover and distribution of non-coral habitats in the area. More frequent sampling (3-6 months) undertaken at some seagrass cells showed cover estimates vary markedly and not always consistently between spatially distributed habitats within short-term intervals. The highest short-term variability was observed among nearshore cells (<5 m) between Beadon Creek and Coolgra Point. The seagrass composition within cells continued to change with *Cymodocea* and *Halodule* observed in samples collected in December 2015. It is suggested that external factors such as thermal anomalies and flood events may have had a profound influence on non-coral communities between 2010 and 2015. A total of 17 seeds from *H. decipiens* and *H. ovalis* were found from 10 sediment cells sampled which increased from previous surveys (Chevron, 2017).

When these results were interpreted over the areas initially mapped the distribution of seagrass, macroalgae and filter feeders in the area was shown to extend beyond the original habitat boundaries although at lower cover of dominant mapped habitat, which are more broadly typically comprised of a combined habitat cover varying between 0% to 10%. Dominant biota was also absent in 2014 and 2015 for cells within each individual mapped habitat type. For example, seagrass cover was absent from numerous nearshore cells between Beadon Creek and Coolgra Point which had earlier been mapped as seagrass habitat based on the baseline surveys. The results of monitoring non-coral cells during the Wheatstone dredging indicate seagrass, macroalgae and filter feeder habitats in this area rarely form large contiguous and homogenous habitat areas and instead the seafloor is characterised by patches of different communities. These habitat patches vary in size and in cover through time in response to natural processes such as seasonal influences, disturbance, senescence and recruitment.

The Onslow region supports relatively high diversity of filter feeder communities which potentially constitutes species adapted to living in highly turbid habitats. Baseline data on the biodiversity and variability of trawl bycatch on and off the trawl grounds in Exmouth Gulf and Onslow was reported in (Kangas, et al. 2006). These surveys captured 59 species of sponge from 25 families and 34 octocoral species from 10 families. Kangas et al. (2006) suggests these nearshore communities are adapted to frequent historic disturbance regimes associated with living in relatively harsh physical environmental conditions such as elevated turbidity, fresh water flow, cyclones and annual trawling effort.

Wahab et al. (In Press) monitored benthic community composition with a focus on sponges near the channel before and after the Wheatstone Project dredging program in the inner, mid and outer sections of the Project area. Sessile taxa dominated the benthos across dredge periods with filter and suspension feeders such as sponges, ascidians, gorgonians and hydrozoans dominant in the inner zones. A total of 102 sponge, 20 cnidarians (hard and soft corals and gorgonians), 18 ascidians, 6 bryozoans and 3 hydrozoans were identified prior to dredging. Post dredging 90 sponges, 55 cnidarians, 18 ascidians, 4 bryozoans and 1 hydrozoan were identified, 42% of which had not been collected prior to dredging. Assessments of the change in the density of filter feeder communities in nearshore (inner) areas during the Wheatstone Project using towed video are shown in **Table 2-3**. A pronounced decline in abundance was recorded for macroalgae and hydrozoans, although the remainder of taxa show relatively minor increases and decreases in abundance making it difficult to attribute an effect to dredging activities (Wahab et al. In Press).

Table 2-3 Mean densities of benthic taxa change sampled prior to and post the Wheatstone Project dredging program (Wahab et al. In Press)

Taxa	Pre-Dredge (Mean m^2)	Post-Dredge (Mean m^2)	Change Density
Macroalgae	2.469	0.097	-2.372
Rhodolith	0.108	0.059	-0.049
Seagrass	0.033	0.021	-0.012
Hard coral	0.740	0.809	0.069
Soft coral	0.046	0.043	-0.003
Gorgonian	0.934	1.504	-0.57
Zoanthid	0.004	0.039	0.035
Sponges	2.357	1.963	-0.394
Ascidian	0.818	0.022	-0.112
Hydrozoan	2.192	0.069	-2.123
Bryozoan	0.1	0.088	-0.012
Asteroidea	0.011	0.009	-0.002
Crinoid	0.0	0.015	0.015

Emphasis in Wahab et al. (In Press) was paid to sponges. The sponge functional morphology was dominated by encrusting (20-59%), massive (11-29%) and erect forms (15-38%) both prior to and post dredging. The cup morphotype formed a minority group (2.5-7.7%), which is likely to be attributable to susceptibility of this morphology to high sediment loads within the nearshore area. The patterns in sponge functional morphology remained relatively stable through the dredging period. The results indicate natural environmental filtering may have selected morphologies and traits of taxa present tolerant to turbidity and sedimentation stress (Wahab et al. In Press).

2.3. Field Survey Results

2.3.1. Intertidal Site Description

The tidal embayment adjacent to the proposed pipeline route between the back of the LIA and the DMMA located at Onslow Airport is broad and flat with narrow mangroves fringing the western tributary of Beadon Creek backed by extensive mudflats.

Back dune of the Light Industrial Area

The high to low tidal sequence of the intertidal habitat at the back dune of the LIA is described as:

- Landward margin samphire and other halophytic (salt tolerant) shrubs on upper mudflats.
- Bioturbated mudflat.
- Landward mangroves-open shrubland and thickets of *A. marina.*
- Tidal-creek fringing mangroves-dense *A. marina* shrubland.

Small micro-deltas extend north of the creek in certain locations and the associated tidal depressions create a broader zone of dense mangroves, where mangroves fringing the creek converge with delta fringing mangroves. Upper samphire mudflat high spots also occur between these fringing mangroves where the habitats are separated. The mangrove zone is typically narrow along the main west arm tributary. The largest tidal creek fringing mangroves occur closer to Beadon Creek and along the banks of the small micro-deltas. Typical view of the zonation of the intertidal sequence at the back dune of the LIA is presented in **Plate 2-1**.

Between Light Industrial Area and DMMA

This section describes the intertidal area between the back dune of the LIA out to the DMMA at Onslow Airport. The upper mudflats with samphire shrub habitat transitions into algal mat benthic habitat to the western side of the back dune. The algal mat forms a thin sheet cover (i.e. <5 mm) over a relatively broad section of the upper intertidal zone (up to 150 m). The algal mat extends further south for approximately 500 m although it becomes less dense and patchy beyond this distance.

The high to low tidal sequence of the intertidal habitat from the northern part of this area is described as:

- Algal mat
- Bioturbated mudflat
- Micro-delta fringing open shrubland and thickets of *A. marina*
- Bioturbated mudflat and open shrubland
- Tidal-creek fringing open shrubland and thickets of *A. marina*.

A tidal depression associated with micro-deltas extending from the west arm tributary behind the back dune of the LIA splits the bioturbated mudflat zone. Mangroves form a relatively low cover within tidal depressions of the micro-deltas and fringing the creek. Dense fringing *A. marina* shrubland occurs at the southern end associated with the eastern bend of the creek and along a micro-delta extending west of the creek and branching north and south.

The high to low tidal sequence of the intertidal habitat from the southern part of this area is described as:

- Algal mat
- Bioturbated mudflat
- Landward mangroves-open shrubland and thickets of *A. marina*
- Tidal-creek fringing mangroves-dense *A. marina* shrubland.

The main micro-deltas from the west arm tributary appear to be oriented towards the direction of the surface runoff flow. An open stormwater runoff drain from Onslow Road is located at the southern end of this area which is separated by an island with a west and east arm. The east arm appears to flow into the branching tributary. Excessive volumes of litter were recorded at the opening of the stormwater drain onto the salt flats immediately north of the DMMA indicating the area has previously been used as a rubbish DMMA. Typical views of the area between the LIA and the proposed disposal area are presented in **Plate 2-2** to **Plate 2-4.**

Dredge Material Management Area

The proposed DMMA is located immediately north of the Onslow Airport and west of the airport runway extending north to an existing stormwater open runoff drain (see **Figure 1-1**). The site contains bare salt flats bounded to the west by an undulating terrestrial dune system and overlies a small area of algal mat in the north-east corner immediately adjacent to the runway. The vegetation of the terrestrial dune system is described in **Section 4.3** and **Section 4.4**. A fence and an underground pipeline intersects the proposed disposal location at the boundary of the airport lease and another fence borders the runway.

The salt flat portion of the proposed DMMA area overlies part of an exposed limestone pavement. Numerous exposed isolated coral fossils were observed on the salt flat/algal mat zone border indicating the limestone pavement is possibly a previous coastline (possibly the Pleistocene period). (Damara, 2010) and (URS, 2010b)recorded similar outcrops occasionally supporting *in-situ* fossil corals close to the surface of the mudflats adjacent to creeks to the west of the Project area and around sandstone islands on the north coast of the salt ponds, indicating this is likely to be a regionally common geoheritage feature of the region.

The majority of algal mat within the DMMA overlies limestone pavement at the edge of the salt flats, with a small area of algal mat on upper mudflats bounded to the east by the runway. Landgate's Shared Land Information Platform (SLIP) identified sediments from the intertidal zone are classified as a high probability of PASS occurrence, although with very low confidence. Therefore, acid sulphate soil testing will be required if the soil is to be disturbed within this area and the risk of acid sulfate soils should be identified in the acid sulfate soil management plan which will be prepared for the project (O2 Marine, 2017).

The high to low tidal sequence of the intertidal habitat from the DMMA is described as:

- Salt flats underlain by limestone pavement
- Extensive algal mat
- Bioturbated mudflat
- Landward mangroves-open shrubland and thickets of *A. marina*/tidal creek
- Fringing mangroves-dense *A. marina* shrubland.

There were few mangroves were observed at the lower end of west arm tributary at the base of the airport runway, and the mangrove system becomes larger moving up the creek. The algal mat forms a thin sheet (i.e. <5 mm) covering a broader section of the intertidal zone (up to 300 m) than observed at the areas surveyed further north. Typical views of the proposed DMMA area are presented in **Plate 2-5** to **Plate 2-9**.

Lagoon Flat adjacent to the Turning Circle

There is a tidal lagoon flat on the eastern side of Beadon Creek, near the mouth and adjacent to the existing turning circle. Part of this lagoon flat will be dredged to widen the turning circle. The tidal lagoon is composed of bioturbated sand with abundant crab burrows. Small areas of *A. marina* seedlings/saplings have colonised the northern and southern edges of the lagoon flat, with a couple of larger trees in the southern assemblage. An isolated mangrove also occurs on the exposed intertidal oyster platform southwest of the lagoon. Typical views of the lagoon flat are presented in **Plate 2-10** to **Plate 2-11**.

Plate 2-1 Typical intertidal zonation sequence at the back dune of the LIA looking towards the airport (west tributary of Beadon Creek to left of image)

Plate 2-2 Upper intertidal zone transitions from mudflats with samphire communities to algal mat at the western end of the back dune behind the LIA

Plate 2-3 Algal mat forms a thin sheet on the upper intertidal area

Plate 2-4 Typical intertidal zonation sequence from the northern area between the LIA and the proposed DMMA showing a line of mangroves associated with micro-delta depressions splitting the mudflats

Plate 2-5 Litter on the salt flats at eastern side of the stormwater drain

Plate 2-6 Salt flat overlying an exposed limestone pavement, fence (right) and pipeline (left) intersecting the proposed DMMA. Fence bordering the runway in background with algal mat on upper mudflats

Plate 2-7 Extensive algal mats bordering the salt flats and few mangroves at the base of the runway increasing up the creek (left)

Plate 2-8 Coral fossils found on the salt flat/algal mat border possibly indicating previous coastline

Plate 2-9 Sandy substrate with abundant fiddler crab burrows of the intertidal lagoon flat of which a portion will be dredged for the proposed turning circle

Plate 2-10 Isolated *A. marina* trees and seedlings/saplings have colonised the southern edge of the lagoon flat

Plate 2-11 ***A. marina* seedlings/saplings have colonised the northern edge of the lagoon flat**

2.3.2. Subtidal Site Description

A total of 30 drop camera transects were undertaken targeting an area from east of Beadon Point to Third Creek and ~2 km offshore which was previously classified as 'seagrass habitat' during baseline investigations for the Wheatstone Project (**Figure 2-2**). O2 Marine note the survey was undertaken in March, which is just outside of the predicted period from November to February when seagrass in the area are likely to have highest cover and have therefore adopted a precautionary interpretation for predicting and managing the impacts of dredging. However, seagrass was observed in patchy low cover throughout the survey area.

The seabed in the nearshore area is gently sloping with depths recorded across sites ranged from 4 m to 8 m. The relief within sites indicates the area surveyed is a flat subtidal plain with some small areas of undulating low-profile reef and rock outcrop. The substrate was dominated by silt or sand with prolific areas of rubble/broken shells and occasional low-profile reefs. Sand colour and coarseness changed from brown silty sand near Beadon Creek becoming coarser and white towards Coolgra Point. The habitat surveyed typically comprised a mosaic of intermixed community types consisting of filter feeders (e.g. sponges, octocorals, hydroids, ascidians), turf algae and macroalgae (Phaeophyceae: *Sporochnus*, *Hormophysa, Sargassum* & *Dictyota*; Rhodophyceae: *Asparagopsis*; Chlorophyceae: *Caulerpa*, *Halimeda*), and *Halophila* seagrass (*H. ovalis, H. decipiens* & *H. spinulosa*). The total cover of biota was typically low (i.e. <3%) and rarely exceeding 10%, although small patches of undulating reef at one location adjacent to Beadon Creek (approximately 1 km from the proposed dredging channel) and three locations adjacent to Third Creek all recorded much higher total cover of sessile biota (i.e. up to 80%). These low-profile reefs typically comprised of a mixed community of filter feeders (sponges, octocorals, hydroids), macroalgae (*Sporochnus*) and hard corals (*Turbinaria*). Another two sites toward Coolgra Point also recorded patches of abundant and conspicuous stands of macroalgae (*Sporochnus*). The overall estimate of total cover of biota for these locations was ultimately reduced due to the patchy nature of these habitats reflecting heterogeneity in the substrate types. The abundance of rubble and broken shell observed at almost all sites surveyed may reflect historical levels of natural and anthropogenic disturbance such as cyclone damage or commercial trawl fishing activities. Very little bioturbation was recorded except for one shallow site closest to Beadon Creek where abundant crustacean burrows were noted. A summary of the observations and site coordinates are provided in **Appendix A**.

Due to the intermixed nature of the communities comprising of a range of habitat types, these habitats were classified in accordance with the substrate type (i.e. silt, sand, rubble, reef low-profile), dominant habitat type and total cover of biota. Habitat classes and the results of the distribution of these habitats are shown in **Table 2-4** and **Figure 2-4**, respectively. It is important to note that whilst the recorded dominant habitat is listed, this should not be interpreted as a homogenous habitat type and total cover of biota will usually comprise an assortment of the habitats described. Interestingly, hard substrate platforms on which a higher cover of BCH was recorded appear to be associated with areas adjacent to the creek systems. Indicating there may be a natural geological trend to predicting habitat types in the area.

Table 2-4 The six classes used to define BCH across the nearshore area during the ground-truth survey

Class	Depth	Substrate	Dominant BCH	Cover	Description	Image
Si/UV <1%	5 m	Silt	Unvegetated	<1%	Brown silty sand with occasional rubble. Very sparse sponges, octocorals & macroalgae. Burrows common.	
Sa/UV <1%	4-8 m	Sand	Unvegetated	<1%	Rippled sand in shallower sites. Broken shell/coral rubble common deeper. Rare sand veneered pavement/ isolated low-profile reef. Sparse patchy turf algae, macroalgae, seagrass, sponges, octocorals & hard corals	
Si/FF <1-3%	4-8 m	Silt	Mixed	1-3%	Shelly sand between occasional patchy sand veneered pavement/ coral rubble. Patchy turf algae, seagrass, sponges, octocorals & hard corals.	

Class	Depth	Substrate	Dominant BCH	Cover	Description	Image
Si/Sa/R-R(LP)/ FF 1-3%	5-7 m	Silty Sand, Rubble & Reef (Low Profile)	Filter Feeders	1-3%	Rubbly sand/ occasional patchy sand veneered pavement. Benthic sponges, octocorals predominate. Patchy seagrass	
Sa/MA 3-10%	6 m	Sand	Macroalgae	3-10%	White coarse shelly and. Dense patches of macroalgae rhodophytes (*Sporochnus* sp.). Occasional sand veneered pavement with benthic sponges, octocorals.	
R-R(LP)/ FF >10%	4-6 m	Rubble & Reef (Low Profile)	Mixed	>10%	Rubble/ sand veneered pavement with seagrass, macroalgae, sponges and octocorals. Occasional low-profile reef with mixed benthic communities including octocorals, hard corals, sponges, macroalgae	

The data from the first post development monitoring for the Wheatstone Project dredging program undertaken in November/December 2015 was reviewed and reclassified into 10 classes shown in **Table 2-5** to identify the abundance and distribution of BCH within the OMSB Project area. The locations monitored prior to, during and post the Wheatstone Project dredging program have been overlaid onto the distribution of habitats recorded during the field assessment (**Figure 2-4**) and the results from November/December 2015 are shown in **Figure 2-5** to compare the results between surveys. Both surveys determined filter feeder habitats are the dominant community within the nearshore zone.

The results from some nearshore sites from (Chevron, 2017) either correlate very closely with those recorded in the recent field assessment, which revealed a low-profile reef system with a high and diverse cover dominated by filter feeders or were typically higher in cover estimates than recorded during the current survey. There is likely to be discrepancy associated with differences in methodology and post-hoc analysis of the results for Chevron, (2017), which used a range in cover estimates for each individual habitat type, which is an analysis technique lending itself to overestimating the total biota cover directly. However, the field assessment determined that there is very high small scale spatial variability between habitats based on the association of the increase in BCH cover with hard substrate (and relief) availability. Therefore, any discrepancy between surveys may be associated with small changes in the availability of suitable substrate within the area surveyed. It is noted (Chevron, 2017) targeted these nearshore monitoring blocks for seagrass, although the current survey found transects with highest seagrass cover coincide within areas with high cover of other benthic invertebrates. The comparison between surveys highlights the dynamic nature and small spatial scale variability of the BCH within the area, and difficulty in monitoring and classifying these communities over a broad spatial scale.

Table 2-5 The information presented in Chevron (2017) was converted into the following ten classes used to define BCH across the West Pilbara region

Class	Dominant BCH Type	Cover
Unvegetated	Unvegetated	0%
0-3% S	Seagrass	0-3%
0-3% MA	Macroalgae	0-3%
0-3% FF	Filter Feeders	0-3%
0-3% Mixed	Mixed	0-3%
3-10% S	Seagrass	3-10%
3-10% MA	Macroalgae	3-10%
3-10% FF	Filter Feeders	3-10%
3-10% Mixed	Mixed	3-10%
>10% FF	Filter Feeders	>10%
>10% MA	Macroalgae	>10%

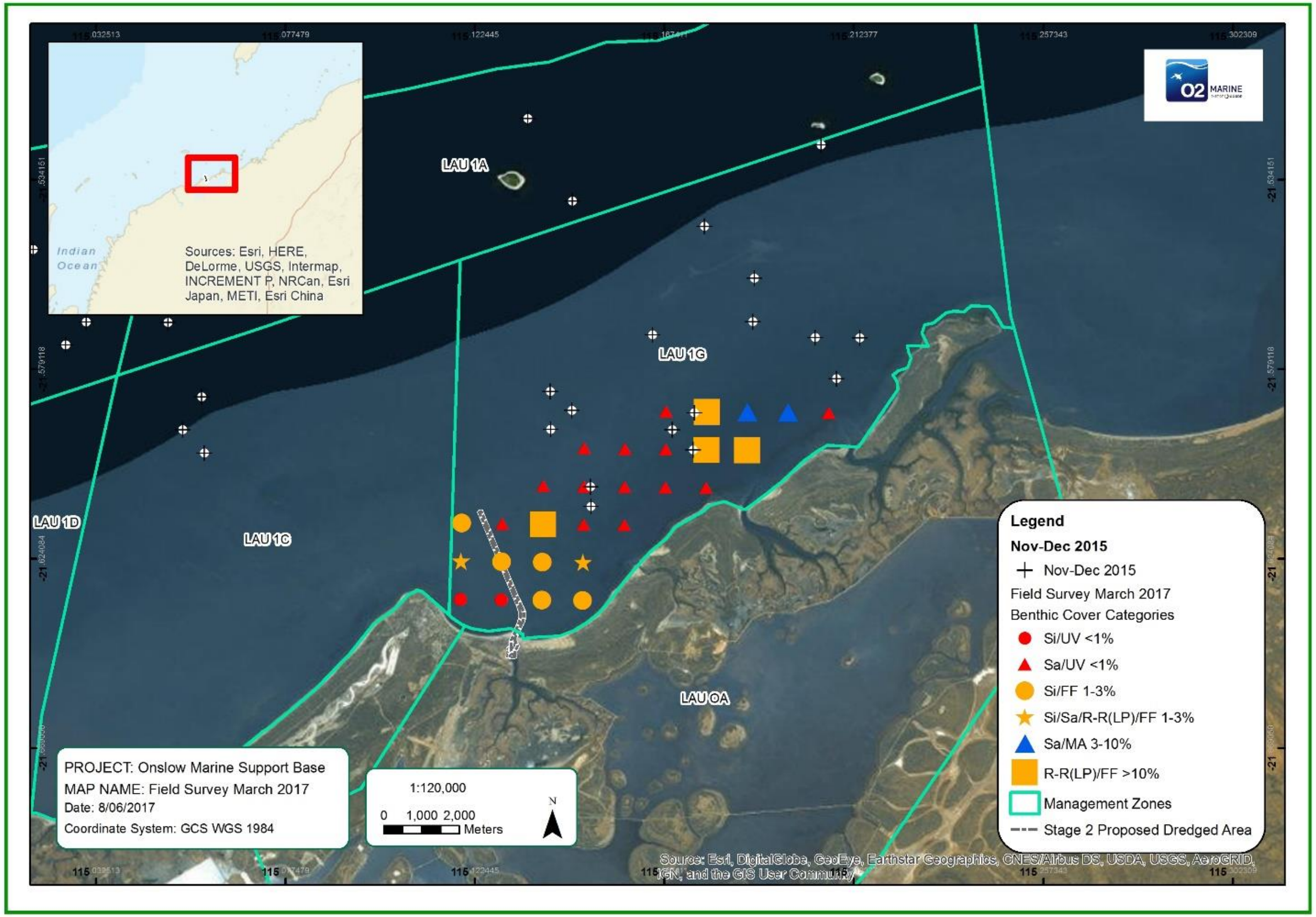

Figure 2-4 Distribution of habitat classes shown in Table 2-4 within the area surveyed during the field assessment. The location of the sites monitored in November/December 2015 are shown for comparison of the results

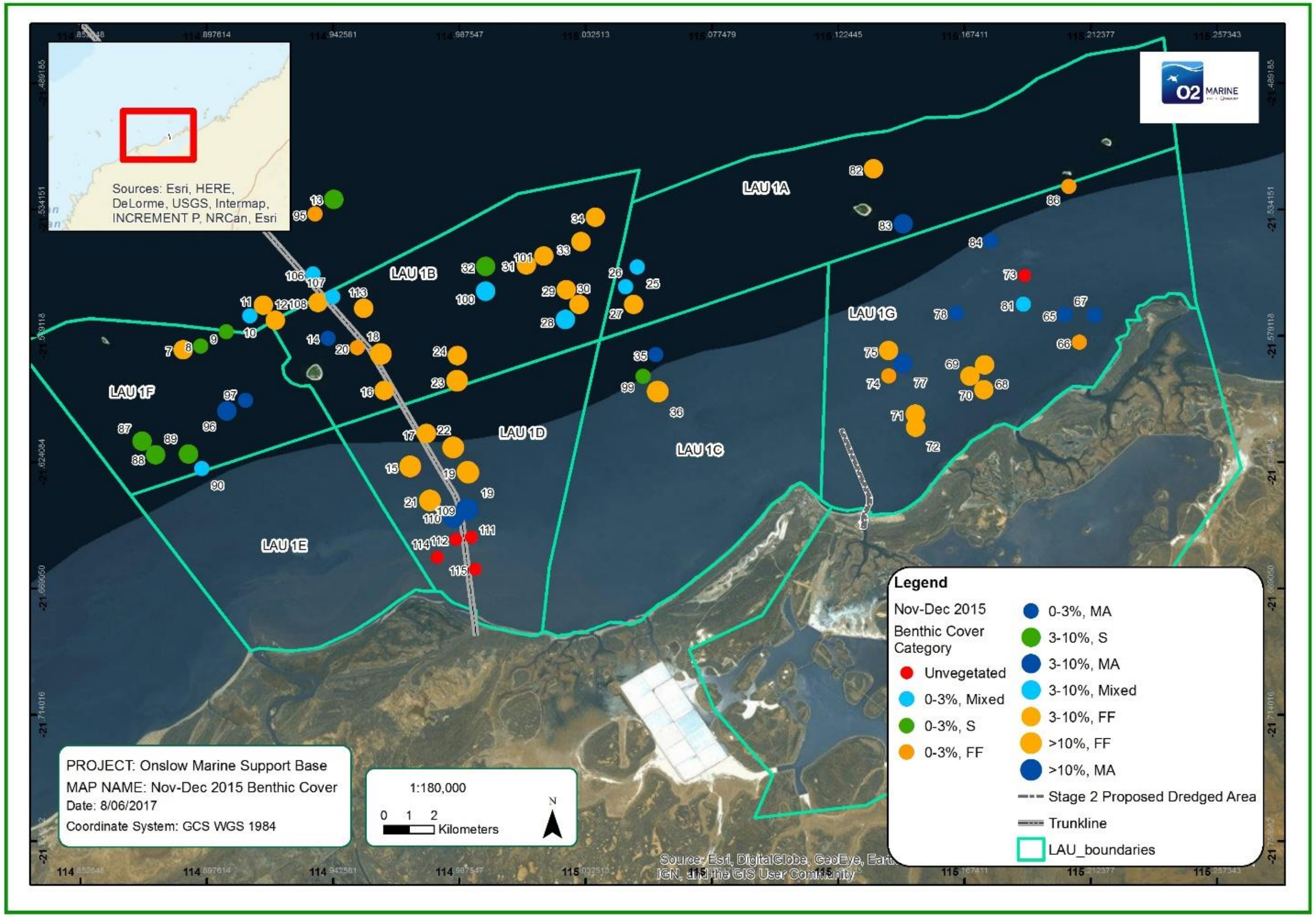

Figure 2-5 The results from the monitoring undertaken for (Chevron, 2017) converted into classes in Table 2-5 used to provide a comparison of BCH types recorded during the field assessment

2.3.3. Benthic Habitat Mapping

Mapping of BCH has been generated from review and collation of all relevant historical information and the field assessment. The assumptions for generating maps are based on technical guidance provided in EPA (2017a, 2017b) and recommendations within documents recently published by the dredging node of the Western Australian Marine Science Institution. It should be noted that incorporating the recommended assumptions for mapping the BCH in the Onslow region requires converting the results of studies presented in the previous section into different categories and is not intended to define the current abundance and distribution of BCH. Recommended assumptions considered for mapping BCH include:

- Mapping the area of habitat that support, or have the potential to support, benthic communities (EPA 2017a)
- Consideration of the uniformity (or heterogeneity) of biological communities (EPA 2017b)
- Identification of where different BCH types can be distinguished and mapped separately (EPA 2017a)
- The map should be produced with little regard for the relative quality of the benthic community (i.e. at the time of preparing the map), although should consider the functional ecological value of the BCH (EPA 2017a)
- Identification of BCH that are not well locally and regionally represented (EPA 2017a)
- Differentiate between areas of habitat that are 'vegetated' or 'inhabited' by benthic communities and areas of habitat that are not (EPA 2017a)
- Consideration of how uncertainty associated with mapping BCH can be reduced (EPA 2017a)
- Characterise historical seagrass distribution as potential seagrass habitat by overlaying all seagrass observations to produce a layer which defines the potential habitat in which low biomass seagrass can grow (McMahon et al. 2017)

The distribution of the various intertidal BCH and adjacent supratidal areas has been mapped for the western margin and the mouth of the Beadon Creek tidal embayment where OMSB Project activities are proposed to occur (**Figure 2-6**). Mapping of the intertidal BCH in the areas of proposed OMSB Project activities will enable assessment of the potential loss of BCH from these activities. The map does not present the distribution of BCH throughout the loss assessment unit (LAU 0A) for assessment of cumulative losses. Rather, the cumulative loss assessment is based on historical area estimates derived for the Onslow Solar Saltfield ERMP (Gulf Holdings, 1990).

The distribution of subtidal BCH in the Onslow region has been mapped and is presented in **Figure 2-7**. The approach to mapping subtidal BCH reviews all relevant data for the presence and absence of BCH within each area. The groups shown in the legend for the map are described in **Table 2-6**. The available historical information and the results of the recent field assessment demonstrate there is considerable spatial and temporal variability of various BCH across the OMSB Project area. Therefore, due to the broad distribution of these habitats, the complex mosaic of BCH associations, and knowledge that habitat boundaries may extend beyond those areas mapped historically means the maps should not be taken as an accurate representation of boundaries for BCH. The following points describe how the recommended assumptions have been considered for the map:

- The entire Onslow region has been considered to have the potential to support BCH;
- The heterogeneity of BCH has been considered by grouping the community types which form, or have historically formed, the major components of the habitat **(Table 2-6)**;
- Coral and seagrass have not previously been recorded throughout the entire area. Areas where these BCH types occur have been grouped separately to distinguish the distribution of these BCH types;
- A nominal total biotic percent cover has been mapped to describe that based on historical information the functional ecology of these communities varies across the Project area. The percent cover is not intended to represent an accurate assessment of the condition of BCH;

- There are no known BCH types that occur within the Onslow region that are not well distributed both locally and regionally;
- Due to the considerable temporal and spatial variability and complex mosaic of BCH associations across the Onslow region, barren areas which do not support at least a low biomass of at least macroalgae or filter feeder BCH types could not be delineated;
- The assumption that all habitat in the Onslow region represents potential BCH was considered to account for uncertainty in mapping the distribution of BCH; and
- Seagrass was recorded in low biomass within outer parts of the Onslow Salt channel and near Ward Reef in Paling (1990), and at the Onslow Salt spoil DMMA during baseline surveys for the Wheatstone Project (URS, 2010c). Monitoring undertaken prior to, during and post the Wheatstone Project concluded that habitat areas extend beyond those areas mapped during the baseline (Chevron 2017). Therefore, the potential distribution of seagrass habitat within the Onslow region has been broadened from the distribution shown in maps presented during the Wheatstone Project.

Table 2-6 Description of the BCH groups presented in Figure 8 within the proposed nearshore Loss Assessment Unit Boundaries (LAU 1) for the OMSB Project

Grouping	BCH Types	Description
Coral Habitat	Coral reef	Coral assemblages previously recorded with >10% cover[1]
Low Cover (<5%) MA/FF	Macroalgae, Filter feeders	Low biomass patchy cover occurring in predominantly very turbid silty sand substrates in nearshore areas influenced by periodic discharges from the Ashburton River
Moderate Cover (5-10%) MA/FF	Macroalgae, Filter feeders	Broad areas of low biomass patchy cover with infrequent areas of higher density although moderate functional value
Moderate Cover (5-10%) S/MA/FF	Seagrass, Macroalgae, Filter feeders	Broad areas of low biomass patchy cover of mixed habitat with infrequent areas of higher density although moderate functional value
High Cover (>10%) S/MA/FF	Seagrass, Macroalgae, Filter feeders	Broad areas of moderate biomass patchy cover of mixed habitat with occasional areas of higher density and moderate functional value

[1] Mapping of coral habitat was limited to within the 10 m isobath based on the predicted impacts of the OMSB Project not extending beyond the nearshore area. Coral habitat beyond the 10 m isobath has been previously mapped for the Wheatstone Project

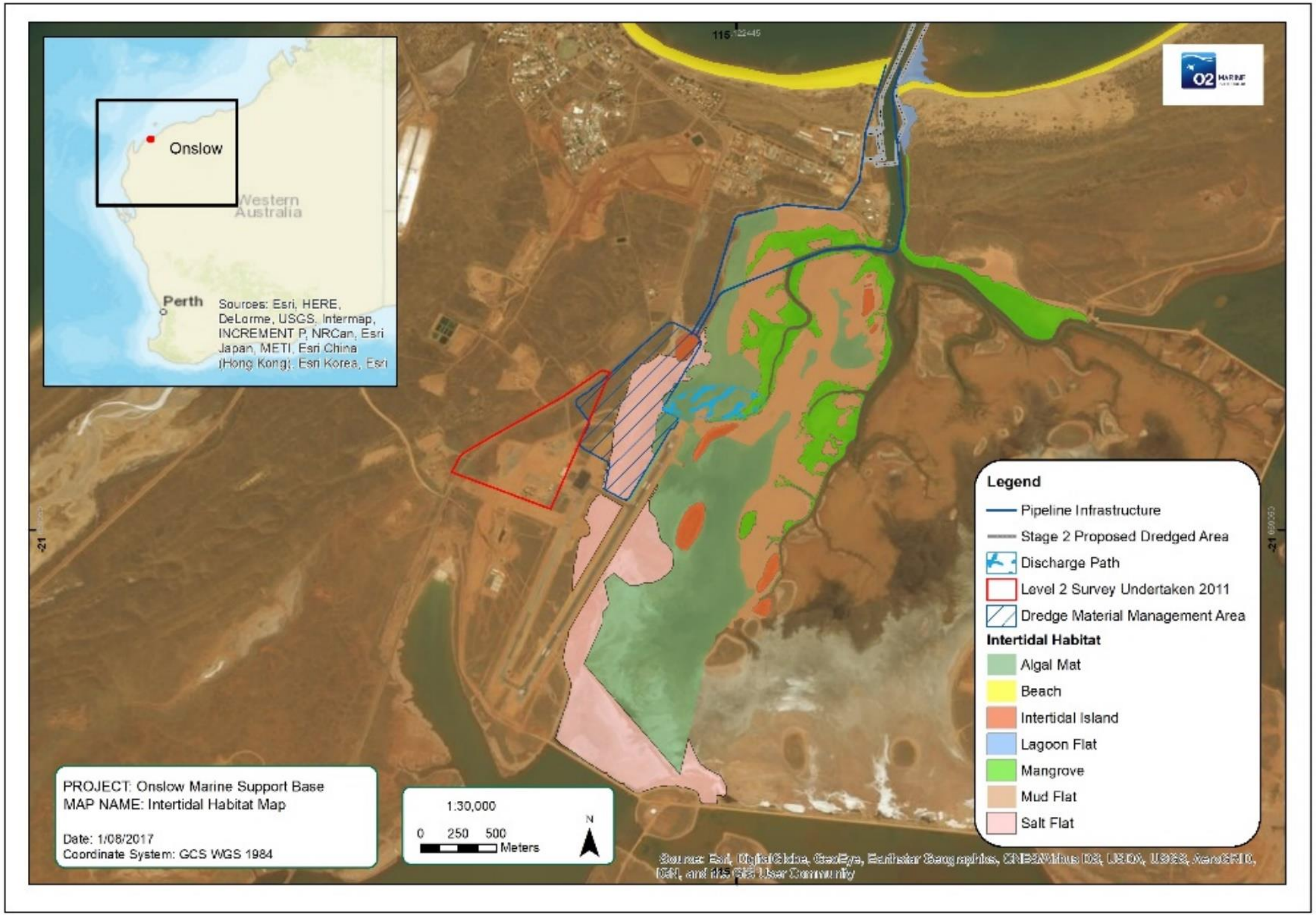

Figure 2-6 **Map of the intertidal BCH relevant to the OMSB Project activities within the proposed Beadon Creek tidal embayment**

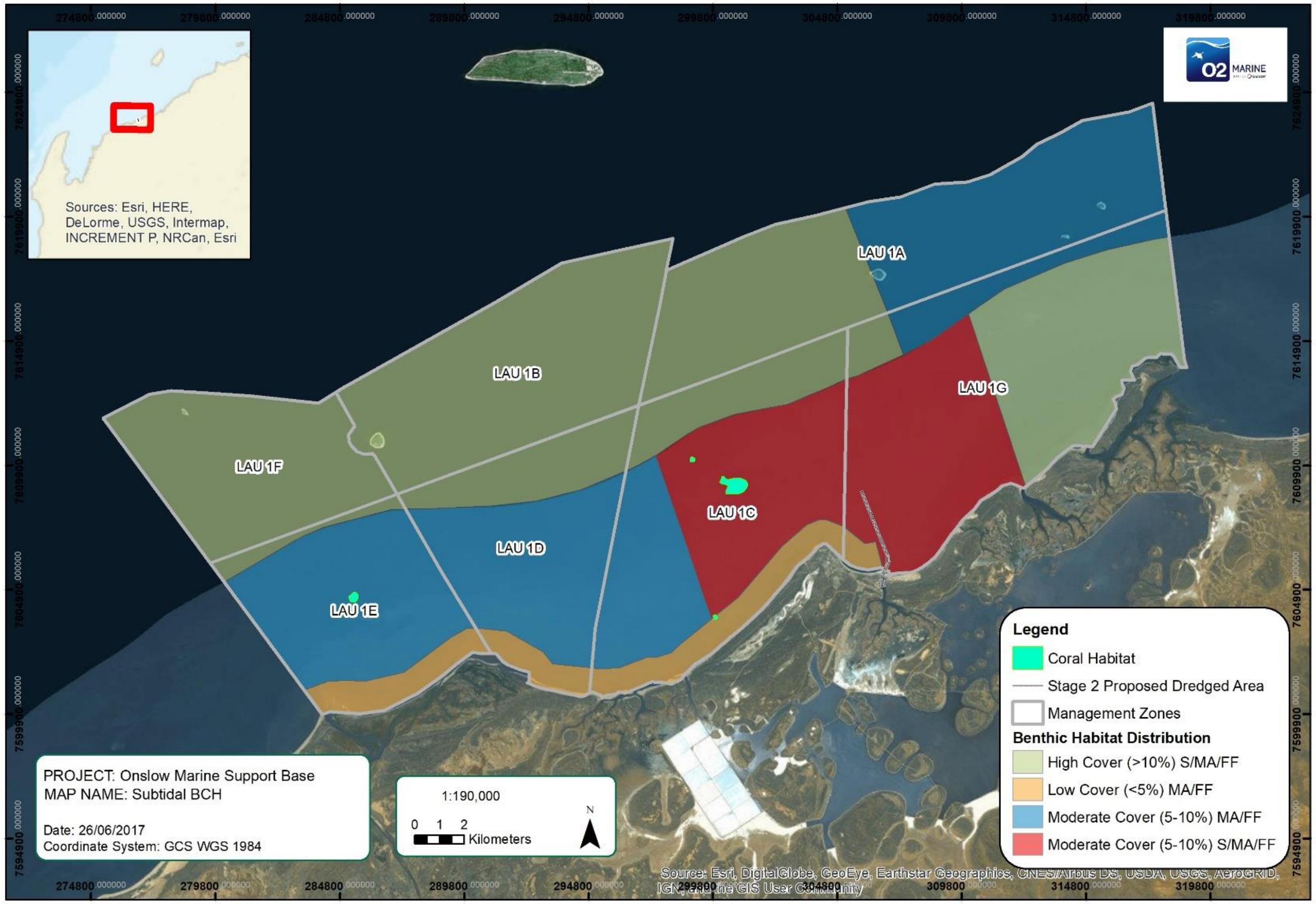

Figure 2-7 **Subtidal BCH within the proposed nearshore Loss Assessment Unit Boundaries for the OMSB Project**

2.4. Benthic Communities and Habitat Loss Assessment

2.4.1. Background

The EPA provides technical guidance on how impacts on BCH are to be considered during an Environmental Impact Assessment for the protection of BCH (EPA, 2016a, 2017b). This approach is based on the extent, severity and duration of any residual changes to the environment caused by a proposed activity after mitigation. A dredge plume impact assessment has been undertaken using outputs from numerical modelling for the OMSB Project in accordance with technical guidance provided by the EPA to predict the indirect impacts on subtidal BCH. A technical document summarising the numerical modelling results is provided in **Appendix B** to support the prediction of impacts from the OMSB Project. This section presents the predicted cumulative impacts and losses to BCH expected from the OMSB Project.

2.4.2. Local Assessment Unit and Current Area of BCH

The preferred approach of the EPA to express and present the cumulative residual loss of, or serious damage to, BCH that may arise from the OMSB Project requires characterising the BCH within defined Loss Assessment Units (LAUs) to calculate the cumulative loss of the area of intertidal and subtidal BCH.

The benthic habitat maps presented in this section define the LAUs considered relevant to apply for the OMSB Project. The appropriateness of the scales and boundaries for the region of the potential impact area for the Wheatstone Project was evaluated and agreed with by the EPA, peer reviewer Dr Barry Wilson and Dr Charles Sheppard (URS, 2010e). This approach subdivides the Onslow region into distinct large Ecosystem Units which share common characteristics. The LAU boundaries and nomenclature described in (URS, 2011) have been applied to the OMSB Project for consistency.

The LAU 0A extends from Onslow to Coolgra Point which is shown in **Figure 2-8**. Only those areas within the Beadon Creek Tidal embayment that could potentially be impacted by the proposed dredging and disposal activities for this Project have been mapped (**Figure 2-6**). Estimates of the total areas (ha) within LAU 0A have been defined based on information provided in previous EIS/ERMPs and are provided in **Table 2-7**.

The LAUs within Ecosystem Unit 1 for offshore Onslow were first defined in URS (2011) and are considered appropriate for use in the current project assessment. The location and boundaries of these LAUs are presented in **Figure 2-8**. Only the nearshore LAUs (LAU 1C, LAU 1D, LAU 1E, LAU1G) are considered relevant for the project risks of the OMSB Project. Estimates of the areas (ha) within LAU 1C, LAU 1D, LAU 1E and LAU1G occupied by each subtidal BCH have been calculated from the mapping and are provided in **Table 2-7**.

2.4.3. Areas of Conservation, Ecological or Social Value

The EPA places conservation significance on the arid zone mangroves of the Pilbara coast due to their geographical distribution, biodiversity, productivity and ecological function. A guidance statement issued by the (EPA, 2001) lists mangrove habitats at both the Ashburton River Delta and Coolgra Point as "regionally significant", with very high conservation value. The Ashburton Delta Mangrove Management Area is approximately 16 km west and Coolgra Point Mangrove Management Area is approximately 5.5 km east of the proposed harbour approach channel. Both areas are located beyond the 'Worst Case' Zone of Influence (ZoI) for sedimentation impacts predicted for the proposed dredging and therefore occur outside of the potential impact from proposed OMSB Project activities (**Appendix B**). All other mangrove areas from Onslow to Coolgra Point inside designated industrial and associated port management areas which area afforded a high conservation value under Guideline 4. The EPA's operational objective for Guideline 4 areas is that the impacts of development on mangrove habitat and ecological function of the mangroves should be reduced to the minimum practicable level (EPA, 2001).

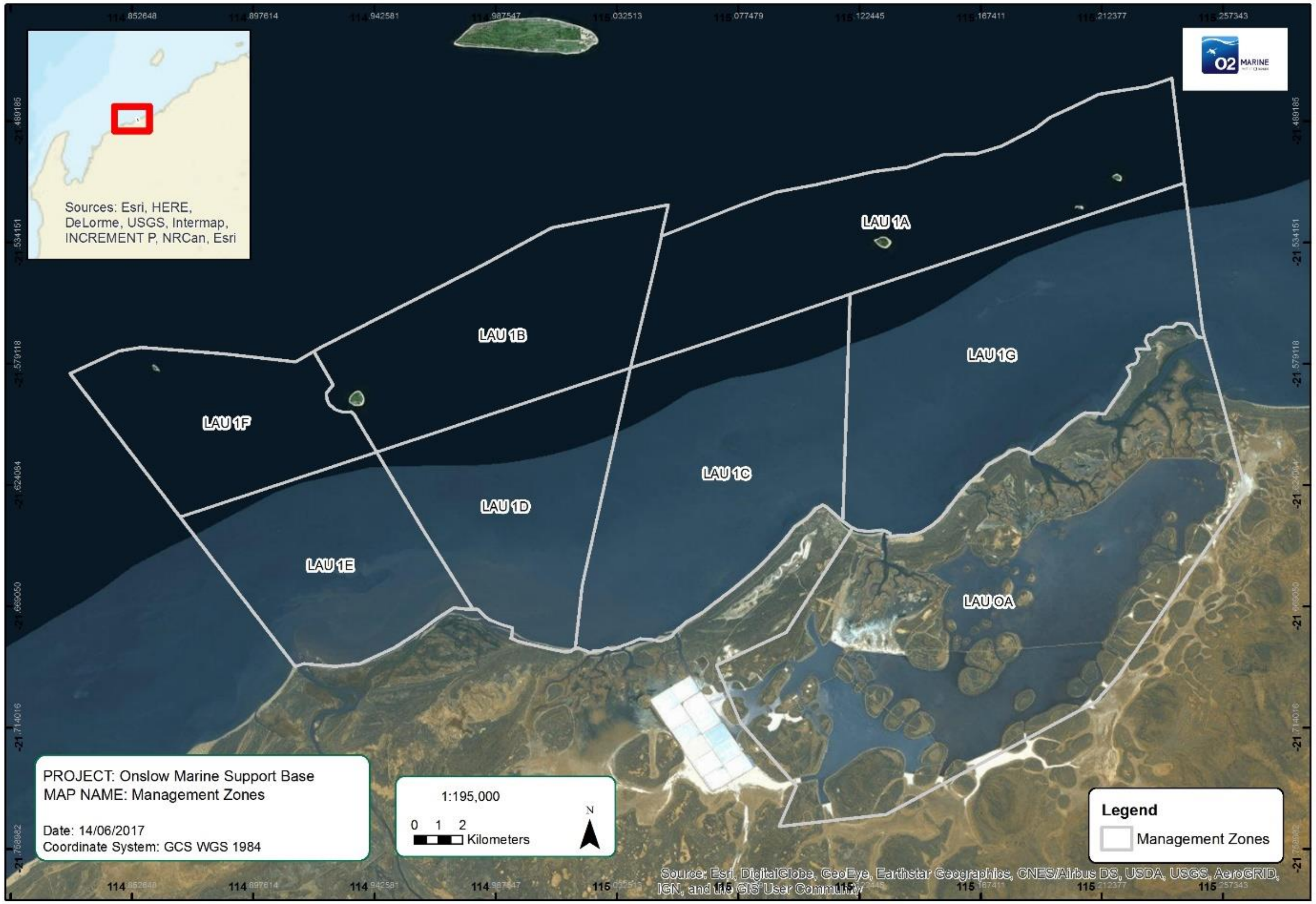

Figure 2-8 Proposed Loss Assessment Units (LAUs) for the OMSB Project (adopted from (URS, 2011))

Table 2-7 Descriptions of LAUs and estimates of current areas occupied by BCH within each LAU (URS, 2011)

ECU	Descriptor	LAU	Descriptor	BCH	~Area (ha)
0	Intertidal habitats between the HAT and Lowest Astronomical Tide (LAT).	0A	Beadon Creek tidal embayment	Mangrove[1]	836 ha
				Bioturbated mudflats/ samphire zone[1]	1,120 ha
				Algal mats[1]	813 ha
1	Waters between LAT and 10 m CD in relatively complex bathymetry covering mainly soft substrates but includes a ridge of scattered patch shoals which support corals and sponges.	1C	Nearshore inner port area between Ashburton navigation channel and Beadon Point	Corals	35 ha
				Seagrass, Macroalgae & Filter Feeders	5,312 ha
				Macroalgae & Filter Feeders	2,841 ha
		1D	Nearshore inner port area between Ashburton channel and western port limit	Seagrass, Macroalgae & Filter Feeders	2,743 ha
				Macroalgae & Filter Feeders	1,440 ha
		1E	PPA port west boundary to Ashburton River	Corals	11 ha
				Seagrass, Macroalgae & Filter Feeders	373 ha
				Macroalgae & Filter Feeders	5,345 ha
		1G	PPA port east boundary (Onslow) to Coolgra Point	Seagrass, Macroalgae & Filter Feeders	10,228 ha
				Macroalgae & Filter Feeders	1,309 ha

[1] Derived from habitat estimates provided from Gulf Holdings (1990)

Islands of the West Pilbara, including Thevenard Island, Bessieres Island, Serrurier Island, Airlie Island and Locker Island, are listed as Class C Nature Reserves. The marine environment around the islands forms part of the Rowley Shelf. They are known to be important areas for migratory seabirds, turtles and dugong and support large areas of macroalgal beds and both biogenic coral reef and coral communities on pavement. Of these islands, only Locker Island falls within the vicinity of, although occurs outside of, the ZoI for the 'Worst Case' suspended sediment plume for coral and seagrass (**Appendix B**). Therefore, all Class C Nature Reserve islands occur outside of the potential impact from suspended sediment concentration (SSC) and sedimentation generated from OMSB Project dredging activities.

Ward Reef is a relatively large reef (40 ha) close to Beadon Point that has previously been recognised as being regionally important for recreational fishing and conservation value (Gulf Holdings, 1990; URS, 2010e). It is unusual given that previous surveys determined the reef supports a high diversity and cover of corals which survive in an area that regularly experiences a turbid water environment. However, recent coral bleaching events have drastically reduced the percent cover of coral on this reef (see **Section 2.2.2**), with 2.2% coral cover recorded on the site during monitoring undertaken in May 2015 (Chevron, 2017). Ward Reef occurs outside the predicted "best case" and "worst case" Zone of Moderate Impact (ZoMI) although part of the reef occurs within the predicted ZoI. The definition of the ZoI presents the area where above background concentrations will occur which is not predicted to result in any material and/or measurable effect. Potential impacts on Ward Reef are therefore not predicted for the OMSB Project.

2.4.4. Historical Loss of BCH in the OMSB Project Area

URS, (2010e) identified the Beadon Creek tidal embayment and nearshore waters adjacent to Onslow has a long development history and the following BCH impacts are known to have occurred to date:

- Development of the Beadon Creek Boat Harbour has resulted in minor loss of mangroves on the western shore of the creek.
- Development of the Onslow solar salt ponds has resulted in loss of upper tidal flats, algal mat and salt flats from Coolgra Point to Four Mile Creek, plus minor loss of mangroves near the pump station on Beadon Creek.
- Seafloor habitat modification near the Onslow Salt shipping channel.
- Modification by the local prawn trawling industry (Kangas,2015) of the seafloor benthos distribution on the nearshore (5-15 m CD) soft substrates.

The locations of the historical losses as presented in (URS, 2010e) are shown in **Figure 2-9**. Additional losses due to development activities undertaken since preparation of this review in 2009 which have resulted in the further loss of BCH include:

- Development of nearshore infrastructure for the Wheatstone Project and nearshore DMMA.
- Onslow Aerodrome Redevelopment undertaken by the Shire of Ashburton completed in 2015 resulted in the minor loss of algal mat habitat in the Beadon Creek tidal embayment.
- The construction of the land-backed wharf in Beadon Creek for Stage 1 of the OMSB Project and the Onslow community Boating Precinct resulted in the removal of 0.08 ha of mixed mangroves in the reclamation area.

The estimated cumulative historical loss of BCH arising from previous developments is presented in **Table 2-8**. This assessment is based largely on information available within reports prepared for the Onslow Salt Project (Gulf Holdings, 1990; EPA, 1997), the Wheatstone Project (URS, 2010e), Stage 1 of the OMSB Project (Oceanica, 2014) and calculation of the area of the Onslow airport runway that overlies algal mat BCH.

Potential Impacts to BCH Excluded from Historical Loss Estimates

Estimating the potential loss of BCH from past trawling activity is difficult given that it is not known what the condition of the original habitat was like prior to trawling. However, some information is available from the DoF which suggests that little habitat modification has resulted from this activity (DoF 2003). The DoF applied to the then Commonwealth Department of Environment and Heritage for the Onslow Prawn Managed Fishery (OPMF) to be certified as being managed in an environmentally sustainable manner (DoF 2003). The impact on seagrasses was deemed negligible based on the following three factors:

1. Most areas of seagrass are in areas that are closed to trawling.
2. Most trawlers actively avoid trawling near seagrass areas as rolls of broken off seagrass get caught in the mouth of the codend, causing the net to stop fishing and for the prawns already caught in the net to become entangled and difficult to release.
3. The introduction of Bycatch Reduction Devices and Fish Exclusion Devices will encourage trawlers to avoid seagrass areas since the grid component for both devices is highly susceptible to clogging by balls of seagrass.

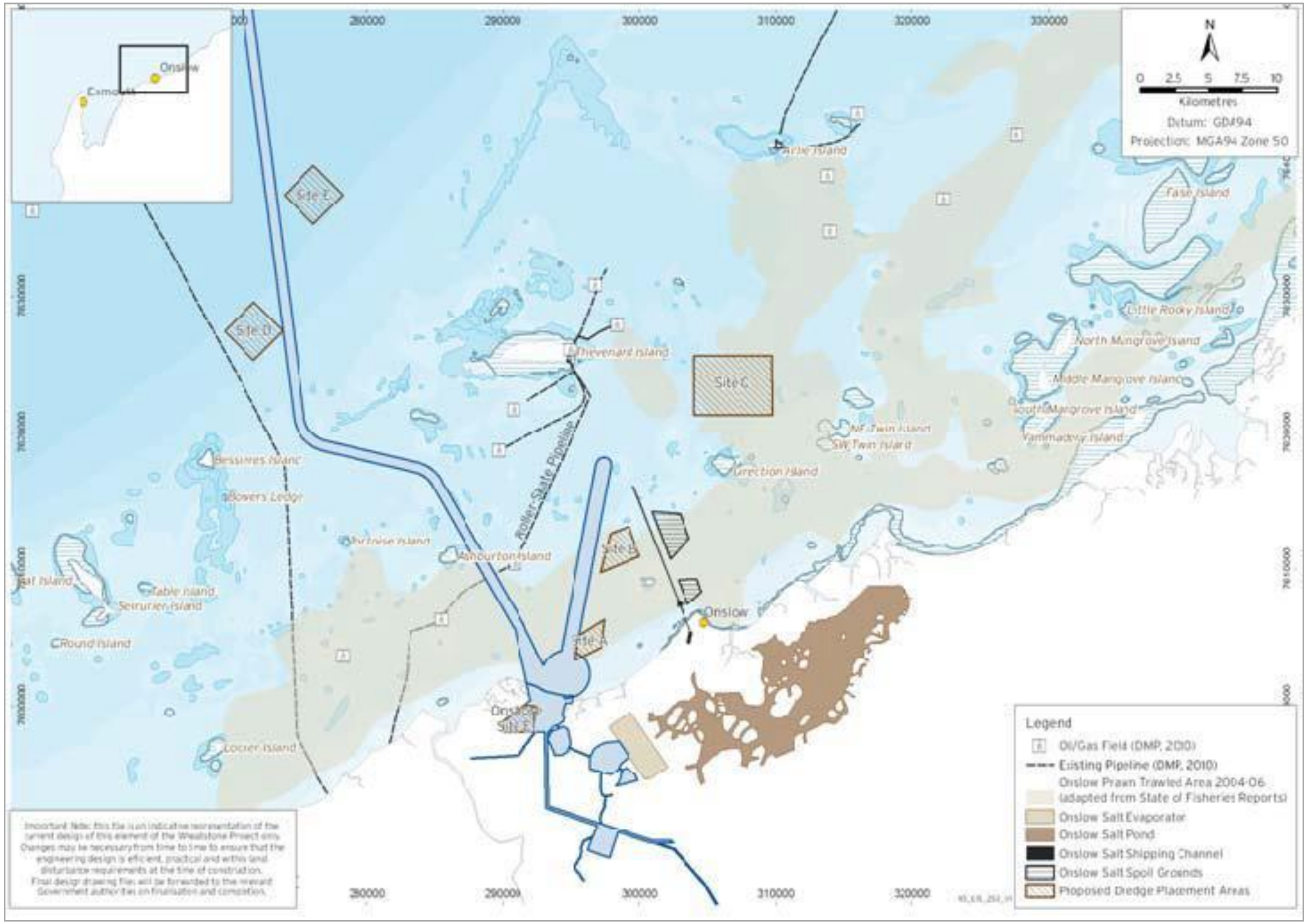

Figure 2-9 Historical areas of intertidal and subtidal seafloor BCH disturbance from (URS, 2010e)

Table 2-8 Estimated historical loss of intertidal and subtidal BCH within relevant LAUs for the OMSB Project

LAU Unit	BCH	Original Extent (ha)	Historical Loss		Remaining Area (ha)
			(ha)	(%)	
LAU 0A	Mangroves	839 ha	3.0 ha[1]	0.4%	836 ha
	Bioturbated mud flat/ samphire zone	1,160 ha	40 ha[2]	3.5%	1,120 ha
	Algal mats	1,008 ha	195 ha[3]	19.4%	813 ha
LAU 1C	Corals	35 ha	-	-	35 ha
	Seagrass/Macroalgae/Filter Feeder	6,000 ha	688 ha[4]	11.5%	5,312 ha
	Macroalgae/Filter Feeder	3,775 ha	934 ha[4]	24.7%	2,841 ha
LAU 1D	Macroalgae/Filter Feeder	4,447 ha	1,704 ha[5]	38.3%	2,743 ha
	Seagrass/Macroalgae/Filter Feeder	1,787 ha	347 ha[5]	19.4%	1,440 ha

[1] Onslow Salt intake (Gulf Holdings 1990) and Beadon Creek Maritime Facilities (BMT Oceanica 2015)
[2] Onslow Salt ponds (Gulf Holdings 1990)
[3] Onslow Salt ponds (Gulf Holdings 1990) and Onslow Airport
[4] Wheatstone Project Channel, MOF, PLF, Dredge Material Placement Site A & B, Onslow Salt Channel (Chevron, 2010)
[5] Wheatstone Project Channel, MOF, PLF & Trunkline (Chevron, 2010)

Based on the above assessment and given the ephemeral nature of seagrasses, no attempt has been made to assess historical loss of BCH from trawling. It is possible and evidence of abundant rubble and broken shells indicate that prawn trawling which occurs over a significant part of the area impacts on sessile invertebrate abundance in those areas close to shore, although BCH in the area may also have been negatively impacted by natural disturbances such as cyclones.

The Onslow Salt spoil disposal sites were excluded from historical loss estimates. Baseline investigations of benthic habitats for the Wheatstone Project surveyed the Onslow Salt dredge spoil grounds and found no obvious differentiation between sediments and benthic habitats within the spoil grounds compared to adjacent areas (URS, 2010c). The presence of benthic fauna such as hydroids, bryozoans, sparse seagrass (*Halophila spinulosa*) and invertebrate burrows indicated that the disposal ground had been recolonised.

The Wheatstone Project predicted further partial mortality of subtidal BCH within the Zone of Moderate Impact (ZoMI) resulting from dredge plumes generated by dredging activity. The losses of BCH predicted based on SSC plume model outputs for optimised dredge scenarios on corals and seagrass are shown in **Table 2-9**. To reflect that the predicted loss is <50% mortality, the area of predicted loss was divided by two. Note, these loss calculations were prepared based on the distribution of habitats previously mapped. The results of post dredging surveys however, show that areas of monitored BCH had higher cover of coral and filter feeders at the end of the dredging program compared to the final survey undertaken prior to the commencement of dredging (Chevron, 2017). The cover of seagrass and macroalgae was lower although there were no obvious spatial patterns in cover correlated with distance from dredging activity or patterns in cover related to levels of turbidity or benthic light associated with dredging activity. The differences in cover reported appear to be consistent with the natural dynamics of these communities (Chevron, 2017). Therefore, areas of historical loss for the Wheatstone Project have been limited to the predicted areas within the Zone of High Impact (ZoHI).

Table 2-9 The predicted losses within the Zone of Moderate Impact for the Wheatstone Project excluded from historical loss assessment

LAU Unit	Area of Predicted Impact	BCH	Loss Area (ha & %)
LAU 1C	West of Beadon Point & NW Ward	Coral Reef	2.5 ha or 2.6%
LAU 1G & LAU 1A	Beadon Point to Coolgra Point	Seagrass	2570 ha or 12.6%
		Macroalgae	730 ha of or 3.0%
LAU 1D & LAU1B	West of the Port of Ashburton Channel to Port Limits	Macroalgae	1234 ha or 5.5%
LAU 1E & 1F	Port of Ashburton Port Limits to Ashburton River Mouth	Seagrass	102 ha or 1.5%

Summary of Historical Loss

There has been very little loss (0.4%) of mangrove habitat within LAU 0A. Losses are restricted to Beadon Creek and include loss of approximately 1 ha near the solar ponds intake and a possible small reduction in mangrove productivity through diverting water away from the catchment, and another cumulative 1-2 ha on the west side of Beadon Creek as part of development of the Beadon Creek Maritime Facilities.

There has been substantial algal mat (19.3%) and moderate bioturbated mud flat/ samphire zone (3%) BCH losses in the tidal flat system which now supports the Onslow solar salt ponds. Approximately 200 ha of algal mat and 40 ha of bioturbated mud flat/ samphire zone have been lost within LAU 0A, predominantly removed from the Beadon Creek tidal embayment (Gulf Holdings, 1990). Additional loss of approximately 4 ha of algal mat in LAU 0A was associated with recent development of the runway as part of the upgrade of the infrastructure at the existing Onslow Airport completed in 2015.

A 9.6 km x 120 m shipping approach channel was dredged to -10.8 m CD west of Beadon Point for the Onslow Solar Saltfield and ongoing shipping movements have likely resulted in the direct loss of 115 ha (1.9%) of sparse Seagrass/ Macroalgae/ Filter Feeder BCH within LAU 1C that was previously reported within this area (Paling, 1990). Dredging to enable shipping access to nearshore coastal infrastructure such as the PLF and MOF for the Wheatstone Project resulted in direct loss of an area of approximately 583 ha (15.4%) of Macroalgae/ Filter Feeder and 52% (<1%) of Seagrass/Macroalgae/Filter Feeder BCH within LAU 1C. Disposal of dredge material at nearshore dredge material placement sites A and B for the Wheatstone Project resulted in further loss of 351 ha (9.3%) of Macroalgae/ Filter Feeder and 632 ha (10.5%) of Seagrass/ Macroalgae/ Filter Feeder BCH from LAU 1C.

Dredging to enable shipping access to nearshore coastal infrastructure and installation of the trunkline for the Wheatstone Project resulted in direct loss of an area of approximately 1,704 ha (38.3%) of Macroalgae/ Filter Feeder and 347 ha (19.4%) of Seagrass/Macroalgae/Filter Feeder BCH within LAU1D.

2.4.5. Intertidal BCH Loss Assessment

The OMSB Project will entail a range of activities that have the potential for impacts to intertidal BCH from:

- Construction of the DMMA;
- Dredging of the turning;
- Installation of pipeline route Option B;
- Dewatering of dredge material from the DMMA;

- Sedimentation from dredging and dewatering; and
- Modification of the bathymetry altering hydrodynamic patterns in Beadon Creek.

Permanent Loss

DMMA

The location of the proposed DMMA is shown in **Figure 1-1**. The DMMA is located immediately north of the Onslow Airport and west of the airport runway extending north to an existing stormwater open runoff drain covering an area of approximately 44 ha. The habitat beneath the proposed DMMA is comprised of approximately 18.6 ha of terrestrial vegetation (see **Figure 4-3**), 23 ha of bare supratidal salt flats and 2.4 ha of algal mat. Historical loss estimates of salt flats have not been included into the assessment of intertidal habitat due to this area being virtually devoid of vegetation and marine invertebrates. The primary functional ecological role of the salt flats is to form part of the drainage catchment of the mangrove ecosystem, which is discussed further in **Section 2.5**. The area of algal mat lies directly adjacent to the airport runway in the north-east corner of the proposed DMMA. This algal mat comprises 0.2% of remaining algal mat within the LAU 0A.

The proposal is predicted to result in the *irreversible loss* of 2.4 ha (0.2%) of algal mat BCH within LAU 0A from the construction of the DMMA as shown in **2-10**.

Turning Circle

Dredging is proposed to be undertaken on a small portion of the tidal lagoon near the mouth and on the east side of Beadon Creek to widen the existing turning circle. The tidal lagoon is composed of bioturbated sand with abundant fauna of burrowing ocypodid fiddler crabs (i.e. species of *Uca*) like tidal mudflat habitats. A small area of *A. marina* seedlings/saplings have also colonised the northern and southern edges of the lagoon flat, with a few established trees in the southern assemblage. The proposed turning circle footprint does not encroach on mangrove trees or existing rhizomes. An area of 0.8 ha of bioturbated sand will be directly removed from the tidal lagoon to widen the turning circle. This has been classified as direct loss of bioturbated mudflats/ samphire, although it is unknown if this lagoon was included in calculations of the extent estimates for bioturbated mudflats/ samphire from Gulf Holdings (1990) as it does not represent the typical upper tidal mangrove commonly associated with this habitat type.

The proposal is predicted to result in the *irreversible loss* of 0.8 ha (<0.1%) of bioturbated mudflats/ samphire BCH within LAU 0A from the dredging the tidal lagoon for the turning circle as shown in **2-10**. A further 1.4 ha of coarse sand will be removed from the sand spit on the east side of the mouth of Beadon Creek, although this dynamically shifting habitat was not found to support invertebrate populations.

'Serious Damage' and *Recoverable Impacts*

Pipeline Route Option B

Two options are provided for the dredge discharge pipe route (see **Figure 1-1**). Option A presents the floating pipeline from the CSD emerging directly from Beadon Creek (i.e. dredging in Beadon Creek) or Onslow Beach (i.e. dredging the outer channel), with the proposed route crossing from the shore over approximately 2,470 m of terrestrial land until it reaches the DMMA. Option B navigates up the western tributary of lower Beadon Creek, crossing the intertidal flats before connecting to the DMMA at a total length of 2,315 m. This assessment estimates the permanent loss of intertidal BCH associated with Option B pipe route.

Due to the length of pipeline required, one or multiple booster pumps will be installed along the discharge line between the dredge pump and the DMMA. Booster pumps will be installed to avoid intertidal habitat using barges in the creek for Option B. The pipeline is proposed to cross diagonally over approximately 450 m of intertidal zone from the northern to southern section of the area between the LIA and the DMMA. The high to low tidal sequence of this area is described as:

- Algal mat;
- Samphire/Bioturbated mudflat;
- Micro-delta fringing open shrubland and thickets of *A. marina*;
- Bioturbated mudflat; and
- Creek fringing open shrubland and thickets of *A. marina*.

The vehicles used to install and remove the pipe will avoid areas of mangrove and algal mat habitat. However, a 2 m wide corridor of *irreversible loss* to mangrove, samphire/bioturbated mudflat and algal mat has been estimated for the area of direct pipelay. The predicted permanent loss of each BCH type within LAU 0A is presented in **2-10**. The total predicted *irreversible loss* to mangrove, samphire/bioturbated mudflat and algal mat is estimated to be minimal at 0.1 ha (<0.1%) within LAU 0A.

Dewatering from the DMMA

Dewatering activities may result in a temporary indirect ecological shift in intertidal BCH through changing the salinity gradient and subsequent physical, chemical and biological functions maintaining the zonation of intertidal BCH within the area affected by the discharge flow-path. It is expected that return water discharged from the DMMA will pool and flood over 10.2 ha of BCH within the intertidal zone north of the airport runway as it free-flows back into the western tributary of Beadon Creek. Potential impacts on intertidal BCH from dewatering are expected to recover once the salinity gradients are re-established following completion of OMSB Project dewatering activities.

The predicted *recoverable loss* of each BCH type within LAU 0A is presented in **2-10.** The predicted *recoverable loss* of intertidal BCH for dewatering activities is 1.3 ha (0.2%) of mangrove, 0.4 ha (<0.1%) of samphire/bioturbated mudflat and 8.5 ha (0.8%) of algal mat.

Dredging and Dewatering Sedimentation

Dredging and Dewatering activities from the DMMA has the potential to result in indirect smothering by fine sediments on intertidal BCH. Mangrove, bioturbated mudflats/ samphire and algal mat BCH are relatively tolerant to the impacts of sedimentation. Historical dredging in Beadon Creek and within other areas of the Pilbara coast with mangrove fringed tidal creek systems (e.g. Port Hedland) has not resulted in significant indirect impacts to mangroves from dredging related sedimentation. Settlement of fine suspended sediments within the DMMA can be managed through appropriate design and construction management techniques. The impacts of sedimentation within Beadon Creek is not predicted to result in any loss of BCH. The risk and significance of the potential impact of sedimentation generated from dredging and dewatering on intertidal BCH within Beadon Creek is discussed in more detail in **Section 2.5**.

Bathymetry Modifications to the Tidal Prism

The depth of the channel, turning circle and berth pocket is proposed to be modified near the mouth of Beadon Creek. Modelling investigations were undertaken to assess the potential for upstream changes to the hydrodynamics (i.e. water level and velocity) from the proposed modification of the bathymetry near the mouth of Beadon Creek which may cause loss of intertidal BCH. Baird (2017) prepared submergence curves to indicate the length of time that nominated water levels occur at point locations within the upper creek. This would indicate if there is a significant change to the inundation characteristics (i.e. height, duration) for intertidal BCH post dredging. Modelling of post construction bathymetry depths indicate there is very minimal change to the submergence characteristics (i.e. virtually undetectable) in various parts of upper Beadon Creek (Baird 2017) and therefore no loss of intertidal BCH is predicted due to the changes in creek bathymetry.

Table 2-10 Estimated ***irreversible loss*** **of intertidal BCH and** ***recoverable impacts*** **from the proposed OMSB Project**

LAU Unit	BCH	Original Extent (ha)	Recoverable Impact		Irreversible Loss	
			(ha)	(%)	(ha)	(%)
LAU 0A	Mangrove	839 ha	1.3 ha[1]	0.2%	0.1[2]	<0.1%
	Bioturbated mudflats/ samphire	1,160 ha	0.4 ha[1]	<0.1%	0.8[2,3]	<0.1%
	Algal Mat	1,008 ha	8.5 ha[1]	0.8%	2.4[2,3]	0.2%

[1] Community shift of intertidal BCH from dewatering activities
[2] Permanent loss of mangrove, bioturbated mudflat/samphire and algal mat from pipeline route option B
[3] Permanent loss of algal mat within the proposed DMMA footprint

2.4.6. Subtidal BCH Loss Assessment

Permanent Loss

The location of the approach channel is shown in **Figure 1-1**. The approach channel is in shallow (-6 m CD) nearshore turbid waters (~2 km offshore) adjacent to the mouth of Beadon Creek. Benthic habitat surveyed in close vicinity to the proposed approach channel is described as predominantly bare silty sand substrate with broken shells/rubble and a sporadic low cover of biota. The biota consists of a mosaic of intermixed filter feeders, turf algae, macroalgae and occasional patches of *Halophila* seagrass. Total cover of sessile biota is typically between 1-3%, although small patches of higher cover are found on patchy low-profile rocky outcrops adjacent to the channel (See **Section 2.3.2**). This mosaic of intermixed low cover seagrass/macroalgae/filter feeders is widespread throughout the area, with low cover of filter feeders and macroalgae recorded in all nearshore areas and seagrass recorded from west of Beadon Point to Coolgra Point (Paling, 1990; URS, 2010c).

The highest cover and diversity of seagrass within the nearshore area and previous dugong tracking indicates seagrass at Coolgra Point, which is not predicted to be impacted from proposed OMSB Project activities, may represent the most important functional role of nearshore BCH in the region (URS, 2010c; Chevron, 2013).

The proposed dredging program is predicted to result in the *irreversible loss* of 21 ha (0.2%) of seagrass/macroalgae/filter feeder BCH within LAU 1G from the construction of the approach channel as shown in **Table 2-11**.

'Serious Damage' and *Recoverable Impacts*

Dredge Plume Impact Assessment

The model outcome interpretations developed for the OMSB Project are based upon an adaptation of the using previously calibrated, validated and approved modelling outputs of the predicted plumes and sedimentation rates generated by dredging activities prepared for the Wheatstone Project by DHI, (2010a, 2010b). The OMSB project is in proximity to the site of dredging operations undertaken for the Wheatstone Project and the prevailing physical characteristics used as inputs for the Wheatstone Project modelling, particularly for the nearshore channel dredging, are essentially the same in terms of prevailing climate, hydrodynamics, and bathymetry given the model domain used in the Wheatstone Project entirely overlaps the OMSB development footprint. There is also strong similarity in sediment characteristics although there appear to be less fines as a sediment constituent in the material to be dredged for the OMSB Project.

Outlines of the model plume outputs from the Wheatstone Project were converted to the outer-most point of the proposed OMSB Project harbour approach channel and Zones of impact were applied using the same thresholds defined as relevant for the region by the Wheatstone Project. A summary of the capital dredging plume impact assessment approach and results of the plume impact assessment are described below, and more details of the methods and the proposed zones of impact are provided in the Capital Dredging Plume Modelling Assessment in **Appendix B**.

Dredging Scenario 1 modelled in (DHI, 2010a; 2010b) closely resembles the proposed dredging for the OMSB Project, with the exception that the size of the dredge and subsequent production rates are much reduced for proposed dredging activities. Mills (2016) suggest it would be reasonable to assume that the spill rate generated from a cutter head is proportional to the rate of sediment dredged. The simulation was based on production rates for the large CSD of 155,000 m^3/week in sand, although dredging equipment proposed for the OMSB Project is planning to involve a small to medium CSD with expected weekly production rates of 40-50,000 m^3. Model predictions of the Zone of High Impact (ZoHI), Zone of Moderate Impact (ZoMI) and Zone of Influence (ZoI) are based on one quarter of the 'realistic case' suspended sediment concentrations (SSC) and sedimentation generated in Wheatstone modelling outputs, and 'worst case' predictions assume one third the extent of the zoned areas designated from the model. This is equivalent to estimated production rates of 38,750 m^3/week ("best case") and 51,667 m^3/week ("worst case") for dredging equipment proposed for the OMSB Project.

Calculation of the percent loss of BCH within LAUs involves the overlay of various figures and area calculations using ArcGIS software. The impact zones arising from exceedance of the tolerances for coral and seagrass on the BCH map, including LAU boundaries, are presented in the Capital Dredging Plume Modelling Assessment in **Appendix B**.

"Worst case" model outputs of the ZoI indicate that SSC plumes above background concentrations are likely to extend between 15-17 km east and west along the coast depending on season (west in winter and east in summer). Hence the potential impact area for the OMSB Project in shallow waters which support BCH is large and covers an area of approximately 160 km^2 which extends some 32 km along the coast and about 5 km offshore. The ZoI represents the area within which changes in environmental quality are predicted during dredging operations, but these changes would not result in a detectable impact on biota. The predicted impact zones for sedimentation impacts on corals and seagrass are more localised than for SSC.

Table 2-11 presents LAUs that fall within the ZoHI and ZoMI, the original extent of BCH within each LAU and the predicted area or proportion of reversible impacts and *irreversible loss* within the LAU. The predicted loss is based on the "worst case" zones of impact. The calculation of loss estimates is based on the zones of impact for SSC plume model outputs only (i.e. ZoHI & ZoMI). Sedimentation predicted impacts are restricted to the immediate vicinity of the channel within predicted SSC zones of impact and are therefore considered by default. The results for "best-case" zones of impact are presented in **Appendix B** and are discussed further in **Section 2.5.3**.

Irreversible loss in **Table 2-11** represents 'serious damage' to BCH associated with elevated suspended sediment levels in the water column leading to reduced light and increased turbidity and/or sedimentation smothering BCH. The area of predicted *irreversible loss* is presented as the ZoHI in model outputs, which describes the area lacking a capacity to return or recover to a state resembling that prior to being impacted within a timeframe of five years or less[2].

[2] In accordance with the EPA Act Precautionary Principle, BCH within the ZoHI has been classified as '*irreversible loss*' although the BCH community is likely to either not be impacted to this degree or is likely to recover within a timeframe of five years. This is discussed further in Section 2.5.3.

The proposed dredging program is predicted to result in the "worst case" *irreversible loss*[3] of:

- LAU 1G: 459 ha (4.5%) of Seagrass/Macroalgae/Filter Feeder and 96 ha (7.3%) of Macroalgae/Filter Feeder BCH; and
- LAU 1C: 18.5 ha (0.3%) of Seagrass/Macroalgae/Filter Feeder BCH.

Recoverable impacts in **Table 2-11** is presented as the ZoMI model outputs and describes the area where impacts or losses of benthic communities occur, but there is confidence that the community, and the ecological services it provides, will fully recover within five years. The proposed dredging program is predicted to result in the following "worst case" *irreversible loss* of BCH:

- LAU 1G: 975 ha (9.5%) of Seagrass/Macroalgae/Filter Feeder and 71 ha (5.4%) Macroalgae/Filter Feeder BCH; and
- LAU 1C: 236 ha (3.9%) of Seagrass/Macroalgae/Filter Feeder and 102 ha (3.2%) of Macroalgae/Filter Feeder BCH.

Table 2-11 Estimated *irreversible loss* of subtidal BCH and *recoverable impacts* from the proposed OMSB Project

LAU	BCH	Original Extent (ha)	Recoverable Impacts[1]		Irreversible Loss[2]	
			(ha)	(%)	(ha)	(%)
LAU 1C	Corals	35 ha	-	-	-	-
	Seagrass, Macroalgae, Filter Feeders	6,000 ha	236 ha	3.9%	18.5 ha	0.3%
	Macroalgae, Filter Feeders	3,240 ha	102 ha	3.2%	-	-
LAU 1G	Seagrass, Macroalgae, Filter Feeders	10,228 ha	975 ha	9.5%	459 ha	4.5%
	Macroalgae, Filter Feeders	1,309 ha	71 ha	5.4%	96 ha	7.3%

[1] Area predicted within the "worst case" ZoMI
[2] Area predicted within the "worst case" ZoHI including area of permanent loss

2.4.7. Potential Cumulative Loss

The potential cumulative loss of each BCH in each LAU predicted to be impacted by the OMSB Project is presented in **Table 2-12**. The potential cumulative loss is derived by adding the estimated area of permanent loss and serious damage within each LAU to the known historical loss and expressing that as a percentage of the original area of BCH.

The OMSB Project is predicted to cause minimal additional loss of intertidal BCH (i.e. <1%) within LAU 0A. While the construction of the DMMA, dredging of the turning circle and installation of pipeline Option B would result in a small loss of BCH, these losses are likely to be within the range of errors inherent in mapping BCH in the intertidal zone where the delineation of boundaries between BCH is often difficult. The predicted *irreversible loss* of 2.4 ha was added to the historical loss of 195 ha of algal mat to result in a cumulative loss of 197.4 ha (19.7%). The predicted *irreversible loss* of 0.8 ha was added to the historical loss of 40 ha of bioturbated mudflat/ samphire to result in a cumulative loss of 41 ha (3.5%). The potential cumulative loss of mangroves would remain at 3.1 ha (0.4%). The effects from project activities are limited to a possible option of laying the pipeline from the creek across the intertidal zone. It is considered that likely impacts resulting from pipeline installation/removal and dewatering of sediments from the proposed DMMA will

[3] Including permanent loss

recover to the pre-impact state within five years post project activities. The interpretation of the predicted impacts on the ecological integrity and biological diversity of BCH at local and regional scales are discussed further in **Section 2.5**.

The OMSB Project is predicted to cause permanent loss of 21 ha (0.2%) of seagrass/macroalgae/filter feeder BCH for the approach channel. Sediment plumes generated from dredging activities is predicted to result in *irreversible loss* of 459 ha (4.4%) and 18.5 ha (0.3%) of Seagrass/Macroalgae/Filter Feeder BCH within LAU1G and LAU 1C, respectively, and 96 ha of Macroalgae/Filter Feeder BCH within LAU 1G. Historical loss on BCH within LAU 1G has previously not been recorded[4] and therefore the cumulative loss is limited to the predicted loss from the OMSB Project. The loss of 18.5 ha (0.3%) was added to the historical loss of 636 ha from development of the Onslow Salt channel, Wheatstone Project Channel, MOF and PLF and spoil disposal at nearshore Dredge Material Placement Sites (A & B) within LAU 1C to create a cumulative loss of 654 ha (10.9%) of Seagrass/Macroalgae/Filter Feeder BCH. The interpretation of the predicted impacts on the ecological integrity and biological diversity of BCH at local and regional scales are discussed further in **Section 2.5**.

Table 2-12 Potential cumulative loss of BCH from historical projects and the proposed OMSB Project

LAU	BCH	Original Area (ha)	Historical Loss		Irreversible Loss		Cumulative Loss	
			(ha)	(%)	(ha)	(%)	(ha)	(%)
LAU 0A	Mangroves	839 ha	3 ha	0.4%	0.1	<0.1%	3.1 ha	0.4%
	Bioturbated mud flat/ samphire	1,160 ha	40 ha	3.5%	0.8	<0.1%	41 ha	3.5%
	Algal mats	1,008 ha	195 ha	19.3%	2.4	0.2%	199 ha	19.7%
LAU 1C	Seagrass, Macroalgae, Filter Feeder	6,000 ha	636 ha	10.6%	18.5 ha	0.3%	654 ha	10.9%
	Macroalgae, Filter Feeder	3,240 ha	351 ha	10.8%	-	-	351 ha	10.8%
LAU 1G	Seagrass, Macroalgae, Filter Feeder	10,228 ha	-	-	459 ha	4.4%	459 ha	4.5%
	Macroalgae, Filter Feeder	1,309 ha	-	-	96 ha	7.3%	96 ha	7.3%

2.5. Risk/Significance of Project Activities

2.5.1. Project Risks

This section provides an assessment of the potential consequences of the impacts and risks of project activities on ecological integrity and biological diversity of BCH at local and regional scales. Potential ecological consequences are reviewed for mangroves, bioturbated mudflats /samphire, algal mat, corals, seagrass, macroalgae and filter feeders.

Construction of the DMMA and dredging of the turning circle will result in the permanent loss of intertidal BCH and the disposal activities at the DMMA, including installation of the pipeline and dewatering of the dredge material, has been assessed for the potential to alter the ecological integrity and biological diversity of BCH in the OMSB Project area. Two options are presented for the pipeline route, Option B extends along Beadon Creek and up the western tributary crossing the intertidal flats resulting in the potential direct impact

[4] Information on the habitat condition in LAU 1C & LAU 1G prior to trawl commercial fishing activities is not available and has not been included in the cumulative loss estimates (see **Section 2.4.4**)

on intertidal BCH such as mangroves, mudflats and algal mat. Dewatering from the DMMA located on the salt flats involves the discharge and free-flow of return water over the intertidal area. This activity has the potential for indirect effects on the adjacent intertidal habitat. Other aspects of the OMSB Project that have been assessed for the potential to impact the ecological integrity or biological diversity of the intertidal BCH is the potential for direct removal of intertidal BCH habitat when dredging near the mouth of the creek to create the turning circle, as well as assessing the effects of modifications to the hydrodynamics of the creek from changes to the bathymetry near the mouth of the creek potentially causing a reduction in the availability of habitat for intertidal BCH.

The aspect of the OMSB Project with the greatest potential for causing loss or structural change in subtidal BCH is capital dredging. Direct impacts largely occur within the approach channel where dredgers excavate the seabed mapped as moderate cover seagrass/macroalgae/filter feeders. Impact zones were created within the survey area to determine the indirect effects on BCH and are based on the tolerance limits of corals and seagrasses to turbidity (suspended sediment within the water column) and sedimentation rates (sediment deposited on the sea floor) that were deemed appropriate for the region during the recent Wheatstone Project dredging program. The zones of impact are presented in **Appendix B** and calculation of the 'worst case' area of BCH likely to be impacted is provided in **Section 2.4**. A sediment investigation determined that the material to be dredged is comprised of clean uncontaminated sands with low nutrient concentrations and fine sized sediments (O2 Marine, 2017). Therefore, this assessment is primarily concerned with the physical effects of suspended sediments and sedimentation.

The Western Australian Institute of Marine Science Institution (WAMSI) has recently prepared numerous documents to help understand the functional ecology of BCH and the potential impacts from dredging. These documents have been considered in the below assessment.

2.5.2. Intertidal BCH

Ecological Significance

Mangrove areas from Onslow to Coolgra Point are afforded a high conservation value and the EPA recommends the impacts of development on mangrove habitat and ecological function of the mangroves should be reduced to the minimum practicable level.

An assemblage of fishes and invertebrates utilise the food resources of mangals on a temporary basis. There are also some fish and invertebrate taxa whose adult populations are restricted to mangrove habitats, referred to as "mangal obligates". These mangrove habitats play a major role in supporting coastal food webs and nutrient cycles in the coastal zone and they are often an efficient sink of dissolved nitrogen, phosphorus and silicon (Alongi, 1996). The variety of mangrove plants and diversity of fishes and invertebrates supported by mangrove is not great and benthic invertebrates typically show a strong negative correlation with the salinity gradient across the intertidal zone. The density of fauna in mangals may be very high.

Landward of the mangrove zone, large areas of mudflats typically extend to the hinterland margin or merge with the supratidal salt flats. These mud flat areas occur in the upper sections of the intertidal zone and hence are not regularly inundated by tides. Two habitat types are recognised within the mud flats, these being bioturbated mud flats with samphire communities and algal mats. The samphire plants and algal mats, like mangrove trees, are primary producers in the strict sense, while bioturbated mud flats are areas of high secondary production essential to the output of nutrients by the plants in the ecosystem. Cyanobacteria within the algal mats use a variety of nitrogen sources including ammonia, several amino acids, nitrite and nitrate. They can also use nitrogen directly. All steps of the nitrogen cycle may be present in the microbial mat in which cyanobacteria play a particularly important role.

Permanent Loss

DMMA

The location of the proposed DMMA overlies approximately 18.6 ha of terrestrial vegetation, 23 ha of bare supratidal salt flats and 2.4 ha of algal mat. Assessment of the potential consequences of the impacts of construction of the DMMA on the ecological integrity and biological diversity of terrestrial vegetation is provided in **Section 4.5**.

Construction of the DMMA on the salt flats is not predicted to impact the ecological integrity and biological diversity of intertidal BCH. The area selected for development is underlain by limestone pavement and is devoid of marine plants and invertebrates. Therefore, there are no predicted direct impacts to intertidal flora and fauna associated with the construction of the DMMA on salt flats.

The primary functional ecological role of the salt flats is to form part of the drainage catchment of the mangrove ecosystem. Drainage of the intertidal zone within the proposed site for the DMMA has already been modified by the Onslow Salt ponds, Onslow Road and the Onslow Airport. Stormwater runoff enters the salt flats through an existing stormwater drain from Onslow Road at the north of the DMMA. However, natural flow is obstructed and diverted around the airport runway. These salt flats would only be inundated on rare occasions by either extreme sea level events or during flood periods. (Biota, 2005) investigated similar mangrove habitats on the east side of Exmouth Gulf and concluded that freshwater input related mechanisms appear to be of negligible importance in the routine maintenance of mangrove systems with the tidal flats being considered as a dry estuary, due to high evaporation rate, small catchment, low rainfall and lack of perennial runoff. This conclusion is also evidenced by the extensive development of 8,000 ha of salt ponds which have significantly reduced the catchment area but have resulted in minimal effects on mangrove productivity within the Beadon Creek tidal embayment. There are two channels within the existing stormwater drain and the design of the DMMA has planned for stormwater runoff from Onslow road to be diverted through the northern channel into the intertidal zone. Therefore, restriction of flushing from rainfall is not expected to occur on the intertidal area adjacent to the proposed DMMA and any subsequent indirect impacts such as increases in groundwater salinity in this area caused by the reduced floodwater flushing regime is considered highly unlikely.

Construction of the DMMA will smother 2.4 ha (0.2%) of algal mat directly east of the airport runway, so a reduction in productivity and nutrient supply is expected from this source. The algal mat BCH within this area has already been modified due to the construction of the airport runway. The algal mat predicted to be permanently lost forms a very small proportion of the primary productivity output for algal mat locally and regionally.

A reduction in primary productivity for mangrove, bioturbated mud flat/ samphire or algal mat associated with reduced floodwater flushing is not expected. Construction of the DMMA immediately north of the Onslow Airport and west of the airport runway is not predicted to affect the ecological integrity and biological diversity

Turning Circle

Dredging to widen the existing turning circle will result in the direct removal of 0.8 ha of tidal lagoon habitat near the mouth and on the east side of Beadon Creek. The tidal lagoon community is comparable to communities found within bioturbated mud flat/ samphire BCH and is comprised of abundant fauna of burrowing ocypodid fiddler crabs (i.e. species of *Uca*). No mangroves occur on the tidal lagoon within the proposed area to be dredged. Bioturbated mud flat/ samphire habitat is well represented both locally and regionally and the loss of 0.8 ha represents the *irreversible loss* of <0.1% of BCH within LAU 0A.

Direct removal of this small area of tidal lagoon BCH to widen the turning circle is unlikely to affect the ecological integrity and biological diversity of intertidal BCH at local and regional scales. A further 1.4 ha of coarse sand will be removed from the sand spit on the east side of the mouth of Beadon Creek, although this dynamically shifting habitat was not found to support invertebrate populations.

Irreversible Loss* and *Recoverable Impacts

Pipeline Route Option B

Two options are presented for the pipeline route. Option B extends along Beadon Creek and up the western tributary crossing the intertidal flats resulting in the potential direct impact on intertidal BCH such as mangroves, bioturbated mud flat/ samphire and algal mat. A 2 m wide corridor of *irreversible loss* to mangrove, samphire/bioturbated mudflat and algal mat has been estimated for the area of direct pipelay which results in the predicted *irreversible loss* of <0.1% of BCH within LAU 0A. Although this loss represents minimal impacts within the Project area, consideration should be provided to the potential ecological effects of pipeline route Option A to reduce the impacts of development on mangrove habitat and ecological function of the mangroves to the minimum practicable level in accordance with Guideline 4 (EPA, 2001).

Intertidal mangroves, bioturbated mud flat/ samphire and algal mat are widespread locally and regionally and disturbance of <0.1% is unlikely to affect the ecological integrity and biological diversity of these BCH.

Dewatering from the DMMA

A decrease in salinity from free-flowing less saline return water over the intertidal zone adjacent to the DMMA may result in temporary, indirect changes to BCH within the flow path to the creek. Return water will be discharged from the north-west corner of the DMMA adjacent to the airport runway at a rate of approximately 14,880 L/min, based on the rate of dredged material being pumped into the DMMA.

Paling (1990) recorded large areas of algal mat overlain with water visible 16 hours after a spring tide, suggesting the area is not sufficiently flushed by seawater resulting in high evaporation rates and high salinity in the upper intertidal zone. URS (2014) also describe that tidal exchange is limited in efficiency and consequently the headwaters of the tidal reaches tend to accumulate salt due to evaporation losses.

A digital elevation model of the intertidal zone was generated using Lidar data provided from Chevron which presents a low-gradient, creek-ward sloping landform of intertidal flat (**Figure 2-10**). Inundation of these areas by streamflow or highest astronomical tide may occur only for a few days of each year and the evaporation and associated salt accumulation is a significant process in this area (URS 2014). The uniform topography and previous observations of tidal water evaporation in the upper areas if the intertidal zones indicates that flood water must find its own gradient to the creek and consequently water flow velocities will be low. Therefore, return water discharged from the DMMA is expected to pool and flood as it free-flows across the intertidal area.

The relationship between tidal elevation and frequency of tidal inundation establishes salinity gradients across the intertidal zone that influences the zonation of BCH (due to differing salinity tolerance) (Semeniuk 1993). In the OMSB Project area mangroves typically occupy the section of the intertidal gradient from 0 m to 0.7 m AHD, bioturbated/samphire zone mudflats to 1.0 m AHD and algal mats to 1.2 m AHD. The tidal exchange and associated groundwater recharge function regulates salinities and provides for the maintenance of this zonation. The discharge of return water which is less saline than the receiving environment during the dredging operation could possibly lead to modification of the salinity gradient and subsequent physical, chemical and biological functions maintaining the zonation of intertidal BCH within the area affected. This may result in a temporary community shift, the specifics of which are not well understood and have possible temporary beneficial consequences. Temporary less saline conditions in the upper intertidal zone may favour further colonisation of mangroves due to prolonged inundation, or conversely the reduction in samphire/ bioturbated mudflats. Inundation of dehydrated algal mats is likely to promote productivity which may increase nutrient levels to the mangrove systems, although nutrient recycling within lower intertidal zones may be reduced resulting in elevated nutrient output entering the water column.

Conversely, lowering salinity levels within algal mat habitat may also result in higher rates of predation from grazing invertebrates such as the extensive crustacean and mollusc populations with lower salinity tolerance in the high tidal mud flat habitat.

Any impacts on intertidal BCH from dewatering are expected to recover once the salinity gradients are re-established following completion of OMSB Project activities. In consideration of the EPA Act Precautionary Principle and due to uncertainty of potential consequences of dewatering activities, 1.3 ha (0.2%) of mangrove, 1.4 ha (<0.1%) of samphire/bioturbated mudflat and 8.5 ha (0.8%) of algal mat BCH within the predicted flow-path of return waters has been assessed as *recoverable impacts* to allow for any temporary loss of habitat that may occur. Potential impacts from dewatering activities are temporary and unlikely to affect the ecological integrity and biological diversity of intertidal BCH at local and regional scales.

Dredging and Dewatering Sedimentation

Dredging and dewatering activities have the potential to result in indirect impacts from sedimentation on BCH in intertidal areas. Mangroves are highly tolerant to the magnitude of sedimentation typically generated from previous dredging activities in Beadon Creek. Mangrove species have adapted to water logging and anoxia in the sediments of tidal mudflats via the development of various modifications to their root systems including pneumatophores, stilt roots and knee roots, all which rise above the mud and provide oxygen to the plant's root system through small pores. Burial of these modified root systems by fine marine sediments from dredging or onshore disposal activities has the potential to impact mangrove tree health, or even cause tree deaths. A review of sediment burial of mangroves in Australia (Ellison 1998) reports the mortality of *A. marina,* the dominant mangrove in the OMSB Project area when buried by sedimentation depths of 12-50 cm. Sedimentation in the intertidal areas over the duration of dredging is anticipated to be well within sedimentation burial depths for mangroves.

Settlement of fine suspended sediments within the DMMA can be managed through appropriate design and construction management techniques. An area of 44 ha is proposed for the DMMA, which allows sufficient area for the design of a dredge disposal strategy to ensure that dredged materials are disposed of within the designated DMMA and not released into return waters. Monitoring of suspended sediment concentrations (via turbidity) can be conducted at the weir box and the discharge from the pond can be controlled to ensure that management targets for the protection of intertidal BCH can be met.

Assessment of the potential for indirect impacts to mangroves from dredging and dewatering indicates that impacts to the ecological integrity and biological diversity of BCH at local and regional scales are unlikely given consideration of the following factors:

- Natural levels of sedimentation are likely to be high under extreme conditions and the relative increase in concentrations due to dredging and dewatering activities is predicted to be comparable.
- The dredge plumes are not expected to give rise to additional sedimentation at a scale that could threaten mangrove communities.
- Previous dredging within Beadon Creek and other areas of the Pilbara coast with mangrove fringed tidal creek systems (e.g. Port Hedland) has not resulted in significant indirect impacts to mangroves from dredging related sedimentation.
- Suspended sediments within the dredge slurry will settle in the DMMA and return water discharged from the pond will contain low suspended sediment concentrations. Management will need to be in place to ensure suspended sediments have settled within the pond prior to discharge.

Bathymetry Modifications to Hydrodynamics

Modification of the bathymetry near the mouth of Beadon Creek for the OMSB Project has the potential change hydrodynamics, with potential for loss of intertidal BCH resulting from altering the tidal regime. Baird (2017) undertook hydrodynamic modelling of the planned capital dredging to determine that there is only a minor (<1%) predicted increase to the overall tidal prism within Beadon Creek. Therefore, potential indirect impacts from proposed changes to the bathymetry at the entrance of Beadon Creek is unlikely to affect the ecological integrity and biological diversity of intertidal BCH.

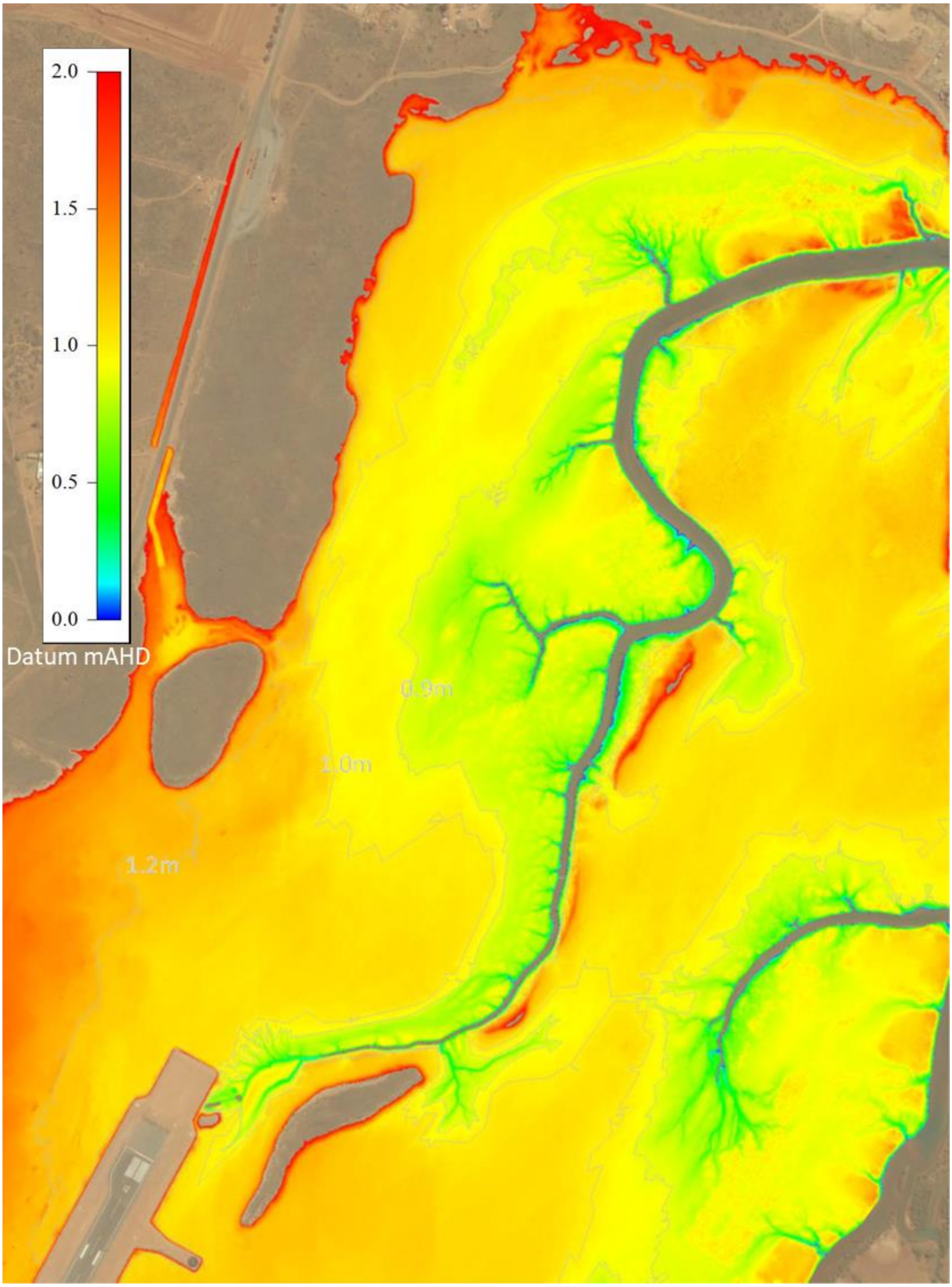

Figure 2-10 **The topography of the intertidal zone generated through analysis of Lidar imagery provided from Chevron**

2.5.3. Subtidal BCH

Corals

Ecological Significance

Coral reef communities offshore of Onslow are predominantly found within the ecosystem unit between 10-20 m. Coral colonies can be found on areas of exposed hard substrate in the shallower nearshore waters to 10 m depth, although are typically associated a low coral cover. Ward Reef, Roller Shoal and Glennie Patches are the known exceptions, having previously been recorded to support a moderate to high coral cover. Ward Reef is a relatively large reef close to Beadon Point that has previously been recognised as being regionally important for recreational fishing and conservation value (Paling, 1990; URS, 2010e).

Key stressors to corals associated with dredging are identified as being elevated SSCs affecting feeding processes in corals, reduction in light intensity and quality affecting photosynthesis and sedimentation smothering corals. These stressors can act independently or synergistically in a constant state of transition during dredging programs (Jones, 2017). Recent natural disturbance events such as warm water temperatures and cyclones during summer periods have caused a community shift on local reef systems resulting in recovering coral communities in the area. Recent monitoring of Ward Reef in May 2015 recorded a coral cover of only 2.2% (Chevron, 2017). Therefore, succession of these reefs to return to vibrant coral communities which were previously dominated by fast growing Acroporidae corals will be largely reliant on larval recruitment from upstream sources (Babcock, 2017).

Babcock et al. (2017) suggests the use of environmental windows for the protection of sexual recruitment of larvae from upstream sources. Fast growing species of corals typically spawn in autumn during the transitional period when the extent of the SSC plume is reduced, although typically follows a north-east trajectory adjacent to the coast. Modelling of sediment plumes during coral spawning periods for the Wheatstone Project indicate the OMSB Project area is located downstream of potential coral settlement habitat and therefore dredging activities is unlikely to interfere with the passage of coral larvae to sink reefs to the west and generally further offshore. Therefore, dredging during coral spawning windows for the OMSB Project is unlikely to result in any impacts on coral recruitment on nearby coral reef communities.

***Irreversible Loss* or *Recoverable* Impacts**

Dredge plume modelling results are presented in **Appendix B**. No areas mapped as coral habitat occur within the ZoHI or ZoMI for “best-case” or “worst-case” model outputs. The predicted ZoI overlaps a small reef (2.8 ha) known as ‘West of Beadon Point’ and a portion (40 ha) of Ward Reef. However, the ZoI is defined as the area within which changes in the environmental quality associated with dredge plumes are predicted and anticipated during the dredging operations, but where these changes would not result in a detectable impact on BCH.

Dredging of the OMSB Project approach channel is unlikely to affect the ecological integrity and biological diversity of coral BCH.

Seagrasses, Macroalgae and Filter Feeders

Permanent Loss

Only 21 ha of seagrass/macroalgae/filter feeder BCH will be permanently lost for the OMSB Project approach channel. The LAU 1G is comprised almost entirely of BCH mapped as seagrass/macroalgae/filter feeder except for smaller areas of macroalgae/filter feeder’ habitat in the north-east and south-west corners of the LAU. The predicted loss of 21 ha represents only 0.2% of seagrass/macroalgae/filter feeder BCH in LAU 1G located within Port of Onslow seabed. This habitat locally and regionally widespread within the West Pilbara region.

Permanent loss of 21 ha (0.2%) of seagrass/macroalgae/filter feeder BCH for the OMSB Project approach channel is unlikely to affect the ecological integrity and biological diversity of seagrass/macroalgae/filter feeder BCH.

Irreversible Loss* and *Recoverable Impacts

Previous and existing surveys of the area have determined communities within these habitats are not discrete spatial distributions of individual habitat types, and are instead distributed as a mosaic representing patches of intermixed benthic communities interspersed with areas of bare substrate. Assessment of the impact on the ecological integrity and biological diversity of these communities considers the significance of mixed BCH and evaluates the functional role and resilience of each key BCH type separately.

The 'best case' and 'worst case' ZoHI and ZoMI for SSC and sedimentation generated from proposed dredging activities are predominantly located over benthic habitat described as 'Moderate cover (5-10%) seagrass/macroalgae/filter feeders', which occur nearshore between Sunset Beach (i.e. Onslow back beach) and Third Creek. These plumes also cover a smaller nearshore area mapped as 'Low cover macroalgae and filter feeder' habitat. The zones of impact are limited to two Loss Assessment Units: LAU 1C and LAU 1 G.

The BCH which falls within the ZoHI and ZoMI is predicted to result in either minimal impacts or is expected to recover to a state resembling that prior to being impacted within a timeframe of five or less years or less. The rationale for this assumption is evaluated within the assessment of SSC and sedimentation impacts on the ecological integrity and biological diversity for each BCH type individually below. However, in consideration of the EPA Act Precautionary Principle and guidance provided from the EPA for environmental impact assessment of marine dredging proposals (EPA 2017), BCH within the ZoHI has been conservatively assigned as *irreversible loss*.

The SSC ZoHI dredge plume "worst case" modelling outputs represent the maximum predicted area of serious damage to BCH associated with elevated SSC generated during proposed dredging activities. The predicted area of *irreversible loss* predominantly occurs within LAU 1G, estimating 459 ha (4.5%) of Seagrass/Macroalgae/Filter Feeder and 96 ha (7.3%) of Macroalgae/Filter Feeder BCH compared to 18.5 ha (0.4%) of Seagrass/Macroalgae/Filter Feeder BCH within LAU 1C. The *irreversible loss* within LAU 1C for the "best case" is only 5 ha (0.1%) of Seagrass/Macroalgae/Filter Feeder BCH, compared to 391 ha (3.8%) of Seagrass/Macroalgae/Filter Feeder and 58 ha (4.4%) Macroalgae/Filter Feeder BCH within LAU 1G.

Historical loss of BCH was not recorded for LAU 1G located within the Port of Onslow, although commercial trawling has been historically operating in the nearshore area of Onslow and it is well known that trawling alters the physical structure of benthic habitats (Kangas et al. 2006) and it is likely the biodiversity and habitats in the trawled areas of Onslow have changed significantly since trawling began. Based on a lack of sufficient baseline data prior to trawling activities, cumulative loss of BCH within LAU 1G is assumed to be limited to that predicted for the OMSB Project. Conversely, significant coastal development has occurred in LAU 1C within the Port of Ashburton. Historical losses calculated include the Onslow Salt shipping approach channel and nearshore infrastructure construction, dredging and DMMA for the Wheatstone Project. This has resulted in an estimated historical loss of 636 ha (10.6%) of Seagrass/Macroalgae/Filter Feeder and 351 ha (10.8%) of Seagrass/Macroalgae/Filter Feeder BCH. Dredge plume modelling outputs predict only small areas of additional *irreversible loss* of Seagrass/Macroalgae/Filter Feeder BCH within LAU 1C (i.e. worst case 18.5 ha or 0.3%) which is expected to be within the range of error inherent in mapping accuracy of subtidal BCH.

The SSC ZoMI dredge plume model outputs represent the predicted area impacts on BCH associated with elevated SSC will recover within a period of five years following completion of dredging activities. The predicted area of *recoverable impact* from "worst case" SSC model outputs predominantly occurs within LAU 1G, estimating 975 ha (9.5%) of Seagrass/Macroalgae/Filter Feeder and 71 ha (5.4%) of Macroalgae/Filter Feeder BCH compared to 236 ha (3.9%) of Seagrass/Macroalgae/Filter Feeder and 102 ha

(3.2%) Macroalgae/Filter Feeder BCH within LAU 1C. The *recoverable impact* within LAU 1C for the "best case" is 157 ha (2.6%) of Seagrass/Macroalgae/Filter Feeder and 46 ha (1.4%) of Macroalgae/Filter Feeder BCH, compared to 838 ha (8.2%) of Seagrass/Macroalgae/Filter Feeder and 109 ha (8.3%) Macroalgae/Filter Feeder BCH within LAU 1G.

The impact zones for sedimentation are more localised than for SSC. The sedimentation dredge plume "worst case" and "best case" modelling outputs predict 157 ha (1.5%) and 111 ha (1.1%) of *irreversible loss* of Seagrass/Macroalgae/Filter Feeder BCH within LAU 1G, respectively. The predicted *recoverable impacts* for the "worst case" and "best case" modelling outputs is 220 ha (1.9%) and 192 ha (2.2%) within LAU 1G, respectively. No impact zones from the predicted sedimentation dredge plume model outputs occur outside of plumes predicted in SSC dredge model outputs. Therefore, the SSC dredge plume modelling outputs represent the maximum predicted potential impacts for the OMSB Project activities.

It should be noted that a conservative approach has been applied to the predicted model outputs and loss estimates to represent the total extent of all seasonal effects throughout the year to allow flexibility in the dredging schedule as the time required for planning and regulatory approvals is presently unknown. The proposed dredging activities of the outer channel for the OMSB Project will be undertaken over a period of approximately 13 weeks. The direction of sediment plumes generated from dredging activities is strongly seasonal, with sediment plumes tracking easterly during summer, westerly during winter and are typically more localised and uniformly spread during transitional periods. Realistic potential impacts will be confined to areas in the direct plume flow path based on the scheduled timing of the dredging program. Therefore, the total extent of potential impacts will be significantly reduced, expected to be approximately half that predicted, based on an assessment undertaken once the period of 13 weeks has been scheduled. For example, if the dredging was undertaken through summer (i.e. Dec-Feb) the predicted plume would not extend into LAU 1C or impact Macroalgae/Filter Feeder BCH, and the "worst case" *irreversible loss* and *recoverable impact* for Seagrass/Macroalgae/Filter Feeder BCH within LAU 1G would reduce to approximately 270 ha (2.6%) and 700 ha (6.8%).

The BCH within LAU 1C and LAU 1G is predicted to have a natural resistance or resilience to elevated SSC and sedimentation generated from dredging as it is an area of high natural levels. The functional ecological value of BCH is considered 'common' as these BCH are widespread both locally and regionally and do not appear to support critical habitat for conservation significant species. The impact zone is represented as a nursery for the commercial OMPF. However, the faunal assemblages, biodiversity and habitats in the trawled areas of Onslow have changed significantly since trawling began and have now reached a new 'balance' compatible with recurring natural (cyclones) and anthropogenic (trawling) disturbances (see **Section 3.5**). Connell (1978) suggests that the ecological integrity and biological diversity of these habitats is maintained at intermediate scales of disturbance, termed the 'intermediate disturbance hypothesis'. Trawling activities are known to reduce the complexity of the habitats through direct removal of biogenic (sponges, hydroids, bryozoans, amphipod tubes, shell aggregates) and sedimentary structures (sand waves, depressions). This may provide explanation for extensive areas of bare silty sand and rubble substrates within the impact zone. Some common species such as commercial prawn species and portunid crabs within the nearshore areas of Onslow benefit when the structural complexity of a habitat is reduced. Increases in Filter Feeder cover throughout the Onslow region during recent years may reflect restricted trawling effort during recent years.

The potential impacts of SSC and sedimentation generated from proposed dredging activities are unlikely to affect the ecological integrity and biological diversity of seagrass/macroalgae/filter feeder or macroalgae/filter feeder BCH within the nearshore area of Onslow. The potential impacts on the ecological integrity and biological diversity of each BCH type is evaluated separately below.

Seagrasses

Nearshore seagrasses within the BCH type are patchily distributed, predominantly ephemeral and highly dynamic systems, typically composing a low abundance (<3%) of structurally small species of low biomass *Halophila* spp. The *Halophila* genus found within the predicted zone of impact is known to be important rapid colonisers of bare substrates, reflecting life-history traits with short ramet turnover times (< months), fluctuating total standing biomass, a high level of reproductive effort producing seeds and an ability to build up a seed bank (McMahon et al. 2017a). In Western Australia, this genus is the most widespread of the tropical seagrass species, can colonise the widest range of habitat types and appears to be genetically diverse (McMahon et al. 2017a; McMahon et al. 2017b; McMahon et al. 2017c). Despite the collection of site-specific monitoring data on these seagrasses since 2011, trends have not been identified on the spatial and temporal dynamics of the seagrass in the area to determine their sensitivity to dredging. Reduced seagrass cover was recorded among sites during the most recent post-dredging surveys (Chevron, 2017). Due to high temporal and spatial variability, monitoring was unable to determine if dredging contributed to declines in seagrass in the area (Chevron, 2017). With such low cover estimates it is difficult to be sure the patterns recorded are not an artefact of low precision monitoring (McMahon et al. 2017a). Spatial and temporal fluctuations are likely to be influenced by naturally limiting processes in the area, such as the resuspension of sediments in nearshore waters, elevated warm water events and cyclones during recent summer months. Biomass or cover is likely to be highest late in the year (i.e. November/December), although this is not always the case. There have been some observations of flowering and fruiting in November, December and February for *H. ovalis*, *H. decipiens* and *H. spinulosa* (Chevron, 2017; Vanderklift et al. 2017a). However, the seasonal growth and reproductive pattern for these seagrasses is spatially and temporally variable and no clear and generally applicable environmental window can be specified (Short et al. 2017).

Seagrasses are known to provide valuable ecosystem services such as carbon storage (Lavery et al. 2013), filtering nutrients and particles from the water column (Agawin & Duarte, 2002), stabilising sediments (Koch et al. 2006) and providing high primary productivity, but their sparse distribution in the area means that they are likely to make only a small contribution to these ecosystem services. Seagrasses provide an important source of foraging habitat for the endangered dugong and green turtle and are also linked to commercially important fisheries species, such as prawns. A dugong tracking study undertaken in the area in 2012 identified that although seagrass habitat in the area was typically low, dugong was found to spend most of their time around shallow seagrass mapped areas near Coolgra Point and surrounding the islands further offshore. Higher diversity and density of seagrass was recorded at Coolgra Point or at seagrass areas further offshore during baseline mapping investigations for the Chevron Wheatstone Project. Prawn nursery areas occur either side of Beadon Creek, extending south of Beadon Point and north of Second Creek, for the OPMF. The proposed dredging impacts represent the minimal overlap of prawn nursery areas within the Onslow region through development of the existing Port of Onslow which has already been considered for defining management areas for commercial fishing activities. Seagrass areas at Coolgra Point and further offshore have been assigned a higher functional value nominally by identifying a higher benthic cover than the BCH immediately adjacent to Beadon Creek. The proposed dredging program is not predicted to impact the seagrasses of Coolgra Point or further offshore.

McMahon et al (2017a) recommends guidance needs to be provided on what constitutes significant seagrass habitat in the Pilbara worthy for inclusion into assessments to determine impacts to seagrass habitat from dredging. In the Great Barrier Reef, a cover of 5% or less are considered significant habitat warranting protection during dredging, with ecological significance as fisheries habitat and dugong forage (Unsworth et al. 2010). It is noted that research undertaken on natural seagrass dynamics selected areas comprised of a much higher seagrass cover and diversity in clearer waters surrounding islands further offshore, for which the spatial and temporal dynamics are highly variable (Vanderklift et al. 2017a). Nearshore areas with little or patchy low cover and diversity are exposed to a greater variability in environmental conditions and it is therefore not surprising that previous monitoring programs have found extremely high variability in these communities (Chevron 2017). Based on recommendations from McMahon et al. (2017a), the OMSB Project has adopted a precautionary approach to characterise and map the historical distribution of seagrass as potential seagrass habitat. This was generated by overlaying all seagrass observations generated over time to produce a layer which defines the habitat in which low biomass seagrass can grow. However, due to the highly patchy nature of seagrass, typical low cover and spatial extent, seagrass in this area is likely to only occur over a very small proportion of the area mapped as continuous 'Moderate cover (5-10%) seagrass/macroalgae/filter feeder habitat'. Therefore, the significance of 'seagrass' habitat as mapped within turbid nearshore waters offshore of Onslow is exaggerated.

Three stressors that are likely to impact seagrass that are of most interest in impact prediction and management of dredging events are reduced benthic light quantity for photosynthesis, burial by sediment and sediment anoxia and increased hydrogen sulphide production (McMahon et al 2017a). A sediment investigation determined that the material to be dredged contains a low organic carbon content so impacts are focussed towards assessment of the physical effects of benthic light and sedimentation (O2 2017). Suspended sediment concentration thresholds have been used as a proxy for benthic light in the modelling developed for the Wheatstone Project to predict the impacts on seagrass (DHI, 2010a; DHI, 2010b). Whilst this is not considered ideal based on recent WAMSI publications, DHI claim that they have successfully applied SSC-based tolerance limits for seagrass over approximately five years of monitoring for various dredging and reclamation projects in South-East Asia. The outputs present a prediction of impacts that can be interpreted for a mixed benthic community and are considered appropriate in the absence of more suitable available data.

Halophila spp. are considered to have a low resistance to low light levels and burial stress although attain a high recovery potential, indicating recovery potential within the 5 years for reversible impacts (McMahon et al. 2017a; Short et al. 2017; Vanderklift et al 2017b). Seagrasses are flowering plants and capable of sexual reproduction through flowers fruits and seeds, but they are also clonal plants capable of recovery through asexual colonisation. The ability to recover from a disturbance will be controlled by the reproductive and life-history strategy. Recently disturbed areas tend to be dominated by pioneer species characterised by abundant seed production, high dispersal power and rapid growth. *Halophila ovalis* is the fastest growing tropical species making it a common pioneer species that can rapidly colonise areas and survive well in unstable depositional environments following a disturbance (Birch & Birch 1984, Vermaat et al, 1995).

Vanderklift et al. (2017b) investigated the seagrass recovery mechanisms by vegetative growth and recruitment from seed. The study found fast regrowth of vegetative regrowth in *Halophila ovalis*, leading to the assumption of areas within the ZoMI should recover relatively quickly assuming some vegetative material remains from the partial mortality or induced stress (but not death) of seagrasses across the zone for rhizomes to colonise from. However, seeds in sediments in the region are not abundant and the relative importance of seeds in post-disturbance the recovery of the presence of seagrass is less well understood (Vanderklift et al. 2017b). An example of the recovery potential of *Halophila* spp. from Exmouth Gulf is provided in Loneragan et al. (2013). The study investigated the recovery of seagrass and macroalgae following extensive loss caused by Cyclone Vance in March 1999. No seagrass nor rhizomes were found across many sites in Exmouth Gulf during surveys post the cyclone in 1999. Using Tent Island at the mouth of Exmouth Gulf as an example, very little recovery in percent cover or the number of sites with seagrass (*Halodule uninervis* & *Halophila* spp) was detectable 20 months following the event. However, by October and November 2003, the number of sites with seagrass had increased from 16 to 62 sites and seagrass percent cover increased from 0.16 to >30% (Loneragan et al. 2013). The lack of the presence of rhizomes during the first post-cyclone surveys and slow initial speed of recovery suggests vegetative regrowth was unlikely and there are likely sources of seed within the region. This study provides very strong evidence that very low biomass seagrass cover across the predicted ZoHI (with patches of 3-10%) are likely to recover within a timeframe of five years or less.

The potential impact on seagrass from proposed dredging activities are unlikely to affect the ecological integrity and biological diversity of BCH at local and regional scales.

Macroalgae

Increased SSC, sediment deposition and turbidity have the potential to affect macroalgae within BCH classified as 'Moderate cover (5-10%) seagrass/macroalgae/filter feeders'. Tropical macroalgae such as crustose coralline algae (CCA) lay down calcium carbonate as calcite, forming pink to red crusts on a variety of surfaces. The CCA are crucial to the formation and maintenance of coral reefs (Littler, 1972), cementing and binding reef materials (Bak, 1976) and affect the settlement and establishment of corals (Adey, 1998). Some tropical species such as *Halimeda*, make a significant contribution to local sediments (Maxwell, 1968). Many other macroalgae algae perform similar ecological roles to most plants:

- Food source;
- Provide habitat and shelter for other organisms;
- Nutrient cycle from decomposition

Tropical macroalgae are typically less dense and rarely form conspicuous beds when compared to temperate areas in WA, except for ephemeral species which are known to increase in abundance during summer in the south-west Pilbara such as *Sporochnus* and *Sargassum*, which were observed in the area. The CCA have a variable response to elevated SSC and sedimentation, are considered sensitive to reductions in light (Riul et al. 2008) although they contain mechanisms to survive burial (Keats et al. 1997). Algal CCA and turfs are commonly found growing on coral rubble and low-profile reefs in the area although these foundations and exposure to environmental conditions provide limited habitat to support coral reefs. The responses of Phaeophyta, Chlorophyta and Rhodophyta species to sedimentation are variable, although these algae are generally considered relatively resistant to the negative effects of sedimentation if it is already established in a system (Short et al. 2017). These algae may also be considered relatively resistant to low levels of SSC and sedimentation, although they may be vulnerable during periods of peak reproductive activity. Annual reproduction for *Sargassum* spp. in temperate Western Australia is suspected to occur in late summer, following a spring-summer growth period, although this may not apply to tropical populations (Short et al. 2017). The phenology of most green and red algae is unknown and generalities with respect to these groups cannot be made at this stage. Short et al. (2017) recommends dredging during August–September would pose the lowest risk to macroalgae.

The cover of macroalgae was shown to decrease over recent years from 8.8% to 2.1% in surveys undertaken by Chevron between 2012 and 2015 at locations across the entire region (Chevron, 2017). Thermal anomalies and flood events may have had a profound influence on non-coral communities over the period 2010-2015, however, the sampling was not frequent enough to quantify or infer impacts of such events on non-coral communities. The decline in macroalgae cover over all sites regardless of distance from dredging activity makes it difficult to determine whether dredging has contributed to the decrease in macroalgae cover during this period (Chevron, 2017).

Algal biomass is expected to rapidly recover once the dredging program ceases. Evidence from natural disturbance (storm events) suggests that macroalgae can recover to pre-disturbance abundance within six to eight months after the cessation of disturbance (Williams 1988). Surveys conducted adjacent to the Onslow salt shipping channel and DMMA in 2009 indicated that seagrass and macroalgae had recolonised after a disturbance (URS, 2010c). The ephemeral nature of the dominant macroalgae species, suggests that any potential loss resulting from the OMSB Project is likely to be temporary and regeneration will occur within 5 years. An example of the recovery potential of macroalgae from Exmouth Gulf is provided in Loneragan et al. (2013). The study investigated the recovery of seagrass and macroalgae following extensive loss caused by Cyclone Vance in March 1999. Macroalgae cover, which included similar genera found within the Onslow region such as *Sargassum*, *Caulerpa*, *Udotea*, *Padina* and *Halimeda*, across all areas in Exmouth Gulf increased from 2.8% in June 1999 to 21.6% in 2003 (Loneragan et al. 2013). This study provides very strong evidence that low biomass macroalgal cover across the predicted zones of impact (i.e. ZoHI and ZoMI) are likely to recover within a timeframe of five years or less.

The potential impact on macroalgae from proposed dredging activities are unlikely to affect the ecological integrity and biological diversity of BCH at local and regional scales.

Filter Feeders

Benthic filter feeders (secondary production) can be important both in terms of ecological connectivity and in terms of providing food for pelagic, demersal and even for commercially important species. Schönberg (2017) recently undertook a review of the effects of dredging on filter feeder communities with a focus on sponges. This review identifies the many adaptive strategies for sponges in high sediment environments which are listed in **Table 2-13**. These strategies provide filter feeders with distinct advantages to tolerate naturally high sediment environments when compared to benthic primary producer habitats such as seagrass and macroalgae. Therefore, although there is very little known regarding tolerance levels for filter feeder communities, predictions of impacts on filter feeders based on tolerance levels for benthic primary producer habitats is extremely conservative and exaggerate possible estimates of *irreversible loss* and *recoverable impacts*.

Dredge monitoring undertaken from 2011 to 2015 during the recent Wheatstone dredging identified the mean cover of filter feeders increased across all areas from 0.99% to 2.4%, and very little spatial difference in cover was observed between locations close to dredging activities and reference areas further from dredging activities. These findings indicate there has been no detectable impact in filter feeder communities from a much larger capital dredging program than the one proposed by OMSB. Wahab et al. (2017) monitored sessile benthic community composition with a focus on sponges near the channel before and after the Wheatstone Project dredging program in the inner, mid and outer sections of the Project area. Filter feeder communities were comprised of sponges, octocorals, ascidians, bryozoans and hydrozoans. The hydrozoans showed a pronounced decline in density (change of -2.1individuals/m^2), although the remainder of taxa show relatively minor increases and decreases in abundance making it difficult to attribute an effect to dredging activities (Wahab et al. 2017). Three hydrozoans were recorded prior to dredging whilst only one was recorded post-dredging. These results suggest there may be a couple of hydrozoan species which were vulnerable to the effects of SSC and sedimentation generated during the Wheatstone dredging program. The patterns in sponge functional morphology remained relatively stable through periods of elevated sediment levels, which indicates an established community adapted to living in environments exposed to high sediment load (Wahab et al. 2017).

Sedimentation and turbidity generated by dredging activities have the potential to alter the structure of filter feeding communities by reducing fitness and hence competitive advantage and survival. Physiological responses of sponges to acute and chronic sediment stress may range from elevated respiration, reduced or arrested pumping, pore closure, tissue retraction and changes in sponge morphology. Other responses included changes in choanocytes (flagellated cells that drive the water current through the sponge), pore size and pore density, bleaching, necrosis, disease and maceration (Schönberg, 2017). These physiological responses may present a substantial energy drain that could lead to lower growth rates, a reduced proportion of organic to inorganic components, decreased reproductive output, and impaired defence and recovery processes (Schönberg, 2017). Sponges may be highly susceptible during early life-history stages of their life-cycle. In NW Australia, sponges predominantly reproduce between February and March (Fromont, 1999; Fromont et al. 2015; Schönberg, 2017) although general understanding of reproductive biology in filter feeders is limited, with prolonged reproductive and spawning periods known for many sponge species. Short et al. (2017) suggests the reduction of dredging during environmental windows to protect corals during neap tides in autumn may also be of importance in the life cycle of a range of tropical marine invertebrate species based on two presented examples of a polychaete and echinoderms spawning synchronously. However, this suggestion does not adequately consider the complexity of the number of reproductive strategies used by benthic invertebrates, even for the complexity of reproductive strategies for hard corals alone the suggestion of a single timeframe for all communities would not be considered sound guidance without further knowledge and assessment of the reproductive strategies of the primary species of concern to be impacted from dredging activity.

Many sponge species have enormous healing and regrowth abilities and some sponges can outlast adverse conditions with environmentally tolerant resting bodies, the gemmules (e.g. Schönberg, 2002). Where impacts do not result in complete mortality of entire communities, the recovery of disturbances may be relatively short. If the original substrate condition has not changed, recovery will be driven by growth and dispersal capabilities of the filter feeders which is relatively undetermined. However, ongoing effects of the spreading of dredging sediments in denuded areas may take more than a decade for filter feeders to recover to their original state (e.g. Van der Veer et al. 1985).

Table 2-13 Strategies and processes used by filter feeders to tolerate high sediment environments

Strategy	Processes
Natural relationships with sediments	Live partially buried in sediments (endopsammic) Columnar body parts above sediments Naturally accumulate sediments on the surface
Responses for avoidance of sediments	Settlement preference for avoiding fine sediments, Specialised inhalant sieves Vertical or irregular shaped morphological surfaces for sediment diversion; Exhalant openings or other adaptations on prone surfaces for sediment diversion
Passive Cleaning Processes	Self-cleaning surfaces; and Symbiotic relationships with epibionts (i.e. holothurians, crustaceans) providing a cleaning function;
Active Sediment Cleaning Processes	Mucous production Tissue sloughing Backflushing of inhalant pores; Selective retention and rejection of material during filter feeding Phagocytosis with removal/digestion Re-organisation of canal system when blocked

Schönberg (2017) and Wahab (2017) conducted fieldwork in the Onslow nearshore area described as a shallow, very turbid site. This area is characterised by very fine fluvial sediments (Semeniuk 1993), where a high proportion of the sponge community was patchily covered with fine sediments and was strongly represented by endopsammic sponges. Schönberg (2017) and Wahab (2017) suggest that environmental filtering may have selected morphologies and traits of taxa present in nearshore Onslow region which are tolerant to turbidity and sedimentation stress and are expected to adapt best to dredging pressure. Within nearshore Onslow the filter feeder community has special adaptations with respect to a naturally high sediment environment (**Table 2-13**), which provides increased resistance of sponges to the effects of dredging (Wahab 2017).

The potential impact on filter feeders from proposed dredging activities over a 13 week duration are unlikely to affect the ecological integrity and biological diversity of BCH at local and regional scales.

2.5.4. Summary of Risk/Significance of Project Activities

The results indicate that the potential impacts of the proposed OMSB Project activities are summarised below.

Permanent Loss: Intertidal BCH

- The location of the proposed DMMA overlies approximately 23 ha of bare supratidal salt flats and 2.4 ha of algal mat BCH. The salt flats are devoid of marine plants and invertebrates and subsequent indirect impacts from reduced floodwater flushing of the intertidal area is considered highly unlikely. Direct smothering of 2.4 ha (0.2%) of algal mat which has already been modified by the Onslow Airport runway is unlikely to cause a significant reduction in local and regional primary productivity and nutrient cycling; and
- Dredging to widen the existing turning circle will result in the direct removal of 0.8 ha of tidal lagoon habitat near the mouth on the east side of Beadon Creek, which represents only <0.1% of similar bioturbated mudflat/samphire BCH within LAU 0A which is locally and regionally widespread. Mangrove BCH will not be removed from the tidal lagoon for the proposed turning circle.

***Irreversible Loss* and *Recoverable Impacts*: Intertidal BCH**

- Pipeline route Option B will result in the direct removal of 0.1 ha (<0.1%) of mangrove, bioturbated mudflat/samphire and algal mat BCH within LAU 0A. Despite only low levels of predicted impact, consideration should be provided to use of pipeline route Option A to reduce the impacts of development on mangrove habitat and ecological function of the mangroves to the minimum practicable level in accordance with Guideline 4 (EPA 2001);
- The OMSB Project is predicted to cause minimal additional loss of intertidal BCH (i.e. <1%) within LAU 0A for calculations of cumulative losses. The predicted loss of intertidal BCH is likely to be within the range of errors inherent in mapping BCH in the intertidal zone where the delineation of boundaries between BCH is often difficult;
- Dewatering and free-flow of return waters to the creek may result in a community shift of intertidal habitats based on changing the zonation of the salinity gradient or inundation of upper intertidal areas, the specifics of which are not well understood and may have possible temporary beneficial consequences. However, impacts on intertidal BCH from dewatering are expected to recover once the salinity gradients are re-established following completion of OMSB Project activities. In consideration of the EPA Act Precautionary Principle and due to the uncertainty of potential consequences resulting from a shift in intertidal communities, 1.4 ha (0.2%) of mangrove, 0.3 ha (<0.1%) of samphire/bioturbated mudflat and 8.5 ha (0.8%) of algal mat BCH within the predicted flow-path of return waters has been assessed as *recoverable impacts* to allow for any temporary loss of habitat that may occur;
- Indirect suspended sediment impacts on intertidal BCH is not predicted from dredging and dewatering activities. Previous dredging within Beadon Creek and other areas of the Pilbara coast with mangrove fringed tidal creek systems (e.g. Port Hedland) has not resulted in significant indirect impacts to mangroves from dredging related sedimentation. Suspended sediments will settle in the DMMA and return water discharged from the pond will contain low suspended sediment concentrations. Management will need to be in place to ensure suspended sediments have settled within the pond prior to discharge; and
- Modelling changes in hydrodynamics associated with modifying the bathymetry near the mouth of Beadon Creek predicts there will be no change to the intertidal BCH distribution upstream from changes to heights, submergence times and current velocities.

Permanent Loss: Subtidal BCH

- A total of 21 ha (0.2%) of permanent loss of Moderate Cover (5-10%) seagrass/macroalgae/filter feeder BCH is estimated in LAU 1G for the approach channel. This habitat is locally and regionally widespread within the Pilbara and the small area of proposed permanent loss within the existing Port of Onslow is unlikely to affect the ecological integrity and biological diversity of this BCH on a local and regional scale.

Irreversible Loss **and** ***Recoverable Impacts*****: Subtidal BCH**

- The BCH which falls within the ZoHI and ZoMI is predicted to result in either minimal impacts or is expected to recover to a state resembling that prior to being impacted within a timeframe of five or less years or less. The rationale for this assumption is evaluated within the assessment of SSC and sedimentation impacts on the ecological integrity and biological diversity for each BCH type individually. However, in consideration of the EPA Act Precautionary Principle and guidance provided from the EPA for environmental impact assessment of marine dredging proposals (EPA 2017), BCH within the ZoHI has been conservatively assigned as *irreversible loss*;
- The predicted area of *irreversible loss* from "worst case" SSC model outputs predominantly occurs within LAU 1G, estimating 459 ha (4.5%) of Seagrass/Macroalgae/Filter Feeder and 96 ha (7.3%) of Macroalgae/Filter Feeder BCH compared to 18.5 ha (0.3%) of Seagrass/Macroalgae/Filter Feeder BCH within LAU 1C;
- The predicted *irreversible loss* for "best case" SSC dredge plume modelling outputs is 391 ha (3.8%) and 58 ha (4.4%) of Seagrass/Macroalgae/Filter Feeder and Macroalgae/Filter Feeder habitat, respectively LAU 1G. The *irreversible loss* within LAU 1C for the "best case" is only 5 ha (0.1%) of Seagrass/Macroalgae/Filter Feeder BCH;
- Cumulative loss of BCH within LAU 1G is assumed to be limited to that predicted for the OMSB Project. Conversely, significant coastal development within LAU 1C has resulted in an estimated historical loss of 636 ha (10.6%) of Seagrass/Macroalgae/Filter Feeder and 351 ha (10.8%) of Seagrass/Macroalgae/Filter Feeder BCH. Dredge plume model outputs predict only small areas of additional *irreversible loss* of Seagrass/Macroalgae/Filter Feeder BCH within LAU 1C (i.e. worst case 18.5 ha or 0.3%), which is expected to be within the range of error inherent in mapping accuracy of subtidal BCH;
- The predicted area of *recoverable impact* from "worst case" SSC model outputs predominantly occurs within LAU 1G, estimating 975 ha (9.5%) of Seagrass/Macroalgae/Filter Feeder and 71 ha (5.4%) of Macroalgae/Filter Feeder BCH compared to 236 ha (3.9%) of Seagrass/Macroalgae/Filter Feeder and 102 ha (3.2%) Macroalgae/Filter Feeder BCH within LAU 1C;
- The predicted *recoverable impact* for "best case" SSC dredge plume model outputs is 838 ha (8.2%) of Seagrass/Macroalgae/Filter Feeder and 109 ha (8.3%) Macroalgae/Filter Feeder BCH within LAU 1G, and 157 ha (2.6%) of Seagrass/Macroalgae/Filter Feeder and 46 ha (1.4%) of Macroalgae/Filter Feeder BCH in LAU 1C;
- The impact zones for sedimentation are more localised than for SSC. No impact zones from the predicted sedimentation dredge plume model outputs occur outside of plumes predicted in SSC dredge model outputs; and
- The model outputs represent the potential areas of impact which may occur during winter, summer and transitional seasons throughout the year due to uncertainty in the timing required for approvals and planning. However, dredging of the approach channel is scheduled to occur over a period of only 13 weeks. Therefore, the total extent of potential impacts will be significantly reduced once the timing for the dredging activity can be confirmed and the seasonal effects over the 13 week period is used to determine the potential impacts.

2.5.5. Maintenance Dredging

There will be an ongoing requirement for maintenance dredging of the approach channel during the lifetime of the Project from sedimentation infill. Maintenance dredging will be managed in accordance with the DoT Environmental Quality Management Framework (Oceanica, 2016).

The coastal modelling study has shown that under average conditions in summer, the eastward littoral drift is likely to generate sediment infill around the end of the training wall at a rate of between 5,000 m^3 and 15,000 m^3 per annum. Modelled simulations of a direct hit from a category 5 Cyclone would result in approximately 45,000 m^3 of infill into the dredged areas from a single event, likely to consist of soft sediments (Baird, 2017). An additional 5,000 m^3 of material is expected to settle in the inner channel from run-off and upstream sources within Beadon Creek and 5,000 m^3 of infill is estimated for the outer channel. Therefore, regular maintenance dredging of the channel will be required by OMSB Pty Ltd.

The location where most infill is expected to occur is at the end of the training wall outside the mouth of Beadon Creek. Dredge material removed from this area by maintenance dredging is proposed to be used for replenishment of the beach on the east side of the mouth to restore natural bypassing. A small dredge would be used to undertake maintenance dredging. These works are unlikely to cause further *irreversible loss* of BCH as is evidenced by minimal impacts recorded from historical dredging campaigns within the existing Beadon Creek channel. Given the habitats within the area routinely experience elevated suspended sediments and sedimentation on a seasonal basis, the short timescale of this activity and the periodic nature of the suspended sediment and sedimentation generated poses little risk to the limited BCH which occur adjacent to the nearshore parts of the channel. The spatial and temporal scale of suspended sediments and sedimentation generated by maintenance dredging is expected to be small in comparison to the proposed capital dredging. Therefore, it is considered regular maintenance dredging will not pose greater risk to BCH.

2.6. Management/Mitigation Measures for Benthic Communities and Habitats

We recommend:

- Preparation of a Dredging and Spoil Disposal Management Plan which will include:
    - Specifications for hydrographic surveys of dredged areas & real-time monitoring of dredge position to ensure channel is within proposed boundaries;
    - Details for water quality monitoring of sediment plume and discharge waters which may include: daily plume MODIS imagery, plume sketches and telemetered water quality monitoring;
    - Develop tiered protocols which trigger management response for environmental risks of project activities, including:
        - Acid sulfate soils
        - Protected marine fauna
        - Water quality
        - Waste disposal
        - Hydrocarbon spills
    - Details of management measures which specify the appropriate response to be implemented if the above triggers are exceeded.
- Preparation of Department of Water Beds and Banks Permit to Disturb, if required pending outcome of Part IV assessment; and
- Discussion will need to be held with the Shire of Ashburton regarding the existing underground pipeline and Onslow Airport boundary fence from the runway across the salt flats which are located within the proposed onshore disposal site.

The objective of the DSDMP is to ensure that the scale of impacts is less than indicated in this assessment, particularly to revalidate predicted dredge modelling. Should actual plume concentrations vary considerably from impact predictions, the mitigation measures and monitoring programs will be amended accordingly.

Monitoring of BCH may not be a viable technique to assess the impacts from dredging activities for this project due to the low cover, patchy distribution and temporal and spatial dynamics of the communities' present. Previous monitoring suggests detecting change in BCH that is attributable to dredging activities will be difficult to accurately estimate due to lack of precision in the monitoring program based on low cover, and high natural temporal and spatial variability.

Consideration may be afforded to:

- Detailed modelling of discharge free-flowing return waters to determine the potential area and environmental consequences of the flow-path OR provide further management measures for controlling return water flow such as pipelines and pumps to mitigate potential uncertainties related to shifts in intertidal BCH during the dredging program;
- Use of pipeline route Option A to reduce potential impacts of development on mangrove habitat and ecological function of the mangroves to the minimum practicable level in accordance with Guideline 4 (EPA 2001); and
- Undertake future maintenance dredging in accordance with DoT's existing, approved Environmental Quality Management Framework for maintenance dredging.

3. Marine Fauna

The Environmental Protection Authority (EPA) has developed technical guidance for the protection of Marine Fauna in recognition of the importance their ecological roles, the iconic nature of many marine fauna and the importance society places on them, including traditional aboriginal cultural usage. The EPAs objective for the factor marine fauna is *"to protect marine fauna so that biological diversity and ecological integrity are maintained"*.

This report characterises the marine fauna within the area of the OMSB Project using desktop investigations and ground-truth field surveys to assess the potential effects of project activities on marine fauna, and provide recommendations for mitigating these effects.

The assessment process implemented for this report is undertaken in accordance with the technical guidance document provided from the EPA for the Environmental Factor Marine Fauna (EPA, 2016c).

3.1. Desktop Investigations

The Commonwealth Department of the Environment (DoE) Protected Matters search tool (PMST) was used to identify species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that may occur within the search area. The PMST is a predictive database that identifies EPBC Act listed species and communities with a 'moderate potential to occur' in the search area based on bioclimatic modelling. The search area was defined by the latitude/longitude coordinates -21.64556, 115.13103 with a 10 km buffer.

Database search results were also obtained from the Department of Biodiversity, Conservation and Attractions (DBCA) Threatened (Declared Rare) and Priority Fauna database and the Threatened and Priority Fauna List. The search area was defined by the latitude/longitude coordinates 115° 06' 09'' E, 21° 39' 59'' S and 115° 10' 27'' E, 21° 35' 59'' S with a 20 km buffer. Database search results were also obtained from DBCA's Threatened and Priority Ecological Communities database for the area defined by the latitude/longitude coordinates 115° 06' 09'' E, 21° 39' 59'' S and 115° 10' 27'' E, 21° 35' 59'' S with a 20 km buffer with a 20 km buffer.

The desktop review for characterising seabirds and migratory shorebirds within the area of the OMSB Project is presented in **Section 4**: Terrestrial Fauna. Previous surveys undertaken in the Onslow area for seabirds and migratory shorebirds have typically been part of terrestrial focussed surveys. The potential impacts on seabirds and shorebirds however are considered relevant to both marine and terrestrial fauna aspects from OMSB Project activities. Therefore, the significance/risk from OMSB Project activities to seabirds and shorebirds are discussed in both the marine (**Section 3**) and terrestrial fauna (**Section 4**) sections of this document.

The following studies that have previously been conducted within or near the site were reviewed:

- Onslow Salt ERMP Volume 2 Technical Appendix C Report on the Biological Environments near Onslow, Western Australia (Paling, 1990);
- The draft EIS for Chevron Australia's Wheatstone project (Chevron Australia, 2010);
- Intertidal Habitats of the Onslow Coastline (URS, 2010b);
- Biota of subtidal habitats in the Pilbara Mangroves, with reference to the Ashburton Delta and Hooley Creek (URS, 2010f);
- Sea Noise Logger Deployment: Wheatstone and Onslow – April to July 2009 Preliminary Analysis (McCauley & Kent, 2010);
- A Description of Mega Fauna Distribution and Abundance in the SW Pilbara Using Aerial and Acoustic Surveys –Final Report 2010 (CWR, 2010);

- Survey of Fish in Hooley Creek and North-eastern Lagoon of the Ashburton Delta (URS, 2010g);
- Draft Protected Marine Fauna Management Plan (Chevron, 2010);
- Wheatstone Project Literature Review of Listed Marine Fauna (URS, 2010h);
- Marine Turtle Beach Survey: Onslow Mainland Area and Nearby Islands 25 January – 6 February 2009 (Pendoley, 2010);
- Possible Effects of Underwater Noise on Marine Fauna and Fish in the Wheatstone Project Area (URS, 2010i);
- Potential Interactions with the Onslow Prawn Managed Fishery (URS, 2011b);
- Marine Turtles Technical Report (RPS, 2010a);
- Marine Mammals Technical Report (RPS, 2010b);
- Desktop Study of Marine Biosecurity in the Wheatstone Project Area (URS, 2010j);
- Biomass Attributes of the Intertidal Habitats in the Hooley Creek Area (URS, 2011c);
- Dugong Aerial Survey Report (RPS, 2010c);
- Identification and Risk Assessment of Marine Matters of National Environmental Significance (RPS, 2010d);
- Satellite Telemetry of Nesting Flatback Turtles from Ashburton Island (RPS, 2010e); and
- Seagrass Dynamics and the Consequence of Seagrass Loss on Marine Megafauna: A Briefing Note (Chevron, 2010b).

Likelihood of Occurrence Assessment

An assessment was undertaken of the likelihood of occurrence for threatened species identified through the desktop review. The DoE and DBCA do not have prescriptive likelihood of occurrence guidelines within their policies but rather clarify the scale of assessment required to determine the level of impact (e.g. level of assessment, previous record searches, and distribution maps). The following criteria have been developed by O2 Marine with the aim of considering the assessment classifications to identify the likelihood of occurrence for threatened species:

- **Low potential to occur** – the species has not been recorded in the region (no records from desktop searches) and/or current known distribution does not encompass project area and/or suitable habitat is generally lacking from the project area;
- **Moderate potential to occur** – the species has been recorded in the region (desktop searches) however suitable habitat is generally lacking from the project area OR species has not been recorded in the region (no records from desktop searches) but potentially suitable habitat occurs at the project area;
- **High potential to occur** – the species has been recorded in the region (desktop searches) and suitable habitat is present at the project area; and
- **Known to occur** – the species has been recorded on-site in the recent past (i.e. last 5-10 years) and the site provides suitable habitat for it.

The results for the fauna likelihood of occurrence assessment is presented in **Appendix D**.

3.1.1. Field Assessment

A specific survey targeting marine fauna was not undertaken for the OMSB Project. However, incidental marine fauna encountered during the field survey and recorded during analysis of the benthic habitat video are presented in this report.

3.1.2. EPBC Matters Search

Conservation significant marine fauna species listed under the provisions of the Commonwealth EPBC Act include Endangered, Vulnerable and Near Threatened species as well as internationally protected wildlife and migratory species. The PMST results (**Appendix C**) returned 14 listed threatened species, 7 listed migratory species and 40 listed marine species within the search area.

3.1.3. Department of Biodiversity, Conservation and Attractions

Conservation significant fauna species are those species listed under the provisions of the Western Australia *Wildlife Conservation Act 1950* (WC Act), including threatened (Critically Endangered, Endangered, Vulnerable, Conservation Dependent, Other Specially Protected species) and priority species (Priority 1, Priority 2, Priority 3, Priority 4). The DBCA search returned 10 conservation significant species, all listed migratory species for the area (**Table 3-1**).

Table 3-1 Conservation significant species returned by the DBCA search

Class	Species Name	Common Name	EPBC Act Status	WC Act Status	IUCN Status
FISH	*Pristis zijsron*	green sawfish	V, M	VU	CR
MAMMAL	*Dugong dugon*	Dugong	MM, Ma	OS	VU
MAMMAL	*Megaptera novaeangliae*	humpback whale	V, MM	CD	LC
MAMMAL	*Orcaella heinsohni*	Australian snubfin dolphin	M	P4	NT
MAMMAL	*Sousa sahulensis*	Australian humpback dolphin	M	P4	
REPTILE	*Caretta caretta*	loggerhead turtle	E, MM, Ma	EN	EN
REPTILE	*Chelonia mydas*	green turtle	V, MM, Ma	VU	EN
REPTILE	*Crocodylus porosus*	salt-water crocodile	M, Ma	OS	LR/LC
REPTILE	*Eretmochelys imbricata*	hawksbill turtle	V, MM, Ma	VU	CR
REPTILE	*Natator depressus*	flatback turtle	V, MM, Ma	VU	DD

- EPBC Act (species listed under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999): Ex = Extinct, CE = Critically Endangered, E = Endangered, V = Vulnerable, M = Migratory, MM = Migratory Marine, MT = Migratory Terrestrial, MW = Migratory Wetlands, Ma = Listed Marine
- WC Act Status (species listed under the Western Australian *Wildlife Conservation Act 1950*):
  - Threatened Species: EX = Presumed Extinct, CR = Critically Endangered, EN = Endangered, VU = Vulnerable, IA = Migratory birds protected under an International Agreement, CD = Conservation Dependent, OS = Other Specially Protected
  - Priority Species: P1 = Priority 1, P2 = Priority 2, P3 = Priority 3, P4 = Priority 4
  - IUCN (species listed under the International Union for Conservation of Nature (IUCN) Red List of Threatened Species): EX = Extinct, EW = Extinct in the Wild, CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern , LR = Lower Risk, DD = Data Deficient.

3.1.4. Historical Surveys and Monitoring

Mammals

Humpback Whales (*Megaptera novaeangliae*)

Humpback whales migrate annually from Antarctic feeding grounds to tropical waters. Six separate populations have been identified in the southern hemisphere, with the Group IV population being associated with Australia's NWS bioregion. This WA population is thought to have been recovering at an annual rate of between 7 and 12 percent since the cessation of whaling in 1963 (CWR, 2010). This group utilises the nearshore waters of the Kimberley coast for calving during the winter. A portion of the population during the migration also comes close to shore in the Pilbara. The exact timing of the migration is variable, attributed to annual variations in food availability in the Antarctic (CWR, 2010). Generally, northbound migration takes place from May to July on the continental slope at an average depth of 300 m. A transitional phase takes place in August, in which whale distribution varies in areas with water depths ranging from 50 to 1200 m. During the migration south, from September to November, high densities of cow-calf pairs have been observed resting in Exmouth Gulf for periods of up to two weeks. During the southern migration, most of the whales are in waters shallower than 75 m (CWR 2010).

The Centre for Whale Research (CWR) undertook a 12-month program of fortnightly aerial surveys over the Onslow region. In addition, sea noise loggers were deployed at nearshore and offshore locations in Onslow

(CWR 2010). During 26 surveys, 801 pods containing 1221 individual whales were recorded. A total of 95 cow-calf pairs were sighted, predominantly from September to October. Humpback whales first appeared in the Onslow region from early to mid-June. Whales were typically observed seaward of Thevenard Island and over the continental slope at an average of 49 km offshore (CWR 2010). Migration patterns changed from predominantly northward to southward bound in mid-August. Higher proportions of resting/milling pods were sighted during the southern migration, at an average of 36 km offshore. Cows and Calves predominantly rest when inside of the 50 m isobaths (CWR 2010), with some whales recorded in waters less than 10 m deep during the latter part of the migration. The data does not indicate the area represents the same importance for resting or calving as Exmouth Gulf or Camden Sound, respectively.

Other Whales

Sightings during aerial surveys and data from acoustic surveys indicated the presence of a greater range of species in small numbers further offshore, including Brydes Whales, Minke Whales, Pygmy Blue Whales, Killer Whales, Pilot Whales and Sperm Whales. These whales are believed to only transit through oceanic waters well offshore from the shallow waters of the OMSB Project area (CWR 2010).

Dolphins

Survey of dolphins within the Onslow region suggest that the Australian humpback dolphin (*Sousa sahulensis*) and Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) are the most abundant species and both occur inside the 20 m isobath (CWR 2010). These dolphin species are likely to be present in shallow and nearshore waters of the Onslow region at any time. The Australian snubfin dolphin (*Orcaella heinsohni*) has also previously been recorded in the region but is presumed to be an occasional visitor from the Kimberley region. According to (Prince, 2001; RPS, 2010b), coastal species of dolphin occur in low numbers in the Pilbara and are widely dispersed. There is taxonomic uncertainty surrounding the genus *Tursiops* in Australian waters. Recent genetic investigation off northern WA suggests that Indo-Pacific bottlenose dolphins occur within the 20 m bathymetric contour, whereas common bottlenose dolphins (*T. truncatus*) most likely occur beyond the 50 m contour (Allen et al., In review.). The Australian humpback dolphin was recognised as a new species, distinct from Indo-Pacific humpback dolphins (*Sousa chinensis*) on 01 August 2014 (Jefferson, 2014).

Except for three flights between late December and late January, dolphins were spotted during every survey between May 2009 and April 2010 (CWR 2010). A total of 1681 dolphins were sighted with peak numbers observed in late May. Dolphins were predominantly sighted in the South-west portion of the Onslow region in water depths less than 50 m (i.e. towards Exmouth Gulf). Coastal dolphins were documented in varying abundance levels, with group sizes varying from seven to over 200 dolphins during the 12-month survey, although smaller groups (1-20 animals) were observed less than 5 km from shore (CWR 2010). The abundance of dolphins in nearshore areas is generally highest during winter (RPS, 2010b).

An aerial survey for dugongs undertaken of the Onslow region and Exmouth Gulf in August 2010 also recorded incidental observations of dolphins (RPS, 2010c). A total of 26 observations were recorded of 111 individual animals from the Onslow region compared to 11 observations and 26 individuals within Exmouth Gulf. Group size varied from 1-2 animals to large pods of 20 dolphins. Dolphins were distributed throughout the Onslow region typically closer to the coastline or islands at an average of approximately 5 km from land (including islands, RPS, 2010c).

The coastal dolphins are generally known to inhabit estuarine areas with mangrove forests and shallow coastal waters with seagrass, rock and/or coral reefs. Except for the Australian snubfin dolphin, the species are likely to have small home-ranges (<10 km), limited long-distance movements with a high level of residency (RPS, 2010b). Other species of dolphins are likely to be present further offshore. (Hanf, 2015) undertook species distribution modelling of inshore dolphins in the Western Pilbara to explain the broad distribution patterns of dolphins in the region. The model outputs showed both similarities and differences between habitat suitability for bottlenose and humpback dolphins. Whilst there is some overlap in suitable habitat between species, at a broad scale, bottlenose dolphin distribution appeared to be linked to the slope at the 20 m contour while humpback dolphin distribution was more often near intertidal areas. The humpback dolphin habitat suitability was concentrated on the 20 m isobath slope and around the Muiron Islands. Areas of relatively high humpback dolphin habitat suitability were depicted around islands, the north-eastern portion of Exmouth Gulf and the large intertidal area between Barrow Island and the mainland (Hanf 2015). Therefore, the OMSB Project area was typically assigned a relatively Low mean relative habitat suitability for bottlenose dolphins and Moderate mean relative habitat suitability for the humpback dolphin.

Dugongs (*Dugong dugong*)

Exmouth Gulf and Ningaloo Reef to the south of Onslow are recognised Biologically Important Dugong habitats, each with about 1,000 individuals (Grech, 2012). Recent evidence suggests that some populations have strong patterns of migration, which are thought to be driven by variations in food availability (Gales, 2004) and possibly by water temperature at the higher end of their latitudinal distribution (Sheppard et al., 2006). Prince (2001) estimated dugong population sizes for Exmouth Gulf at 95 animals and the Pilbara coastline at 2046 animals in 2000. This equated to density estimates of up to 9.1 individuals per 100 km of coastline in the Onslow to Dampier onshore sector. The low number of dugongs within the Exmouth Gulf area was attributed to the removal of seagrass by Cyclone Vance, causing animals to move to Shark Bay in search of new foraging ground (Prince 2001, Gales et al. 2004). Prince's (2001) Pilbara survey block encompassed coastal waters to the 20 m isobath north to the Montebello Islands, 20 km east of Robe River and 10 km west of Serrurier Island. Most dugongs were found to be distributed east of Barrow Island and Mary Anne Passage (Prince 2001).

During 26 aerial surveys completed between mid May 2009 and late April 2010 a total of 169 dugongs were recorded (CWR 2010). Individuals were sighted in all but six of the of the 26 flights. Numbers were highest during June to September, peaking at 31 in the late-June survey. It is considered that at least some Dugongs are resident in the area year-round but with seasonal variation in density (CWR 2010). Cow/calf pairs accounted for 10% of the herds sighted. Dugongs were predominantly sighted in the South-west and North-east portion of the Onslow region (i.e. towards Exmouth Gulf and east of the Mangrove Islands, respectively), and in water depths less than 10 m. There was also a less dense cluster area identified offshore from Coolgra Point (CWR 2010). Dugongs were often sighted near areas of known seagrass habitat. It remains unclear whether all key life processes of feeding, mating, calving and weaning occur in this area. The OMSB Project area is not considered to have the same importance for dugongs as Exmouth Gulf.

(RPS, 2010c) undertook an additional aerial survey of the Onslow and Exmouth Gulf regions in August 2010, the time of year the highest relative abundance of dugongs was recorded during the previous year. The focus of the RPS survey was to provide an estimate of the abundance and distribution of dugongs. The absolute abundance of dugongs within the Onslow region was less than one-sixth that of Exmouth Gulf, with population estimates of 287 and 1760 individuals, respectively. The density of dugongs for the Onslow region and Exmouth Gulf was estimated to be 11 and 59 individuals per 100 km of coastline, respectively. Six calves were recorded from Exmouth Gulf but no calves were recorded from the Onslow region. Dugongs were primarily found in the north-west portion of the Onslow area (i.e. east of Coolgra Point) often close to the coast or in the lee of reef-fringed islands and sometimes near areas where seagrass has previously been recorded. Surveys in the Onslow region never observed more than two animals together while herds of up to eight animals were recorded in Exmouth Gulf. Assessment of the data collected, combined with previous observational data, led to the conclusion that the Onslow region is not an area heavily occupied by dugongs and the area is unlikely to represent important habitat for these animals. It was considered unlikely that dugongs in high densities or at sensitive life stages, such as calving, will be present within the coastal region from Ashburton North to Beadon Creek (RPS 2010c).

Satellite tracking research on the Great Barrier Reef of 70 dugongs over periods ranging from 15 to 551 days indicated a large range of movement behaviours; 37% of animals were relatively sedentary (<15 km), whilst

63% made large-scale movements (>15 km, up to 560 km) (Sheppard et al. 2006). A four-year satellite tracking program has recently been undertaken by the Murdoch University Cetacean Research Unit in the Onslow area as part of a comprehensive Dugong Research Plan, although the data has not been published and Chevron reports based on the data were unavailable.

Reptiles

Turtles

Green (*Chelonia mydas*) and flatback turtles (*Natator depressus*) are known to occur in the Onslow region during all sensitive life-history phases (mating, nesting and inter-nesting) and may be present all year round. Loggerhead (*Caretta caretta*) and hawksbill turtles (*Eremochelys imbicata*) are less abundant and their distribution in the Onslow region is unclear. Leatherback (*Dermochelys coriacea*) and olive ridley turtles (*Lepidochelys olivacea*) have not been previously recorded in the Onslow region, nor are they known to nest in the Pilbara. The Pilbara is known to be used for nesting by four species of turtles. Nesting activity is generally greater on the islands than on the mainland. The flatback, green, hawksbill and loggerhead turtle rookeries in the Pilbara are considered significant to the populations of these species throughout north-west Australia. Peak nesting periods vary slightly between species, as do preferred nesting and foraging habitats (RPS, 2010a).

There is very little nesting activity on the mainland beaches between Locker Point and Onslow. A snapshot survey of turtle nesting activity was undertaken in February 2009 (Pendoley, 2010). Flatback turtles were predominantly found nesting on nearshore islands with smaller aggregations on the mainland and the south coast of Thevenard Island. Green turtles were found to nest predominantly on outer islands such as Bessieres, Serrurier and the north and west coasts of Thevenard Island. Only one hawksbill nest was documented during the survey period at Bessieres Island and no loggerhead turtle nesting was found in the Onslow region. On the mainland, low density flatback turtle nesting was observed on a beach adjacent to the Ashburton delta approximately 4 km west of Ashburton North. A secondary survey of this beach in December 2009 by RPS (2010a) suggests that approximately 20 to 35 flatback turtles attempt to nest each night at the peak of the flatback turtle season, and that five to nine of these turtles were successful (RPS 2010a). Most of the turtle's nest towards the eastern end of the beach. This survey also recorded fresh flatback turtle nesting tracks on Ashburton Island (RPS 2010a).

Previous surveys have indicated that 'low level' flatback turtle nesting may occur elsewhere on the mainland. At Onslow's Sunset Beach (known as "back beach") area, two nests were recorded during a survey undertaken by AECOM (Pendoley 2010) and a similarly low level of flatback turtle nesting has also been recorded between Beadon Point and Coolgra Point (RPS 2010a). The nesting activity observed on the mainland beaches in both studies was very low density with large sections of beach apparently not used. The results of the surveys indicate that most marine turtle nesting that occurs on mainland beaches in the Onslow region is by flatback turtles at the Ashburton River delta beach, approximately 4.5 km west of Ashburton North. The level of flatback turtle nesting along mainland beaches is not regionally or even locally significant and none of the mainland beaches surveyed are considered to support locally or regionally significant breeding colonies (Pendoley 2010).

The most abundant turtles in the area are typically Green turtles observed around the islands (CWR 2010, RPS 2010a). These turtles are likely to be residents at their foraging grounds. Foraging Green turtles are likely to be found in seagrass and algal habitats near the Onslow region, and may utilise mangrove habitats (Pendoley 2010). A boat-based survey found 104 turtles from 92 transects covering 28 km^2 of the sea surface within the Onslow region. Highest turtle densities (82.7%) were observed at shallow offshore reefs, suggesting this habitat is important compared with adjacent inter-reef habitat characterised by unconsolidated sediment (RPS 2010a). Very few loggerhead (3) and flatback (2) turtles were recorded during the boat-based foraging survey, 69 (66%) green turtles were recorded and 30 turtles could not be identified. Aerial surveys during mid-May 2009 to April 2010 counted 2,152 turtles and these were predominantly located inside the 50 m depth contour (CWR 2010), but species could not be distinguished from the air. Turtle numbers sighted during flights varied from 3 to 261 over all surveys with no obvious temporal pattern, and likely influenced by sea state conditions for observations.

An aerial survey for dugongs undertaken of the Onslow region and Exmouth Gulf in August 2010 also recorded incidental observations of sea turtles. A total of 170 individual turtles were recorded within the Onslow region, compared to 134 individual turtles from Exmouth Gulf (RPS 2010). Very few turtles were observed close to the coast (<5 km) in the Onslow region, with the mean distance recorded at 22 km from the mainland. Turtles were commonly observed near reefs, both fringing and submerged, with mention of large aggregations around habitats fringing Thevenard Island (RPS 2010c).

Adult green turtles can migrate thousands of kilometres between foraging areas and breeding areas (RPS 2010a). The average migration distance of green turtles nesting at the GBR is approximately 400 km. Within their foraging habitats green turtles are typically sedentary. During the inter-nesting period, green turtles appear to remain within shallow nearshore waters (<20 m) (RPS, 2010e).

A satellite tagging study of six flatback turtles from Ashburton Island found that these turtles typically remain nearshore between Ashburton River and Coolgra Point (i.e. approximately 35 km) during the inter-nesting period (RPS 2010e). No preference for any area was observed along this coast during this time. The benthic habitats within this stretch of coastal sea (i.e. soft sediments with sparse macroalgae and filter feeders) are widespread. The mean re-nesting interval for tagged flatback turtles was 15 days. Two of the six turtles from Ashburton Island were recorded also nesting at nearby islands (i.e. Direction Island, Thevenard Island) during the same season, indicating nesting site fidelity is not exclusive. The mean dive depth during the inter-nesting period was 10 m and maximum dive depth 20 m which correspond with the bathymetry of their location. All six turtles undertook post-nesting circular movements for a short period (i.e. 3-20 days), typically remaining in the nearshore area before commencing post-nesting migration. Three tagged flatback turtles were tracked following a similar pathway to other flatback turtles from Barrow Island, Roebuck Bay and Cemetery Beach, (and observed in green and hawksbill turtles), towards the Kimberley region. These three turtles displayed the behavioural characteristic of milling around the mouth of rivers, which were proposed to take advantage of food sources that flush out of the river systems. The other three tagged flatback turtles remained in the Pilbara region migrating between 73 and 291 km north-east to the Dampier Archipelago and Barrow Island between depths from 20 m to 100 m (RPS 2010e).

Flatback turtles make long reproductive migrations (RPS 2010a). Satellite tracking of flatback turtles from Barrow Island suggest that these turtles migrate along the north coast from the Pilbara and into the Kimberley region on the conclusion of the nesting season. However, some individuals remain in the Pilbara during the inter-nesting period (RPS 2010a).

One green turtle was captured in the trawl net during fishing activities in July 2004 near Ward Reef and three flatback turtles were captured in November close to shore near Urala and Ashburton River delta areas (Kangas et al. 2006). The capture of flatback turtles nearshore close to the Ashburton River mouth in November 2004 is consistent with previous nesting activity recorded in November/ December. A loggerhead turtle was also captured in the trawl net further West near Locker Point in November 2004 (Kangas et al. 2006).

Sea Snakes

A total of 17 sea snakes were captured in the trawl net from three surveys of Exmouth Gulf and Onslow between March and November 2004 (Kangas et al. 2006). Thirteen sea snakes were captured from sites located in the southern part of Exmouth Gulf, and a further three sea snakes were caught in the central area of Exmouth Gulf. Five species of sea snake were recorded which included the Critically Endangered short-nosed sea snake (*Aipysurus apraefrontalis*) (1), and listed marine species dubois' sea snake (*Aipysurus duboisii*) (12), olive sea snake (*Aipysurus laevis*) (2), olive-headed sea snake (*Disteira major*) (1) and stoke's sea snake (*Disteira stokesii*) (1). Thirteen sea snakes were caught during the March survey, the stoke's sea snake was the only sea snake caught during July and three dubois' sea snakes were caught in November 2004. No sea snakes were caught from the OPMF area during surveys undertaken in 2004 (Kangas et al. 2006). Whilst it is possible that sea snakes occur in the Onslow region, surveys undertake in 2004 suggest the OMSB Project area is not considered to have the same importance for sea snakes as Exmouth Gulf.

Elasmobranchs

Sharks

Four Whale sharks (*Rhincodon typus*) were sighted during the aerial survey from May to April 2010 (CWR 2010). Whale sharks were sighted in May (1), November (2), and December (1) during the aerial survey period. Three sightings were approximately 30 to 50 km offshore of Onslow, the other sighting was north-east of Barrow Island (CWR 2010).

Seven black-tip reef sharks (*Carcharhinus melanopterus*) were seen off the southern coast of Flat Island during a turtle survey in February 2009. Three black-tip reef sharks were sighted off the southern coast of Locker Island. Numerous sharks, rays and large fish were seen off the north-western, western and south-western coasts of Thevenard Island (RPS 2010a).

Sharks captured in the trawl net from three surveys of Exmouth Gulf and Onslow between March and November 2004 included the brown banded catshark (*Chiloscyllium punctatum*), banded catshark (*Atelomycterus* sp.), milk shark (*Rhizoprionodon acutus*), sicklefin weasel shark (*Hemigaleus australiensis*) and the tasselled wobbegong (*Eucrossorhinus dasypogon*) (Kangas et al. 2006).

Rays

Three species of sawfish are known from the Onslow area, including the green sawfish (*Pristis zijsron*), the freshwater sawfish (*Pristis pristis*) and the narrow sawfish (*Anoxypristis cuspidata*). In addition, the western extent of the dwarf sawfish's (*Pristis clavata*) range has not been fully resolved, and this species may therefore also occur in the Onslow region. The Centre for Fish and Fisheries Research recently undertook a research project for Chevron that investigated sawfish populations to establish baseline distributional area data for different species in the Onslow region and examined the population demographics and movement patterns of the resident species (Morgan et al., 2012). The study was undertaken in the Ashburton River, Hooleys Creek and Four Mile Creek to the west of Beadon Creek and involved setting gill nets to capture sawfish, fitting them with an acoustic tag and recording transmissions from the tags within the detection limits of the acoustic receivers positioned at various locations inside and outside the creeks. Green sawfish were captured in the creeks and rivers to the west of Beadon Creek (i.e. Four-Mile Creek, Hooley Creek, Ashburton Delta & Ashburton River). The mouth of the Ashburton River is suggested to be an important pupping ground for green sawfish and after approximately 3 to 6 months old they are suggested to move into adjacent creeks before moving offshore to mature at a length of about 3 m (Morgan et al. 2012). Evidence suggests green sawfish are most likely to breed and pup in January, during the wet season. Freshwater species were also recorded in the upper sections of the Ashburton River. These species are born in the estuary and migrate to and remain in freshwaters for about 5 years before leaving the river to attain maturity (Morgan et al. 2012). A review of sawfish in the Onslow area and potential impacts to sawfish associated with construction activities for Stage 2 of the Onslow Marine Support Base Project is provided in a technical memorandum in **Appendix D**.

One hundred and thirteen Manta Rays (*Mobula* spp.) were sighted during 24 aerial surveys from May 2009 to April 2010 (CWR 2010). Manta rays congregate inside the reef as well as in deep water. Manta rays were sighted during all but five of the 24 aerial survey flights and were broadly and sparsely distributed in depths of 50-150 m (CWR 2010).

Five white-spotted shovelnose rays (*Rhynchobatus australiae*) listed as Vulnerable IUCN status were captured in the trawl net from three surveys of Exmouth Gulf and Onslow between March and November 2004 (Kangas et al. 2006). This information suggests there is a moderate potential that these species may occur in the OMSB Project area. Other rays caught as bycatch in Exmouth Gulf and Onslow during 2004 surveys included the giant shovelnose ray (*Glaucostegus typus*), blue-spotted stingray (*Neotrygon kuhlii*), brown reticulated stingray (*Dasyatis leylandii*), black-spotted whipray (*Himantura toshi*), butterfly/rat-tailed ray (*Gymnura australis*), ornate eagle ray (*Aetomylaeus vespertilio*) and banded eagle ray (*Aetomylaeus nichofii*) (Kangas et al. 2006).

Fish and Invertebrate Fauna

Sygnathiformes

The Sygnathiformes are an order of ray finned fishes that includes listed marine species of the family Sygnathidae (seahorses, pipefishes, pipehorses and seadragons) and the genus Solenostomus (ghost pipefishes). A total of 19 seahorses from four species were captured in the trawl net from three surveys of Exmouth Gulf and Onslow between March and November 2004 (Kangas et al. 2006). The species included the western spiny seahorse (*Hippocampus angustus*) (11), the flat-faced seahorse (*Hippocampus planifrons*) (5), winged seahorse (*Hippocampus alatus*) (2) and zebra seahorse (*Hippocampus zebra*) (1). Two of these species were not identified within the EPBC desktop searches and the record for the zebra seahorse in the 2004 survey is notable given the species is known only from north eastern Australia and the west-central pacific (Fishbase, 2017).

Seahorse preferences for suitable habitat can be very diverse. Four species reported from the region each have individual preferences for suitable habitat ranging from soft bottom debris, algal rubble reefs, seagrass beds and coral reefs (Kangas et al. 2006). This information suggests there is a moderate potential that some of these species may occur in the OMSB Project area.

Subtidal Fish and Invertebrate Fauna

Baseline data on the biodiversity and variability of trawl bycatch on the off the trawl grounds in OPMF was reported in Kangas et al. (2006). The study examined the seasonal and annual variation in abundance and diversity measures and trawl efficiency in capture of bycatch species. Sites sampled within Area A of the OPMF recorded a low to moderate abundance of fish and invertebrates, with species richness ranging from low close nearshore to high further offshore. The moderate abundances and low species richness at nearshore sites are likely because of the Ashburton River which flows heavily in summer after cyclone rains resulting in extreme seasonal fluctuations in salinity, temperature, turbidity and silt loading. These conditions can only be tolerated by a limited number of species, or by species that are quick to recolonise an area after a cyclone has passed. These extremes of environmental conditions are slightly moderated further offshore (Kangas et al. 2006). A site not subjected to trawling located further offshore of Onslow close to the 10 m isobath and near rich fish populations of the Mackerel Islands (Hutchins, 2001) contained the greatest species richness of all sites (including Exmouth Gulf).

The abundance of fish recorded from all three surveys (March, June/July, November) from seven sites during 2004 ranged from 235 to 730 per nautical mile and the species richness ranged from 38 to 80 species. The most abundant 10 to 20 species of fish at most of the survey sites in Onslow represent a high proportion (i.e. ~80%) of the total catch. The 15 species shown in **Table 3-2** were the most common and widespread fish species recorded across all samples from Onslow and Exmouth Gulf. Other species abundant in Onslow samples included sunrise goatfish (*Upeneus sulphureus*), pearly-finned cardinalfish (*Jaydia poecilopterus*), giant salmon catfish (*Arius thalassinus*), ochre-banded goatfish (*Upeneus sundaicus*) and the blotched javelinfish (*Pomadasys maculatus*). Except for the reference (not previously trawled sites) located slightly further offshore near the 10 m isobath, the common fish species occurring in Onslow samples differentiated the Onslow fish community as a separate assemblage from assemblages recorded in Exmouth Gulf (Kangas et al. 2006).

Ninety-one percent of the fish species recorded from Exmouth Gulf and Onslow were tropical species, compared to subtropical and warm-temperate species composing 6% and 1.3% respectively. Only 5.8% of species are endemic to Western Australia, in contrast to sub-tropical species where there is typically more endemism (Kangas et al. 2006).

Table 3-2 The most common and widespread fish species recorded from Onslow and Exmouth Gulf (Kangas et al. 2006)

	Scientific Name	Common name	Av No./nm
1	*Paracentropogon vespa*	Wasp roguefish	130
2	*Equulites moretoniensis*	Zig-Zag Ponyfish	98
3	*Upeneus asymmetricus*	Asymmetrical Goatfish	95
4	*Inegocia japonica*	Rusty Flathead	79
5	*Calliurichthys grossi*	Gross's Stinkfish	78
6	*Paramonacanthus choirocephalus*	Hair-finned Leatherjacket	60
7	*Engyprosopon grandisquama*	Spiny-headed Flounder	53
8	*Pentapodus vitta*	Western Butterfish	46
9	*Terapon theraps*	Banded Grunter	45
10	*Sillago burrus*	Trumpeter Whiting	43
11	*Repomucenus sublaevis*	Multifilament Stinkfish	39
12	*Saurida undosquamis*	Large-scaled Lizardfish	31
13	*Monacanthus chinensis*	Fan-bellied Leatherjacket	30
14	*Sillago lutea*	Mud Whiting	30
15	*Parapercis nebulosi*	Red-barred Grubfish	29

The abundance of invertebrates recorded from all three surveys (March, June/July, November) from seven sites during 2004 ranged from 280 to 685 per nautical mile and the species richness ranged from 22 to 54 species. The most abundant 20 species of invertebrates for most of the survey sites in Onslow represent a high proportion (i.e. ~90%) of the total catch. The 11 species shown in **Table 3-3** were the most common and widespread invertebrate species recorded across all samples from Onslow and Exmouth Gulf. These sites were dominated in abundance by crabs and prawns, and the mantis shrimp (*Carinosquilla australiensis*) was also among the most abundant species for Onslow sites. The nearshore sites in Onslow generally reflect the assemblages found towards Exmouth Gulf mainly due to a lack of Western king prawn species in these samples. The abundance of the Western king prawn species increased in samples with proximity from shore whilst the abundance of the brown tiger prawn decreased. Sediments within Onslow sites were variable indicating the physical sediment particle distribution was not the primary determinate for the differences in invertebrate species assemblages (Kangas et al. 2006).

Table 3-3 The most common and widespread fish species recorded in trawl bycatch (Kangas et al. 2006)

	Scientific Name	Common name	Av No./nm
1	*Penaeus esculentus*	Brown tiger prawn	461
2	*Penaeus latisulcatus*	Western king prawn	153
3	*Metapenaeus endeavouri*	Endeavour Prawn	150
4	*Metapenaeopsis rosea*	Rosy Prawn	110
5	*Portunus rubromarginatus*	Swimmer Crab	59
6	*Portunus pelagicus*	Blue Swimmer Crab	52
7	*Trachypenaeus curvirostris*	Southern Rough Prawn	46
8	*Charybdis truncata*	Crab	38
9	*Metapenaeopsis crassissima*	Coral prawn	29
10	*Eduarctus martensii*	Slipper lobster	23
11	*Comatula solaris*	Crinoid	18

Three sampling periods were undertaken in Exmouth Gulf and Onslow in 2004 to help understand the seasonal, annual and spatial variation in abundance and diversity measures. A small seasonal decline in fish abundance was observed, although not significantly different, between seasons for either trawled or not trawled sites. However, significant declines in fish abundance were detectable between March and November 2004 and a significant seasonal decline in species richness was recorded at both trawled and not trawled sites. For invertebrate species in Onslow there was a significant seasonal decline in abundance between March, July and November in 2004 for both trawled and not trawled sites. Interestingly, the abundance of invertebrates recorded in November 2004 was significantly higher at trawled sites than not trawled sites. The decline between March and July is suggested to be attributable to trawling and the migration of prawns out of nearshore areas. However, all four diversity measures were higher at not trawled sites than trawled sites and species richness showed a seasonal decline (Kangas et al. 2006).

There was a high spatial and temporal variation evident when the most common fish and invertebrate species were examined independently. Most species were widespread and occurred throughout most sites but the temporal patterns of abundance and diversity varied between species, surveys and sites. The areas which were exposed to high trawl effort showed a lower faunal abundance, although there was no difference between areas of no trawl effort and moderate trawl effort. Sponges demonstrated higher abundance in areas of no trawling. Results suggest very high seasonal, annual, spatial as well as diurnal variability in species abundance and diversity measures making it difficult to detect impacts from anthropogenic disturbances and other factors in addition to fishing effort are important in determining faunal abundances and diversity measures (Kangas et al. 2006).

A significantly higher proportion of smaller prawns were caught at the start of the season, indicating this is the main recruitment period. An increase in mean size was observed between March and July, although no continued increase in size was observed between July and November. No more than three cohorts were observed for the prawn species. Similarly, three fish species showed only two to four cohorts (annual or recruitment events). Examination of the otoliths from three common fish species estimated fish species in the age range of 1-5 years. This indicates in general that many of the common and most abundant fish species could be relatively short lived. Short-lived species usually have R type life history traits with high fecundity and high productivity with high input into reproduction during their relatively short life spans. The species measured fit this type of category and fall into similar life history categories as the target species of prawns and scallops. Differences in timing of recruitment for prawns and scallops is also reflected in differences of timing of recruitment in some fish species. These species all appear to be characterised by annual variation in recruitment levels and are likely to be influenced by environmental fluctuations (Kangas et al. 2006).

Anecdotal information suggests larger fish may have been caught in higher numbers early in the development of these fisheries as well as prior to high levels of recreational fishing activity. There is however no data to verify these early observations (Kangas et al 2006). Some general observations can be made that many common species and the target species are short lived and highly productive. This however does not dismiss the likelihood that long-lived species have contributed to the food webs and productivity within these regions in the past, but are now in lower numbers and consequently play a lesser role.

Wahab et al. (2017) monitored sessile benthic community composition near the channel before and after the Wheatstone Project dredging program in the inner, mid and outer sections of the Project area. Sessile taxa dominated the benthos across dredge periods with motile taxa including Asteriodea, Echinoidea, Holothuroidea, Nudibranchia and Polychaeta forming less than 0.1 m^2.

Subtidal Creek Fauna

Animal populations in mangroves can be divided into three components:

1. Species that enter mangroves at high tide and depart at falling tide
2. Species that enter mangroves at low tide and depart on rising tide
3. Species that remain in mangroves throughout the tidal cycle.

The muddy or sandy sediments of the mangroves may be home to a variety of epibenthic, infaunal and meiofaunal invertebrates. The composition and importance of these communities vary enormously between habitats depending on the sediment characteristics of the individual mangrove community. Catches in mangrove creeks in Queensland are dominated by crustaceans (caridean shrimp, mysids, tanaids and penaid prawns), polychaetes and fish (Laegdsgaard & Johnson, 1995). Juvenile banana prawns are concentrated in the Ashburton Delta, which is a nursery area for the fishery (DoF, 2003).

A total of 26 fish species were identified from the lower section of West Hooley Creek and the North eastern Ashburton Lagoon. The dominant large species were sea mullet (*Mugil cephalus*) and Yellowfin Bream (*Acanthopagrus latus*). There were also individuals of the Giant Catfish (*Arius thalassinus*). Hardyheads (*Craterocephalus* sp.) (<80 mm in standard length) dominated in West Hooley Creek while the small fish in the north-eastern Ashburton lagoon were juvenile mullet (<80 mm) and pony fish (<60 mm, Family Leignathidae) (URS, 2010g).

The fish biota of the Pilbara mangroves is poorly known, but over 120 species have been recorded in mangroves. Many of the fish in mangrove creeks are occasional and sporadic visitors to the system that enter opportunistically during high tides. This includes groups such as sharks, longtoms, trevallies, queenfish, mackerel, pike and flatheads. A minority of species contribute most of the catch numbers. Whilst some species consistently occur in tidal creeks in mangrove areas, none are regarded as obligate mangrove species (URS 2010g).

Intertidal Invertebrate Fauna

An assemblage of fishes and invertebrates is commonly associated with mangrove ecosystems, with some dependant on mangrove ecosystems. Conspicuous among these are fishes known as mud-skippers (*Periopthalmus*), certain gastropod molluscs of the families Neritidae, Littorinidae, Potamididae and Ellobiidae, some barnacles, sesarmid and ocypodid crabs and several species of mud lobster and ghost shrimps. Six species of previously undescribed species were collected during surveys indicating very little is known of these diverse communities. All the species recorded during baseline surveys for the Wheatstone Project belonged to taxa that are widespread in the Indo-Pacific region or are endemic to shores of the NW Shelf but have biogeographic affinities with that region ((URS, 2010b).

A moderately diverse and abundant fauna of burrowing crabs (families Ocypodidae and Sesarmidae) are key secondary producers in the mangrove systems. The ocypodid crabs *Uca flammula* and *U. elegans* were very common and widespread along the muddy banks of the creeks and three other species of *Uca* (*U. dampieri*, *U. capricornis* and *U. mjobergi*) were also common but patchy in their distributions. The Sesarmid species, *Neosamartium meinerti* and *Parasesarma* sp. were also abundant at most mangal flat sites. *Perisesarma semperi* and *Perisesarma* sp. were also present at some sites. A predatory grapsid crab, *Metograpsus frontalis* and the mangrove portunid crab, *Scylla Serrata*, were abundant at nearly all the mangal sites. Mangal obligate mollusc species recorded in a previous survey include *Littoraria articulata* and *L. cingulata* as common. *Cerithidea reidi*, *C. largillierti*, *Terebralia palustris*, *T. semistriata* and *Telescopium telescopium* were recorded but were absent from most sites. Three species of barnacles were found on mangroves, none of them common within areas surveyed in the Onslow region. Fish known as mud-skippers (*Periopthalmus* spp.) are often conspicuous in shallow pools and gutters within the mangal flats intertidal zone (URS 2010b).

The bioturbated mud flats consisted exclusively of colonies of detrital feeding potamidid gastropods *Terebralia semistriata*, *Cerithidea largillierti* and *Cerithideopsila cingulata*. Ocypodid and sesarmid crabs were extremely abundant in this habitat. Fiddler crabs of the genus *Uca* were present in vast numbers over wide areas of the high tidal mud flats and account for most of the bioturbation there. *Uca elegans* was the most prominent and less common were *U. mjobergi*, *U. dampieri* and *U. capricornis*. Four species of sesarmid crabs were also conspicuous burrowers *Neosarmatium meinerti*, *Parasesarma* sp. and two *Perisesarma* sp. Two small ghost shrimps, *Upogebia giralia* and *Lepidothalmus* sp. were also recorded, with the latter not previously found in Australian waters (URS 2010b).

Marine fauna is rare in the algal mat zone although insects and insect larvae are sometimes seen under the algal mats. No marine invertebrates were found living in the salt flats. The salt flats are predominantly devoid of marine invertebrates (URS 2010b).

Introduced Marine Species

No introduced marine species listed as species of concern on the National Introduced Marine Pests Coordination Group (NIMPCG, 2006) have been recorded in the Onslow region (Huisman et al., 2008). One introduced species, the barnacle *Megabalanus tintinnabulum* has been recorded in Onslow (Huisman et al., 2008). This species is not considered a pest, and has been recorded at several other WA ports (URS, 2010j). The WA Biosecurity and Agricultural Management Act 2007 was recently passed to provide a stronger legislative base for mapping all aspects of biosecurity, including the marine environment. Marine pests known to be established in or adjacent to the North-west Marine Region are provided in **Table 3-4**.

Table 3-4 Marine pests known to be established in or adjacent to the North-west Marine Region (DSEWPaC, 2012)

Pest name	Location	Impact	Habitat
Hydroid (*Gymnangium gracilicaule*)	Port Hedland	Fouler in hulls.	Occurs primarily in shallow water on coral rock and rubble but has been recorded to depths of up to 100m.
Bryozoan (*Amathia distans*)	Port Hedland	Fouling organism. No known predators of this species.	Grows in waters up to 20 m in depth on a wide variety of surfaces, including other bryozoans, algae, seagrasses, oyster valves, sandstone boulders, docks, pilings, breakwaters and man-made debris.

Pest name	Location	Impact	Habitat
Bryozoan (*Bugula neritina*)	Port Hedland	An abundant fouling organism.	The species colonises heavily on any freely available substratum, including many artificial underwater structures, vessel hulls, ship intake pipes and condenser chambers. In Australia, it occurs primarily in sheltered waters of up to 30 m in depth on artificial substrata, such as jetty pylons.
Bryozoan (*Schizoporella errata*)	Shark Bay	Fouling organism, known to inhibit the growth of adjacent species.	Found in shallow water in ports and harbours on hard substrates (pilings, hulls, coral rubble, etc.) and reefs. Forms encrustations on ships, piers, buoys and other man-made structures.
Bryozoan (*Watersipora subtorquata*)	Shark Bay	Is tolerant to certain antifouling coatings and hence is an abundant fouler of ships hulls. It also facilitates the fouling and spread of other marine invasive species.	Most common in lower intertidal and shallow subtidal areas and grows on docks, vessel hulls, pilings, debris and rocks. Found in depths of up to 10 m and temperatures of 12–28 °C.
Bryozoan (*Zoobotryon verticillatum*)	Shark Bay and Port Hedland	Common fouling species that can have ecological and economic impacts due to its capacity to colonise and dominate suitable habitat. Few known predators.	Is common in ports and harbours in warmer waters with optimal temperatures above 22 °C. Can grow on virtually any hard-subtidal surface.
Acorn barnacle (*Megabalanus rosa*)	Ranges from Cockburn Sound in the south to Cockatoo Island in the Kimberley	A fouling species that readily colonises ship hulls. No recorded predators.	This species is often found on wharf pylons, vessel hulls and other artificial structures. It is recorded to a depth of 300 m, in waters ranging in temperature from 15 °C to 28 °C.
Colonial ascidian (*Botrylloides leachi*)	Dampier Archipelago and offshore at the Rowley Shoals	Dominant competitor, overgrowing and excluding many other suspension-feeding species. Fouling on aquaculture structures can decrease water flow as well as compete for food with suspension-feeding aquaculture species. May also encrust coral reefs.	Grows on both natural and artificial substrata in the lower intertidal and shallow subtidal zones. It is often seen on seagrasses and may occur on reefs.
Solitary ascidian (*Styela plicata*)	Montebello Islands	A fouler of ships, boats, docks and aquaculture facilities, attaching to hard substrates. It competes with other organisms, excluding them from the space it occupies. Its larvae are capable of invading occupied space and growing to a large size in a relatively short period of time, attached to other organisms. *S plicata* then sloughs off because of its large size, often taking other marine organisms with it. This sloughing may destabilise the marine community.	Occurs from low intertidal to 30 m depths, where it is found on hard substrata in protected embayment and harbours. Its range extends throughout tropical to warm temperate seas and it can tolerate great fluctuations in salinity.

Commercially and Recreationally Important Species

Commercial fisheries in the Onslow region target a variety of species including finfish, crustaceans, molluscs and echinoderms. The Western Australian Fishing Industries Council (WAFIC) provided the following list of state-managed commercial fisheries possibly occurring in the area that may be potentially impacted by the OMSB Project:

- Onslow Prawn Trawl Managed Fishery
- Mackerel Managed Fishery (Zone 2)
- Sea Cucumber (Beche de Mer) Fishery
- Marine Aquarium Fish Managed Fishery
- Pearl Oyster Managed Fishery (Zone 1)
- Pilbara Line Fishery
- Pilbara Developmental Crab Fishery
- Specimen Shell Managed Fishery

The WAFIC also identified the following Commonwealth-managed fisheries which overlap the OMSB Project area:

- Western Skipjack Tuna Fishery
- Southern Bluefin Tuna Fishery
- Western Tune and Billfish Fishery

A summary of each fishery is provided in (WAFIC, 2017). The OPMF is described below in greater detail as this fishery has the greatest risk of potential impact from OMSB Project activities.

The DoF provided the details in **Table 3-5** for spawning/aggregation times of key species in the North Coast Bioregion during stakeholder consultation.

The numerous creek systems, mangroves, rivers and beaches provide shore and small boat fishing for a variety of finfish species including barramundi, tropical emperors, mangrove jack, trevallies, sooty grunter, threadfin, cods, catfish, and invertebrate species including the blue swimmer crab, mud crabs and squid. Offshore islands and coral reef systems provide recreationally caught species including tropical snappers, cods, coral and coronation trout, sharks, trevally, tuskfish, tunas, mackerel and billfish (URS, 2010g)

Table 3-5 Spawning/aggregation times for key species in the North Coast Bioregion

Bioregion	Key Fish Species within zone	Spawning / Aggregation times
North Coast	Blacktip shark *(Carcharhinus tilstoni and C. limbatus)*	November - December
North Coast	Goldband snapper *(Pristipomoides multidens)*	January - April
North Coast	Pink snapper *(Chrysophrys auratus)*	May - July
North Coast	Rankin cod *(Epinephelus multinotatus)*	August - October
North Coast	Red emperor *(Lutjanus sebae)*	October - March
North Coast	Sandbar shark *(Carcharhinus plumbeus)*	October - January
North Coast	Spanish mackerel *(Scomberomorus commerson)*	August - November

Onslow Prawn Trawl Managed Fishery

The OPMF is located on the north coast of WA, 39,748 km^2 in area. The waters within the fishery are further divided into three fishing areas: Area 1, Area 2 and Area 3 (**Figure 3-1**). In addition, there are also three dedicated nurseries (**Figure 3-1**): Ashburton Nursery, Coolgra Point Nursery and Fortescue Nursery. The average catch of 96.8 tonnes is dominated by Tiger Prawns (*Penaeus esculentus*) and King Prawns (*P. latisulcatus*), with significant contributions from Endeavour Prawns (*Metapenaeus endeavouri*) and Banana Prawns (*P. merguiensis*). Minor species in the fishery include Moreton Bay Bugs, Squid, Blue Swimmer Crabs, Cuttlefish, other prawn species (i.e. coral prawns), and some finfish species. Consistent annual fishing effort occurs mostly between the Ashburton River and Onslow (Area 1) for banana and king prawns, and in the Mangrove Passage (Area 2) for tiger prawns. The nursery areas are managed as Size Management Fishery Grounds to allow sections of these areas to be fished on a seasonal basis when prawns are considered to have grown to an appropriate size and the area deemed suitable. The fishing season typically operates between March and November (URS 2011b).

Fertilisation of the egg in penaeid prawns occurs while it is still attached to the female. Approximately one month after mating, the female prawns migrate into deeper offshore waters predominantly between August to October to spawn the fertilised eggs. The eggs hatch within 24 hours and the free-swimming nauplii have a relatively short 2-4-week planktonic larval stage before settling to the bottom and developing into juvenile prawns in shallow coastal areas. The young grow rapidly, reaching adult size within 3- 6 months. As they near the adult stage, the young prawns migrate offshore into the fishery area (URS, 2011b). Adult and juvenile prawns are thus spatially separated. Estuaries represent an important habitat for Banana Prawns. Postlarvae settle in the upper reaches of small creek systems and the success of juvenile populations emigrating from the creeks correlates positively with rainfall during the wet season (Vance et al., 1998).

The annual catches of brown tiger prawns and king prawns in the OPMF have fluctuated widely from 2004 to 2014 (**Figure 3-2**), typically following the same catch trends as observed in the Exmouth Gulf fishery for brown tiger prawns. Due to recent nearshore oil and gas developments undertaken in the waters off Onslow, there has been a very low fishing effort since 2010 which has resulted in reduced catches (Fletcher et al., 2015; Fletcher et al., 2017). The total landings of major penaeids for the 2015 season slightly increased to 10.1 t, comprising 5.6 t of brown tiger prawns, <0.1 t of western king prawns, 0.5 t of endeavour prawns and 4.0 t of banana prawns. The breeding stock of brown tiger prawns is protected with low landings and low effort primarily due to marginal profit opportunities (Fletcher et al., 2017). High water temperatures in recent years are considered to have been impacting the northern trawl fisheries that target brown tiger prawns and western king prawns (Caputi, 2014).

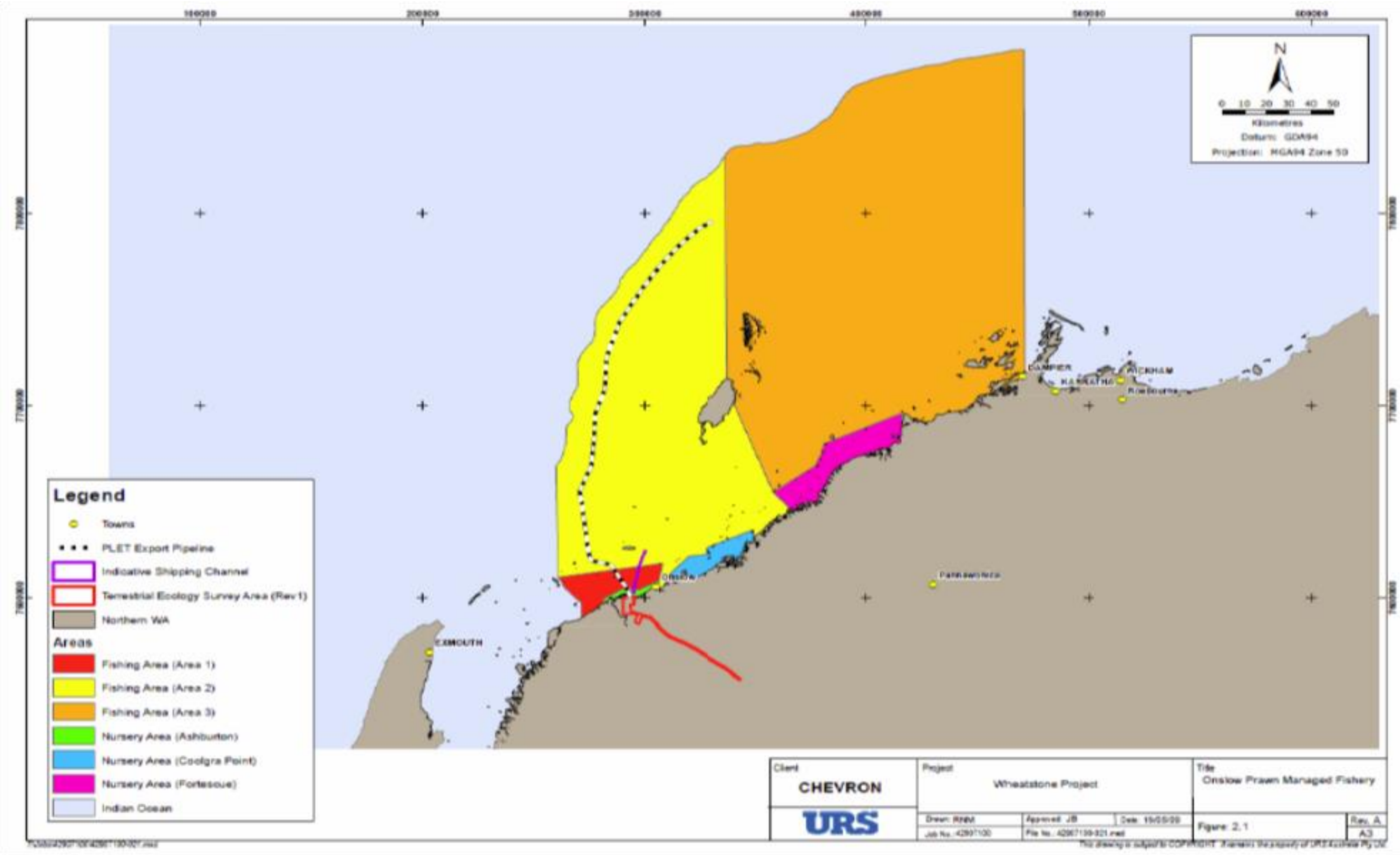

Figure 3-1 **Onslow Prawn Managed Fishery (OPMF) licence areas and nursery grounds (URS, 2011b)**

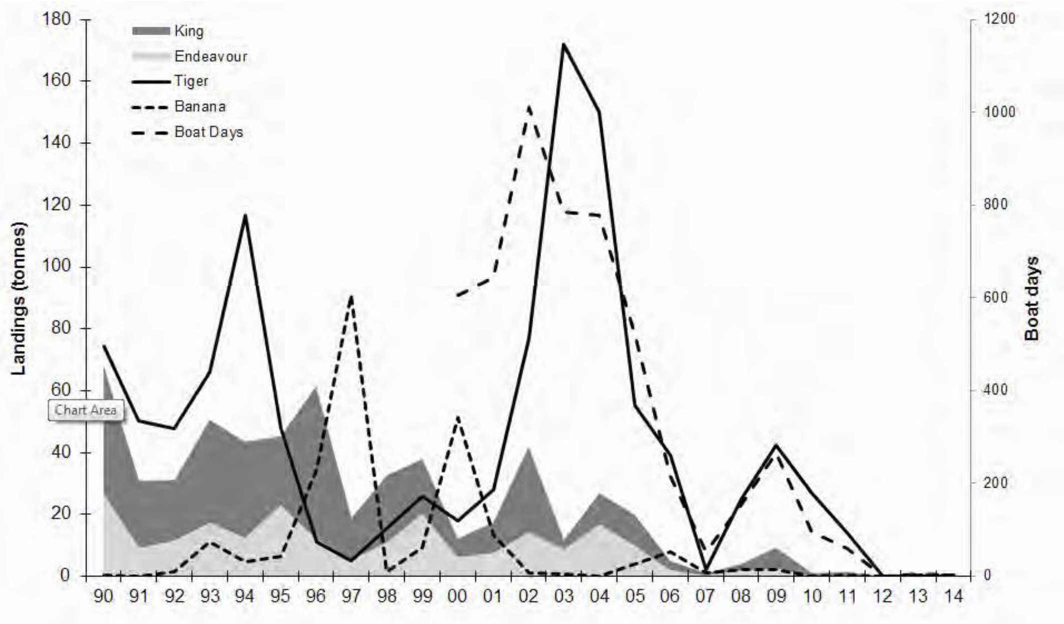

Figure 3-2 **Annual landings and number of boat days (From 2000) for the Onslow Prawn Managed Fishery (OPMF) (Fletcher & Santoro, 2015).**

3.1.5. Desktop Investigation Summary

The nearshore area of the Onslow region contains a low to moderate abundance of fish and invertebrates. Marine species within the nearshore area are predominantly tropical and are short lived with high productivity, resulting in life-history traits of high fecundity and high productivity and high input into reproduction during their relatively short life spans. Alternatively, longer-lived species may use nearshore waters as nursery areas before migrating further offshore. Invertebrates in the area are dominated by crustacean species. Most species are widespread and occurred throughout most sites. These species all appear to be characterised by annual variation in recruitment levels and are likely to be influenced by variability in key environmental parameters such as rainfall, salinity, turbidity and the effects of cyclones. The abundance and species diversity is typically higher in March than November, possibly due to migratory patterns of potential food sources such as prawns, which migrate further offshore later in the annual period. Many of the fish in mangrove creeks are occasional and sporadic visitors to the system that enter opportunistically during high tides. Conversely, the intertidal invertebrate fauna described for mangrove habitats in the Onslow region are generally associated with mangrove systems throughout north-West Australia.

Potentially occurring marine fauna species are listed in **Appendix D** with an account of their likelihood of presence within the study area. The Onslow region supports numerous large marine megafauna including mammals, reptiles and elasmobranchs. Many of these animals are conservation significant or marine migratory listed species. The list of conservation significant species with at least a moderate potential to occur in the OMSB Project area is provided in **Table 3-6** and species which are listed as migratory are presented in **Table 3-7**.

The nearshore area of the Onslow region represents important nursery habitat for the OPMF and several other commercial fisheries possibly occur or overlap with the OMSB Project area. No introduced marine species listed as species of concern have been previously recorded in the Onslow region.

Table 3-6 Conservation significant species likely to occur within the OMSB Project area

Class	Species Name	Common Name	EPBC Act Status	WC Act Status	IUCN Status
MAMMAL	*Dugong dugon*	Dugong	MM, Ma	OS	VU
MAMMAL	*Megaptera novaeangliae*	humpback whale	V, MM	CD	LC
MAMMAL	*Orcaella heinsohni*	Australian snubfin dolphin	M	P4	NT
MAMMAL	*Sousa sahulensis*	Australian humpback dolphin	M	P4	
REPTILE	*Aipysurus apraefrontalis*	Short-nosed Sea snake	CE, Ma	CR	CR
REPTILE	*Caretta caretta*	loggerhead turtle	E, MM, Ma	EN	EN
REPTILE	*Chelonia mydas*	green turtle	V, MM, Ma	VU	EN
REPTILE	*Crocodylus porosus*	salt-water crocodile	M, Ma	OS	LR/LC
REPTILE	*Dermochelys coriacea*	Leatherback Turtle, Leathery Turtle, Luth	E, MM, Ma	VU	VU
REPTILE	*Eretmochelys imbricata*	hawksbill turtle	V, MM, Ma	VU	CR
REPTILE	*Natator depressus*	flatback turtle	V, MM, Ma	VU	DD
SHARK	*Carcharodon carcharias*	White Shark, Great White Shark	V, MM	VU	VU
SHARK	*Pristis clavata*	Dwarf Sawfish, Queensland Sawfish	V, MM	P1	EN
SHARK	*Pristis zijsron*	green sawfish	V, M	VU	CR
SHARK	*Rhincodon typus*	Whale Shark	V, MM	OS	VU
SHARK	*Rhynchobatus australiae*	White spotted Guitarfish	-	-	VU

- EPBC Act (species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*): Ex = Extinct, CE = Critically Endangered, E = Endangered, V = Vulnerable, M = Migratory, MM = Migratory Marine, MT = Migratory Terrestrial, MW = Migratory Wetlands, Ma = Listed Marine
- WC Act (species listed under the Western Australian *Wildlife Conservation Act 1950*):
  - Threatened Species: EX = Presumed Extinct, CR = Critically Endangered, EN = Endangered, VU = Vulnerable, IA = Migratory birds protected under an International Agreement, CD = Conservation Dependent, OS = Other Specially Protected
  - Priority Species: P1 = Priority 1, P2 = Priority 2, P3 = Priority 3, P4 = Priority 4
- IUCN (species listed under the International Union for Conservation of Nature (IUCN) Red List of Threatened Species): EX = Extinct, EW = Extinct in the Wild, CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern , LR = lower Risk, DD = Data Deficient

Table 3-7 Migratory species protected under the EPBC Act returned in database records

Class	Species	Common Name	EPBC Act Status	WC Act Status	IUCN Status
MAMMAL	*Orcaella heinsohni*	Australian snubfin dolphin	M	P4	NT
MAMMAL	*Orcinus orca*	Killer Whale, Orca	MM		DD
MAMMAL	*Sousa chinensis*	Indo-Pacific Humpback Dolphin	MM		NT
MAMMAL	*Sousa sahulensis*	Australian humpback dolphin	M	P4	
MAMMAL	*Tursiops aduncus*	Spotted Bottlenose Dolphin (Arafura/Timor Sea populations)	MM		DD
REPTILE	*Aipysurus laevis*	Olive Sea snake	Ma	-	LC
REPTILE	*Crocodylus porosus*	Salt-water Crocodile	M, Ma	OS	LR/LC
REPTILE	*Hydrophis ornatus*	Spotted Sea snake, Ornate Reef Sea snake	Ma	-	-

- EPBC Act (species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*): Ex = Extinct, CE = Critically Endangered, E = Endangered, V = Vulnerable, M = Migratory, MM = Migratory Marine, MT = Migratory Terrestrial, MW = Migratory Wetlands, Ma = Listed Marine
- WC Act (species listed under the Western Australian *Wildlife Conservation Act 1950*):
  - Threatened Species: EX = Presumed Extinct, CR = Critically Endangered, EN = Endangered, VU = Vulnerable, IA = Migratory birds protected under an International Agreement, CD = Conservation Dependent, OS = Other Specially Protected
  - Priority Species: P1 = Priority 1, P2 = Priority 2, P3 = Priority 3, P4 = Priority 4
- IUCN (species listed under the International Union for Conservation of Nature (IUCN) Red List of Threatened Species): EX = Extinct, EW = Extinct in the Wild, CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern , LR = lower Risk, DD = Data Deficient

3.1.6. Field Assessment

The marine fauna encountered during the field survey are shown in **Table 3-8**. During the sediment sampling program, a juvenile green turtle was recorded within the mouth of Beadon Creek swimming against the current during an incoming spring tide. The green mud crab was recorded in shallow water next to the intertidal lagoon and the shovelnose ray with approximately 10 pups was recorded on the sandspit at the mouth of Beadon Creek.

Finfish recorded during the benthic habitat drop camera survey were predominantly tropical species commonly associated with coral reef or in sand/rubble areas adjacent to coral reefs. These fish were predominantly recorded on low profile reef substrates with a high abundance and diversity of benthic habitat found adjacent to Second Creek compared to very few fish recorded adjacent to the channel within the predicted areas of impact. The species typically recorded included damselfish, tuskfish, cardinalfish, wrasse, angelfish, goatfish, surgeonfish and a rainbow runner. These species are typically widespread throughout the North West.

Table 3-8 Marine fauna observed during the survey and recorded during analysis of the benthic video

Date	Scientific Name	Common Name	Description
16/03/2017	*Chelonia mydas*	green turtle	Juvenile turtles dragged into the mouth of Beadon Creek during strong incoming spring tidal currents. Trying to swim back out mouth of Beadon Creek.
17/03/2017	*Rhinobatidae* spp.	shovelnose ray	Observed in shallow waters near entrance to Beadon Creek with pups
17/03/2017	*Scylla serrata*	green mud crab	Waters below lagoon near entrance
19/03/2017	*Elagatis bipinnulata*	rainbow runner	Site 130 Sandy/rule habitat
19/03/2017	Labridae: *Choerodon* spp	tuskfish	Site 134 Sandy/rubble habitat
19/03/2017	*Cheilodipterus macrodon*	tiger cardinalfish	Site 134 Sandy/rubble habitat
19/03/2017	Unidentified	(x3)	Site 138 Sandy/rubble habitat
19/03/2017	Labridae: *Thalassoma lutescens*	Green moon wrasse	Site 158 Sandy substrate
19/03/2017	Family Pomacentridae	Damselfish	Site 160 Low profile reef
19/03/2017	*Coradion chrysozonus*	Margined coralfish (x2)	Site 160 Low profile reef
19/03/2017	Blenidae: *Omobranchus* spp.	Blenny	162: Low profile reef
19/03/2017	Sygnathidae	pipefish	Site 162 Low profile reef
19/03/2017	*Chaetodontoplus duboulayi*	Scribbled Angelfish	Site 162 Low profile reef
19/03/2017	*Caesio caerulaurea*	Goldband Fulsilier	Site 184 Sandy/rubble habitat
19/03/2017	*Choerodon* spp.	tuskfish	Site 186 Low profile reef
19/03/2017	Family Pomacentridae	Damselfish	Site 186 Low profile reef
19/03/2017	*Upeneus tragula*	Striped Goatfish	Site 188 limestone pavement
19/03/2017	Family Acanthuridae	Surgeonfish	Site 192 Sandy/rubble habitat

3.2. Risk/Significance of Project Activities

3.2.1. Project Risks

The OMSB Project will entail a range of activities that have the potential for significant impacts to marine fauna from:

- Underwater noise emissions;
- Habitat modification;
- Human presence at sensitive sites;
- Change in hydrological regime;
- Increased turbidity;
- Nutrient pollution;
- Vessel strike;
- Dredge entrainment;
- Chemical leaks or spills;
- Entanglement or ingestion of debris;
- Artificial light spill; and
- Invasive species.

An overview of the vulnerability of marine fauna to project risks is provided in **Table 3-9**. Seabirds and shorebirds with a moderate potential to occur in the OMSB Project area are described in **Section 5.2** due to previous surveys for bird species typically undertaken using land-based techniques. However, marine pressures have the potential to affect seabirds and shorebirds so the risk for potential significant impacts are also considered in the marine fauna section.

The potential impacts to sawfish from OMSB Project activities was raised as an item to address during a pre-referral meeting held with the EPA. O2 Marine sought independent technical advice and consultation from Dr Dave Morgan from the Centre of Fish and Fisheries Research and Dr Rory McCauley, Elasmobranch Research Scientist from the Department of Fisheries. The assessment of potential impacts on sawfish are provided in **Appendix F**. The outcome of this consultation determined that the OMSB Project is unlikely to have a significant impact on sawfish.

Key vulnerabilities of concern and potential concern are listed below:

- Concern:
    - Turtles: habitat modification, human presence, entanglement or ingestion of debris, artificial lighting and invasive species;
    - Dugong: habitat modification; and
    - Sawfish: habitat modification, change in hydrological regime.
- Potential Concern:
    - Seabirds and shorebirds: habitat modification, human presence, increased turbidity, chemical leaks or spills, artificial light spill and invasive species;
    - Humpback whale: underwater noise, vessel strike;
    - Dolphins: underwater noise, habitat modification, human presence, change in hydrological regime, nutrient pollution, chemical leaks or spills and entanglement or ingestion of debris;
    - Dugong: vessel strike, increased turbidity, entanglement or ingestion of debris and invasive species;
    - Turtles: underwater noise, increased turbidity, vessel strike and dredge entrainment;
    - Sea snakes: habitat modification and chemical spills;
    - Sawfish: entanglement or ingestion of debris;
    - Other Sharks and Rays: chemical spills;

- Finfish: habitat modification, change in hydrological regime and chemical spills; and
- Invertebrates: habitat modification, change in hydrological regime and invasive species.

These vulnerabilities are assessed against the potential for significant impacts to the ecological integrity of marine fauna, which is evaluated through:

- Harm of individual and/or declines in the population or the range of conservation significant species;
- Reductions in populations of species of local and regional importance;
- Impacts to species or groups of species that fulfil critical ecological functions within the ecosystem;
- Loss or impact to critical marine fauna habitat, including habitats such as nesting beaches, nursery areas, specific foraging or breeding areas and fish spawning aggregation areas;
- Reduction in species diversity in an area, due to factors such as migration or range contraction resulting from the decline in the quality of the local environment; and
- Introduction and/or spread of invasive marine species or diseases.

Potential impacts to commercial and recreational fisheries are considered separately following analysis of potential impacts to marine fauna to enable assessment of coinciding risks to species on a whole of fishery basis. The assessment includes consideration of specific environmental windows and/or key habitat that the dredging schedule may consider for commercially and conservation significant species.

3.2.2. Underwater Noise Emissions

Anthropogenic noise poses a threat to some marine fauna species because it may mask sounds that are vital for their essential activities and behaviours, modify behaviour through attraction and avoidance to sound or cause temporary or permanent physical injury (DSWEPaC 2012). Humpback whales, dolphins and turtles are classified as “potential concern” in relation to the vulnerability of the animals to underwater noise, and dugong are classified as “less concern”.

The potential effects of pile driving underwater noise risks on marine fauna for the OMSB Project have effectively been eliminated through the decision to use anchored navigation markers for the harbour entrance channel. Therefore, dredging and vessel movements during construction are the primary underwater noise generating activities which pose a risk to marine fauna. Existing geotechnical information suggests blasting using explosives will not be required.

Dredging is at the lower end of the scale with regards to emitted sound pressure levels in aquatic environments (CEDA 2011). The source sound pressure of underwater noise from a CSD ranges from 172 to 185 dB re 1 µPa, with peak intensity between 100 and 500 Hz (CEDA 2011). The sensitive auditory ranges of marine fauna species compared with the predicted noise frequencies from dredging indicate that the frequencies are at the lower end of hearing sensitivity for toothed whales and sirenians, and within the hearing range for baleen whales, turtles, sharks, bony fish and prawns (**Table 3-10**).

Table 3-9 Summary of the vulnerability of marine fauna to OMSB project risks (C=Concern (Red), PC=Potential Concern (Gold), LC=Less Concern (Green), NC= Not of Concern (Grey), DD=Data Deficient (White)) (adapted from DSEWPaC 2011)

Assessment	Underwater Noise	Habitat Modification	Human Presence	Change Hydrology	Increased Turbidity[1]	Nutrient Pollution	Vessel Strike	Dredge Entrainment	Chemical Spills	Litter/ Debris	Light Pollution	Invasive Species
Seabirds & shorebirds	NC	PC	PC	LC	PC	NC	NC	NC	PC	LC	PC	PC
Humpback whale	PC	NC	NC	NC	NC	NC	PC	NC	LC	LC	NC	NC
Dolphins	PC	PC	PC	PC	DD	PC	LC	NC	PC	PC	NC	DD
Dugong	LC	C	LC	NC	PC	NC	PC	NC	LC	PC	DD	PC
Turtles	PC	C	C	LC	PC	LC	PC	PC	LC	C	C	C
Sea snakes	DD	PC	NC	NC	DD	DD	LC	LC	PC	DD	NC	DD
Sawfish	DD	C	LC	C	NC	LC	LC	LC	LC	PC	NC	LC
Other Sharks & Rays	DD	LC	NC	NC	DD	LC	NC	LC	PC	DD	NC	LC
Finfish	DD	PC	DD	PC	DD	LC	NC	PC	PC	LC	NC	LC
Invertebrates	NC	PC	NC	PC	LC	LC	NC	PC	LC	NC	NC	PC

[1] Increased turbidity includes smothering from suspended sediment

Table 3-10 **Approximate auditory ranges of important marine fauna (URS, 2010i)**

Marine Fauna	Auditory Range (Hz)
Baleen whales (e.g. humpback whales)	200 – 10,000 Hz
Toothed whales (e.g. dolphins)	40 – 75 Hz up to 105,000 – 150,000 Hz
Sirenians (e.g. dugong)	400 – 46,000 Hz
Turtles	400 – 1,000 Hz
Sharks	20 – 800 Hz
Finfish	Up to 3,000 – 4,000 Hz
Prawns	100 – 3,000 Hz

CEDA (2011) reviewed expected impacts from dredging on marine fauna and concluded that it is very unlikely that underwater sound from dredging operations can cause injury. Temporary loss of normal hearing capabilities might occur if individuals are in the immediate vicinity of a dredge and are exposed for a long time, which is unlikely. Underwater noise has the potential to impact listed threatened marine fauna near dredging operations. Most effects are short, perhaps medium-term behavioural reactions to avoid the area of dredging operations and potential masking of low-frequency calls in humpback whales, although this is expected only at close range to the source (Nedwell and Howell 2003). There is also a possibility that many species will become habituated to the noise and remain within the vicinity (Whittock et al. 2017). Avoidance behaviour due to underwater noise from dredging could impact foraging or nesting behaviour of marine turtles in the immediate area. It is considered unlikely that significant masking of low-frequency calls in humpback whales will occur due to the shallow depths of the operation (i.e. <6 m isobath) and the paucity of humpback whales likely to occur within the 10 m bathymetry isobath.

The OMSB Project will result in only minimal additional dredge support vessel movements within and adjacent to the Beadon Creek Maritime Facility during dredging activities. This work will be conducted using small support vessels for minor duties such as anchor handling and personnel transfer. Due to the small scale of the operation and dredge plant, the vessels to be used will be small and the noise minimal in comparison to other commercial vessels regularly using Beadon Creek.

The primary noise generating activities during operations of the OMSB facility will be from increased vessel movements. Once construction is complete, approximately 700 vessels per annum are anticipated to use the facility during operations. The highest noise levels are broadband in nature and so would likely encompass the region of best hearing in fishes. The source sound pressure of underwater noise from a 64 m supply vessel with a 5 m draught and engines totalling 8,000 HP, equivalent to the largest vessels of this type capable of entering the harbour, was recorded as 120 dB re 1 µPa at 0.5-1 km whilst underway at 11 knots (McCauley 1998). The OMSB Information Handbook outlines the approach speed within the proposed channel are set to not more than 5 knots for supply vessels using the OMSB facility, but may be less depending on the type, size and manoeuvrability characteristics of the vessel. Underwater noise from supply vessel movements whilst travelling at 5 knots are generally expected to be less than or equal to the lower range of noise levels generated from the CSD. Based on an approximation of 700 vessels per year, vessels movements are predicted to occur for short periods approximately twice a day during the operational phase of the OMSB Project. Although this may result in localised, transient disturbance to some individuals, it is likely that impacts will be minimal, with individuals/populations potentially habituated to the noise from vessel activity within the Port of Onslow.

The nature of the sounds from dredging activities and supply vessel movements suggests that potential impacts to marine fauna will primarily be general avoidance of the area. Information gathered on the distribution of marine fauna in this investigation indicates that, except for sawfish, the proposed approach channel to be dredged does not represent critical habitat for conservation significant species, particularly humpback whales, coastal dolphins and turtle species vulnerable to underwater anthropogenic noise pollution. Any behavioural impacts from underwater noise would be temporary and only occur at close range to dredge operations, the potential impacts on marine fauna are considered negligible. The sawfish risk assessment recommends potential impacts on sawfish could be mitigated using a soft start-up procedure for each new or re-start operation which will involve running the dredge for a few minutes for deterrence and hazing of sawfish and any other sensitive marine fauna from the area prior to the commencement of dredging. Other planned management measures require using small to moderate sized dredge equipment, the dredge is to meet industry standards and regular maintenance of the dredge and vessels for efficient running machinery in accordance with manufacturers specifications.

Noise generated from the proposed activities is unlikely to trigger any long-term, persistent or significant impacts upon marine fauna in the OMSB Project area. In the unlikely event marine fauna are disturbed by the underwater noise generated from dredging or during operations and cause them to leave the area, the representative habitat is widespread and abundant alternative suitable habitat can be found in other areas in the region outside of the already operational Onslow Port.

3.2.3. Habitat Modification

This section reviews potential impacts on subtidal and intertidal BCH and creek bed bathymetry which is known to provide critical habitat for a range of marine fauna in the Onslow region. Dugong, turtles and sawfish have been classified as “Concern” in relation to the vulnerability of these animals to modification of critical habitat, birds, dolphins, sea snakes, finfish and invertebrates have been classified as “potential concern” and “other sharks and rays are classified as “less concern”.

Seagrasses and algae BCH provide important feeding habitats for species of conservation significance, such as dugongs and turtles, so removal can have substantial effects on survival, distribution and feeding habits (Gales et al., 2004). Seagrass habitat is a potential food source for dugongs, flatback turtle and green turtle. It is possible the abundance and distribution of dugongs and turtles may vary if there is reduced availability of seagrass meadows due to OMSB Project activities. Therefore, loss of seagrass due to dredging may have a potential impact on the foraging potential of dugong, flatback and green turtles in the Onslow region. Vegetated coastal habitats are also known to be important for supporting fisheries production and biodiversity (e.g. Loneragan et al. 2013). These vegetated habitats are hypothesised to provide an enhanced food supply, increased survival due to the provision of refuges from predation, and reduced wave action and water flow that stabilises sediments for fish and invertebrates (e.g. Manson et al., 2005). For example, tiger prawn stocks are associated with sheltered coastal waters and seagrass habitat, which forms the main juvenile habitat for these species (Loneragan et al. 2013). Similarly, settlement of the post-larvae of banana prawns typically occurs in protected estuarine areas with mangrove forests and high catches of banana prawns are associated with high rainfall (Vance et al., 1998). These areas rich in productivity and biodiversity, as well as coral reefs, provide important hunting grounds for secondary order predators such as coastal dolphins, sharks and sawfish. Mangrove habitats are also known to provide feeding opportunities for green turtles especially when large numbers of propagules of *Avicennia marina* are present (Limpus & :Limpus, 2000).

Dredge plume modification of critical marine fauna habitat

The potential impacts of dredging activities on BCH are discussed in **Section 2.5.** The main concerns for dredging activities on BCH are physical removal, smothering and a decrease in light intensity resulting in local-scale change in the composition, structure and function of the coastal and estuarine habitat. The BCH identified to be impacted by the OMSB Project include subtidal BCH in coastal areas adjacent to Beadon Creek and intertidal BCH within Beadon Creek.

The desktop assessment indicates the proposed approach channel does not occur within critical marine fauna habitat. There are extensive areas of seagrass/macroalgae/filter feeder habitat in the Onslow region the majority of which is located outside the predicted extent of potential impact. The area to be impacted generally represents the lowest density and diversity of seagrass and macroalgae in the area supporting a low to moderate abundance of fish and invertebrates which are typically found throughout the Onslow region and tropical coastal waters in the Indo-Pacific. Field assessment of seagrass/macroalgae/filter feeder habitat identifies that the benthic cover increases towards Coolgra Point, which was recorded to support an increasing abundance and diversity of marine fish species. A summary of the distribution and abundance of marine fauna is provided below.

Conservation significant marine fauna recorded within the Onslow region are typically recorded east, west or further offshore from the OMSB Project area, with very few records within the predicted impacted area. Dugong satellite tracking studies implicate Coolgra Point is the closest area which may represent potentially important foraging habitat for dugongs. Aerial surveys recorded dugong sightings predominantly occur in highest densities within the southwest (e.g. toward Exmouth Gulf) and north east (e.g. Mangrove Islands) of the Onslow region. Turtles were distributed throughout the Onslow region although the most abundant were green turtles typically observed around the islands further offshore. There is very little turtle nesting activity on the mainland beaches between Locker Point and Onslow, with nesting of green, flatback and hawksbill turtles predominantly recorded on island beaches further offshore. Low level flatback turtle nesting occurs on a beach east of the Ashburton River, and two nests were previously reported at both Onslow's Sunset Beach (known as "back beach") and between Beadon Point and Coolgra Point. The level of flatback turtle nesting along mainland beaches is not regionally or even locally significant and none of the mainland beaches surveyed are considered to support locally or regionally significant breeding colonies (Pendoley, 2010).

Aerial surveys sighted coastal dolphin species and manta rays and distributed throughout the Onslow region. Dolphins were sighted predominantly in the south-west portion of the study area (i.e. towards Exmouth Gulf). Manta rays were predominantly sighted nearshore east of Coolgra Point (i.e. Mangrove Islands) and further offshore north-west of Onslow beyond the 20 m isobath. The deepest depth of 6 m likely represents the nearshore limit for the humpback whale during the southern migration only, typically occurring 36 km offshore. Preferences for suitable habitat of listed seahorses, pipefish and sea snakes can be very diverse and includes vegetated soft-bottom substrates and rocky outcrop habitat for some species (e.g. western spiny seahorse, flat face seahorse, dubois' sea snake), indicating the potential to occur in the area. Seahorses and pipefish are among the site-associated fish genera that have life histories that render them vulnerable to habitat damage, and sea snakes are slow re-colonise disturbed habitats or may not do so at all. However, significant habitat in the nearshore area of Onslow is not known for any seahorses, pipefish and sea snake species.

The findings from the desktop assessment imply that the nearshore BCH potentially impacted by dredging activities of the approach channel is unlikely to represent critical marine fauna habitat. Any loss of habitat from this area will be temporary and is unlikely present a significant impact to marine fauna.

Dredge Material Management Area

The DMMA is located on supratidal salt flats on exposed limestone pavement which is devoid of marine invertebrates. The fauna associations of the terrestrial area within the proposed DMMA are discussed in **Section 5.2**.

Direct Impact on Intertidal BCH from Pipeline Route Option B

The area of intertidal habitat to be temporarily disturbed represents a 2 m wide corridor which is unlikely to result in significant changes to the abundance and species diversity of the intertidal fish and invertebrate communities of the Onslow region.

Intertidal habitat modification from Dewatering

In terms of conservation significance, the intertidal habitats of Beadon Creek have previously been regarded as low (species-richness and genetic diversity) to moderate (ecosystem diversity) biodiversity although with a high to very high functional role for primary and secondary productivity. The biodiversity significance, expressed in species-richness terms, was low on global and regional scales. These were not biodiverse ecosystems. In fact, in some respects they are restricted, even when compared to other mangrove habitats of the Pilbara (nearshore) Bioregion. The intertidal surveys undertaken for the Wheatstone Project revealed no intertidal species that were abundant within the study area but rare elsewhere or in need of special protection. The biodiversity significance expressed in terms of local endemicity was low. There is a high proportion of regional endemic species in the fauna, endemics of the study area are representative of the region and there is no evidence of locally distinctive genetic forms. The intertidal flats were assessed to have a high primary and secondary productivity, important to the adjacent coastal ecosystems, though this was not quantified. Accordingly, they are assessed as having a very high conservation significance.

The discharge of return water which is less saline than the receiving environment during the dredging operation could possibly lead to modification of the salinity gradient and subsequent physical, chemical and biological functions maintaining the zonation of intertidal BCH within the area affected. The discharge is predicted to create a sheet flow of water from the DMMA to the tributary covering an area of 10.2 ha of intertidal BCH. Areas of mangroves and low-lying mudflats of the upper intertidal zone which are typically only tidally inundated during high tidal periods are expected to be permanently flooded for the duration of dewatering. This is likely to result in a temporary shift in the fish and invertebrate communities commonly associated with the mangrove and mudflat ecosystems.

The intertidal surveys undertaken for the Wheatstone Project revealed no intertidal species that were abundant within the study area but rare elsewhere or in need of special protection. The biodiversity significance expressed in terms of local endemicity was low. All species observed during this study belonged to taxa that are widespread in the Indo-Pacific region or are endemic to the shores of the north-west Shelf but have biogeographic affinities with that region. The fish and invertebrate taxa of the intertidal area, which predominantly comprises surface-dwelling and burrowing invertebrates, are essential secondary producers and will likely be influenced by flooding of the intertidal zone during dewatering. It is conceivable that nutrient recycling within the potentially impacted zone may be slightly reduced during dewatering activities caused by the shift in marine fauna within the intertidal zone. The intertidal community within the projected flow-path of the discharge waters will likely return to the pre-disturbed community structure once dewatering activities are completed and salinity gradients return to the natural range once the tidal regime becomes the dominant influence on salinity again.

Previous dredging projects dealing with land-based reclamation where a slurry of material is pumped to the DMMA have recorded shore birds being attracted to reclamation ponds (e.g. Gladstone, Brisbane, Fremantle and Port Hedland). The DMMA and the flooded tidal area therefore have the potential to create shore bird habitat which may attract feeding and roosting migratory shorebirds. The level of shore bird aggregation at the DMMA may need to be monitored if impacts to birds are likely and deterrents could be implemented to minimise impacts to birds aggregating near construction works. Further complications arise due to proximity of the DMMA to the Onslow Airport. Special consideration maybe required in relation to the timing of these works to limit bird/aircraft interaction. Higher numbers of migratory shorebirds were recorded in the area during the wet season. However, there is already a significant expanse of similarly created artificial habitat (8,000 ha) as part of the Onslow Salt Ponds surrounding the Beadon Creek catchment.

Direct Impact in Intertidal BCH from Dredging the Tidal Lagoon for the Proposed Turning Circle

The intertidal habitat to be dredged to widen the turning circle within Beadon Creek represents a small area of lagoon flats with abundant fiddler crab burrows. The small area to be disturbed is unlikely to result in significant changes to the abundance and species diversity of the intertidal fish and invertebrate communities of the Onslow region.

Modification of bathymetry of Beadon Creek

The depth of the channel, turning circle and berth pocket is proposed to be modified near the mouth of Beadon Creek. The proposal to deepen and widen the channel, turning circle and berth pocket in Beadon Creek also has the potential to impact critical sawfish habitat within Beadon Creek. Dr Morgan provided advice that juvenile sawfish spend almost all their time within shallow waters less than 1 m depth at the mouth of creeks and recommended to undertake an assessment of the existing and proposed shallow water habitats at the mouth of Beadon Creek. The subsequent assessment determined critical shallow water habitats near the mouth of the creek have already been significantly modified from historical dredging of Beadon Creek and the proposed slope of the channel will not significantly change the continuity or area of suitable habitat on the east bank. These findings suggest that the modified entrance at Beadon Creek is not currently ideal critical habitat for green juvenile sawfish and there is more potential for significant populations of this species in the adjacent creeks and rivers to the east and west of Beadon Creek. The details of this assessment are provided in **Appendix F**.

3.2.4. Human Presence

Important behaviours including nesting, breeding, feeding or resting can be disturbed by vessels, vehicles and human beings. Turtles and sawfish have been classified as "Concern" in relation to the vulnerability of these animals to human presence, birds and dolphins have been classified as "potential concern" and dugong and sawfish are classified as "less concern".

The proposed OMSB Project will be within the existing working Port of Onslow and Beadon Creek Maritime Facility. This port facility already represents an area of intensive human use, which has developed from a small facility supporting local and charter fishing activities to what is now a significant facility supporting the myriad of industrial and commercial activities in Onslow. In addition, OMSB have recently successfully completed dredging and reclamation for Stage 1 of the OMSB Project. The human presence within Beadon Creek from the OMSB Project construction and operational activities is not anticipated to represent significant additional potential risks to marine fauna. The proposed dredging activity will mean a more constant presence of vessels in the area than the current movement of vessels in and out of the harbour but the proposed operational activities anticipate an increase of approximately two vessel movements daily which will not add significantly to the already busy harbour activities. Potential impacts to marine fauna from vessels and associated human presence would primarily be general avoidance of the area. The extra vessels and human presence from the proposed OMSB are unlikely to add significantly to the current levels of avoidance by marine fauna vulnerable to human presence. Any change in behavioural impacts during dredging would be temporary and only occur at close range to dredge operations, and the potential consequence on marine fauna are considered negligible. In the unlikely event marine fauna are disturbed by dredging or during operations and cause them to leave the area, the representative habitat is widespread and abundant alternative suitable habitat can be found in other areas in the region outside of the already operational Onslow Port.

Marine turtles and seabirds are particularly sensitive while on shore for nesting or roosting and can be easily disturbed by movement and light, modification or destruction of breeding habitat, displacement of breeders, nest desertion, destruction or predation of eggs and exposure of young. The proposed activities for the OMSB Project will not disturb beaches and dune systems which provide critical nesting areas for both turtles and birds. Turtle nesting predominantly occurs on offshore islands and near the Ashburton delta beach on the mainland. Only two records of turtle nests have previously been recorded at both Onslow back beach and between Beadon Creek and Coolgra Point. High number of birds roosting, nesting and foraging near Onslow have been recorded near Beadon Point. The abundance of shorebirds recorded at the mouth of Beadon Creek during the same survey was significantly lower (Bamford 2009). The pipeline route Option A is the only beach crossing activity planned. This shoreline crossing occurs on the modified area at Town Beach adjacent to the training wall to the west of the mouth of Beadon Creek. The proposed pipeline route Option B crosses the intertidal area on the extensive tidal mudflats in the western tributary of Beadon Creek adjacent to the proposed DMMA. Neither of these areas represent existing critical habitat for turtles or birds.

3.2.5. Changes in Hydrological Regimes

Changes in hydrological regimes can cause siltation, changes to saltwater intrusion, and a reduction in connectivity and environmental or lifecycle cues between estuary and offshore waters. Sawfish have been classified as "Concern" in relation to the vulnerability of these animals to changes in hydrological regimes, inshore dolphins have been classified as "potential concern" and dugong are classified as "less concern". The vulnerability ratings are based either on the life-history representing estuaries and creek systems as critical habitat (i.e. juvenile sawfish) or populations are generally thought to be small and localised (i.e. inshore dolphins).

The predicted changes in the hydrological regime (i.e. water level and velocity) and siltation (i.e. sediment transport) resulting from the proposal to deepen and widen the channel, turning circle and berth pocket in Beadon Creek have been modelled and are presented in Baird (2017). The modelling investigations indicate that whilst there is an increase in storage volume associated with OMSB Project capital dredging, there is only a minor (<1%) increase to the overall tidal prism. The upstream impacts to water level and velocity in Beadon Creek show only negligible changes compared to the existing condition. Interpretation of the indirect impacts of intertidal BCH (i.e. mangroves, samphire and algal mats) due to upstream impacts from changes to the hydrological regime is discussed in **Section 2.5.2**. It is predicted that there will be very minimal change to the submergence characteristics (i.e. virtually undetectable) in various parts of upper Beadon Creek. These slight changes are unlikely to modify habitat for marine fauna that utilise Beadon Creek.

The sediment transport model outputs predict annual total sedimentation in the range of 18,000 m^3 to 28,000 m^3 could occur in the navigable areas of the OMSB footprint (navigation channel, entrance channel, turning circle and berth area) (Baird 2017). Post-dredging estimates of sedimentation in lower Beadon Creek (south of the OMSB footprint) show the rate of sedimentation could increase by approximately 30% from those historically reported (from approximately 1,700 m^3 to 2,300 m^3). There is minor sedimentation predicted for the OMSB berth, turning circle and inner channel approach areas, with the largest sedimentation volumes expected to occur within the OMSB navigation channel both offshore and on the lee side of the training wall as eastward littoral drift of sediment is trapped in the deep navigation channel. Maintenance dredging of the sediment that is directed into the navigation channel will be required to maintain navigable depth in this area, with some form of bypassing required that can restore the natural eastward supply of sand to the eastern shoal and eastern shoreline. These changes are considered unlikely to cause a reduction in connectivity and environmental or lifecycle cues between estuary and marine waters.

3.2.6. Increased Turbidity

Classification in the vulnerability assessment of "potential concern" for increased turbidity on turtles in DSEWPaC (2011) is derived from the potential impact of turbidity on seagrass and macroalgae habitat on which these turtles use for foraging. For the same reason, the dugong has therefore also been afforded the same classification level. The impacts of the dredge plume on seagrass/macroalgae/filter feeder habitat is discussed in **Section 2.5.3** and further evaluation of whether this habitat represents critical habitat for turtles and dugongs is presented in **Section 3.2.3**. This BCH is well represented locally and regionally and any impacts on this habitat are likely to be temporary and unlikely to significantly influence the populations of turtles and dugongs in the Onslow region. Birds are also classified as "potential concern" in relation to the vulnerability of these animals to increased turbidity. Changes in turbidity could adversely affect shorebird foraging behaviour, affecting their ability to replace used energy reserves (body fat) or to prepare for breeding or migration. However, the coastal area of the Onslow region is naturally turbid and the predicted area over which there are likely to be elevated levels of turbidity during the proposed dredging campaign comprises a very small area of the total foraging habitat available.

The "less concern" classification for invertebrates is based predominantly on the risk of smothering of invertebrates. Dredging can result in changes in sediment structure to finer material. Sediment deposition can smother or bury marine organisms associated with the seabed. Non-mobile organisms and early life-stages that are unable to move out of the path of dredgers are most at risk. Impacts are highly species-specific and depend on the species ability to either tolerate or escape burial. The extent of sedimentation predicted by the plume models is limited to a small area either side of the channel. In regularly disturbed habitats characterised by fast-growing opportunistic species such as those of the nearshore Onslow region, the species affected are less and recover quicker than stable habitats monopolised by slow-growing sessile fauna and flora (Tillin et al., 2011). These general life-history characteristics of species likely to occur in this area indicate the impacts on invertebrates will be minimal.

The marine fauna associated with the expansive tidal flats of Beadon Creek is generally tolerant to the magnitude of sedimentation and suspended sediments typically generated from previous dredging activities in Beadon Creek. Assessment of the potential for indirect impacts to marine fauna from suspended sediment and sedimentation generated during dredging and disposal activities indicates that significant impacts are unlikely due to:

- Suspended sediments within the dredge slurry will settle in the DMMA and return water discharged from the pond will contain low suspended sediment concentrations. Management will need to be in place to ensure suspended sediments have settled within the pond prior to discharge; and
- Previous dredging within Beadon Creek and other areas of the Pilbara coast with mangrove fringed tidal creek systems (e.g. Port Hedland) has not resulted in significant indirect impacts to intertidal invertebrates from dredging related sedimentation.

The vulnerability classification for the remaining marina fauna is "Data Deficient". A potential impact of increased turbidity on marine fauna may reduce hunting success for species that rely on vision for feeding. However, many species of marine fauna which inhabit turbid environments utilise a range of adaptations to enhance other senses and vision is not relied upon solely (Todd et al., 2015). The limited information available indicates that increased turbidity generated from dredging is unlikely to have a substantial impact on most of marine fauna that often inhabit naturally turbid or dark environments. Wenger et al., (2017) found fish have markedly different tolerances to suspended sediment, with some species able to withstand concentrations up to 28,000 mg/L, while others experience mortality starting at 25 mg/L. Suspended sediment can also result in behavioural changes in fish, foraging/predation success and physiological effects. However, the estuary and nearshore waters are naturally turbid and the fish assemblage within this area is naturally adapted to turbid conditions and exhibit life-history characteristics adapted to exposure to recurring disturbances, indicating species can recover quickly in the unlikely event impacts occur. Therefore, dredging is unlikely to significantly impact the abundance and distribution of marina fauna species directly.

3.2.7. Nutrient Pollution

Various nutrient pollutants enter Australian waters from many different sources, including industrial and sewage discharges, catchment run-off and groundwater infiltration. Coastal dolphins have been classified as "potential concern" for their vulnerability to nutrient pollution, turtles and sawfish were classified as "less concern". Nutrient pollution has the potential to effect marine fauna in numerous ways such as algal blooms lowering oxygen levels in the water column causing mortality or displacement, the algae may provide substandard diets which hinder growth, development and reproduction, or some algae have toxic effects on marine fauna.

There is a slight potential for elevated nutrients to enter the water column during dewatering of the dredge material in the event inundation of dehydrated algal mats promotes productivity and increases the export of biologically available nitrogen. Organic nitrogen, nitrates and ammonium are all lost from the mats and typically enter a relatively complex cycle of export to marine waters, uptake by primary producers (mangroves and samphire) and geochemical mineralisation and immobilisation in intertidal sediments. Export is principally organic nitrogen and estimates for the Pilbara coast indicate export values of 68 kg of N/ha/yr. (Paling & McComb, 1994). Due to flooding of the areas it is plausible that some of the process will be modified resulting in reduced recycling of nitrogen in the intertidal zone and slightly higher concentrations entering the estuarine environment. However, it is also possible that the mats will be grazed directly by invertebrates which are usually restricted to lower salinity environments and the production and nutrient cycling from within the predicted sheet-flow path will be reduced. In any case, the potential change in nutrient concentration in the water column is highly unlikely to cause any impacts on marine fauna due to the very slight increase in nutrients and the temporary nature of the activities. Once dewatering activities cease the intertidal zonation of the salinity gradients and associated marine fauna distribution will return to that which is naturally regulated by the relationship between tidal elevation and frequency of tidal inundation.

3.2.8. Vessel Strike

Increasing vessel activity around Onslow Port supporting the myriad of recent industrial and commercial activities and the abundance of marine megafauna in the Onslow region means that the likelihood of vessel strikes is increasing. Humpback whales, dugongs and turtles have been classified as “potential concern” for their vulnerability to vessel strike, coastal dolphins, sea snakes and sawfish were classified as “less concern”. The consequence of vessel strike on marine fauna may result in injury or mortality, although potential impacts from OMSB activities only are unlikely to result in significant declines in the local or regional populations of species and their distribution, or reductions in the diversity of species.

The likelihood of a vessel strike during dredge and construction from OMSB Project activities is considered low due to the small scale (i.e. spatial movements) of the operation and dredge plant (i.e. slow-moving and small support vessels). Similarly, the risk of vessel strike on marine fauna during the operational stage is considered unlikely due to limited movements (i.e. two vessel movements per day) and speed restrictions of less than 5 knots for the approach channel described in the OMSB Information Handbook (OMSB, 2017). A speed limit of 5 knots is also present within the Beadon Creek Maritime Facility (DoT, 2017). Laist, (2001) found significant increase in the risk of vessel collision between marine megafauna and vessels at speeds above 10 knots. More severe and lethal injuries were found to be caused by vessels travelling at speeds above 14 knots. Based on the findings from Laist et al. (2001), vessel speeds can be managed to afford greater protection of individual animals from a broad range of sensitive marine fauna to the potential impacts from vessel strikes. Therefore, with appropriate management implemented in the OMSB Project it is anticipated the increased risk of vessel strike on marine fauna can be minimised.

3.2.9. Dredge Entrainment

Turtles, fish and invertebrates have been classified as “potential concern” for their vulnerability to dredge entrainment, sea snakes, sawfish and other sharks and rays were classified as “less concern”. Entrainment describes the unintentional removal of organisms by the suction field created by hydraulic dredgers.

Turtles are known to be vulnerable to dredging entrainment. The US Army Corps of Engineers reported 401 incidental entrainment takes of sea turtles between 1995 and 2008 when dredging across military harbour areas in the south-Atlantic and Gulf of Mexico off the east coast of North America (Dickerson, 1995). Whittock et al., (2017) undertook satellite tracking of 48 flatback turtles during capital dredging for the recent Gorgon Project at Barrow Island and found increased utilisation of recently dredged areas during inter-nesting whilst dredging was still under operation. However, no events of entrainment were recorded. A very ‘low level’ of nesting activity occurs on the beach between Beadon Creek and Coolgra Point, with two nests recorded during a survey undertaken by AECOM, which is not considered to be locally or regionally significant

(Pendoley 2010). Turtles were found to be distributed throughout the Onslow region, although the most abundant were green turtles typically observed around the islands further offshore.

All marine organisms associated with the seabed are at risk from entrainment. Benthic fauna and demersal fish that are associated strongly with bottom substrates are considered more at risk from entrainment than highly mobile species. Overall, consensus within the literature appears that, entrainment of adult fish and many shellfish species, has minimal population level effects (Todd et al 2015). Dredging-related entrainment is considered more of an issue for young fish, and eggs and larvae of marine organisms, as their reduced swimming ability means they are unable to actively avoid the suction field (Todd et al. 2015). Consequently, dredging in spawning areas can affect survival rate of organisms to adulthood, and therefore population structure and growth.

Entrainment rates depend on numerous factors, including depth, dredger type, speed, and strength of suction field. The OMSB Project proposes to use a small to moderate CSD. The risk of entrainment using this dredge equipment is significantly reduced compared to a large Trailer Suction Hopper Dredge with stronger suction fields used on recent dredging projects in the region. These risks could be further reduced through timing the planned activity to avoid critical times for marine fauna (see **Section 3.2.15**), implementing a soft start-up procedure (**Appendix F**) and having trained observers onboard to mitigate interaction and detect injury and mortality events. The risk of entrainment for the OMSB Project is not predicted to result in declines in the abundance and dispersion of conservation significant species or the species diversity of other marine fauna. However, implementation of the above mitigation protection methods will further reduce the risk of harm to individual animals.

3.2.10. Chemical Spills

Whilst spills are unpredictable events and the likelihood of a significant event from these types of commercial operations is low based on historical evidence, the potential consequences could be severe. Birds, dolphins, sea snakes, sharks and rays and finfish have been classified as "potential concern" for their vulnerability to chemical spills, humpback whale, dugong, turtle, sawfish and invertebrates were classified as "less concern". Leaks and spills of hydrocarbons could occur during the construction or operational stages of the OMSB Project. The main substance of concern is diesel and small amounts of lubricating oil and grease for maintenance of the dredge or vessel equipment which may be accidentally spilled during regular vessel activities (i.e. accidental discharge, collision, deck drain and refuelling). Pollution has the potential to result in toxicity and direct oiling causing fatalities of marine fauna and/or impact on critical habitat. Marine fauna such as seabirds and air breathing vertebrates which spend a significant amount of time at or near the surface and in intertidal areas are the most vulnerable.

A dredge management plan has been prepared which provides the details to minimise the risk of a spill occurring during the construction phase of the OMSB Project and the OMSB Information Handbook (OMSB 2017) provides the details for the requirement of the logistics company which will operate the facility to prepare and implement an Oil Spill Contingency Plan. Hazardous substances must be appropriately stored such that they do not pose a threat to the health and safety of personnel and the environment. Spill kits for accidental spillage of hydrocarbons will be kept onboard vessels and on the wharf and personnel will be trained in oil spill response. Contractors will work to the required refuelling management plans and Oil Spill Contingency Plans reviewed and approved by DoT, and in accordance with the refuelling policy for DoT maritime facilities. In the event of accidental spillage, the Contractor will cease work immediately and ensure contamination is cleaned up prior to recommencing. A comprehensive environmental incident report will then be completed and provided to the DoT.

3.2.11. Litter/Debris

Injury and fatality to conservation significant marine fauna caused by ingestion of, or entanglement in, harmful marine debris is listed as a key threatening process under the EPBC Act (DSEWPaC 2012). Debris harmful to marine wildlife includes plastics washed or blown from land into the sea, and solid floating materials (such as plastics) from ships at sea. Turtles have been classified as "Concern" in relation to the vulnerability of these animals to marine pollution, inshore dolphins, dugongs and sawfish have been classified as "potential concern" and birds, humpback whales and finfish are classified as "less concern". Litter/debris is human-created waste that has deliberately or accidentally been released in a lake, sea, ocean or waterway.

The two primary threats from debris to marine fauna are entanglement and ingestion. The throat structure of marine turtles prevents the turtles regurgitating swallowed items making them particularly vulnerable to marine pollution. Swallowed items are trapped in the gut where they decompose and leak gases into the body cavity, causing the animals to float and ultimately die. White plastic debris (e.g. plastic bags) is of most concern to turtles, as it is often mistaken for jellyfish, which are a key prey for some species (Derraik, 2002). Toxins within the materials are also being absorbed by the animals with potential negative effects on their demography and marine fauna may also be killed or injured if they become entangled in debris.

A dredge management plan has been prepared which provides the details for waste management during the construction phase of the OMSB Project and the logistics company which will operate the facility to prepare a waste management plan. Wastes will be segregated and secured to avoid the potential for wind-blown wastes entering the marine environment or terrestrial areas of Beadon Creek. Contractors will work to the required waste management plans reviewed and approved by DoT, and in accordance with the waste management policy for DoT maritime facilities.

3.2.12. Light Pollution

Light pollution is defined as excessive or obtrusive artificial light, which itself is distinct from natural light in five main ways: source, scattering, reflection, directivity and direction. Turtles have been classified as "Concern" in relation to the vulnerability of these animals to artificial lighting, birds, dugongs, sawfish and finfish are classified as "less concern".

For marine turtle and seabird species, light pollution along, or adjacent to, nesting beaches or rookeries may cause alterations to critical nocturnal behaviours, particularly the selection of nesting sites and the passage of emerging turtle hatchlings from the beach to the sea. Potential impacts include a decrease in nesting success, beach avoidance by nesting females and disorientation resulting in increased mortality. Bright light can also disorient flying birds and subsequently cause their death through collision with infrastructure or starvation due to disruption in the ability to forage at sea. For wedge-tailed shearwaters (which have been previously recorded in the OMSB Project area) light pollution is an issue due to their nocturnal habits, and other migratory shorebirds can be affected as they undertake their migratory flights at night (Geering et al., 2007). Artificial lights on the onshore facility or vessels at sea may attract migrating shorebirds and birds may be disoriented where lighting is situated adjacent to rookeries. The attraction some species have for artificial light sources can also significantly increase their vulnerability to predation.

The proposed OMSB Project will be in the existing working Onslow Port and Beadon Creek Maritime Facility and artificial light is already present. Given this facility occurs inside the creek, it is not expected that light will be directed to the beach or sea surface. The area of Beadon Creek does not represent existing critical habitat for nesting turtles or birds. However, lighting for the facility will consider design recommendations provided in the Environmental Assessment Guideline for Protecting Marine Turtles from Light Impacts (EPA, 2010).

The impact of artificial light emissions from the vessels (dredge, support vessels) based on the potential light spill and glow reaching significant turtle habitats and/or nesting beaches and rookeries is expected to be negligible. The Wheatstone Project established 1.5 km distance from turtle nesting beaches as the area within which light emissions would need to be managed (Chevron, 2016). The known nearest turtle nesting beach to the proposed activities occurs on Direction Island, approximately 10 km north of the nearest point of the Project area at the end of the approach channel. Two nests have been previously recorded between

Beadon Point and Coolgra Point although this low level of nesting would not be regarded as a turtle nesting beach (RPS, 2010a). The locations of those nests were unable to be determined although there is a high probability that these nests were located beyond 1.5 km from Beadon Creek along this 15 km stretch of beach.

3.2.13. Invasive Marine Species

Marine pests can be introduced through ballast water exchange or via biofouling. High-risk vessels for the introduction of species include those that are slow moving, have space where marine species can settle, come in close contact with the sea bottom or remain in a single area for extended periods. These characteristics increase the likelihood that a species can establish on a vessel, from where it can be introduced to new regions. Vessels in this category include dredges and supply boats. Shallow and inshore areas, particularly port areas and sites where infrastructure development and maintenance take place, have the highest risk of marine pests becoming established.

There is a low risk of marine pests becoming established and affecting the biodiversity values and/or ecological integrity of the local environment when appropriate mitigation measures are adopted. Mitigation measures consistent with the National System for the Prevention and Management of Marine Pest Incursions, the Australian Ballast Water Management Requirements, the National biofouling management guidelines for commercial vessels reduce the risk that OMSB Project activities will result in the introduction of marine pests in port and inshore environments, such that they might significantly impact on the Commonwealth marine environment.

3.2.14. Impacts to Commercial Fisheries

The Western Australian Fisheries Industry Council (WAFIC), as the representative body for commercial fisheries in Western Australia, was consulted to identify relevant commercial fishing stakeholders relevant to the OMSB Project and to contact commercial fishing leaseholders to offer opportunity to provide comment on the proposal. Eight state-managed fisheries and three Commonwealth managed fisheries overlap the OMSB Project area (WAFIC, 2017). Seven of the state fisheries are likely to target depths <6 m as occur within the OMSB Project area, with the remaining fisheries targeting species which typically occur in deeper water further offshore or no fishing occurs in WA. The seven fisheries are:

- Beche de Mer;
- Marine aquarium fish;
- Pearl Oyster Managed Fishery;
- Pilbara Line Fishery;
- Onslow Prawn;
- Pilbara Developmental Crab; and
- Specimen shell.

The licence areas for these fisheries are typically very broad with the proposed OMSB Project area forming a negligible component of fishing zones, and multiple licence holders (i.e. Marine Aquarium Fish, Specimen Shell, Pilbara Line, Pilbara Developmental Crab and Beche de Mer) noted that this project will not impact their commercial fishing activities. Stakeholder communication with fishery licence holders identified the need to provide notification of the OMSB Project schedule prior to commencing activities and recommend the period between October to April for scheduling dredging activities to avoid interference with commercial fishing operations (WAFIC, 2017).

The remainder of this section focusses on information relevant to the OPMF, although information can also be interpreted for the likely impact on target species from other fisheries. Ongoing consultation will be held with these fisheries to resolve any items raised regarding the proposal.

Onslow Prawn Managed Fishery

Commercial trawling has been historically operating in the nearshore area of Onslow. There is insufficient baseline data to measure the spatial and temporal variability of faunal assemblages in the regions prior to the commencement of commercial trawling. It has been observed elsewhere that high levels of trawling may not only decrease the complexity of the habitat and biodiversity of the fauna, but also enhance the abundance of opportunistic species including prey species that are important in the diet of some commercial species (Engel & Kvitek, 1998). Kangas et al. (2006) suggests that the faunal assemblages, biodiversity and habitats in the trawled areas of Onslow have changed significantly since trawling began, but have now reached a new 'balance' compatible with trawling. The 'intermediate disturbance hypothesis', which describes that the highest diversity of species is maintained at intermediate scales of disturbance (Connell, 1978) is offered to explain why higher species richness and greater abundance of fish and invertebrates occur in sites which are regularly trawled and exposed to harsh physical conditions compared to non-trawled sites sampled during investigative surveys in the nearshore Onslow area. The community is dominant with short-lived species which exhibit life history traits of high fecundity, high productivity and with high input into reproduction during their relatively short life spans[5] (Kangas et al. 2006). These findings imply that the biological diversity and ecological integrity of marine fauna, at least for historically trawled areas in the nearshore environment of Onslow, is maintained through periodic anthropogenic disturbance. The effects of dredging generated suspended sediments and sedimentation is likely to have little impact on a community that exhibits these characteristics. For example, some common species such as commercial prawn species and portunid crabs prefer the disturbed, low-relief, soft sediment habitats modified by trawling and potentially altered by dredging (Kangas et al., 2006). These species benefit when the structural complexity of a habitat is reduced. However, the Wheatstone Project has restricted trawling activities for the OPMF in recent years and the current health of the stock is unknown but considered to be acceptable (Fletcher et al., 2017).

The Ashburton Nursery and Coolgra Point Nursery areas for the OPMF occur to the east and west of Onslow Port. Predicted zones of impact only slightly overlap the boundaries of the nursery areas, although turbidity at threshold concentrations developed for photosynthetic organisms on the outer boundary of the predicted plumes are unlikely to cause impact on juvenile prawns which bury themselves within the sediments. In the absence of a distinct change in BCH type between the Ashburton Nursery, the Onslow Port and the Coolgra Point Nursery, it is considered that the nursery boundaries do not continue through the Project area based on recognition of an existing operational Port occurring at Beadon Creek. Therefore, the potential impacted area has been designated historically by the DoF as the Onslow Port area and is not considered a nursery ground for commercially important juvenile prawn species. Estuaries, particularly the Ashburton River for the Onslow area, represents an important habitat for Banana Prawns. Postlarvae settle in the upper reaches of the estuaries and the success of juvenile populations emigrating from these estuaries correlates positively with rainfall during the wet season (Vance et al. 1998). The catchment area of Beadon Creek has been significantly reduced through the development of 8,000 ha of salt ponds for Onslow Salt. The Beadon Creek system has already been significantly modified and is unlikely to represent critical habitat for banana prawn stocks in comparison to areas east and west of Beadon Creek such as the Ashburton River.

[5] It is noted the trawl is not an accurate representation of the total fish fauna. Trawling data is considered relevant to evaluate impacts from Project activities as it misses the more mobile active and pelagic species which can move from disturbed areas and focusses on smaller or sessile species with reduced movement capabilities.

3.2.15. Environmental Windows or Key Habitat

Conservation Significant Species

A summary of the environmental windows and key habitat for conservation significant species relevant to the proposed OMSB Project is provided in **Table 3-11**. **Table 3-11** also provides an indication of whether a Commonwealth identified Biologically Important Area (BIA) occurs within the OMSB Project area for any conservation significant species. The highest abundance of migratory shorebirds was recorded during the late wet season (Jan-Mar) typically roosting on tidal flats, coastal claypans and inland marshes. The OMSB Project area overlaps with BIAs for breeding and foraging of the lesser crested tern and wedge-tailed shearwater. The southern migration represents the time when humpback whales with their calves have a higher potential to occur within the OMSB Project area, although 2 km would represent the boundary limit of their nearshore distribution, typically occurring at an average of 36 km offshore. Dolphins were predominantly found around islands to the west of Onslow, although are generally broadly distributed throughout the area and throughout the year. Highest dugong numbers in the area were recorded from June to September predominantly to the east and west outside of the Project area. Turtle nesting of green, flatback, hawksbill and loggerhead turtles predominantly occurs between October and March on islands offshore of Onslow. The OMSB Project area overlaps with nesting and inter nesting BIAs for flatback and hawksbill turtles. Sawfish have been recorded pupping between September and October in the Ashburton River and whale sharks are known to aggregate at Ningaloo each year between March and June.

Environmental windows may be introduced year-round to minimise specific risk to certain conservation significant species, although significant impacts on any conservation significant marine fauna are not predicted for the Project. Planning to consider environmental windows would need to consider the net environmental benefit against the Project schedule demands.

Table 3-11 Environmental Window, Key Habitat and Biological Important Area (BIA) relevant to the proposed OMSB Project (DSEWPaC, 2012)

Conservation Significant Species	Environmental Window	Key Habitat	BIA	Reference
Migratory Shorebirds (abundance)	Late Wet Season Jan – Mar	Tidal flats: Coastal claypans and inland marshes	Lesser Crested Tern (Breeding) Wedge-tailed Shearwater (Breeding/Foraging)	Bamford et al. (2009)
Humpback Whales (nearshore Southern Migration)	Aug – Nov	36 km offshore	Migratory	CWR (2010)
Dolphins (abundance)	Unknown	West of Project area Exmouth Gulf		CWR (2010)
Dugong (abundance)	June – Sept	<10 m NE & SW of Project area		CWR (2010)
Turtle Nesting Season	Oct-Mar	Offshore Islands	Flatback (Nesting/Internesting) Hawksbill (Internesting)	Pendoley (2009)
Sea snakes	Unknown	Unknown		
Sawfish (pupping)	Sept - Oct	Ashburton River		Morgan (pers comms)
Whaleshark	Mar-June	Ningaloo		

The DoF provided a list of spawning aggregation times for key species present in the North Coast Bioregion (**Table 3-5**). The list suggests environmental windows may be introduced year-round to minimise specific risk to commercially significant finfish. The locations of the spawning/aggregation areas were not provided for evaluating the risk of potential impacts relevant to the OMSB Project. A search of spawning aggregation literature for the species listed by the DoF in the North of WA recovered studies conducted from Shark Bay, Carnarvon, Ningaloo and the Kimberley. Some of the species habitats occur further offshore in water depths >60 m (i.e. Goldband snapper) and some species were found to aggregate in shallow waters (i.e. Blacktip reef shark). A second document was reviewed by the DoF which compiled a list of 22 species of fisheries importance that form spawning aggregations (Mackie et al., 2009). The list of 22 species is shown in **Table 3-12**. Except for three case studies, the timing or locations of spawning aggregations are not provided to inform dredge management. A search of the aggregation areas for the 22 listed species found information recorded from various locations in Australia and overseas, although aggregations in WA were predominantly recorded in temperate waters. The current information on spawning/aggregations of commercially important fish species is not considered sufficiently robust enough for use in defining environmental windows during a dredging program for the protection of these events.

Table 3-12 A preliminary list of 22 aggregating species of fisheries importance from (Mackie et al., 2009)

Scientific Name	Common Name	Description
Choerodon rubescens	Baldchin groper	Abrohlos Islands
Centroberyx gerrardi	Bight redfish	Cape Naturaliste
Achoerodus gouldii	Blue groper	Temperate Waters
Polyprion americanus	Bass groper	Temperate Waters
Acanthopagrus butcheri	Bream	Shark Bay
Nelusetta ayraudi	Chinaman leatherjacket	Temperate Waters to NW Cape
Plectropomus leopardus	Common coral trout	Great Barrier Reef
Glaucosoma hebraicum	Dhufish	Cape Naturaliste
Rexea solandri	Gemfish	Temperate continental shelf & upper slope waters
Hypothordus octofasciatus	Grey-banded cod	Micronesia
Polyprion oxygeneios	Hapuka	Temperate Waters
Sillaginodes punctatus	King George whiting	Temperate Waters
Argyrosomus japonicus	Mulloway	Mosman Bay, Swan River
Pagrus auratus	Pink snapper	Cockburn Sound
Nemadactylus valenciennesi	Queen snapper	Temperate Waters
Centroberyx australis	Red snapper	Continental Shelf
Seriola hippos	Samson fish	West of Rottnest Island
Mugil cephalus	Sea mullet	Females migrate offshore in deep waters to spawn (Florida)
Pseudocaranx dentex	Silver trevally	Temperate Waters
Lethrinus miniatus	Sweetlip emperor	Great Barrier Reef
Hyperoglyphe antarctica	Trevalla	Continental Slope
Seriola lalandi	Yellow tail kingfish	Temperate Waters

3.2.16. Summary of the Risk/Significance of Project Activities

Assessment of potential impacts from proposed OMSB Project activities determined that significant impact to marine fauna is unlikely. The basis of this conclusion is that although several species of high conservation status are likely to be present in or near the area at some-time during Project activities, long-term population declines is unlikely because large populations are not restricted to the Project area, nor are critical habitats identified for these species in the Project area. Any impacts to these species arising from the OMSB Project are considered either not significant and/or manageable through the incorporation of appropriate mitigation measures. The spatial and temporal variability of faunal assemblages in the regions prior to the commencement of commercial trawling is not known although the biodiversity of the nearshore area is comprised of an assemblage adapted to harsh physical environmental conditions and frequent anthropogenic and natural disturbances such as trawling activities, warm water temperatures and cyclonic conditions. This is reflected in life-history characteristics that indicate species can recover quickly in the unlikely event they are impacted by the proposed dredging activities. Therefore, dredging is unlikely to significantly impact the abundance and distribution of marina fauna species directly.

3.3. Management/Mitigation Measures for Marine Fauna

We recommend:

- Establish project roles and responsibilities for implementing training, vessel management procedures and reporting;
- Soft start-up procedure for each new or re-start operation which will involve running the dredge for a few minutes to haze sawfish and any other sensitive marine fauna from the area prior to the commencement of dredging;
- Ensure vessels are maintained in good condition to minimise the transfer of noise into the water;
- Undertake training for project personnel on marine fauna, environmental management and reporting procedures prior to commencing works and ensure suitably trained vessel crew can implement fauna observer duties at a times during the dredging program;
- Document a log of incidents and management procedures invoked, in-water incidents and observed injured/dead marine megafauna and report to DBCA within 48 hours;
- Implement restrictions for dredging when marine megafauna are observed near dredging activities to minimise the potential impacts on marine megafauna. Suggest adopting the Australian National Guidelines for Whale and Dolphin Watching (2005) to determine the appropriate exclusion zonation;
- Vessel logs of marine fauna interaction should be submitted to DBCA at the completion of the Project;
- Monitor supernatant waters for suspended sediments prior to discharge and in the creek, consider inclusion of nutrients if algal mats within the predicted sheet flow are not predated. Monitor the community shift of the intertidal area within the flow-path of dewatering (i.e. changes in algal mat, invertebrates and vegetation) prior to, during, post dredging activities and the return of the community to the original state;
- Prepare management for the attraction of migratory shorebirds to the onshore disposal site and dewatering discharge area. Anticipate the need for deterrent devices with consideration that the disposal site is located next to the Onslow airport runway and the risk of airplane/bird interaction;
- Develop management actions in a dredge or construction management plan to minimise risk to marine fauna through implementation of spill and waste management practices during construction works;
- Implement mitigation measures for the risk of marine pests consistent with the National System for the Prevention and Management of Marine Pest Incursions, the Australian Ballast Water Management Requirements, the National biofouling management guidelines for commercial vessels;
- All vessels that mobilise to the Port of Onslow from interstate of international waters are required to complete the WA DoF's Vessel Check' risk assessment (https://vesselcheck.fish.wa.gov.au); and

- Continue consultation with relevant fisheries licence holders to resolve any items raised regarding the proposal.

Consider:

- Consider avoiding works during habitat use by migratory species (i.e. Onslow Town beach and intertidal flats during late summer);
- Consider limiting vessel speeds during dredging and navigation marker installation activities to 10 knots unless in the event of an emergency;
- Environmental Assessment Guideline for Protecting Marine Turtles from Light Impacts (EPA 2010) for minimising light pollution on the vessels; and
- Consider relevant environmental windows to minimise impacts on priority or highest at risk marine fauna.

4. Flora and Vegetation

The Environmental Protection Authority (EPA) has developed technical guidance for the protection of flora and vegetation in recognition of the importance of protecting flora and vegetation as it provides a representation of the ecological processes and the diversity of interactions in terrestrial ecosystems, and certain vegetation may hold spiritual, cultural, and/or economic values. The EPAs objective for the factor flora and vegetation is *"to protect flora and vegetation so that biological diversity and ecological integrity are maintained"*.

This report aims to characterise the flora and vegetation within the area of the OMSB Project using desktop investigations and ground-truth field surveys to enable an assessment of the potential effects of project activities on flora and vegetation, and provide recommendations for mitigating these effects. Environmental impact assessment and management requires investigation of the extent, severity and duration of OMSB Project activities, and includes consideration of the cumulative effect of the proposal with previous impacts or approvals, and the connectivity of the environment.

The assessment process implemented for this report is undertaken in accordance with the technical guidance document provided from the EPA for the Environmental Factor Flora and Vegetation (EPA, 2016d).

4.1. Method

4.1.1. Desktop Assessment

A desktop assessment of available State and Commonwealth databases was undertaken to identify records or potential occurrences of conservation significant flora species and vegetation communities within the study area. The desktop assessment used the below databases and documents.

The Interim Biogeographic Regionalisation for Australia (IBRA) is endorsed by all levels of government and provides the national and regional planning framework for the systematic development of a comprehensive, adequate and representative National Reserve System. IBRA7 (the current version) classifies Australia's landscapes into 89 large geographically distinct bioregions based on common climate, geology, landform, native vegetation and species information. These are broken into 419 subregions based on more localised and homogenous geomorphological units in each bioregion.

The National Vegetation Information System (NVIS) provides information on the extent and distribution of vegetation types in Australian landscapes. It was developed to allow a nationally consistent vegetation dataset from data collected by States and Territories and is an ongoing collaborative initiative between the Australian and State and Territory governments. The NVIS can be used to understand vegetation present in the landscape.

The Commonwealth DoE PMST was used to identify species and vegetation communities listed under the Commonwealth EPBC Act that may occur within the search area. The PMST is a predictive database that identifies EPBC Act listed species and communities with a 'moderate potential to occur' in the search area based on bioclimatic modelling. The search area was defined by the latitude/longitude coordinates -21.64556, 115.13103 with a 10 km buffer.

Database search results were obtained from the DBCA Threatened (Declared Rare) and Priority Flora database, the Threatened and Priority Flora List and the Western Australian Herbarium Specimen database for Threatened and Priority flora species opportunistically collected in the search area. The search area was defined by the latitude/longitude coordinates with a 20 km buffer.

Database search results were obtained from DBCA's Threatened and Priority Ecological Communities database for the area defined by the latitude/longitude coordinates 115° 06' 09'' E, 21° 39' 59'' S and 115° 10' 27'' E, 21° 35' 59'' S with a 20 km buffer.

Naturemap, a joint project of DBCA and the Western Australian Museum, presents comprehensive information on the distribution of Western Australia's flora species. The search area was defined by the latitude/longitude 115° 06' 09'' E to 115° 10' 27'' E and 21° 39' 59'' S to 21° 35' 59'' S.

The Atlas of Living Australia (ALA) database contains records of Australia's Virtual Herbarium (AVH) (Council of Heads of Australasian Herbaria, 2014) and provides information on all the known species in Australia aggregated from a wide range of data providers: museums, herbaria, community groups, government departments, individuals and universities. The search area was defined by the latitude/longitude coordinates -21.649109, 115.12656 with a 10 km buffer. Database records were reviewed and used to provide locations of any threatened species records within the area.

The following studies that have previously been conducted within or near the site were reviewed:

- Onslow Townsite Strategy Flora, Vegetation and Fauna Assessment (ENV, 2011)
- Onslow Light Industrial Area Flora, Vegetation and Fauna Assessment (ENV, 2012)
- Vegetation clearing permits to the Shire of Ashburton for the Onslow Airport Upgrade (DEC, 2012)
- Vegetation clearance permits for the development of the Department of Transport (DoT) Beadon Creek Maritime Facilities (DER, 2013)
- Desktop review of the proposed Onslow Micro-Siting Survey Area (Biota, 2013)

Likelihood of Occurrence Assessment

An assessment was undertaken of the likelihood of occurrence for threatened species identified through the desktop review. The DoE and DBCA do not have prescriptive likelihood of occurrence guidelines within their policies but rather clarify the scale of assessment required to determine the level of impact (e.g. level of assessment, previous record searches, and distribution maps). The following criteria have been developed by O2 Marine with the aim of considering the assessment classifications to identify the likelihood of occurrence for threatened species or communities:

- **Low potential to occur** – the species has not been recorded in the region (no records from desktop searches) and/or current known distribution does not encompass project area and/or suitable habitat is generally lacking from the project area;
- **Moderate potential to occur** – the species has been recorded in the region (desktop searches) however suitable habitat is generally lacking from the project area OR species has not been recorded in the region (no records from desktop searches) however potentially suitable habitat occurs at the project area;
- **High potential to occur** – the species has been recorded in the region (desktop searches) and suitable habitat is present at the project area; and
- **Known to occur** – the species has been recorded on-site in the recent past (i.e. last 5-10 years) and the site provides suitable habitat for it.

The results for the flora and vegetation likelihood of occurrence assessment is presented in **Appendix E.**

4.1.2. Field Assessment

Brief notes and photographs were taken of the terrestrial pipeline & DMMA at the following locations to provide an overview of the existing vegetation and condition:

- Shoreline crossing;
- Construction site track;
- Beadon Creek Road crossing; and

- Dune system behind the LIA.

4.2. Desktop Assessment Results

4.3. Interim Biogeographic Regionalisation for Australia (IBRA)

Onlsow is located within the Cape Range (CAR01) subregion of the Carnarvon Bioregion. It is characterised by (DEE, 2012):

- Rugged tertiary limestone ranges and extensive areas of red aeolian dune field, Quaternary coastal beach dunes and mud flats;
- *Acacia* shrublands over *Triodia* on limestone (*Acacia stuartii* or *A. bivenosa*) and red dune fields, *Triodia* hummock grasslands with sparse Eucalyptus trees and shrubs on the Cape Range;
- Extensive hummock grasslands (*Triodia*) on the Cape Range and eastern dune-fields;
- Tidal mudflats of sheltered embayment of Exmouth Gulf support extensive mangroves;
- Beach dunes with Spinifex communities; and
- An extensive mosaic of saline alluvial plains with samphire and saltbush low shrublands along the eastern hinterland of Exmouth Gulf.

4.3.1. National Vegetation Information System (NVIS)

There are three major vegetation groups (MVG) and major vegetation sub-groups (MVS) mapped over the study area (**Table 4-1**).

Table 4-1 Major vegetation (NVIS v4.2)

Major Vegetation Group (MVG)	Major Vegetation Sub-group (MVS)
Chenopod Shrublands, Samphire Shrublands and Forblands	Mixed chenopod, samphire +/- forbs
Hummock Grasslands	Hummock grasslands
Naturally bare - sand, rock, claypan, mudflat	Naturally bare, sand, rock, claypan, mudflat

MVG = Major Vegetation Group; MVS = Major Vegetation Sub-group

4.3.2. EPBC Matters Search

Threatened ecological communities (TECs)

Ecological communities are naturally occurring biological assemblages that occur in a unique habitat. There is currently no Western Australian legislation covering the conservation of threatened ecological communities. However, an informal, non-statutory process is in place. The Minister for Environment may list an ecological community as being threatened if the community is presumed to be destroyed or at risk of becoming destroyed. DBCA's threatened ecological community database holds records of identified and informally listed threatened ecological communities. At 6 October 2016, 69 communities had been endorsed by the Minister, 25 of which are also listed under the EPBC Act. At 30 November 2016, 389 communities with insufficient information available for consideration as a threatened ecological community were allocated to one of five priority categories.

Threatened ecological communities (TECs) protected under the EPBC Act are ecological communities that have been assessed and assigned to a category related to the status of the threat to the community at a national scale, i.e. extinct, critically endangered, endangered, vulnerable, and conservation dependant.

The EPBC Act PMST results (**Appendix C**) returned no TECs within the search area.

Conservation Significant Flora Species

Conservation significant flora species listed under the provisions of the Commonwealth EPBC Act include Endangered, Vulnerable and Near Threatened (EVNT) species. The PMST results (**Appendix C**) returned no EVNT species within the search area.

4.3.3. Department of Biodiversity, Conservation and Attractions

Conservation significant flora species listed under the provisions of the Western Australia WC Act include threatened (Critically Endangered, Endangered, Vulnerable, Conservation Dependent, Other Specially Protected) and priority (Priority 1, Priority 2, Priority 3, Priority 4. Species). The DBCA search returned six conservation significant species for the area (**Table 4-2**). *Grevillea papillosa* (P3) was also returned, however, this species is confined to the area from Nannup to Scott River in the south-west of the State.

Table 4-2 Conservation significant flora species - DBCA results

Family	Species Name	WC Act Status
Fabaceae	*Indigofera roseola*	1
Fabaceae	*Tephrosia rosea* var. Port Hedland (A.S. George 1114)	1
Malvaceae	*Triumfetta echinate*	3
Malvaceae	*Abutilon* sp. Onslow (F. Smith s.n. 10/9/61)	1
Scrophulariaceae	*Eremophila forrestii* subsp. *Viridis*	3
Solanaceae	*Solanum leopoldense*	3

WC Act Status (species listed under the Western Australian *Wildlife Conservation Act 1950*): 1 = Priority 1, 2 = Priority 2, 3 = Priority 3, 4 = Priority 4

4.3.4. NatureMap Search

The Naturemap search returned no conservation significant flora species (**Appendix C**).

4.3.5. Atlas of Living Australia Search

The Atlas of Living Australia search returned one conservation significant flora species, *Triumfetta echinata*, listed as Priority 3 under the WC Act.

4.3.6. Historical Surveys and Monitoring

Regional Historical Surveys

In recent decades, a boom in large-scale regional resource development projects and recent upgrades to Onslow power and water services has resulted in a significant amount of site-specific biological survey work being carried out in the region. Most of this work was undertaken near the ANSIA, along Onslow/Macedon Road into town and site 185 to the west of Macedon Road, for formal environmental impact assessment. Although conducted within the broader region of Onslow, these studies still provide useful contextual information for the current assessment.

A detailed review of these existing studies is provided in (Biota, 2013). Recent surveys which have been undertaken in the Onslow region include[6]:

- Validus (2008). Chevron Domgas Project: Onslow Flora and Vegetation Assessment. Unpublished report prepared for SKM and Chevron Australia, Validus Group, Western Australia;
- Astron (2009). BHPB Macedon Gas Development Flora and Vegetation Survey (Phase 1 and 2). Unpublished report for URS Australia, Astron Environmental Services, Western Australia;
- RPS Australia (2009). Baseline Flora and Vegetation Survey Ashburton North Pipeline Route Option 3. Unpublished report prepared for Chevron Australia, RPS Australia, Perth;
- Biota (2010a). A Vegetation and Flora Survey of the Wheatstone Study Area, near Onslow. Unpublished report prepared for URS Australia Pty Ltd and Chevron Australia Pty Ltd, Biota Environmental Sciences, Western Australia;
- Outback Ecology (2010). Wheatstone Amendment Area: Flora and Vegetation Assessment. Unpublished report for Golder Associates on behalf of Chevron Australia, Outback Ecology, Western Australia; and
- Biota (2011). Wheatstone Rare Flora Survey - March 2011. Unpublished report prepared for URS Australia Pty Ltd and Chevron Australia Pty Ltd, Biota Environmental Sciences, Western Australia.

Ecological Communities

The vegetation of the area west of the proposed DMMA is predominantly classified as Inland Sand Dunes (ID3), with small intersecting areas of Coastal Sand Dunes (CD2), Claypans (C3), Coastal Sand Plains (CS3) and Tidal Mudflats (T1). The community changes to Coastal Sand Dunes (CD2 then CD1) progressing closer to Onslow townsite, with intersecting areas of Claypans (C3) and Tidal Mudflats (T1). The vegetation association description and evaluated conservation significance for each vegetation unit in the area to the west of the OMSB Project and is provided in **Table 4-3** and the distribution of communities is presented in **Figure 4-1**.

The review found no TECs or Priority Ecological Communities[7] (PECs) were found within all surveys of the area to the west of the OMSB Project. Though not recognized as either TEC's or PECs all vegetation has inherent value and Biota (2013) classified each vegetation unit with a conservation significance of High, Medium or Low by considering the following information:

1. the land system/s (Van Vreeswyk, 2004) with which the vegetation units were most strongly associated. The distribution of the land systems through the north-west of WA was gauged as being either widespread or restricted. Each land system was considered relative to the whole distribution of that land system, within the north-west, to determine if it might represent an outlier. Studies have shown that as the distance between sampling sites on the same land system increases, the assemblages became more different (Oliver et al., 2004). Vegetation units located on restricted land systems and/or isolated or outlying sections of a land system are afforded higher conservation concern due to the possibility that their floristic composition may vary significantly from those expected.
2. other features of the vegetation units defined for the study, including their extent within the study area, occurrence on restricted habitats, capacity to support rare or restricted flora, species richness and condition (health); and
3. reservation priorities of ecosystems as identified by DEC (Kendrick & Mau., 2002).

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[6] Other studies near Ashburton River and Tubridgi Point were considered for this review but have not been specifically referenced or listed in the regional historical survey list as they are summarised in Biota (2013).

[7] Flora and fauna communities that are recognised to be of significance but do not meet the criteria for a TEC

The samphire shrublands (C3) was classified as High conservation significance. This vegetation assemblage may contain numerous poorly recognised *Tecticornia* species whose distributions in the region are also difficult to determine. This vegetation unit has the potential to contain the Priority flora species *Eleocharis papillosa*, which is listed as Vulnerable under the EPBC Act (Biota, 2010a). The remainder of the vegetation units were considered Low conservation significance as they are likely to be representative of vegetation units that are widespread in the locality or are substantially invaded by Buffel Grass (**Cenchrus ciliaris*).

Species Diversity

Studies around the Onslow and Wheatstone Project area have recorded a total of 422 species of native vascular plants belonging to 58 families.

Conservation Significant Species

No Threatened flora listed under the EPBC Act or the WC Act have been recorded in the area to the west of the OMSB Project. One flora species (Dwarf Desert Spike-rush: *Eleocharis papillosa*) listed as "Vulnerable" under the EPBC Act was recorded ~800 m south-west of the Peedamulla Station turnoff along Onslow Road, 16 km south of the OMSB Project area. Previous records suggest that this species occurs in a habitat comprised of samphire shrubland vegetation within a tidally influenced creek. Biota (2013) determined that the possibility that this species occurring within samphire shrublands could not be ruled out. Two P3 species (*Eremophila forrestii* subsp. *viridis*, *Triumfetta echinata*) are known to occur within inland vegetation units (ID1 & ID2) of the region. *Abutilon uncinatum* (P1) was found in surveys 25 km from the OMSB Project area in loamy plains supporting a shrubland of *Acacia synchronicia* and *A. bivenosa* over an open hummock grassland of *Triodia epactia*. Biota (2013) determined these species were unlikely to occur near the OMSB Project area due to a lack of suitable habitat. The saltbush *Atriplex flabelliformis* (P3) was recorded from five locations in the southern Wheatstone plant area by (Astron, 2009).

Table 4-3 The description of vegetation association and conservation significance of vegetation units identified from previous surveys of the Onslow region to the west of the OMSB Project area (Biota 2013)

Vegetation Unit	Legend	Unit Code	Description	Conservation Significance
Tidal mudflat		T1	*Tecticornia* spp. scattered low shrubs	Low
Coastal Dunes		CD1	*Acacia coriacea* subsp. *coriacea*, *Crotalaria cunninghamii* tall shrubland over *Spinifex longifolius*, (**Cenchrus ciliaris*) open tussock grassland	Low
		CD2	*Acacia coriacea* subsp. *coriacea* tall shrubland over *Crotalaria cunninghamii*, *Trichodesma zeylanicum* var. *grandiflorum* open shrubland over *Triodia epactia* open hummock grassland with **Cenchrus ciliaris* open tussock grassland	Low
Inland Dunes		ID3	*Acacia stellaticeps* shrubland over *Triodia epactia* hummock grassland	Low
Coastal Sand Plains		CS3	*Acacia tetragonophylla* scattered shrubs over *Scaevola pulchella*, *Indigofera monophylla* low open shrubland over *Triodia epactia* hummock grassland	Low
Claypans		C3	*Tecticornia* spp.2 low shrubland	High

Figure 4-1 **Distribution of Vegetation Units in previous surveys of the Onslow Region west of the OMSB Project area (Biota 2013)**

Seven introduced plant species were recorded in surveys, six of which were found to the west of the OMSB Project area:

- ****Aerva javanica* (Kapok)**: Kapok is found in various habitats and vegetation units and can be a significant weed of loose sandy substrates in coastal areas. This short-lived perennial shrub is common throughout the Pilbara and Kimberley regions;
- ****Cenchrus ciliaris (Buffel Grass)***: Buffel Grass are tufted perennial grasses which were introduced to the Pilbara as fodder species. Buffel Grass has demonstrated allelopathic capacities, whereby it releases chemicals that inhibit the growth of other plants, and it is an aggressive and effective competitor with native flora species. This perennial grass forms dense tussock grasslands, particularly along creeklines, floodplains and in sandy coastal areas of the Pilbara;
- ****Flaveria trinervia* (Speedy Weed)**: Speedy Weed is an annual daisy, commonly occurring in drainage lines and other mesic habitats in the northwest of WA. This species was previously listed as the native *F. australasica*;
- ****Prosopis glandulosa* and **Prosopis pallida* (Mesquite)**: All **Prosopis* species are Declared Plants under the Western Australian Agriculture and Related Resources Protection Act 1976, being listed as P1 (movement of plants or their seeds prohibited) for the State, and P2 (eradicate infestation to destroy and prevent propagation each year until no plants remain) for the Onslow locality. **Prosopis* is also listed as a "Weed of National Significance" by (Thorp & Lynch, 2000);
- ****Tribulus terrestris* (Caltrop)**: Caltrop is a prostrate spreading annual herb with pinnate leaves, which is widespread in the Kimberly and arid zones and is also found in the southwest of WA on road verges; and
- ****Vachellia farnesiana* (Mimosa Bush)**: Mimosa Bush is a spreading, thorny shrub to 4 m high, which is widespread from the Kimberley to near Perth, typically occurring along drainage systems and in adjacent low-lying areas. It has dark grey bark, pinnate leaves and yellow flowers that are visible in winter.

Local Historical Surveys

A Level 2 Flora, Vegetation and Fauna Assessment was conducted for the Shire of Ashburton as part of the Onslow Townsite Strategy in 2011 (ENV, 2011). The 2011 assessment was undertaken for the Onslow town site, including areas between Onslow and Macedon Roads, directly adjacent to the proposed pipeline route and disposal areas, and north of the LIA to the beach west of Beadon Creek (**Figure 4-1**).

The four vegetation communities described within the Onslow Townsite Strategy area are shown in **Table 4-4**. Three of the four vegetation associations were dominated by *Acacia* and *Triodia* species, the remaining vegetation association dominated by Chenopod species (salt bush). The study area predominantly consists of *Acacia* shrublands over *Triodia* hummock grasslands on sand dunes and are represented by vegetation associations 1, 2 and 3. The least commonly occurring vegetation association is 4, which encompasses the chenopod communities in the wet salty depressions within the study area.

A separate Level 2 Flora, Vegetation and Fauna Assessment was undertaken in 2011 for the Shire of Ashburton as part of the redevelopment and upgrade of the Onslow Airport (ENV, 2012). The area surveyed covers a portion of terrestrial habitat within the proposed DMMA which is shown in **Figure 4-3**. The entire site was composed of vegetation association 1 in **Table 4-4**.

No species listed under the EPBC Act, gazetted as Declared Rare Flora under the WC Act, or listed as Priority Flora by the DBCA were recorded in the study area. None of the vegetation associations recorded are listed as TECs under the EPBC Act, as Environmentally Sensitive Areas under the EP Act 1986, or as PECs by the DBCA.

The condition of vegetation within most of the study area was described as generally very good to good, with degraded areas disturbed by the presence of introduced species, tracks, previous clearing and dumped rubbish. The distribution of the condition of habitats as described is shown in **Figure 4-4**.

Table 4-4 Vegetation Associations within the area (ENV 2011)

Type	Description	Area (ha)
1	Scattered Shrubs of Shrubland of *Acacia coriacea* subsp. *coriacea* over Low Shrubland of Acacia *stellaticeps*, *Scaevola sericophylla*, *Indigofera boviperda* subsp. *boviperda* and *Pityrodia loxocarpa* over Open Hummock Grassland of *Triodia epactia* over Open Tussock Grassland of **Cenchrus ciliaris*.	121.73 ha
2	Scattered Shrubs of *Acacia coriacea* subsp. *coriacea* over Low Open Shrubland of *Crotalaria cunninghamii* subsp. *sturtii* and *Tephrosia rosea* var. *clementii* over Hummock Grassland of *Triodia epactia* and *Spinifex longifolius* over Tussock Grassland of **Cenchrus ciliaris* over Open Herbs of *Ipomoea pes-caprae* subsp. *brasiliensis*.	35.02 ha
3	Shrubland of *Acacia coriacea* subsp. *coriacea* and *Rhagodia preissii* subsp. *sturtii* over Low Shrubs of *Tephrosia gardneri*, *Scaevola crassifolia* and *Trichodesma zeylanicum* var. *zeylanicum* over Tussock Grassland of **Cenchrus ciliaris*.	69.77 ha
4	Low Shrubland of *Tecticornia auriculata*, *Tecticornia halocnemoides* subsp. *tenuis*, *Frankenia ambita* and *Atriplex semilunaris* over Open Tussock Grassland of *Eragrostis pergracilis*, *Eragrostis falcata* and *Sporobolus virginicus*.	1.66 ha

Six introduced species were recorded from surveys shown in **Table 4-5.** Five of the six introduced species are listed as environmental weeds as defined by the Environmental Weed Strategy for Western Australia (CALM, 1999). Three introduced species (Kapok: **Aerva javanica*, Buffel: **Cenchrus ciliaris*, Caltrop: **Tribulus terrestris*) were commonly recorded in both studies while isolated records were recorded for the other three species during the first (broader scale) survey only. Verano (**Stylosanthes hamata*) was found in two locations near the west of Onslow Road adjacent to the proposed disposal grounds and terrestrial pipeline route. Mesquite (**Prosopis glandulosa*) and Athel pine (**Tamarix aphylla*) are both listed as Declared Plants under the Agriculture and Related Resources Protection Act 1976 (ARRP Act 1976). Mesquite was recorded in two wet depressions in association with chenopod species, west of Onslow Aerodrome and next to Beadon Creek Road. Athel pine was found closer to Onslow townsite at two isolated locations and is less likely to occur in the proposed area. These two species are also listed as Weeds of National Significance (WONS) by the Australian Government (Thorp, 1988).

Table 4-5 Introduced plant species recorded in ENV (2011, 2012) listed in the Environmental Weed Strategy, WA (CALM, 1999)

Taxon	Common Name	Likelihood	Rating	Criteria		
				Invasiveness	Distribution	Impacts
**Aerva javanica*	Kapok	Common	High	Yes	Yes	Yes
**Cenchrus ciliaris*	Buffel	Common	High	Yes	Yes	Yes
**Tamarix aphylla*	Athel Tree	Unlikely	Moderate	Yes	Yes	-
**Stylosanthes*	Verano	Possible	Mild	Yes	-	-
**Prosopis*	Mesquite	Possible[1]	Low	-	-	-
**Tribulus terrestris*	Caltrop	Common	Not	N/A	N/A	N/A

[1] Mesquite possibly found in the natural stormwater drain within the DMMA

Previous Clearing Permits within the OMSB Project Area

Clearing permits were issued to the Shire of Ashburton in 2012 (DER, 2013) for works at the Onslow Airport and to the Department of Transport in 2013 (DEC, 2012) for works associated with the Beadon Creek Maritime Facility. The areas for the previously approved clearing permits are shown in **Figure 4-2**.

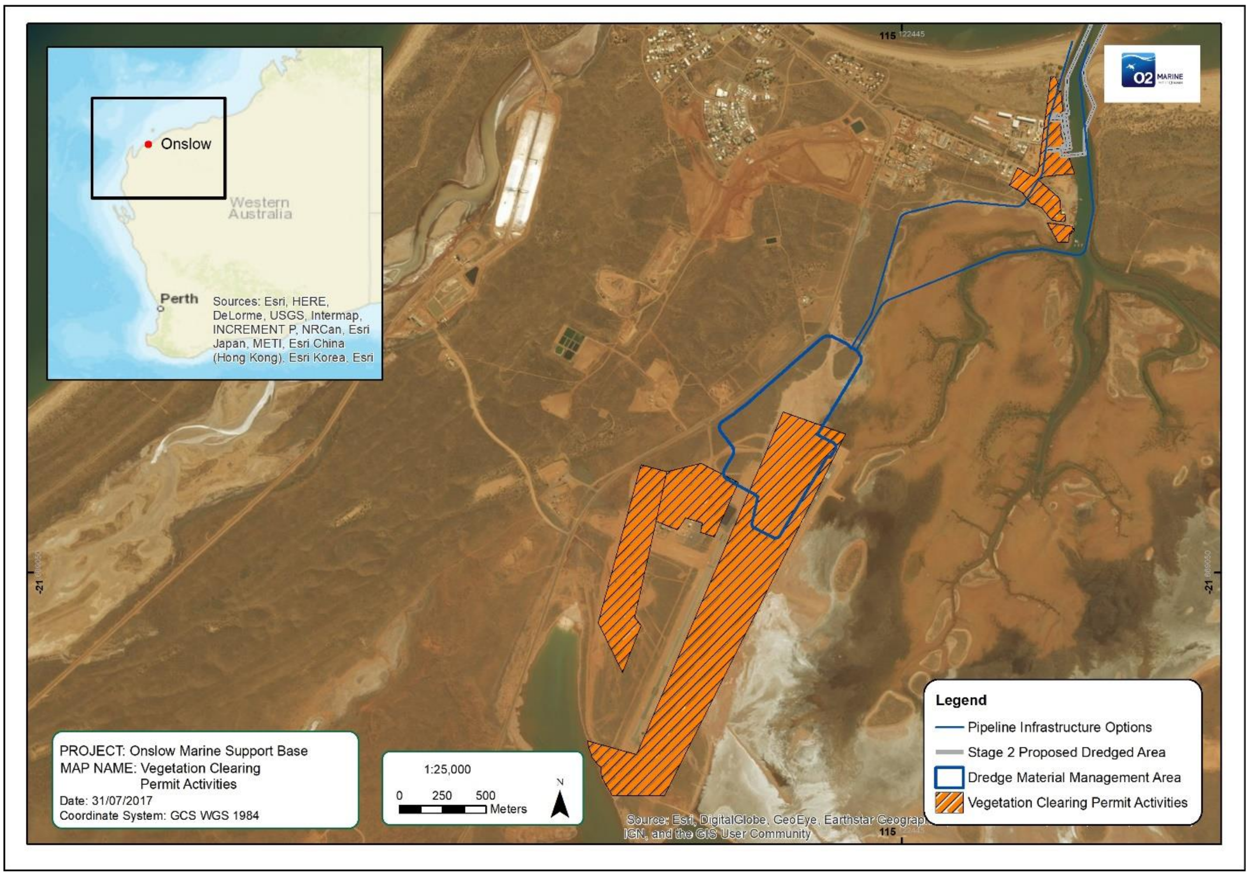

Figure 4-2 Clearing permits previously issued within onshore areas proposed to potentially be disturbed as part of the OMSB Project

4.3.7. Desktop Investigation Summary

Potentially occurring threatened flora species are listed in **Appendix E** with an account of their likelihood of presence within the study area. Not all the threatened species indicated through desktop information are expected to occur within the study area due to the absence of suitable habitat for some species. *Eremophila forrestii* subsp. v*iridis* (P3) and *Triumfetta echinata* (P3) are at least moderately likely to occur within or immediately adjacent to the OMSB Project area according to the definitions in **Section 4.1.1**.

4.4. Field Survey Results

4.4.1. Site Description

Shoreline Crossing

The Option A terrestrial pipeline route comes onto the beach on the Western side of the groin. The pipeline crosses the dune system to reach the unpaved access track. There is sparse vegetation (*Spinifex* and *Ipomoea*) between the bare sandy beach and the trafficked area behind the dune. The condition rating is degraded with numerous vehicle tracks and low vegetative coverage. Notable prominent sand dunes were observed behind the beach immediately west of Beadon Creek, with evidence of historical use as a spoil disposal area for maintenance dredging activities. Typical views are presented in **Plate 4-1** and **Plate 4-4**.

Construction Site Track

Option A terrestrial pipeline route is likely to follow the western edge of the beach track. The route could possibly cross to the reclaimed OMSB wharf construction site, if a booster station is required, or remain on the west side of the track to Beadon Creek Road near the boundary fence of Discovery Park. The soil type is described as light brown sand and the incline is slight. The vegetation association adjacent to the track is Scattered *Acacia* shrubland over low open shrubland of *Crotalaria* and *Tephrosia* over tussock grassland (**Cenchrus ciliaris*) (i.e. Vegetation Association 2). Condition rating is generally good to very good with disturbances recorded as introduced species of Buffel grass (**Cenchrus ciliaris*) and Kapok (**Aerva javanica*) on the low foredunes and construction road/tracks. Typical view is presented in **Plate 4-5**.

Beadon Creek Road Crossing

Option A pipeline route crosses Beadon Creek Road. The landscape has been modified to build roads, open space and commercial infrastructure to support harbour and industrial activities. The vegetation occurs within a stormwater drain and falls within the vegetation clearance permit for the Onslow (Beadon Creek) Maritime Facility. The drain provides a depression for pipe underpass beneath Beadon Creek Rd. Vegetation Association 2 has been modified due to artificial stormwater runoff drain. Typical view presented in **Plate 4-6**.

Back dune of the Light Industrial Area

This area is located landward of the LIA. The slope of the dune is relatively steep, becoming flat approaching the upper intertidal mudflat and mangrove habitats from the lower western arm of Beadon Creek (see **Section 2.3.1**). The soil type is red sand. The vegetation on the dune is Open *Acacia* and *Hakea* shrubland over hummock grassland (*Triodia*) and tussock grass (**Cenchrus ciliaris*). Condition rating is very good with disturbances recorded as introduced species of Buffel grass (**Cenchrus ciliaris*) and Kapok (**Aerva javanica*) on the low foredunes. Rubbish disposal is common and there are 4wd tracks at the base of the steep dune. The cover of shrubs declines towards the flats and the east of the dune which is classified as scattered *Acacia* and *Hakea* shrubland over hummock grassland (*Triodia*) and tussock grass (**Cenchrus ciliaris*). The base of the dune system transitions into the samphire zone on the salt flats. Condition rating is generally degraded with disturbances of several 4wd tracks and possibly saline influence. Typical views from the centre of Area A are presented in **Plate 4-7** and **Plate 4-10**.

Light Industrial Area to Dredge Material Management Area

The DMMA is located adjacent to Onslow Road extending from an open stormwater drain into airport lands. This site overlies both the supra-tidal salt flat described in see **Section 2.3.1** and the adjacent terrestrial dune systems. The vegetation of the dune system from the LIA to the DMMA is *Acacia* and *Hakea* shrubland over hummock grassland (*Triodia*) and tussock grass (**Cenchrus ciliaris*). Condition rating is generally good to very good with minor disturbance of tracks and introduced plants. The open drain consists of "bare" mudflat with only very scattered samphire (*Tecticornia*) shrubs, and thicker low-lying samphire shrubs fringing "Degraded" claypans. Multiple access tracks within the open drain is the primary cause of disturbance. Typical views are presented in **Plate 4-11** and **Plate 4-12**.

Plate 4-1 View north to the western side of the groin where the pipeline crosses the beach, visible car tracks

Plate 4-2 "Degraded" Sparse vegetation (*Spinifex* and *Ipomoea*) on dune systems

Plate 4-3 The beach being used as spoil disposal area for previous maintenance dredging of Beadon Creek (BMT JFA 2013)

Plate 4-4 Prominent dune system has evidence of historical use as a spoil disposal area for maintenance dredging activities

Plate 4-5 "Good to Very Good" Scattered *Acacia* shrubland over low open shrubland of *Crotalaria* and *Tephrosia* over tussock grassland (Cenchrus ciliaris*) along the construction track.**

Plate 4-6 View north-west towards the construction site showing artificial stormwater depression as potential road underpass at culvert point. Modified Vegetation Association 2.

Plate 4-7 "Good to very good" Open *Acacia* and *Hakea* over hummock and tussock grassland at the back of the LIA

Plate 4-8 "Degraded" Scattered *Acacia* and *Hakea* over hummock and tussock grassland at the back of the LIA east towards Beadon Creek

Plate 4-9 Disturbances from back dune of LIA include introduced species of Kapok (Aerva javanica*) and rubbish disposal**

Plate 4-10 "Degraded" Tussock grasslands transitions into samphire zone salt flats

Plate 4-11 View north-east from DMMA back to LIA: "Very Good" *Acacia* and *Hakea* shrubland over hummock grassland (*Triodia*) and tussock grass (Cenchrus ciliaris*).**

Plate 4-12 View looking south-west from open stormwater drain towards airport: the proposed location for the DMMA. From near to far: "Degraded "claypan *Tecticornia* spp. low shrubland and "bare" tidal mudflat with *Tecticornia* spp. scattered low shrubs within the stormwater drain. Background: "Very Good" *Acacia* and *Hakea* shrubland over hummock grassland (*Triodia*) and tussock grass (Cenchrus ciliaris*).**

4.4.2. Vegetation Habitat Mapping

Extensive flora and vegetation survey work completed in the Onslow area was reviewed in a detailed desktop assessment of the OMSB Project area and field ground-truth survey was undertaken. This allowed vegetation units to be extrapolated and mapped within this section of the OMSB Project area with reasonable confidence. The distribution of vegetation associations has been mapped from the shoreline along the proposed terrestrial pipeline route Option A to the DMMA near the airport approximately 3 km south of Onslow. An alternative pipeline route (Option B) has been proposed which tracks Beadon Creek and the western arm tributary crossing the intertidal flats overlying only a small portion of terrestrial vegetation. The pipeline route options are presented in **Figure 1-1**.

The map has been produced from blending the results of previous Level 2 Flora, Vegetation and Fauna Assessments (ENV 2011, 2012) and results from the current field survey. Seven vegetation associations are described:

1. ID3 Inland dunes: Scattered *Acacia* and *Hakea* shrubland over hummock grassland (*Troidia*) and Tussock grassland (*Cenchrus ciliaris*);
2. CD1 Coastal dunes: Scattered *Acacia* shrubland over low open shrubland of *Crotalaria* and *Tephrosia* over Tussock grassland (*Cenchrus ciliaris*);
3. ID4 Inland dunes: Shrubland of *Acacia* and *Rhagodia* over open Tussock Grassland (**Cenchrus ciliaris*);
4. ID5 Inland dunes: Open shrubland of *Acacia* and *Hakea* shrubland over Hummock grassland (*Triodia*) and Tussock grassland (**Cenchrus ciliaris*);
5. T1 Tidal/Creek bare mudflat scattered low samphire shrubs (*Tecticornia* spp.);
6. C3 Claypan low samphire shrubland (*Tecticornia* spp.); and
7. B1 Beach dunes sparse vegetation *Spinifex* and *Ipmoea.*

HML describes Human Modified Land and is typically either “degraded” or private property.

The distribution of the vegetation associations is shown in **Figure 4-3**. Vegetation association B1 is restricted to the coastal dunes, vegetation association CD1 is located on the foredunes and vegetation ID5 and ID3 is located behind the back dune. The habitat condition rating has also been mapped to help optimise the pipeline route to assist with optimising the proposed pipeline route. A map of the habitat condition is presented in **Figure 4-4**.

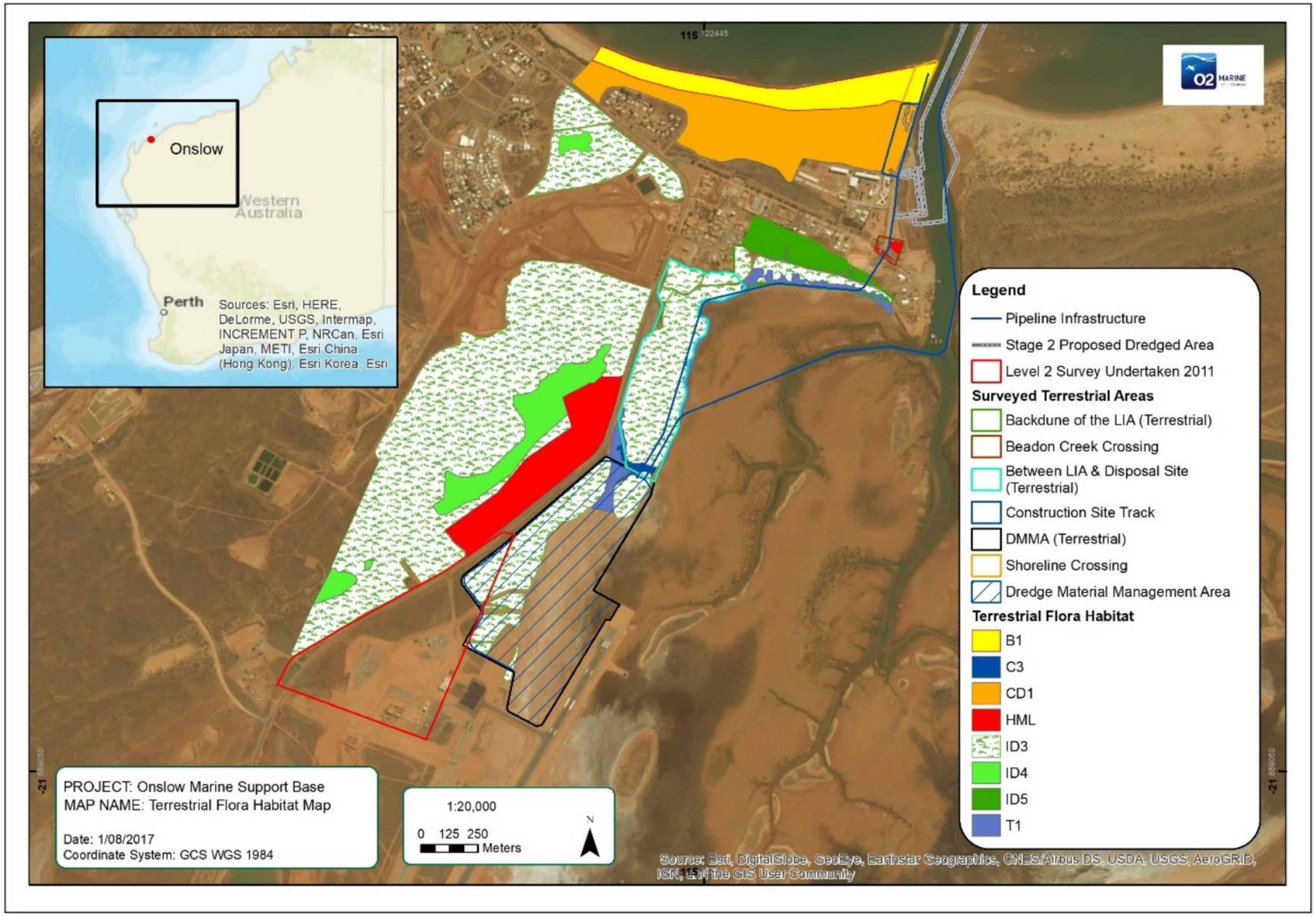

Figure 4-3 **Terrestrial vegetation association habitat map for OMSB Project (Legend Vegetation Associations on previous page)**

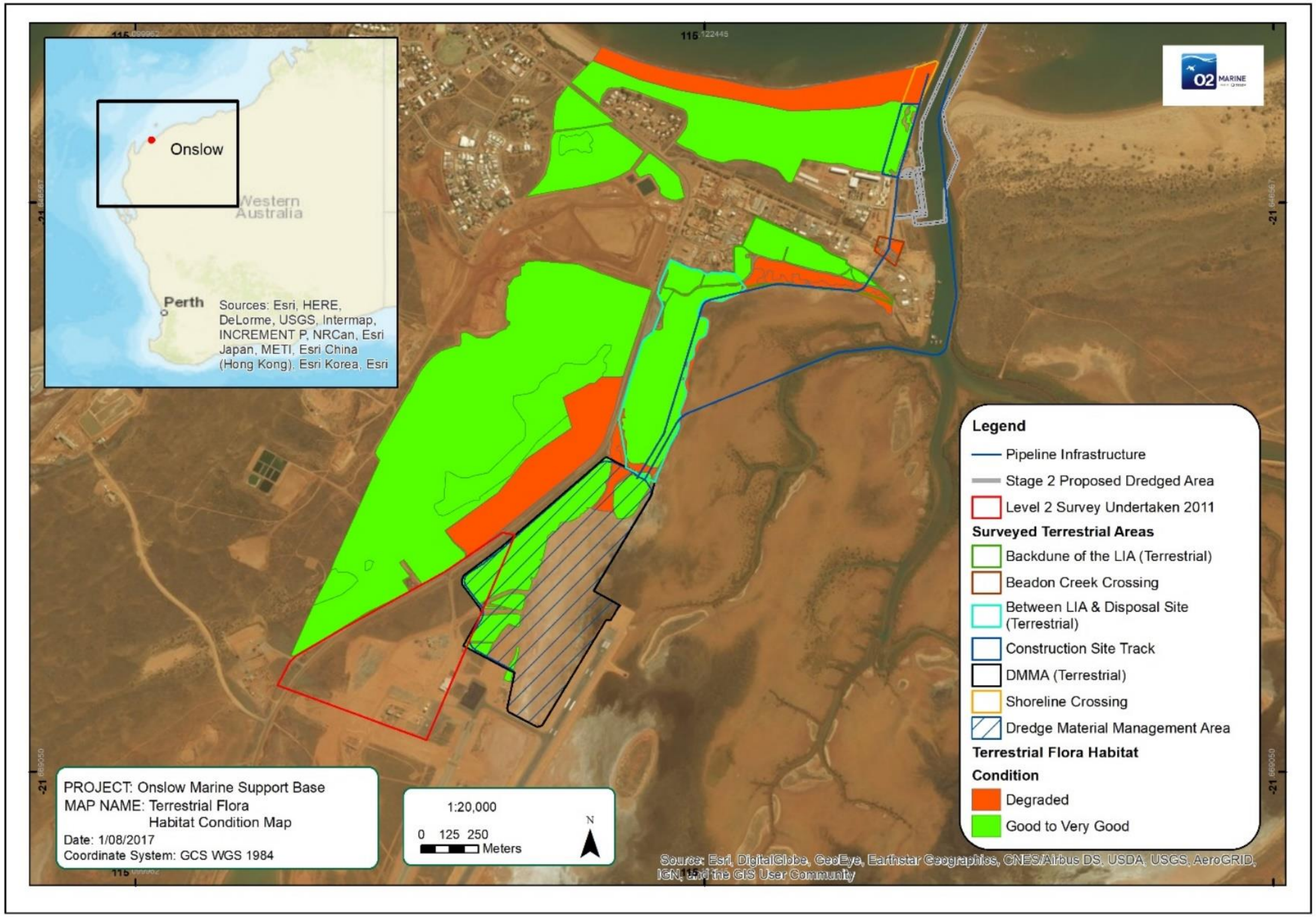

Figure 4-4 **Vegetation condition assessment OMSB Project**

4.5. Risk/Significance of Project Activities

4.5.1. Risk to Threatened or Priority Ecological Communities

Numerous historical surveys have been undertaken in the Onslow region, including two previous detailed Level 2 Flora, Vegetation and Fauna Assessments surveys within the DMMA and across a broader area extending from the airport to Beadon Point adjacent to the proposed pipeline route. This has allowed interpolation of vegetation communities in the OMSB Project area with high-certainty. Brief ground-truth notes and photographs obtained whilst in the field further validated interpolation of vegetation communities within the OMSB Project area. Seven vegetation associations were identified and mapped which are considered widespread both locally and regionally across the Pilbara. These vegetation associations are not listed as a TECs under the EPBC Act, as an Environmentally Sensitive Areas under the EP Act, or as PECs by DBCA.

The vegetation unit 'claypan' (C3), ranked as High conservation significance in Biota (2013), occurs within the OMSB Project area. A small area (<0.1 ha) of "degraded" claypan comprised of samphire shrubland was found within the open stormwater drain. In accordance with Biota (2013) this vegetation unit may contain numerous poorly recognised samphire species which are difficult to determine, and potentially contains the P3 flora species *Eleocharis papillosa*, which is also listed as '*Vulnerable*' under the EPBC Act (Biota 2010a). The condition of the vegetation unit was ranked as "degraded" due to frequent vehicle tracks and dumped rubbish. Any potential impacts from OMSB Project activities attributable to this vegetation unit is insignificant based on the poor condition and small portion of claypan habitat within the OMSB Project area (see also discussion of the conservation significance of *E. papillosa* in **Section 4.5.2**).

The area of each vegetation association that would be required to be removed for pipeline route Option A and Option B, including the clearance of vegetation required for the DMMA, is provided in **Table 4-6**. Approximately 16.1 ha of vegetation will be required to be cleared for the pipeline route Option A and slightly less vegetation clearance of 15.8 ha will be required for pipeline route Option B. Pipeline route Option B involves the disturbance of intertidal habitat which is discussed in **Section 2.5** and will need to be considered when evaluating a decision of which option is preferable for the OMSB Project. However, taking into consideration there is no risk posed to threatened or ecological communities from the clearance of a moderate to minor area of the proposed vegetation associations for the pipeline route and DMMA, either option is considered to have minor significance in terms of environmental impacts.

Table 4-6 Estimated area of each vegetation association required to be cleared for pipeline route options and the DMMA

Vegetation Association	Pipeline Route (ha)		DMMA (ha)	Total (ha)	
	Option A	Option B		Option A	Option B
ID3	0.2 ha	<0.1 ha	14.6 ha	14.8 ha	14.6 ha
CD1	-	-	-	-	-
ID4	-	-	-	-	-
ID5	<0.1 ha	-	-	<0.1 ha	-
T1	<0.1 ha	<0.1 ha	1.1 ha	1.1 ha	1.1 ha
C3	<0.1 ha	<0.1 ha	<0.1 ha	0.1 ha	<0.1 ha
B1	<0.1 ha	-	-	<0.1 ha	-
HML	<0.1 ha				
Total	0.3 ha	<0.1 ha	15.8 ha	16.1 ha	15.8 ha

4.5.2. Risk to Conservation or Priority Flora

Rare flora searches within and around the area (including Biota 2013) provide a sound understanding of the habitats most likely to support population of Threatened or Priority flora, and the identification of vegetation units of elevated conservation significance.

No species listed under the EPBC Act, gazetted as Declared Rare Flora under the WC Act, or listed as Priority Flora by DBCA, have previously been recorded in or adjacent to the OMSB Project area from previous surveys. A search of government databases for species of conservation significance identified six species. While some of these species are known to occur in the region, suitable habitat is unlikely to be present within the OMSB Project area for these species (**Appendix E**).

One species (*E. papillosa*) listed as Threatened Flora has been previously recorded from two locations near the Ashburton north area, approximately 16 km south of the OMSB Project area. This species does not appear in any database searches (i.e. state or Commonwealth). This tiny sedge, known as Dwarf Desert Spike-rush, is listed as *Vulnerable* under the EPBC Act, meaning that it is not considered to be critically endangered, but is facing a high risk of extinction in the medium-term future. This species was not listed on the most recent Declared Rare and Priority Flora listing for Western Australia, although it has since been assigned P3 status (Biota 2013).

A definition of P3 flora is provided below:

"*Species that are known from several locations, and the species do not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat*. *Species may be included if they are comparatively well known from several locations, but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species need further survey.*"

The Dwarf Desert Spike-rush was listed under the EPBC Act on the basis that it was known from only eight populations in the Northern Territory, some of which were under threat from weed invasions and it was considered the area and extent had declined. However, current records from the species indicate *E. papillosa* has a considerably broader distribution, from Northern Territory, South Australia and Western Australia. It is likely that this species has been poorly collected due to its small size and ephemeral nature. It has been recorded from two locations approximately 16 km south of the OMSB Project area within tidally influenced creeks. It is considered it may occur throughout the claypan samphire shrublands vegetation unit.

As described in **Section 4.5.1**, only <0.1 ha of "degraded" claypan samphire shrublands on which *E. papillosa* could be found occurs within the proposed OMSB Project area. The review of the distribution and potential occurrence of this species within the OMSB Project area indicates that the proposed activities are unlikely to have a significant effect on *E. papillosa*.

The Option A pipeline route from the beach to the disposal area includes roads, tracks and highly disturbed areas adjacent to roads and tracks on the edges of vegetation communities. The route would be less likely to impact conservation significant species if the route is optimised to minimise clearing of native vegetation or avoid areas of very good condition rating. The risk would be further eliminated through undertaking a more detailed Level 2 survey of areas previously unsurveyed within the OMSB Project area. However, based on the level of existing information available, which would indicate that conservation species are not likely to occur within the OMSB Project area, it is considered that a Level 2 survey is not required.

4.5.3. Risk of the Spread of Introduced Plants

Introduced plants create numerous environmental impacts including resource competition and the prevention of seedling recruitment of native plant species, alteration of geomorphological and hydrological cycles, changes to soil nutrients, fire regimes and the abundance of indigenous fauna, and genetic changes

(CALM, 1999). The Agriculture Protection Board maintains a list of "Declared Plants". Declared Weeds, under the ARRP Act (1976), are those that landowners are required by law to control. They are required to be controlled as they are considered a significant risk to the Western Australian economy. Many weed species, however, are not declared under this Act as they may have an agricultural role. They may, however, be serious environmental weeds with the potential to affect native ecosystems.

Desktop review and field assessment determined six introduced species have been previously recorded within and adjacent to the OMSB Project area. Three introduced species (Kapok, Buffel, Caltrop) were commonly found during all three previous surveys and are expected to be encountered during any works undertaken onsite. In addition, Verano was found in proximity to the border of the proposed pipeline route and DMMA. Whilst these species may be common and widespread, they are considered significant environmental weeds and are identified for control. Mesquite and Athel pine are listed as Declared Plants under the ARRP Act 1976, although they are considered less likely to occur in the OMSB Project area. Mesquite was not observed during the field survey but if present, will likely be found within the wet depressions of the natural stormwater drain at the DMMA. Athel pine has typically only been found closer to the Onslow townsite.

OMSB Project activities which have the potential to spread weeds include:

- Vegetation clearing;
- Ground disturbance;
- Construction and establishment of infrastructure;
- Vehicle movement; and
- Rehabilitation.

The potential impacts from the introduction and spread of weeds include:

- Damage to native habitats;
- Create additional fuel loads to alter fire regimes;
- Clog natural drains to change the hydrology;
- Remove, or add unwanted, nutrients from soils lowering its nutrient quality;
- Reduce biological biodiversity and abundance;
- Impacts to cultural heritage;
- Genetic changes to indigenous flora; and
- Impacts on landforms such as increased erosion.

There is a high risk of spreading weeds during construction activities for the OMSB Project. Consideration for weed outbreaks will need to be included in project planning.

4.6. Management/Mitigation Measures for Flora and Vegetation

We recommend:

- Obtain clearing permits where vegetation must be cleared, if required pending the outcome of Part IV assessment;
- Maximise the use of disturbed areas and minimise the footprint of works to be conducted within vegetated areas or intertidal flats, including minimising temporary disturbance areas during construction;
- Where possible, avoid areas identified with a higher condition rating and with high biodiversity (such as the high dune at the back of the LIA); and
- Develop management actions in a construction management plan or like minimise the spread of weeds through implementation of weed management practices during construction works which may include:

- Develop and maintain a weed register;
- Undertake inspections prior to commencing construction works;
- Liaise with the Shire of Ashburton regarding weed control activities; and
- Provide environmental induction and identification of weeds identified to potentially occur in the Project area.

5. Terrestrial Fauna

5.1. Method

5.1.1. Desktop Assessment

A desktop assessment of available State and Commonwealth databases was undertaken to identify records or potential occurrences of conservation significant fauna species within the study area. The desktop assessment used the below databases and documents.

The Commonwealth DoE PMST was used to identify species and vegetation communities listed under the Commonwealth EPBC Act that may occur within the search area. The PMST is a predictive database that identifies EPBC Act listed species and communities with a moderate potential to occur in the search area based on bioclimatic modelling. The search area was defined by the latitude/longitude coordinates -21.64556, 115.13103 with a 10 km buffer (**Appendix C**).

Database search results were obtained from DBCA's threatened fauna databases, which include species that are declared as 'likely to become extinct (Schedules 1, 2, and 3)', 'Migratory birds protected under an international agreement (Schedule 5)', 'Conservation dependent fauna (Schedule 6)' and 'Other specially protected fauna (Schedule 7)'. The search area was defined by the latitude/longitude coordinates 115° 06' 09'' E, 21° 39' 59'' S and 115° 10' 27'' E, 21° 35' 59'' with a 20 km buffer.

Naturemap, a joint project of DBCA and the Western Australian Museum, presents comprehensive information on the distribution of Western Australia's fauna species. The search area was defined by the latitude/longitude 115° 06' 09'' E to 115° 10' 27'' E and 21° 39' 59'' S to 21° 35' 59'' S (**Appendix C**).

The ALA database contains records of the Online Zoological Collections of Australian Museums (OZCAM) (CHAFC, 2014) and provides information on all the known species in Australia aggregated from a wide range of data providers: museums, herbaria, community groups, government departments, individuals and universities. The search area was defined by the latitude/longitude coordinates -21.649109, 115.12656 with a 10 km buffer. Database records were reviewed and used to provide locations of any threatened species records within the area.

Likelihood of Occurrence Assessment

An assessment was undertaken of the likelihood of occurrence for threatened species identified through the desktop review. The DoE and DBCA do not have prescriptive likelihood of occurrence guidelines within their policies but rather clarify the scale of assessment required to determine the level of impact (e.g. level of assessment, previous record searches, and distribution maps). The following criteria have been developed by O2 Marine with the aim of considering the assessment classifications to identify the likelihood of occurrence for threatened species:

- **Low potential to occur** – the species has not been recorded in the region (no records from desktop searches) and/or current known distribution does not encompass project area and/or suitable habitat is generally lacking from the project area;
- **Moderate potential to occur** – the species has been recorded in the region (desktop searches) however suitable habitat is generally lacking from the project area OR species has not been recorded in the region (no records from desktop searches) however potentially suitable habitat occurs at the project area;
- **High potential to occur** – the species has been recorded in the region (desktop searches) and suitable habitat is present at the project area; and
- **Known to occur** – the species has been recorded on-site in the recent past (i.e. last 5-10 years) and the site provides suitable habitat for it.

The results for the fauna likelihood of occurrence assessment is presented in **Appendix D**.

5.1.2. Field Assessment

Brief notes and photographs were taken of the terrestrial pipeline & DMMA at the following locations to provide an overview of the existing habitat and condition:

- Shoreline crossing;
- Construction site track;
- Beadon Creek Road crossing;
- Dune system behind the LIA; and
- LIA to DMMA.

The findings of the field assessment are presented in **Section 5.2.7**.

5.2. Desktop Assessment Results

5.2.1. EPBC Matters Search

Conservation Significant Fauna Species

Conservation significant fauna species listed under the provisions of the Commonwealth EPBC Act include EVNT species as well as internationally protected wildlife and migratory species. The PMST results (**Appendix C**) returned 22 listed threatened bird species, 18 listed as migratory (and two additional subspecies of listed migratory species). The PMST search returned two listed terrestrial fauna species: *Dasyurus hallucatus* Northern Quoll, Digul and *Ctenotus angusticeps* Airlie Island Ctenotus.

5.2.2. Department of Biodiversity, Conservations and Attractions

Conservation significant fauna species are those species listed under the provisions of the Western Australia WC Act, including threatened (Critically Endangered, Endangered, Vulnerable, Conservation Dependent, Other Specially Protected species) and priority species (Priority 1, Priority 2, Priority 3, Priority 4). The DBCA search returned 27 conservation significant bird species, including 22 species listed as migratory (and one additional subspecies of listed migratory species) (**Table 5-1**). The DBCA search returned three listed terrestrial fauna species: two mammals: *Dasyurus hallucatus* northern quoll and *Leggadina lakedownensis* Lakeland Downs mouse, and one reptile *Lerista planiventralis maryani* keeled slider.

Table 5-1 Conservation significant species returned by the DBCA search

Class	Species Name	Common Name	EPBC Act Status	WC Act Status	IUCN Status
BIRD	*Apus pacificus*	fork-tailed swift	MM, Ma	IA	LC
BIRD	*Ardea modesta*	great egret, white egret	M, Ma	IA	LC
BIRD	*Arenaria interpres*	ruddy turnstone	M, Ma	IA	LC
BIRD	*Calidris acuminata*	sharp-tailed sandpiper	MW, Ma	IA	LC
BIRD	*Calidris alba*	Sanderling	M, Ma	IA	LC
BIRD	*Calidris ferruginea*	curlew sandpiper	CE, MW, Ma	VU & IA	LC
BIRD	*Calidris ruficollis*	red-necked stint	M, Ma	IA	LC
BIRD	*Charadrius leschenaultii*	greater sand plover, large sand plover	V, M, Ma	IA (& VU at subsp. level)	LC

Class	Species Name	Common Name	EPBC Act Status	WC Act Status	IUCN Status
BIRD	*Charadrius leschenaultii leschenaultii*	greater sand plover (Mongolian)	V, M, Ma	VU (& IA at sp. level)	LC
BIRD	*Charadrius mongolus*	lesser sand plover	E, M, Ma	EN & IA	LC
BIRD	*Chlidonias leucopterus*	white-winged black tern, white-winged tern	M, Ma	IA	LC
BIRD	*Elenus scriptus*	letter-winged kite	-	P4	NT
BIRD	*Glareola maldivarum*	oriental pratincole	MW, Ma	IA	LC
BIRD	*Limosa lapponica*	bar-tailed godwit	Ma, M V	IA (& VU at subsp. level)	NT
BIRD	*Limosa lapponica menzbieri*	bar-tailed godwit (northern Siberian)	-	VU (& IA at sp. level)	-
BIRD	*Merops ornatus*	rainbow bee-eater	M, Ma	IA	LC
BIRD	*Numenius madagascariensis*	eastern curlew	CE, M, Ma	VU & IA	EN
BIRD	*Numenius minutus*	little curlew, little whimbrel	M, Ma	IA	LC
BIRD	*Numenius phaeopus*	Whimbrel	M, Ma	IA	LC
BIRD	*Oceanites oceanicus*	Wilson's storm-petrel	M, Ma	IA	LC
BIRD	*Pezoporus occidentalis*	night parrot	E	CR	EN
BIRD	*Pluvialis squatarola*	grey plover	M, Ma	IA	LC
BIRD	*Puffinus pacificus (Ardenna pacifica)*	wedge-tailed shearwater	M, Ma	IA	
BIRD	*Sterna dougallii gracilis*	roseate tern	M, Ma	IA	LC
BIRD	*Sterna hirundo*	common tern	M, Ma	IA	LC
BIRD	*Sterna nereis nereis*	fairy tern	V	VU	VU
BIRD	*Tringa nebularia*	common greenshank, greenshank	MW, Ma	IA	LC
MAMMAL	*Dasyurus hallucatus*	northern quoll	E	EN	EN
MAMMAL	*Leggadina lakedownensis*	Lakeland Downs mouse, kerakenga	-	P4	LC
REPTILE	*Lerista planiventralis maryani*	keeled slider	-	P1	-

- EPBC Act (species listed under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999): Ex = Extinct, CE = Critically Endangered, E = Endangered, V = Vulnerable, M = Migratory, MM = Migratory Marine, MT = Migratory Terrestrial, MW = Migratory Wetlands, Ma = Listed Marine
- WC Act Status (species listed under the Western Australian *Wildlife Conservation Act 1950*):
  - Threatened Species: EX = Presumed Extinct, CR = Critically Endangered, EN = Endangered, VU = Vulnerable, IA = Migratory birds protected under an International Agreement, CD = Conservation Dependent, OS = Other Specially Protected
  - Priority Species: P1 = Priority 1, P2 = Priority 2, P3 = Priority 3, P4 = Priority 4
- IUCN (species listed under the International Union for Conservation of Nature (IUCN) Red List of Threatened Species): EX = Extinct, EW = Extinct in the Wild, CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern

5.2.3. NatureMap Search

The Naturemap search returned 29 conservation significant bird species listed under the WC Act, including 20 listed migratory species, within the search area. The Naturemap search returned two conservation significant terrestrial fauna species listed under the WC Act: (*Dasyurus hallucatus* northern quoll and *Lerista planiventralis maryani* keeled slider) (**Appendix C**).

5.2.4. Atlas of Living Australia Search

The ALA search returned 33 conservation significant bird species, including 27 listed migratory species, within the search area. The ALA search returned one conservation significant terrestrial fauna species (*Leggadina lakedownensis*: Lakeland Downs Mouse).

5.2.5. Historical Surveys and Monitoring

Regional Historical Surveys

In recent decades, a boom in large-scale regional resource development projects has resulted in a significant amount of site-specific biological survey work being carried out in the region, most of which is undertaken near the ANSIA for formal environmental impact assessment. Although conducted within the broader region of Onslow, these studies still provide useful contextual information for the current assessment. Those most relevant to the current survey are[8]:

- Onslow Solar Saltfield three-phase terrestrial fauna survey (Biota, 2005);
- Chevron Domgas Project Onslow fauna assessment in 2008 (Validus, 2008);
- API Management Onslow Rail Corridor terrestrial fauna survey in 2008 (Biota, 2009);
- Fauna Assessment Macedon Gas Development Terrestrial Plant Site and Linear Infrastructure Corridor (Bamford, 2009);
- Terrestrial Fauna Survey of the Wheatstone Project Area (Biota, 2010b);
- Survey for Migratory Birds in the Wheatstone LNG Area, November 2008 and April 2009 (Bamford et al., 2009); and
- Wheatstone Project Claypan Ephemeral Fauna Survey (Biota, 2010c).

Fauna Habitats

Seven primary fauna habitats were identified on the Wheatstone area:

- Coastal dune: *Acacia coriacea* tall shrubland over *Spinifex longifolius* open tussock grassland on coastal dune system;
- Inland dune: *Triodia epactia* dominated hummock grassland on inland dune system;
- Sand/loam plain: *Acacia* sp. scattered shrubs over *Triodia epactia* hummock grassland on sand/loam plain;
- Buffel on Clay: Buffel Grass tussock grassland on clay plain;
- Samphire: Samphire claypan;
- Tussock on Clay: Tussock grassland on heavy clay plain; and
- Drainage: *Eucalyptus* sp. and Buffel tussock dominated drainage lines.

Ephemeral creek line drainage communities were considered 'ecosystems at risk' within the Cape Range subregion (Kendrick & Mau 2002). In addition, mangrove communities in the intertidal zone are also considered 'ecosystems at risk' within the Roebourne subregion (Kendrick & Stanley, 2001). All remaining habitat types are considered well represented in the locality and wider region and not of elevated conservation significance (Biota, 2010b). Inland dune habitat and drainage habitat exhibited the highest avifauna richness.

[8] Further studies near Ashburton River and Turbridgi Point were considered for this review although have not been specifically referenced or listed in the regional historical survey list

Species Diversity

Environmental studies conducted at Ashburton North for the Wheatstone Project recorded more than 210 native vertebrate fauna species including reptiles, amphibians, birds and mammals. Seven amphibian (frog) species have been recorded including two tree frogs and five ground-dwelling species. A total of 60 reptile species have been recorded on the Project and surrounding area. Seventeen (17) mammal species have been recorded which includes six carnivorous marsupials, two macropods (kangaroos and wallabies), three native mice, one monotreme (Short-beaked echidna) and five bat species. An estimated 130 bird species have been recorded around Onslow and Ashburton North during surveys for the Wheatstone Project. A diverse range of habitats including coastal shoreline, tidal flats, mangroves, inland grassland and woodland support a wide range of bird species of which a number are conservation significant (Biota, 2013)

It was considered unlikely that any Short Range Endemic (SRE) taxa are present in the survey area (Biota, 2013).

Three introduced species were recorded: one murid (House Mouse: *Mus musculus*), one feline (Cat: *Felis catus*) and one bovid (Domestic Cow: *Bos taurus*) (Biota, 2013)

Conservation Significance

The only schedule listed species recorded in the region is the Pilbara Olive Python (*Liasis olivaceus barroni*), a Schedule 1 listed species considered Vulnerable in WA. Three priority listed species were recorded from the Wheatstone area by Biota (2010b):

- Little Northern Freetail-bat (*Mormopterus loriae cobourgensis*) (P1);
- Western Pebble-mound Mouse (*Pseudomys chapmani*) (P4); and
- Australian Bustard (*Ardeotis australis*) (P4)[9].

The Western Pebble-mound Mouse was considered unlikely to occur due to a lack of suitable stony substrate required for mound building. However, the Little Northern Freetail-bat and the Australian Bustard are considered likely to be present. In addition, the following species may also occur:

- Skink (*Lerista planiventralis maryani*) (P1);
- Short-tailed Mouse (*Leggadina lakedownensis*) (P4);
- Eastern Curlew (*Numenius madagascariensis*) (CE/M, VU/IA, EN); and
- Peregrine Falcon (*Falco peregrinus*) (OS).

Three listed migratory species were recorded during field surveys:

- Rainbow Bee-eater (*Merops ornatus*);
- Fork tailed Swift (*Apus pacificus*); and
- White bellied Sea Eagle (*Haliaeetus leucogaster*).

(Bamford et al., 2009) describes 38 waterbird species that are migratory (listed under the EPBC Act) could occur in the area and 26 of these species have been recorded during previous surveys. The remaining species not yet could occur as vagrants.

Local Historical Surveys

A Flora, Vegetation and Fauna Assessment was conducted for the Onslow Townsite Strategy in 2011 (ENV 2011). The assessment was outside the current study area, north of Beadon Creek Road and west of Onslow

[9] No longer provided P4 listing for conservation significance

Road from the proposed disposal areas. The study describes two fauna habitat types within the Onslow Townsite Strategy area:

- Shrubland of *Acacia* species over *Hummock* grassland – a simple habitat with variable shrub cover over consistently high cover of *Triodia*, providing moderate quality fauna habitat for common arid bird species and a diversity of reptile species; and
- Beach and dunes – providing moderate value habitat for migratory bird species, resident bird species and a diversity of reptile species within the dunes.

The shrubland was considered to have a moderate habitat value mainly because of the lack of vegetation structure. The beach was also considered as moderate fauna value because of its value for resident wading birds and a wide range of migratory terns and shorebirds that were previously recorded on Onslow beach but were absent from this survey.

A total of 49 species were recorded during the field survey, which included one amphibian, three reptiles, two mammals and 43 bird species. The green tree frog (*Litoria caerulea*) occurs naturally in the Kimberley and appears to be introduced. Reptiles recorded included two geckos and one dragon. Some of the most commonly recorded bird species were: Nankeen Kestrel (*Falco cenchroides*), Peaceful Dove (*Geopelia striata*), Budgerigar (*Melopsittacus undulatus*), Singing Honeyeater (*Lichenostomus virescens*), White-plumed Honeyeater (*Lichenostomus penicillatus*), Brown Honeyeater (*Lichmera indistincta*), Variegated Fairy-wren (*Malurus lamberti*), Magpie-lark (*Grallina cyanoleuca*), Black-faced Woodswallow (*Artamus cinereus*) and Zebra Finch (*Taeniopygia guttata*). The two mammal species recorded were the Euro (*Macropus robustus*) and scats of a Feral Cat (*Felis catus*).

The survey recorded five conservation significant bird species:

- Western Star Finch (*Neochmia ruficauda subclarescens*) [1];
- Eastern Reef Egret (*Egretta sacra*)[10];
- Eastern Osprey (*Pandion cristatus*)[11];
- Caspian Tern (*Hydroprogne caspia*); and
- Rainbow Bee-eater (*Merops ornatus*).

Although listed as migratory species, the Eastern Reef Egret and Rainbow Bee-eater probably breed locally, and nests of Eastern Osprey are present.

A separate Level 2 Flora, Vegetation and Fauna Assessment was undertaken in 2011 for the Shire of Ashburton as part of the redevelopment and upgrade of the Onslow Airport (ENV, 2012). The area surveyed covers a portion of terrestrial habitat within the proposed DMMA which is shown in **Figure 4-3**. The entire site was composed entirely of the *Acacia* and *Triodia* species fauna habitat type described in ENV (2011).

A total of 18 vertebrate species was recorded during the field survey, comprising 17 bird species and one mammal species. The most commonly observed birds were species typical of grassland or low shrubland throughout the Pilbara and much of arid Australia including the Crimson Chat (*Epthianura tricolor*), Zebra Finch (*Taeniopygia guttata*), Rufous Songlark (*Cincloramphus mathewsi*) and Singing Bushlark (*Mirafra cantillans*). Scats of the Euro (*Macropus robustus*) were also recorded.

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[10] Removed from listing since survey undertaken

[11] Recognised as *Pandion haliaetus* for some conservation listings (i.e. WA)

The study recorded one conservation significant bird species the Rainbow Bee-eater (*Merops ornatus*). Previous recorded surveys in the study area identified potential habitat for the skink (*Lerista planiventralis* subsp. *maryani*) (P1) and short-tailed mouse (*Leggadina lakedownensis*) (P4).

5.2.6. Subterranean fauna

Subterranean fauna lives below the surface of the earth for their entire life cycle and include:

- stygofauna – aquatic and living in groundwater; and
- troglofauna – air-breathing and living in caves and voids.

Western Australia's subterranean fauna is globally significant due to high species richness and high levels of endemism. Knowledge of subterranean fauna has increased in recent years, however, there are still many knowledge gaps and new species are regularly discovered. Geology known to support stygofauna include calcretes; alluvial formations, particularly when associated with alluvial or palaeochannel aquifers; fractured rock aquifers, and karst limestone (EPA, 2016e). Troglofauna are likely to be present in karst, channel iron deposits, banded iron formations, alluvium/colluviums in valley-fill areas, and weathered or fractured sandstone (EPA 2016e).

No subterranean fauna records were returned in the database searches during the desktop assessment. A survey for subterranean fauna was undertaken for the Wheatstone Project area (Biota, 2010d). No troglofauna were collected from 30 groundwater bores over a three-phase field sampling program. Two stygofauna taxa, the copepod *Phyllopodosyllus thiebaudi* and oligochaete worm Enchitraeidae sp. 1 were collected at low frequency from only two locations. The copepod was collected near the beach consistent with the marine lineage of this genus and is a widespread species. The oligochaete worm occurs in sand aquifers and other saturated lithology with small-scale interstices and it is unlikely that this taxon is restricted to the study area (Biota, 2010d).

5.2.7. Field Survey Results

Beach & Dunes

The Beach habitat provides a simple habitat which is vital for a small range of resident beach dwelling fauna such as ghost crabs from the subfamily Ocypodinae, as well as visiting and migratory bird species which were not observed during this survey. Resident bird species may include the Eastern Osprey (*Pandion cristatus*), Australian Pied Oystercatcher (*Haematopus longirostris*), Red-capped Plover (*Charadrius ruficapillus*). The dunes above the beach may provide some habitat for reptiles, although low cover is unlikely to represent valuable habitat.

Bamford et al (2009) recorded locally high concentrations of migratory waterbirds during surveys of Onslow Town Beach on the west facing beach towards Beadon Point. It was suggested this area of Town Beach was favoured by waterbirds due to the low tidal flats being composed of fine silts and muds containing higher invertebrate abundance when compared to coarser sand fractions along other areas of the coastline. The reef flat at Beadon Point also provides suitable habitat for water bird species to forage and roost during low tides. The lower tidal area of the beach to the west of the entrance to Beadon Creek is predominantly composed of sand fractions and the area is highly modified. The beach is accreting due to the training wall interrupting the natural easterly littoral drift and the area previously being used as a historical DMMA.

Typical views of the beach and dune fauna habitat is provided in **Plate 5-1** and **Plate 5-2**.

Shrubland of Acacia species over Hummock grassland

The dominant habitat within the proposed OMSB Project area is relatively simple with little structure or variety. This habitat occurs on coastal dunes behind the beach and inland dunes behind the LIA out to the airport. The dense Triodia cover provides potentially good habitat for reptiles, and possibly some small birds and mammals, but generally relatively few fauna can utilise this habitat. Above the beach there were occasional stands of *Casuarina* to about 10 m in height which can be avoided along the pipeline route. Small stands of open *Acacia* shrubs to about 5 m in height were also recorded along the edge of the beach and in the upper dune system behind the LIA. However, trees were generally absent through most of the study area. The scarcity of trees means that there are very few or no hollows, few logs, little decorticating (loose) bark and greatly simplified roosts and nesting opportunities for birds. Consequently, the avifauna is highly generalised consisting predominantly of common and widespread grassland and woodland species which occur throughout much of arid Australia. In contrast, the reptile fauna is probably quite diverse and includes some regional endemics such as *Lerista onsloviana*. The provision of artificial water sources, as well as tree plantings and open fields around discovery park and Beadon Creek Road has attracted some species such as the Magpielark (*Grallina cyanoleuca*), Little Corella (*Cacatua sanguinea*) and Green Tree Frog (*Litoria caerulea*).

Typical views of the Shrubland of *Acacia* species over Hummock grassland fauna habitat are provided from **Plate 5-3** to **Plate 5-5**.

Samphire Claypan

Terrestrial fauna habitat of the samphire community at the base of the open stormwater drain is expected to be limited in fauna abundance and diversity due to the high saline soils, limited structure and cover provided from small samphire shrubs and degraded nature of the habitat. Biota, (2010b) recorded limited faunal associations in samphire communities throughout the Wheatstone area compared to totals recorded from all habitat types, including no amphibians, one lizard species (*Ctenophorus nuchalis*), seven of 60 bird species and one mammal. These samphire areas were generally much greater in extent, cover and complexity than the stormwater drain, likely associated with the stochastic nature of flooding events for the community. The samphire cover and complexity of the small site is typically low (**Plate 5-6**). These sites are considered inhospitable environments for many species due to very little protection and low prey availability (Biota, 2013). Typical view of the Samphire Claypan fauna habitat is provided in **Plate 5-6**.

Mangrove

Mangrove intertidal systems provide habitat to a range of vertebrate and invertebrate fauna. This includes guilds of bird and bat species which are largely restricted to mangal and associated habitats (Hutchings, 1982, Johnson, 1990). The wide range of marine invertebrate fauna associated with mangrove habitats are discussed in **Section 3.1.4**.

A dedicated mangrove fauna study was not completed as part of the current survey. However, field avifauna data has previously been collected by (Biota, 2010b) near the Wheatstone area, Halpern Glick and Maunsell (HGM, 1998) in the mangrove forests of nearby Middle Creek, and LeProvost (1991) recorded avifauna from mangrove habitats in the Onslow-Ashburton delta. In addition, Johnstone (1990) undertook a regional scale survey which included sites near Onslow. These data allow potential fauna in mangroves near the OMSB Project site to be characterised. Nine species of mangrove birds have been recorded in *Avicennia marina* dominated mangrove habitats: Mangrove Heron (*Butroides striatus*), Bar-shouldered Dove (*Geopelia humeralis*), Mangrove Kingfisher (*Halcyon chloris*), Mangrove Golden Whistler (*Pachycephala melanura*), White-breasted Whistler (*Pachycephala lanioides*), Mangrove Grey Fantail (*Rhiphidura phasiana*), Dusky Gerygone (*Gerygone tenebrosa*), Yellow White-eye (*Zosterops luteus*) and White-breasted Wood Swallow (*Artamus leucorhynchus*). Few other terrestrial vertebrates routinely occur in mangrove habitats in the Onslow region. Other species may include the Long-nosed Water Dragon (*Lophagnathus longirostris*) and the Priority 1 listed Northern Free-tail Bat *Mormopterus loriae coburgensis*. Marine reptiles such as the hydrophiid snakes *Ephalophis greyae* and *Hydrolaps darwineinsis* are also likely to be present (Biota, 2010b).

Plate 5-1 Sandy sediments on low tide near the beach at the mouth of Beadon Creek. Recorded during dewatering of the dredge spoil disposed at the beach during maintenance dredging of Beadon Creek in 2012 (BMT JFA 2013)

Plate 5-2 Accreting beach along the training wall

Plate 5-3 Isolated stands of Casuarina trees behind the beach

Plate 5-4 Stands of open *Acacia* shrubs to about 5 m in height along the back dune of the LIA

Plate 5-5 Dense hummock and tussock grasslands on low lying dune system out to the airport with trees absent

Plate 5-6 Samphire community of the open stormwater drain showing low cover and complexity of *Tectornia* spp.

5.2.8. Habitat Mapping

Extensive flora and vegetation survey work completed in the Onslow area was reviewed in a detailed desktop assessment of the OMSB Project area and field ground-truth survey was undertaken (see **Section 4.4.1**). This allowed fauna habitat types to be extrapolated and mapped within this section of the OMSB Project area with reasonable confidence. The distribution of fauna habitats has been mapped from the shoreline along the proposed terrestrial pipeline route Option A to the DMMA near the airport approximately 3 km south of Onslow as shown in **Figure 5-1**. An alternative pipeline route (Option B) has been proposed which tracks Beadon Creek and the western arm tributary crossing the intertidal flats overlying only a small portion of terrestrial vegetation. The pipeline route options are presented in **Figure 1-1**.

The map has been produced from blending the results of previous Flora, Vegetation and Fauna Assessments (ENV 2011, 2012) and results from the current field survey. These habitats broadly correspond to the vegetation units described in **Section 4.4.2**. Four fauna habitats are described:

1. Shrubland of Acacia species over Hummock grassland;
2. Mangrove communities;
3. Samphire claypan; and
4. Beach & Dunes.

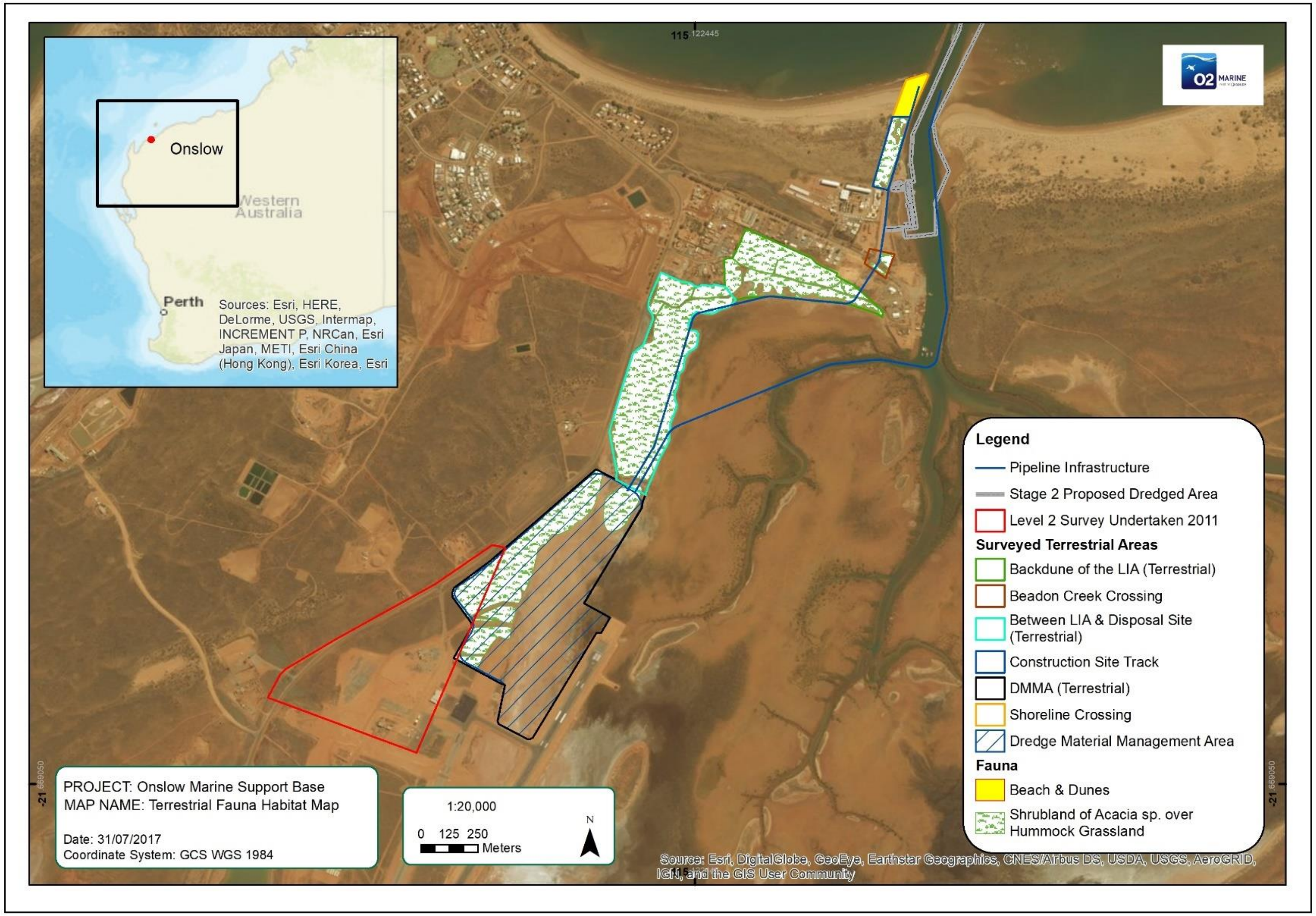

Figure 5-1 **Fauna habitats of the OMSB Project area**

5.2.9. Desktop Investigation Summary

Potentially occurring threatened fauna species are listed in **Appendix D** with an account of their likelihood of presence within the study area. Not all the threatened species identified through the desktop investigations are expected to occur within the study area due to the absence of suitable habitat for some species. **Table 5-2** lists the threatened fauna species that are at least 'moderately' likely to occur within or immediately adjacent to the study area according to the definitions in **Section 5.1.1**. **Table 5-3** lists migratory birds protected under the EPBC Act returned in database records.

Table 5-2 Conservation significant species likely to occur within the project area

Species Name	Common Name	EPBC Act Status	WC Act Status	IUCN Status
Calidris canutus	Red Knot, Knot	E, MW, Ma	IA (& VU at subsp. level)	LC
Calidris ferruginea	Curlew Sandpiper	CE, MW, Ma	VU & IA	LC
Calidris tenuirostris	Great Knot	CE, M, Ma	VU & IA	EN
Charadrius leschenaultii	Greater Sand Plover	V, M, Ma	IA (& VU at subsp. level)	LC
Charadrius mongolus	Lesser Sand Plover	E, M, Ma	EN & IA	LC
Falco peregrinus	Peregrine Falcon	-	OS	LC
Limosa lapponica	Bar-tailed Godwit	Ma, M V (*Limosa lapponica bauera*) CE (*Limosa lapponica menzbieri*)	IA (& VU at subsp. level)	NT
Numenius madagascariensis	Eastern Curlew	CE, M, Ma	VU & IA	EN
Tringa brevipes	Grey-tailed Tattler	M, Ma	IA & P4	NT
Dasyurus hallucatus	Northern Quoll	E	EN	EN
Leggadina lakedownensis	Lakeland Downs Short-tailed Mouse, Kerakenga	-	P4	LC
Mormopterus loriae cobourgensis	Little Northern Freetail-bat	-	1	LC
Lerista planiventralis subsp. maryani	Keeled Slider (NW coast Onslow to Barradale)	-	P1	-

- EPBC Act (species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*): Ex = Extinct, CE = Critically Endangered, E = Endangered, V = Vulnerable, M = Migratory, MM = Migratory Marine, MT = Migratory Terrestrial, MW = Migratory Wetlands, Ma = Listed Marine
- WC Act (species listed under the Western Australian *Wildlife Conservation Act 1950*):
  - Threatened Species: EX = Presumed Extinct, CR = Critically Endangered, EN = Endangered, VU = Vulnerable, IA = Migratory birds protected under an International Agreement, CD = Conservation Dependent, OS = Other Specially Protected
  - Priority Species: P1 = Priority 1, P2 = Priority 2, P3 = Priority 3, P4 = Priority 4
- IUCN (species listed under the International Union for Conservation of Nature (IUCN) Red List of Threatened Species): EX = Extinct, EW = Extinct in the Wild, CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern

Table 5-3 Migratory species protected under the EPBC Act returned in database records

Species	Common Name	EPBC Act Status	WC Act Status	IUCN
Actitis hypoleucos	Common Sandpiper	MW, Ma	IA	LC
Apus pacificus	Fork-tailed Swift	MM, Ma	IA	LC
Ardea modesta	Eastern Great Egret	M	IA	LC
Arenaria interpres	Ruddy Turnstone	M, Ma	IA	LC
Calidris acuminata	Sharp-tailed Sandpiper	MW, Ma	IA	LC
Calidris alba	Sanderling	M, Ma	IA	LC
Calidris ruficollis	Red-necked Stint	M, Ma	IA	LC
Chlidonias leucopterus	white-winged black tern, white-winged tern	M, Ma	IA	LC
Egretta sarca	Easter reef Egret	M, Ma	-	LC
Gelochelidon nilotica	Gull-billed Tern	M	IA	LC
Glareola maldivarum	Oriental Pratincole	MW, Ma	IA	LC
Hydroprogne caspia	Caspian Tern	M, Ma	IA	LC
Merops ornatus	Rainbow Bee-eater	M, Ma	IA	LC
Numenius minutus	Little Curlew	M, Ma	IA	LC
Numenius phaeopus	Whimbrel	M, Ma	IA	LC
Oceanites oceanicus	Wilson's Storm Petrel	M, Ma	IA	LC
Pandion haliaetus	Osprey (includes *Pandion cristatus* Eastern Osprey)	MW, Ma		LC
Pluvialis fulva	Pacific Golden Plover	M, Ma	IA	LC
Pluvialis squatarola	Grey Plover	M, Ma	IA	LC
Puffinus pacificus	Wedge-tailed Shearwater	M, Ma	IA	LC
Sterna albifrons	Little Tern	M, Ma	IA	LC
Sterna bengalensis	Lesser Crested Tern	Ma	-	LC
Sterna bergii	Crested Tern	M, Ma	-	LC
Sterna dougallii	Roseate Tern	M, Ma	IA	LC
Sterna hirundo	Common Tern	M, Ma	IA	LC
Tringa glareola	Wood Sandpiper	M	IA	LC
Tringa hypoleucos	Common Sandpiper	M, Ma	IA	LC
Tringa nebularia	Common Greenshank, Greenshank	MW, Ma	IA	LC

- EPBC Act (species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*): Ex = Extinct, CE = Critically Endangered, E = Endangered, V = Vulnerable, M = Migratory, MM = Migratory Marine, MT = Migratory Terrestrial, MW = Migratory Wetlands, Ma = Listed Marine
- WC Act (species listed under the Western Australian *Wildlife Conservation Act 1950*):
  - Threatened Species: EX = Presumed Extinct, CR = Critically Endangered, EN = Endangered, VU = Vulnerable, IA = Migratory birds protected under an International Agreement, CD = Conservation Dependent, OS = Other Specially Protected
  - Priority Species: P1 = Priority 1, P2 = Priority 2, P3 = Priority 3, P4 = Priority 4
- IUCN (species listed under the International Union for Conservation of Nature (IUCN) Red List of Threatened Species): EX = Extinct, EW = Extinct in the Wild, CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern

5.3. Risk/Significance of Project Activities

Ecological Communities

None of the habitats present in the OMSB Project area are listed as TECs. However, the small area (<0.1 ha) of "degraded" claypan comprised of samphire shrubland found within the open stormwater drain at the convergence point between the pipeline and the DMMA may be considered an 'ecosystem at risk' within the Cape Range subregion (Kendrick and Mau 2002). The potential impacts to samphire communities of the claypan shrubland of the open stormwater drain are discussed in **Section 4.5.1**. This habitat is expected to provide an inhospitable environment for many species due to offering very little protection and prey availability and any disturbance of this area is therefore not likely to represent a significant impact on faunal communities.

Similarly, mangrove communities lining Beadon Creek may be considered 'ecosystems at risk' within the Roebourne subregion (Kendrick & Stanley 2001). The potential impacts to mangrove communities lining Beadon Creek are discussed in **Section 2.5.2**. Bird and bat species restricted to mangrove habitats are generally a subset of the more diverse mangrove fauna present in the Kimberley. The potential impacts to mangroves from OMSB Project activities is unlikely to have significant effect on the populations of mangrove dependant fauna. The potential impacts to mangrove dedicated fauna may be reduced through the selection of unvegetated areas along the Beadon Creek tributary for the crossing of the Option B pipeline and inspection of any mangrove trees prior to removal.

The beach and dune system and the dominant fauna habitat in the OMSB Project area, shrubland of *Acacia* species over Hummock grassland, provides simple habitat given a moderate habitat value. The beach is classified as moderate due to the abundance of waterbird species that may utilise this area. The primary areas of importance for migratory bird species appears to be located near Beadon Point. A pipeline across the beach is unlikely to significantly affect the populations of birds using Town Beach. A total of 0.2 ha of *Acacia* shrubland over hummock grassland will be disturbed for pipeline Option A, <0.1 ha for pipeline Option B and 14.6 ha for the DMMA. Potential impacts on fauna from pipeline Option A may be minimised through selection an optimised route which utilises the roads, tracks and highly disturbed areas to the DMMA and minimising the need to clear the vegetation.

Due to the small area which could potentially be affected by the proposed activities and the widespread local and regional representation of these habitats, any potential impacts from OMSB Project activities is not considered to be of elevated conservation significance.

Species Diversity

Finding from the desktop review indicates the terrestrial fauna within the vicinity of the OMSB Project area are essentially equivalent to those previously surveyed from the Wheatstone area, although were typically recorded at lower diversity. The results from the habitat fauna associations recorded from Wheatstone are therefore considered relevant to the OMSB Project area and in conjunction with database searches, this information provides a broad understanding of the likely fauna to occur. Review of fauna species likely to occur within the OMSB Project area potentially impacted by the proposed activities include a small number of amphibian, reptiles and mammal species, and a comparably high number of bird species which includes resident and migratory species. The proposed development is not expected to significantly affect populations of fauna species in the area as only a small proportion of local habitat suitable for the taxa would be cleared relative to the distribution of that habitat and fauna species in the wider region.

Potential impacts on subterranean fauna are expected to be negligible. No subterranean fauna records were returned in the database searches, no troglofauna were collected from surveys undertaken at the Wheatstone site and two stygofauna species with widespread distributions were recorded from only two locations. Therefore, a diverse or significant subterranean community is unlikely to occur in the study area or in the immediate surrounds.

Conservation Significant Species

There is potential for habitat or individuals of 41 conservation significant species to occur within or immediately adjacent to the OMSB Project area. A total of 13 threatened terrestrial fauna species are at least 'moderately' likely to occur within or immediately adjacent to the OMSB Project area. This list includes 9 species of birds, 8 of which are listed as migratory, and another 28 migratory listed birds have been previously recorded in the area.

The proposed development is not expected to affect the conservation status of Migratory species, as only a small proportion of local habitat suitable for the taxa would be cleared relative to their distribution in the wider region (Biota 2010d). Additionally, migratory waterbirds are known to feed and roost close to industrial areas in many parts of the world, and appear unaffected by lights, noise and other human interaction. Previous projects where significant land-based reclamation has occurred (Gladstone, Brisbane, Fremantle and Port Hedland) would indicate the creation of large reclamation ponds and flooded expansive tidal flats, where material is placed by pumping of a slurry, has the potential to attract shorebirds (feeding and roosting). It is plausible that onshore reclamation and dewatering activities onto intertidal flats will provide preferable foraging and roosting habitat for migratory species and may need to be managed during the OMSB Project duration. The Eastern Reef Egret and Rainbow Bee-eater probably breed locally (ENV 2011). Habitat containing any breeding colonies is likely to be absent from the study area.

The state listed Specially Protected Peregrine Falcon (*Falco peregrinus*) is the only non-migratory bird species 'moderately' likely to occur within or immediately adjacent to the OMSB Project area, possibly within the home range of this species from other locations. Peregrine Falcons prefer cliff faces as nesting sites and a lack of cliffs in the Project area indicates no potential impacts on this species would be expected.

The list of threatened terrestrial species 'moderately' likely to occur within or immediately adjacent to the OMSB Project area includes one reptile, the Keeled Slider (*Lerista planiventralis* subsp. *Maryani*), and three mammals: Northern Quoll (*Dasyurus hallucatus*), Lakeland Downs Short-tailed Mouse, (*Leggadina lakedownensis*) and the Little Northern Freetail-bat (*Mormopterus loriae cobourgensis*).

- Keeled Slider (*Lerista planiventralis* subsp. *Maryani*): The Keeled Slider (State: P1) may potentially occur within the sand of the coastal or inland dunes within the Project area. The P1 state listing for this species recognises that there is very little known for this species. The Keeled Slider is only known to occur within coastal and inland dune sands between Onslow and Barridale. Only a very small proportion of possible habitat would be cleared for the OMSB Project so potential impacts are minimal and temporary.
- Northern Quoll (*Dasyurus hallucatus*): An unconfirmed record for the Northern Quoll (State/Federal: Endangered) was considered moderately likely to occur. The ALA shows the species distribution between Onslow and Marble Bar, then a second distribution above Fitzroy Crossing (Biota, 2010b). Although it is described from a range of habitats, it generally requires some form of rocky area, usually of high relief or rugged and dissected, or within trees, logs or termite mounds for denning purposes. This habitat is not typical of the OMSB Project area. Biota (2013) report that none of the core land systems in which this species occurs in the bioregion are present in the study area.
- Short-tailed Mouse, (*Leggadina lakedownensis*): The Short-tailed Mouse (State: P4) occurs across northern Australia and one population exists on Thevenard Island and Serrurier Island. Since 1977, the number of records for this species has increased substantially such that now it has now been reported from Exmouth Gulf to Cape York. Only a very small proportion of possible habitat would be cleared for the OMSB Project so potential impacts are minimal and temporary.

- Little Northern Freetail-Bat (*Mormopterus loriae cobourgensis*): The Little Northern Free-tailed Bat (State: P1) was recorded via echolocation calls from two mangrove locations from the Wheatstone Project area. This species may occur within mangrove communities of Beadon Creek. It is more widely distributed from Exmouth Gulf to Derby. Only a very small proportion of possible habitat may be cleared for the OMSB Project so potential impacts are likely to be minimal and temporary.

The proposed pipeline route is unlikely to impact habitat of conservation significant species if clearing of native vegetation is minimised through orientating the pipeline along existing roads, tracks and highly disturbed areas adjacent to roads and tracks. Potential risks to the Little Northern Freetail-Bat would be reduced if disturbance of mangrove trees was minimised.

5.4. Management/Mitigation Measures for Terrestrial Fauna

We recommend:

- Obtain clearing permits where vegetation must be cleared, if required pending the outcome of Part IV assessment;
- Maximising the use of disturbed areas and minimising the footprint of works to be conducted within vegetated areas or intertidal flats, including minimising temporary disturbance areas during construction;
- Avoid areas, where possible, identified with a higher condition rating and with high biodiversity (such as the high dune at the back of the LIA); and
- Engage a suitably qualified and licensed fauna spotter/catcher during proposed clearing works to undertake a pre-clearance survey.

Consider:

- Avoiding works during habitat use by migratory species (i.e. Onslow Town beach and intertidal flats during late summer); and
- Individuals may be encountered during construction and fauna interactions may be managed through use of a spotter catcher.

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Appendix A Subtidal Field Assessment Notes

Appendix B Dredge Plume Impact Assessment

Appendix C Database Searches

Appendix F Assessing the Potential Impacts on Sawfish