Ocean Barramundi Expansion Project - Section 38 Referral Supporting Report

Customer	Tassal
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Executive Summary

Introduction

Tassal Operations Pty Ltd (TOPL; referred to as Tassal hereafter) is proposing to implement an expansion of its current ocean barramundi farming operations in Cone Bay, West Kimberley to the broader Buccaneer Archipelago, (the Proposal, see Figure 1). This expansion will allow Tassal to increase allowable annual production from 15,000 tonnes per annum, as currently approved for operations within the boundary of the Kimberley Aquaculture Development Zone (KADZ), to 17,500 tonnes per annum, to be dispersed beyond the KADZ across the broader Buccaneer Archipelago. The Proposal will help meet anticipated demand in the supply of high-quality barramundi across state, national and international markets.

Tassal has referred this Proposal to the Western Australia (WA) Environmental Protection Authority (EPA) under Part IV (Section 38) of the *Environmental Protection Act 1986 (WA)* (EP Act), as a Proposal that has potential to have a significant impact on the environment.

The preliminary key environmental factors relevant to the Proposal include:

- Marine Environmental Quality;
- Benthic Communities and Habitats;
- Marine Fauna;
- Social Surroundings.

After initial review of the Proposal and its supporting documentation, the EPA submitted a formal Request for Additional Information under Section 40(2)(a) of the EP Act on the 6th October 2022, requesting that Tassal submit additional information in the form of a revised Section 38 Referral Supporting Document (this document).

Previously, Tassal's Proposal also included the establishment of three land-based nurseries on the Dampier Peninsula. These have since been removed from the Proposal under Section 43(a) of the EP Act. All reference to these nurseries has now been removed from this referral supporting document, as well as information on EPA Environmental Factors which are no longer relevant.

Tassal has also referred the Proposal to the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW; formerly the Department of Agriculture, Water and the Environment [DAWE]) under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) as a Proposal that has potential to impact matters of national environmental significance (MNES). DCCEEW has since deemed that the Proposal was a Controlled Action, with the potential to impact on the following matters of national environmental significance (MNES):

- National heritage values of a National Heritage Place;
- Listed threatened species and communities;
- Listed migratory species; and
- Commonwealth land.

DCCEEW further determined that the Proposal would be assessed at the level of a Public Environmental Report (PER), with guidelines provided by DCCEEW to assist in preparation of the PER to allow for assessment of the proposal under the EPBC Act. Reference to Matters of National Environmental Significance (MNES) are dealt with directly by the PER (Stantec 2024a); however, a summary of pertinent information is also provided within Section 12 of this document.

Overview of Proposal

Sustainable aquaculture is a key industry to help meet the demand for protein with a growing population both nationally and internationally. In comparison to wild fisheries, sustainable aquaculture reduces fishing pressure on wild stocks, while still managing a greater yield of product for less effort. Sustainable aquaculture can also provide economic benefits through employment, infrastructure and secondary industries. Currently, the farming of barramundi (*Lates calcarifer*) is seen as a form of sustainable aquaculture in Australia, considering the species is native to the waters it is grown in and that the amount of wild caught fish needed to produce fishmeal and oil for barramundi feed is approximately equal to or less than the amount of farmed fish produced (as listed in Australia's Sustainable Seafood Guide). As such, sustainable aquaculture for barramundi in Australia is a potential area of significant growth, particularly as demand for the product increases.

Tassal (then operating as Marine Produce Australia) has operated in the KADZ in Cone Bay since 2004 under Aquaculture Licence No. 1465 which allows for production of up to 15,000 tonnes of barramundi (*Lates calcarifer*) per annum. Tassal operate 32 pens within the KADZ although current operations are not profitable, due to limitations on scale within the existing lease area. The anticipated demand for premium barramundi in both the state and national market is strong. Tassal propose to expand from its Cone Bay operations in the KADZ to seven new sites (under one aquaculture lease) spread across the Buccaneer Archipelago, to improve production and meet anticipated market demand. At the new sites, Tassal plans to produce up to 17,500 tonnes of barramundi per annum, reaching a maximum of ~4,500 tonnes per site before harvesting. Tassal furthermore plans to cease using the current Cone Bay lease once enough of the proposed sites are operational.

The expansion plan involves a shift in operations from relatively shallow to deeper, though still protected, offshore waters. The move further offshore will allow for several management changes which will result in reduced environmental impact on a per site basis. For example, by expanding to seven sites, Tassal will be able to fallow locations for a minimum of one month, whereby all fish stock are removed from sea-pens assisting in the recoverability of sediment and water quality. Sea-pens located in deeper waters will also significantly increase the flow of water across the sea-pens which further increases the dilution of waste material being excreted from the fish. The proposal essentially represents a shift in biomass from the KADZ in Cone Bay, which has a volume of ~1 km^3 (as derived from the hydrodynamic model for this Proposal), to the broader Buccaneer Archipelago, which has a volume of ~10 km^3.

The proposed expansion will be staged, with sites to be developed as and when the growing product demand makes it economical. Each stage consists of the installation of sea-pens within a site, as well as other associated infrastructure such as feed barges. The expansion will result in the direct hire of ~140 employees during operations, substantially expanding Tassal's current workforce (excluding additional hires made for construction) and providing significant economic stimulation in the region.

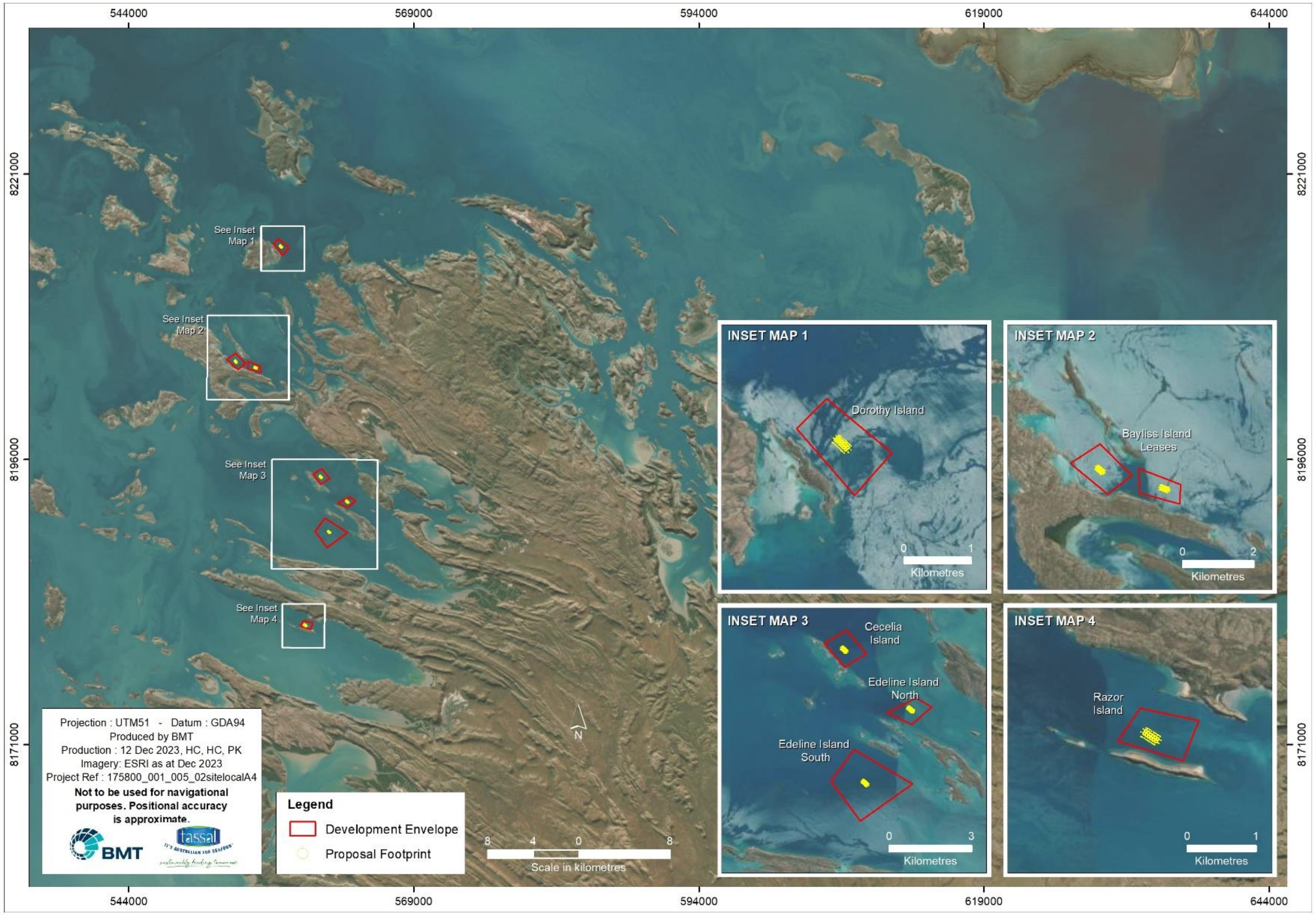


Figure 1. Proposal location

Summary of potential impacts and risks, proposed mitigation and outcomes

Technical studies completed

To assess the potential environmental impacts of the Proposal, the following technical studies were undertaken:

- Integrated hydrodynamic, water quality, particle tracking and fish waste modelling to assess the impacts of fish wastes and excess feed on marine environmental quality, benthic communities and habitats
  - Two scenarios for the Proposal were modelled; a scenario representing the most likely outcome based on the known parameters of the Proposal, and a more conservative scenario representing the worst case
- Field survey of benthic habitats present
- Desktop review of marine fauna present in the vicinity of the Proposal
- Assessment of the potential impacts of the Proposal on social surroundings
- Assessment of the potential greenhouse gas emissions created by the Proposal

These studies identified that the key risks the Proposal presents to the environment are centred on the potential for nutrient enrichment and/or deposition from finfish wastes and feed, which are assimilated into the marine environment. The first risk centres on the potential for elevated dissolved inorganic nitrogen (DIN) concentrations from farmed fish excretions, which could enhance algal growth potential. The integrated model predicted elevations of DIN concentrations to be generally constrained to the immediate vicinity of the sites under the representative scenario, with limited elevations predicted beyond the boundaries of the sites. The second risk centres on elevated phytoplankton concentrations, with the integrated model predicting minor elevations above background concentration in Cone Bay, but limited elevations elsewhere in the Buccaneer Archipelago and no observed elevations at the sites themselves. The third risk centres on the fate of particulate wastes from the sea-pens (i.e. finfish faeces and uneaten feed), where it has the potential to settle on benthic habitats and result in smothering and/or shading effects. Footprints of particulate waste were observed beyond the boundaries of the sites; however, these were generally in low concentrations that would not result in significant impacts to benthic habitats.

Though the modelling did predict some perturbations in the marine environment associated with the Proposal, it did not predict substantial impacts to receptors such as coral. In this sense, the modelling showed that there were changes in line with exceedances of the EPA's Environmental Quality Guidelines (EQG), which if not met indicate there is some uncertainty as to whether the associated environmental quality objective has been achieved. Other indicators, in-line with the EPA's Environmental Quality Standards (EQS) which if not met indicate there is a significant risk that the associated environmental quality objective has not been achieved, were not predicted to change substantially due to the introduction of Proposal activities. As such, the results overall indicate that though the Proposal may influence some aspects of the marine environment, these are not predicted to result in significant impacts to key receptors to the point that the EPA's objectives for the relevant factors would not be achieved.

With regards to impacts on Social Surroundings including consideration of Aboriginal cultural heritage, Tassal has and continue to conduct significant engagement with stakeholders, including the Mayala Inninalang Aboriginal Corporation RNTBC (MIAC) who have Native Title Determination over the entire area of the Proposal, to ensure that the Proposal avoids areas of cultural and/or environmental significance and minimises impacts to Social Surroundings. This engagement has resulted in the removal of several sites that formed part of previous iterations of the Proposal. The overarching outcome of this assessment is that impacts to Social Surroundings, in particular Aboriginal cultural heritage, will be limited, and where residual impacts exist are expected to be managed appropriately under an Environmental Monitoring and Management Plan (EMMP; Annex A).

The predicted residual impacts, following the application of the EPA's mitigation hierarchy (avoid, minimise, manage, restore, offset) are not predicted to risk the EPA's objectives for relevant key factors being maintained. Tassal's approach under the mitigation hierarchy has been primarily to shift operations from the existing shallow water environment within the KADZ in Cone Bay to a broader area across the Buccaneer Archipelago, with a redistribution of the stock load from a maximum allowable biomass of 15,000 tonnes in 1 km^3 of water to 17,500 tonnes in 10 km^3. Further mitigation techniques, such as regular fallowing of the sites after each production cycle, and improved food conversion ratios will reduce the potential environmental impacts of the proposal substantially. Though some residual risks will remain after the implementation of the mitigation hierarchy, monitoring which is commensurate with the level of risk has been prescribed within the EMMP (Annex A). The monitoring will capture any perturbations in the environment that are attributable to the Proposal and ensure management actions are taken prior to impacts occurring.

Potential impacts and risks associated with the Proposal are outlined in Table 1 for the key environmental factors. Proposed mitigation measures and predicted outcomes for each key environmental factor relevant to this Proposal are shown for each impact and/or risk. The significance of the potential environmental impacts was considered following the below definitions, as derived from EPA (2016a, b):

- Major – E.g. Results in permanent changes or long lasting (> 5 years recovery) impacts over a broad extent
- Moderate – E.g. Results in semi-permanent changes (< 5 years recovery) impacts beyond the immediate footprint
- Minor – E.g. Results in short-term changes which are immediately remedied if the pressure is removed, and are generally confined to the immediate footprint

Table 1. Summary of potential impacts and risks, proposed mitigation and outcomes

Marine Environmental Quality	
Potential impacts	Direct impacts or risks to marine environmental quality from: • Changes to hydrodynamic conditions due to sea-pen installations Indirect impacts or risks to marine environmental quality from: • Nutrient enrichment of water and sediments from fish and feed wastes, resulting in elevated phytoplankton biomasses and increased likelihood of algal blooms • Reduced light availability due to shading effects from elevated total suspended solids associated with fish and feed wastes and phytoplankton biomasses • Eutrophication potentially leading to deoxygenation of the water column and surface sediment layer • Sediment or water toxicity associated with heavy metal contamination from fish feeds, chemical therapeutants or hydrocarbon spills

Mitigation hierarchy	Avoidance: • Placement of pen infrastructure in a naturally highly energetic, well mixed environment to assist with dilution • Maintenance of stocking densities and feed inputs to minimise nutrient inputs to the local environment • Use of the best available and most sustainable feeds and feed methods that will help achieve the target food conversion ratio (FCR) and minimise feed wastage. This may include floating feed and/or sinking feed combined with underwater camera surveillance to manage feeding efficiently in response to behavioural cues • All stock will be tested for disease and vaccinated for critical pathogens prior to transfer to the sites, to avoid where possible the need for therapeutant use.
	Minimisation • Use of low-profile mooring blocks or anchors, which reduce the footprint of the anchorages on the benthos • Target a food conversion ratio (FCR) of 1.5 to reduce nutrient enrichment from excess feed • Inclusion of minimum one-month fallowing period at conclusion of the grow-out cycle to help sediments to recover • Feed management response that may include management of feeding to reduce nutrient inputs
	Management • Implementation of an Environmental Monitoring and Management Plan (EMMP) that sets management measures, monitoring, continuous improvement and corrective measures to be implemented during operations over the life of the Proposal (Annex A)
	Monitoring • Nutrient measurements at fixed distances up and downcurrent of the sea-pens • Chlorophyll-a measurements at fixed distances up and downcurrent of the sea-pens and at potentially impacted areas per the modelled results • Total suspended solids measurements at fixed distances up and downcurrent of the sea-pens • Oxygen measurements at fixed distances up and downcurrent of the sea-pens • Videos of sediment condition will be taken to confirm absence of signs of nutrient enrichment
Residual impacts, including assessment of significance	Major – Nil Moderate – Nutrient enrichment, increased phytoplankton biomasses Minor – Light reduction, deoxygenation, toxicity

Proposed environmental outcomes	Considering the mitigation strategies implemented by this proposal, and the little to no cumulative impacts from other proposals or projects, only moderate to minor localised changes to marine environmental quality are expected in the vicinity of the sites. These moderate to minor changes will be monitored and managed under the EMMP. With this monitoring, and the associated corrective actions required if exceedances of relevant triggers are recorded, it is expected that the EPA's objective for Marine Environmental Quality will be met.
Benthic communities and habitats	
Potential impacts	Direct impacts or risks on Benthic Communities and Habitats (BCH) from: • Removal from anchorages for sea-pens, barges • Shading, either from sea-pens or from elevated total suspended solids from fish and feed wastes or elevated phytoplankton biomasses • Smothering from fish and feed wastes Indirect impacts or risks on BCH from: • Nutrient enrichment of sediments • Increased epiphytic growth of algae/phase shift
Mitigation hierarchy	Avoidance • Leases have been sited to avoid BCH as much as feasible • Same avoidance measures listed under MEQ for reducing input of fish and feed wastes
	Minimisation • NA
	Management • Implementation of an EMMP (Annex A)
	Monitoring • Same monitoring requirements as listed under MEQ • Monitoring of coral health / pearl oyster beds in nearshore regions to assess potential impacts of nutrient enrichment
Residual impacts, including assessment of significance	Major – Nil Moderate – nutrient enrichment, smothering Minor – shading

Proposed environmental outcomes	Considering the mitigation strategies implemented by this proposal, and the minimal cumulative impacts from other proposals, only moderate or minor impacts to BCH are expected within the Local Assessment Units (LAU). These moderate to minor changes are for the most part on soft sediments, with a predicted impact to 5.2% of mapped coral across the defined LAUs for the Buccaneer Archipelago. Note that mapped coral habitats are limited to fringing reefs within each LAU, and as such underestimate the total coral cover of the region and is therefore a conservative estimate for impacts to coral health regionally. All relevant factors contributing to the potential impacts on BCH will be monitored under the EMMP (Annex A). With this monitoring, and the associated actions required if exceedances of relevant triggers are recorded, it is expected that the EPA's objective for BCH will be met.
Marine fauna	
Potential impacts and risks	Direct impacts or risks on marine fauna: • Vessel strike • Noise/vibration generation during sea-pen installation/operations or vessel movement • Entanglement with anchorage and/or netting • Change to natural predatory behaviour as a result of attracting prey species to the sea-pens Indirect impacts or risks on marine fauna: • Increased risk of Invasive Marine Species (IMS) introduction • Spread of disease / change to genetic structure in native barramundi populations • Increased likelihood of potentially harmful algal blooms that can pose health risks to marine fauna • Deoxygenation of the water column resulting in fauna kills • Blocking of travel routes for fauna • Light pollution, which can deter fauna from using the area or results in a change of behaviour • Fish escapes which subsequently cause a change in genetic structure of native barramundi populations or introduce diseases not currently present

Mitigation hierarchy	Avoidance • The mooring system used for the sea-pens will not require any drilling or pile-driving, reducing the potential for noise generation • Anchorage lines are kept taught to reduce the likelihood for entanglement • Vessels will only operate at reduced speeds while towing pens, and within the sites during operations, reducing the risk of vessel strikes • A mortality disposal system will be implemented which ensures dead fish are removed from pens as soon as possible • External predator or predator resistant single nets below the water and anti-bird nets above the pens prevent access to fish and fish feed from both groups of predators • Same avoidance methods for reducing phytoplankton biomasses associated with nutrient enrichment and deoxygenation as listed under MEQ
	Minimisation • Vessels used in operations will have invasive marine species checks completed regularly • Any wastes generated from staff living or working on site (i.e. at the sea-pens) will be taken back to the Derby shore-base and disposed of appropriately there • Lighting from vessels on site will be kept to a minimum, with appropriate shading over recreational or residential parts of the barge systems • Broodstock with the same Australian genetic lineage will be used to reduce the potential for changes in the genetic structure in native barramundi populations. • Same minimisation methods for reducing phytoplankton biomasses associated with nutrient enrichment and deoxygenation as listed under MEQ
	Management • Implementation of a EMMP (Annex A)
	Monitoring • DPIRD's biosecurity group will require testing of fish stock before they are transferred to the sea-pens as detailed in DPIRD's translocation policy • Same monitoring requirements for phytoplankton biomass and deoxygenation as listed under MEQ
Residual impacts, including assessment of significance	Major – Nil Moderate – Increased phytoplankton biomasses Minor – Noise/vibration production, light pollution, spread of disease/genetic structure in native barramundi populations, deoxygenation, blocking of travel routes for fauna, increased risk of IMS introduction
Proposed environmental outcomes	Considering the mitigation strategies implemented by this proposal, and the little to no cumulative impacts from other proposals or projects, no significant harm to marine fauna is expected in the vicinity of the Proposal. As such, it is expected that the EPA's objective for Marine Fauna will be met.

Social Surroundings	
Potential impacts and risks	Direct impacts or risks on social surroundings: • Disturbance of culturally significant sites • Disturbance of or impact to cultural values • Disturbance to visual amenity • Loss of access and recreational opportunities • Odour generation • Positive contribution to the local economy and job opportunities • Impacts to environmental values of marine parks or other environmentally sensitive areas • Impacts to the perception of the area being 'natural' and potential subsequent loss of tourism
Mitigation hierarchy	Avoidance • Significant stakeholder engagement has been conducted to ensure sites are located to avoid culturally significant areas
	Minimisation • Leases have been designed to be as small as possible to minimise loss of access
	Management • Implementation of an EMMP (Annex A)
	Monitoring • Tassal will provide annual information (e.g. vessel track logs) to verify vessel activity has not interacted with designated exclusion zones • Training and induction records to be kept up to date for all Tassal staff and contractors with regards to culturally appropriate behaviours
Residual impacts, including assessment of significance	Major – Nil Moderate – Nil Minor – Disturbance to culturally or environmentally significant areas
Proposed environmental outcomes	Considering the mitigation strategies implemented by this proposal, involving extensive consultation with stakeholders to inform appropriate selection of aquaculture sites to avoid areas of cultural or environmental significance, no significant harm to Aboriginal cultural heritage or natural and historic heritage locations is expected in the vicinity of the Proposal. Any indirect impacts to Aboriginal cultural heritage will be managed directly under the EMMP. As such, it is expected that the EPA's objective for Social Surroundings will be met.

Acronyms

2D	Two-dimensional
3D	Three-dimensional
AED	Aquatic Ecodynamics
AFMA	Australian Fisheries Management Authority
AHIS	Aboriginal Heritage Inquiry System
ANOVA	Analysis of Variance
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZG	Australian and New Zealand Guidelines
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BC	*Biodiversity Conservation Act*
BCH	Benthic Communities and Habitats
BOD	Biological oxygen demand
BOM	Bureau of Meteorology
BTAP	Broome Tropical Aquaculture Park
CAPEX	Capital expenditure
Chl-a	Chlorophyll-a
Cu	Copper
DAC	Dambimangari Aboriginal Corporation
DAWE	Department of Agriculture, Water and the Environment
DBCA	Department of Biodiversity, Conservation and Attractions
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DG	Dangerous Goods
DIN	Dissolved inorganic nitrogen
DO	Dissolved oxygen
DoE	Department of the Environment
DoF	Department of Fisheries
DPIPWE	Department of Primary Industries, Water and Environment
DPIRD	Department of Primary Industries and Regional Development

DPLH	Department of Planning, Lands and Heritage
DMA	Decision making authority
DWER	Department of Water and Environmental Regulation
EIA	Environmental Impact Assessment
EMMP	Environmental Monitoring and Management Plan
EPA	Environmental Protection Authority
EPBC	*Environmental Protection and Biodiversity Conservation Act*
EQC	Environmental Quality Criteria
EQG	Environmental Quality Guidelines
EQMF	Environmental Quality Management Framework
EQO	Environmental Quality Objective
EQS	Environmental Quality Standards
ERD	Environmental Review Document
EV	Environmental Values
FCR	Food conversion ratio
FRMA	*Fisheries Resources Management Act*
FRMR	*Fisheries Resources Management Regulations*
GHG	Greenhouse gas
Ha	Hectares
HDPE	High-density Polyethylene
HEPA	High Ecological Protection Area
ILUA	Indigenous land use agreement
IMS	Invasive Marine Species
ISQG	Interim Sediment Quality Guideline
KADZ	Kimberley Aquaculture Development Zone
KPA	Kimberley Ports Authority
LAU	Local Assessment Unit
LEP	Levels of Ecological Protection
MPA	Marine Produce Australia
MEMP	Management and Environmental Monitoring Plan
MEPA	Moderate Ecological Protection Area
MEQ	Marine Environmental Quality

MIAC	Mayala Inninalang Aboriginal Corporation Registered Native Title Body Corporate
MNES	Matters of National Environmental Significance
MS	Ministerial Statement
NH_4	Ammonia
NLSWE	Non-Linear Shallow Water Equations
nMDS	Non-metric multidimensional scaling
NO_x-N	Nitrate and Nitrite
NSW	New South Wales
NTD	Native Title Determination
OPEX	Operational expenditure
PAR	Photosynthetically Active Radiation
PBC	Prescribed Body Corporate
PEC	Protected Ecological Community
PERMANOVA	Permutational Analysis of Variance
PMST	Protected Matters Search Tool
PO_4-P	Ortho-phosphate
PSD	Particle size distribution
PTM	Particle Tracking Model
SI	Surface Irradiance
SPRAT	Species Profile and Threat database
tCO2	Tonnes of Carbon Dioxide
TEC	Threatened Ecological Community
TKN	Total Kjeldahl Nitrogen
TP	Total phosphorous
TOC	Total organic carbon
TSS	Total suspended solids
VSS	Volatile suspended solids
WA	Western Australia
WAMSI	Western Australian Marine Science Institute
WWTP	Wastewater Treatment Plant
ZoHI	Zone of High Impact
ZoI	Zone of Influence
ZoMI	Zone of Moderate Influence

Zn	Zinc

Contents

Tables

Figures

1 The Proposal

1.1 Overview

Tassal (then operating as Marine Produce Australia) has operated in the Kimberley Aquaculture Development Zone (KADZ) in Cone Bay since 2004 under Aquaculture Licence No. 1465 which allows for production of up to 15,000 tonnes of barramundi (*Lates calcarifer*) per annum. Tassal operate 32 pens within the KADZ although current operations are not profitable, due to limitations on scale within the existing lease area. The anticipated demand for premium barramundi in both the state and national market is strong. Tassal propose to expand from its Cone Bay operations in the KADZ to seven new sites (under one aquaculture lease) spread across the Buccaneer Archipelago, to improve production and meet market demand. At the new sites, Tassal plans to produce up to 17,500 tonnes of barramundi per annum, reaching a maximum of ~4,500 tonnes per site before harvesting. Tassal furthermore plans to cease using the current Cone Bay lease once enough of the proposed sites are operational.

The expansion plan involves a shift in operations to deeper, though still protected, offshore waters. The move further offshore will allow for several management changes which will result in reduced environmental impact on a per site basis. For example, by expanding to seven sites, Tassal will be able to fallow locations for a minimum of one month, whereby all fish stock are removed from sea-pens assisting in the recoverability of sediment and water quality. Sea-pens located in deeper waters will also significantly increase the flow of water across the sea-pens which further increases the dilution of waste material being excreted from the fish.

The proposed expansion will be staged, with sites to be developed as product demand makes it economical. Each stage consists of the set-up of sea-pens within a site, as well as other associated infrastructure such as feed barges. The expansion will result in the direct hire of more than ~140 employees during operations, substantially expanding Tassal's current workforce at Cone Bay (excluding additional hires made for construction) and providing significant economic stimulation in the region.

The purpose of this supporting document (which follows the format of an Environmental Review Document or ERD) is to provide regulatory authorities with the appropriate level of information to review the environmental impact of the proposed project. This document will describe the proposed project in detail including maps and coordinates and provide information about the receiving environment. Studies that have been completed to inform the referral include a water and sediment quality baseline, a hydrodynamic model, a particle tracking model (PTM), a sediment diagenesis model, marine habitat mapping and literature reviews for marine fauna. Furthermore, this document will discuss the key environmental factors relevant to this project and the engagement and consultation process with key stakeholders.

A former Proposal submitted by MPA, included the establishment of three land-based nurseries on the Dampier Peninsula. These have since been removed from the Proposal with a submission under Section 43(a) of the EP Act (EPA 2024).

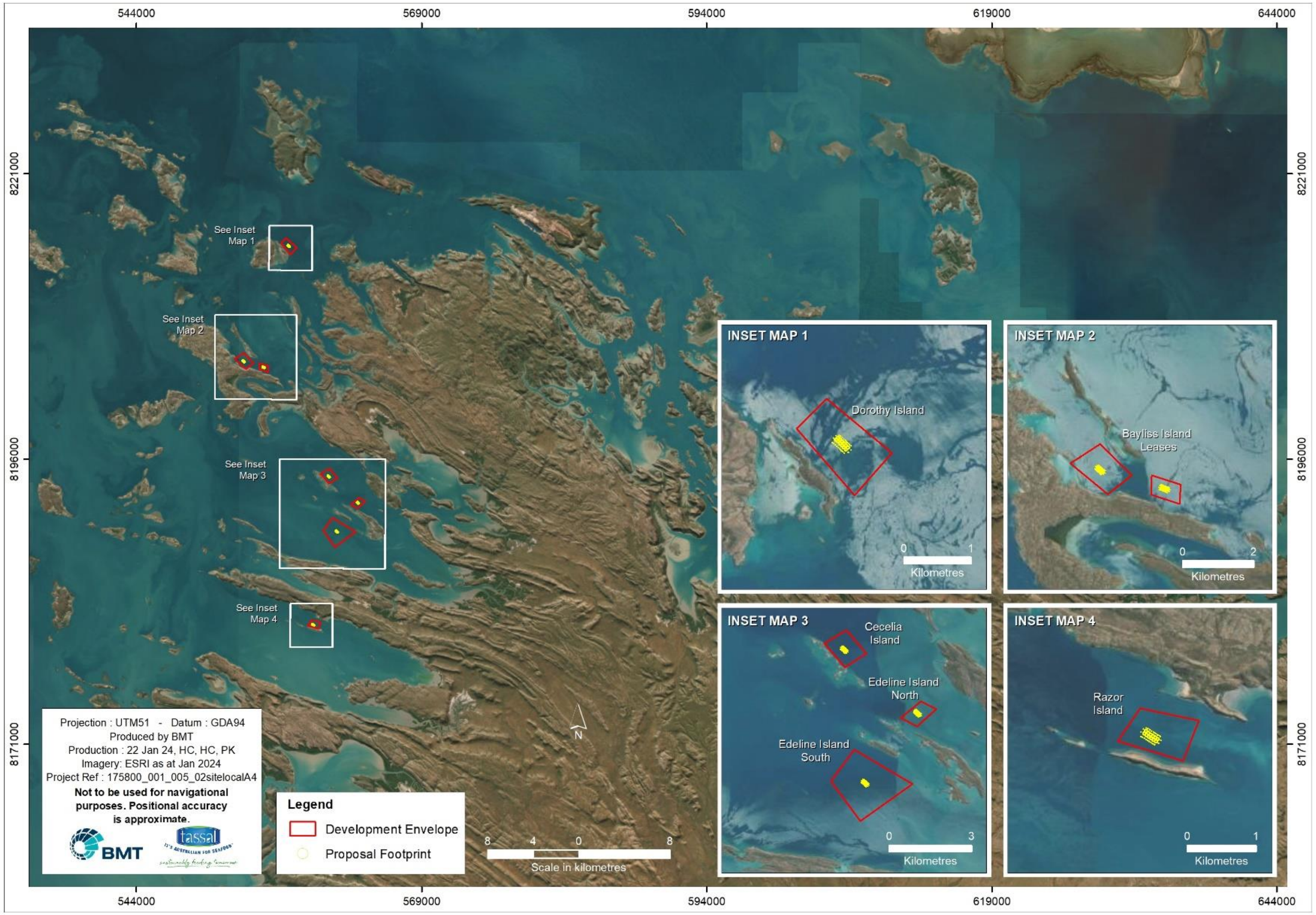


Figure 1.1 Proposal location – seven sites under one aquaculture lease

1.2 Proposal content

Table 1.1 General Proposal Content Description

Proposal Title	Ocean Barramundi Expansion Project
Proponent name	Tassal Operations Pty Ltd
Short description	Tassal (formerly Marine Produce Australia) propose to expand its barramundi farm operations to seven sites spread across the Buccaneer Archipelago, in the Kimberley region.

Table 1.2 Proposal content elements

Proposal element	Location/description	Maximum extent, capacity, or range
Physical elements		
Sea-pen Infrastructure Development Envelope: 7 separate sites each consisting of either 84 12 x 120 m pens (12 per site), or 140 x 80 m pens (20 per site), all managed under a single aquaculture lease provided by DPIRD	Figure 1.1	Direct disturbance of 0.12 ha within the Sea-Pen Development Envelope due to placement of anchors. Development envelope (total extent of proposed sites) within which temporary disturbance of benthic environment via indirect effects is expected – 817 ha
Operational elements		
Sea-pen fish production	Figure 1.1	Maximum standing biomasses of ~4,500 tonnes per site (consisting of 7 separate sites under a single aquaculture lease). Expected maximum total annual production/standing biomass of 17,500 tonnes across all 7 sites once they are fully operational (leases will not all be stocked at maximum standing biomass at any one time).
Greenhouse gas emissions		
Construction		
Scope 1	Construction vessel usage – 53 tCO2-e total	
Scope 2	None	
Operations		
Scope 1	Operational vessel usage per farm – 859 tCO2-e annual total and 6,012 $tCO2_e$ across 7 farms	
Scope 2	None	
Rehabilitation		

Proposal element	Location/description	Maximum extent, capacity, or range
NA		
Commissioning		
NA		
Decommissioning		
Removal and dismantling of all sea-pens, anchorages, and vessels if aquaculture operations are discontinued. Decommissioning of aquaculture sites, if not undertaken by the lease holder, is completed by DPIRD, with any costs incurred recouped through legal means if necessary (pursuant to the relevant provisions of the *Fisheries Resources Management Act (FRMA)* and the Fish Resources Management Regulations 1995 (FRMR)).		
Other elements which affect extent of effects on the environment		
Proposal time	Maximum project life	>42 years (each site is continued if the proponent complies with the licence and lease conditions)
	Construction phase	Total 10-year construction timeline (intermittently over that period as each site comes online – actual pens once constructed offsite only take two-three days to install onsite).
	Operations phase	>42 years (each site is continued if the proponent complies with the licence and lease conditions)
	Decommissioning phase	~6 months if operations are discontinued

1.3 Major Project components

It should be noted that the current Cone Bay lease run by Tassal is not part of this application and has previously been approved under separate approvals summarised in Section 2. Tassal furthermore plans to cease using the current Cone Bay lease once enough of the proposed sites are operational. Tassal also currently operate a nursery at the Broome Tropical Aquaculture Park (BTAP), which supplies the fingerlings that are subsequently grown-out at the sea-pens. However, this nursery does not fall under this Proposal.

1.4 Construction and commissioning

1.4.1 Sea-pen Infrastructure

Tassal will deploy large sea-pens developed for use in extreme weather conditions and remote locations. These pens and their associated anchorage/mooring systems have been specifically designed for use in high energy exposed sites, which frequently receive storm swells and gale force winds. The use of similar, albeit smaller, pens in Cone Bay indicates that they are sufficiently capable of tolerating cyclone force winds and the high current speeds induced by the extreme tidal exchanges in the Kimberley region.

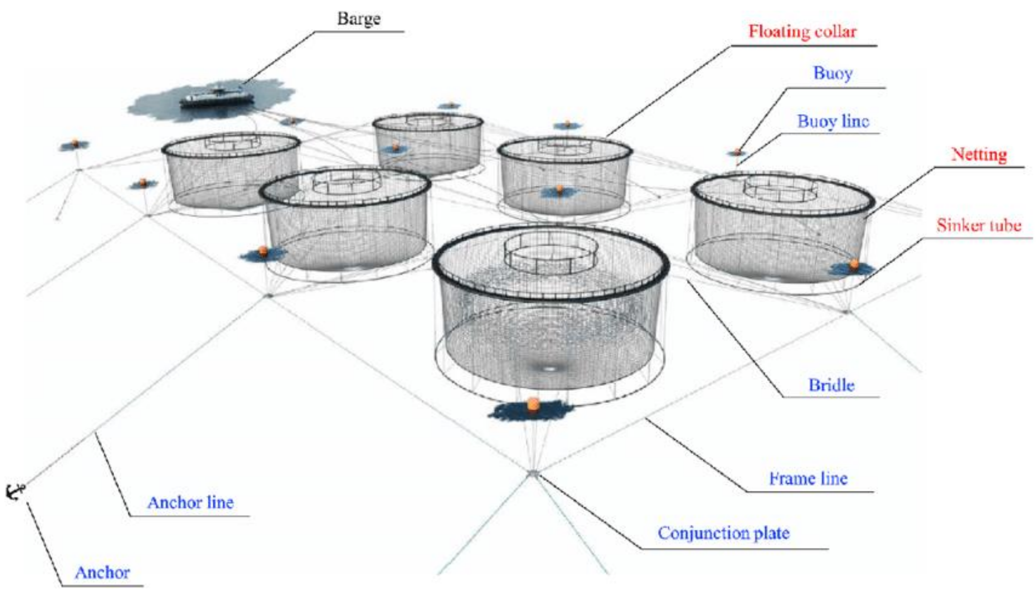
Design features of the proposed sea-pens include:

- Either
  - A double net system that contains fish stock within the inner net and an outer anti-predator net that protects stock from marine predators like sharks and crocodiles.

    - Two kinds of inner net would be used, one for fingerlings and one for the grow out of adult barramundi. All net types are made from either monofilament or polyline high density polyethylene (HDPE).
        - The inner net for the fingerlings has a minimum breaking strain of 260 kg on the knot (the breaking strain is greater on the mesh then directly on the knot), the inner net for grow out has a breaking strain of 260 kg, and the outer predator net a breaking strain of 600 kg. The nets will be sufficient to prevent damage from predators known to be present in the area (e.g. crocodiles, tawny nurse sharks)
        - The mesh sizes for each net type also vary. The mesh ‘gap’ (i.e. size of the gap in the netting as measured on the ‘bar’ of the netting i.e. sides of a single mesh square) for the grow-out range from 10-35 mm and for the predator outer net it ranges from 80-150 mm.
        - The break between the inner and outer predator netting has also increased significantly between operations at Cone Bay and the operations planned for the expansion
    - OR
        - A single net system with a minimum breaking strain of 600 kg, which is still a considerable increase in net strength in comparison to the current net system. The advantage of a single net system is reduced infrastructure in the water as well as better current flow through the sea-pens, which will assist in maintaining concentrations of dissolved oxygen within the sea-pens and subsequently maintaining fish health and reducing overall environmental impacts
- Surface netting with support poles which prevent access to fish stock or feed within the pens from seabirds.
- Covered walkway with handrails and staff access/egress points to allow staff to access the pens safely without coming into contact with predators (Figure 1.2).

These pen specifications are detailed in a Fish Containment Plan (Tassal 2024).

The pens to be used by Tassal will range in size from 40 to 120 m circumference, with net depths ranging between 5 to 25 m for the nets. The extra depth and circumference of the pens results in a lower stocking density and increased dissolved oxygen concentrations within the pen. The larger nets also lessen total farm infrastructure by reducing the required number of pens and moorings. Low-profile anchors will be used to anchor sea-pens in soft sediments meaning no drilling or pile driving is required.



Source: Cheng et al. (2021)

Figure 1.2 Indicative sea-pen configuration and anchoring

1.4.2 Sea-pen installation

Sea-pens are to be towed to the respective site without netting in place (minimising drag and potential for impacts on transient marine fauna) at a speed of <5 knots. Once on site, each of the sea-pens will be secured together in the manner indicated in Figure 1.2. Low-profile anchors used to secure the sea-pens will be fixed into the seabed when dropped from a vessel, without any requirement for pile driving or other drilling. Testing will be conducted at this time to ensure that the sea-pens are secure. Once the sea-pens are secure, both the inner (for the farmed fish) and outer (excluding predators) netting will be installed by divers. Surface netting, which is used to exclude sea-birds, will also be installed at this time. Once all infrastructure is in place, safety and navigational lighting will be installed to indicate the presence of the sea-pens in the water to any mariners moving through the area. It is expected that the installation of 12 sea-pens at a site will take between 3-5 days (weather dependent) once each sea-pen is present. The towing of the sea-pens will likely take up to 7 days to manoeuvre all sea-pens in place at the respective site.

1.5 Operations

1.5.1 Cultured Species

Barramundi (*L. calcifer*) are the sole species to be grown under this Proposal. Barramundi have been grown at the current Cone Bay site since 2004 and are a key finfish aquaculture species in Australia with total production second only to Atlantic salmon (*Salmo salar*). Barramundi is also a keenly sought after target species for recreational fishers across the north of Australia.

Barramundi live in both freshwater and saltwater and grow up to 200 cm in length and 60 kgs in weight. They are distributed throughout coastal waters in northern Australia. With a significant tolerance for a wide range of environmental conditions as well as a broad diet they make an ideal species for aquaculture production.

1.5.2 Derby shore-base

Tassal currently operate a shore base in Derby, from which all staff, equipment and other relevant materials (e.g. feed) are transferred to the proposed sites. No changes to the scale or operations at the shore base are proposed, therefore it is not part of this Proposal. Its relevance to this proposal is that it will be the source of all materials and equipment as well as offices for Tassal from which the proposed expansion will be managed.

All stock for sale will be transported to the Derby shore base from which it will enter the distribution network, for sale both nationally and internationally. Staff, feed, and fuel will be transported to the sea-pens via these same facilities. The transport of the material will be via the Port of Derby, which is managed directly by the Kimberley Port Authority, who have authority over the movement of vessels into and out of the Port. The Derby shore base is not an element of this Proposal noting no changes to its current set-up or usage will be required for the Proposal.

1.5.3 Sea-pen operations

Centralised barge system/operational vessels

Each site will be controlled from a centralised barge containing a feed system, accommodation (3-4 staff on site at any given time), ablution facilities as well as mortality storage for any dead stock. These barges will be approximately 30-50 m long, with power for operations provided via a generator installed on the vessel. The barge may also have capacity to run on battery power as required to keep feed refrigerated and provide lighting and power for accommodation and facility usage by staff when the generator is not running. Staff will be present on site 24 hours a day 365 days a year while stock are in the sea-pens. Barges will be moored with the same size anchorages used for the sea-pens.

Lighting required on site will be minimal, with navigational lighting (flashing LEDs) on moorings in accordance with Australian Maritime Safety Authority regulations. All operations are primarily conducted during daylight hours removing the need for operational lighting at night.

Sullage will be stored in tanks pumped out for disposal when the vessel is in port following Department of Transport (DOT) sullage disposal regulations (DOT Sewage Strategy). No sullage will enter the marine environment. Other wastes will include empty feed bags, staff domestic waste and old ropes and net mesh. All non-perishable garbage will be packed into empty one tonne bulk bags and brought back to Derby for disposal. Perishable garbage will be stored in sealed containers and disposed in Derby. The operation will generate a small quantity of used oil from engine servicing at each site, which will be securely stored and returned to Derby for disposal.

Fish mortalities will be removed from the pens frequently; where practicable this will be daily, but due to weather, operational constraints or in cooler water temperatures and low mortality removal periods may be extended but with the intent to empty all pens at least twice weekly subject to operational requirements. A number of alternative mortality programs have been explored and may be implemented. The first of these involves the mincing and storage of mortalities in secure containers as silage. The silage units use formic acid to stabilise fish waste and are commercially available. Fish silage equipment is commonly used on fish farms worldwide. The silage will be removed from the site when required and transported to Derby for further processing as by-product or disposal (following Shire of Derby/West Kimberley waste disposal regulations). Another alternative is the drying of mortalities at high temperatures, which may allow the mortalities to be used in several industries including biogas fuels or as feed ingredients (insect larvae, crocodiles, pets etc). In the event of a mass mortality, all stock would be transferred to Derby and disposed of in a licenced facility with the permission of the appropriate authorities (i.e. Shire of Derby/West Kimberley, DWER, DPIRD). If the primary licenced facility cannot take the waste, a secondary licenced facility will be used. Unlicensed facilities for waste disposal will not be used at any point.

Feed will be distributed into the sea-pens daily using an automatic feeding system from the centralised barge. The feed system works by delivering feed to the surface of the sea-pens 4-6 pens at a time. Hand-feeding and feed-boats may be used at times, though this is not the primary feeding method. A database which is updated daily and verified regularly tracks the total biomass, growth and feed being inputted into each respective pen. In this database, Tassal can track the respective food conversion ratios, which helps indicate the health of the fish as well as the efficiency at which the site is operating. The automated feed system also helps Tassal target optimal feeding times, which generally occur when dissolved oxygen concentrations are high. Dissolved oxygen concentrations are monitored constantly within the pens for this reason. Feeding at optimal times reduces the overall amount of feed which goes to waste, reducing the potential for nutrient enrichment due to the breakdown of feed in the marine environment.

In addition to the barges, a working vessel will be used to transfer staff, feed, equipment, and other materials to the sites. Each working vessel may supply multiple sites, meaning there will be two working vessels in total across the 7 sites once the phased construction is complete.

Harvesting will also occur directly from each barge. Once the stock has reached the optimal size (~4 kgs) all stock will be harvested from the lease. Stock will then be transferred to the Derby shore base for transport to market.

Vessel movements

The central barges will always remain at each site. The operational vessels will service three to four sites, and as such will move between them periodically depending on operational requirements (e.g. transport of feed, harvested stock, fingerlings for grow-out).

Predator control

The sea-pen infrastructure proposed prevents access to the sea-pens from any predator, including sharks, crocodiles or seabirds. The breaking strain of the netting (240 kg inner net, 600 kg outer net) is such that it will prevent any tearing by marine predators known to be present in the region.

Feed

Feed for the barramundi will likely be sourced from Skretting's production (or other suitable commercial supplier), as is currently the case for Tassal’s Cone Bay operations. The feed will be shipped in bulk bags to each of the respective sites. The bulk of feed will be stored on site in the centralised barge system. The specific feed type is a combination of agricultural crops, wild fish meal, by-products from farmed animals and farmed fish as well as vitamins and minerals added to the feed. The feed type currently used by Tassal is best suited to the environmental conditions present in the Kimberley (e.g. water temperature), though Tassal will continue exploring the use of new feeds as they become available if they are proven to be more sustainable and allow for more efficient growth rates or positive environmental outcomes.

Production model

Tassal aims to implement a continuous production model under this Proposal, operating across multiple sites (once multiple sites are operational). This approach will operate in a manner such that total standing biomass at any site does not exceed 4,500 tonnes. The cycle would operate as follows:

1. A site is stocked with barramundi fingerlings (~110g)
2. Biomass within the site increases as the barramundi grow to harvestable size. Cycle takes approximately 18-24 months for the barramundi to grow to harvestable size at ~4kg
3. Harvesting commences once barramundi within the site have reached harvestable size.

4. Once an individual site has had all stocked barramundi harvested, it will be fallowed for a minimum of one month prior to restocking.

Following best-practice procedures, Tassal are not intending to stock all sites together with high biomasses at the same time. Rather, the stocking of sites will be such that those on the same point of the production cycle are in a different area altogether. This reduces the overall nutrient loading on the environment at a particular location at any point in time as a result of finfish faeces and uneaten feed.

Anti-fouling

Anti-fouling will be used only where necessary to reducing foul load on the netting of the pens. Regular cleaning of the netting will reduce the need for anti-foul usage as much as possible. Only non-copper based anti-fouling will be used to ensure no toxicants leach into the marine environment from the anti-foul.

Disease management

Therapeutants (e.g. antibiotics and antiparasitics) may be used to manage clinically significant diseases and ensure fish welfare. However, the usage of therapeutants will be limited to the approval via an accredited veterinarian, who prescribes the specific dosage and usage of the therapeutant in the event of their usage. Only approved therapeutants which have been thoroughly tested for potential impacts to human health / environmental damage will be used. Further information on therapeutant usage can be found in the EMMP (Annex A). Furthermore, a vaccination program will be put in place which reduces the necessity of therapeutant usage. Finally, to limit risk of disease transfer, Tassal are required to follow DPIRD's regulations for translocation of barramundi, which includes the following:

- The numbers of fish stocked into each pen
- The movements of fish from one pen to another
- The numbers of fish culled and removed from the pens
- The numbers of fish removed from the pens at the time of harvesting
- Barramundi sourced from interstate must be sourced from licensed hatcheries only and be health-tested to the satisfaction of the Senior Fish Pathologist at DPIRD
- Testing standards shall meet with a 95% degree of confidence that the imported population is free of 'nominated' diseases[1] ('nominated' refers to those relevant 'notifiable' diseases as listed under the *Enzootic Disease Regulations 1970*, and any other diseases nominated by the Senior Fish Pathologist at DPIRD for the particular populations to be imported)

Performance indicators and monitoring

With the infrastructure and processes detailed above, Tassal are seeking to achieve the following key performance indicators at each of their proposed sites:

- Mortality rate: 15%
- Average harvest weight: 4 kgs
- Yield: 3.4 kg/juvenile
- Stocking density: average 35 kg/m^3

[1] Freedom from Disease is internationally accepted as meaning a prevalence of detectable pathogen found in less than 2% of the population of animals.

- Food conversion ratio: 1.5 throughout entire grow-out cycle.

To help achieve these KPIs, constant monitoring will be conducted, as described in Table 1.3. This monitoring will be conducted by Tassal staff and does not fall under the environmental monitoring required under an Environmental Management and Monitoring Plan (EMMP) (Annex A), however will be made available to Authorities upon request.

Table 1.3 Operational Monitoring conducted by Tassal at each site

Parameter	Reason for monitoring	Frequency	Location	Reporting
Dissolved oxygen	Important for health of fish stock as well as feeding at optimal times when DO is high	Constantly	Within each sea-pen	Information is fed into Tassal's database, which is reviewed and re-calibrated every 60 days
Fish stock weight	Important to understand the growth rates of the stock within each sea-pen	Bi-monthly	Within each sea-pen	Information is fed into Tassal's database, which is reviewed and re-calibrated every 60 days
Feed input	Important to understand the level of feed input to the pens and the respective growth of the fish stock to ascertain food conversion ratios	Constantly	Within each sea-pen	Information is fed into Tassal's database, which is reviewed and re-calibrated every 60 days
Sea-pen condition	Important to ensure bio-fouling is removed, there are no holes in the mesh etc	Twice weekly	Netting of each sea-pen	Any damage to the netting is reported internally
Mortalities	Important to understand if mortalities are natural or the result of an environmental pressure (water quality, disease)	Daily (subject to operational requirements and limitations)	Within each sea-pen	Information is fed into Tassal's database, which is reviewed and re-calibrated every 60 days. Mass mortalities are reported to the respective authorities as required under State and Federal legislation.

As MPA (now Tassal) have been operating in Cone Bay since 2004, they had the opportunity to make several changes to their operations which have reduced their environmental footprint. Examples of these improvements include:

- Testing of alternative feed types (i.e. floating/sinking) which has reduced feed wastage
- Introduction of an underwater camera surveillance system to manage feed efficiency
- Introduction of a vaccination program to help reduce the risk of the spread of disease on site at the sea-pens and the requirement for antibiotic usage

Through its ongoing monitoring program, Tassal will continue to make changes to further improve the sustainability of their overall operations.

1.5.4 Personnel

Tassal will select local personnel from Broome or Derby or other local communities wherever possible. Having local personnel reduces the accommodation requirements, while also ensuring that many of the indirect economic benefits of the Proposal stay within the region.

Education programs will be implemented at all of Tassal's operation centres to ensure that both Tassal and contractor staff are aware of these cultural and environmental values and subsequently treats them with the appropriate respect.

1.6 Decommissioning

1.6.1 Sea-pen operations

To decommission the sea-pen operations, all fish stock would be harvested and transported to the market facilities for sale. The netting at each sea-pen would then be removed onto the central barge, as well as all the ropes and floats required on site. Once all infrastructure associated with the sea-pens had been removed, the anchorages would be retrieved individually. Each sea-pen would subsequently be towed back to Derby port. No materials or infrastructure would be left on site.

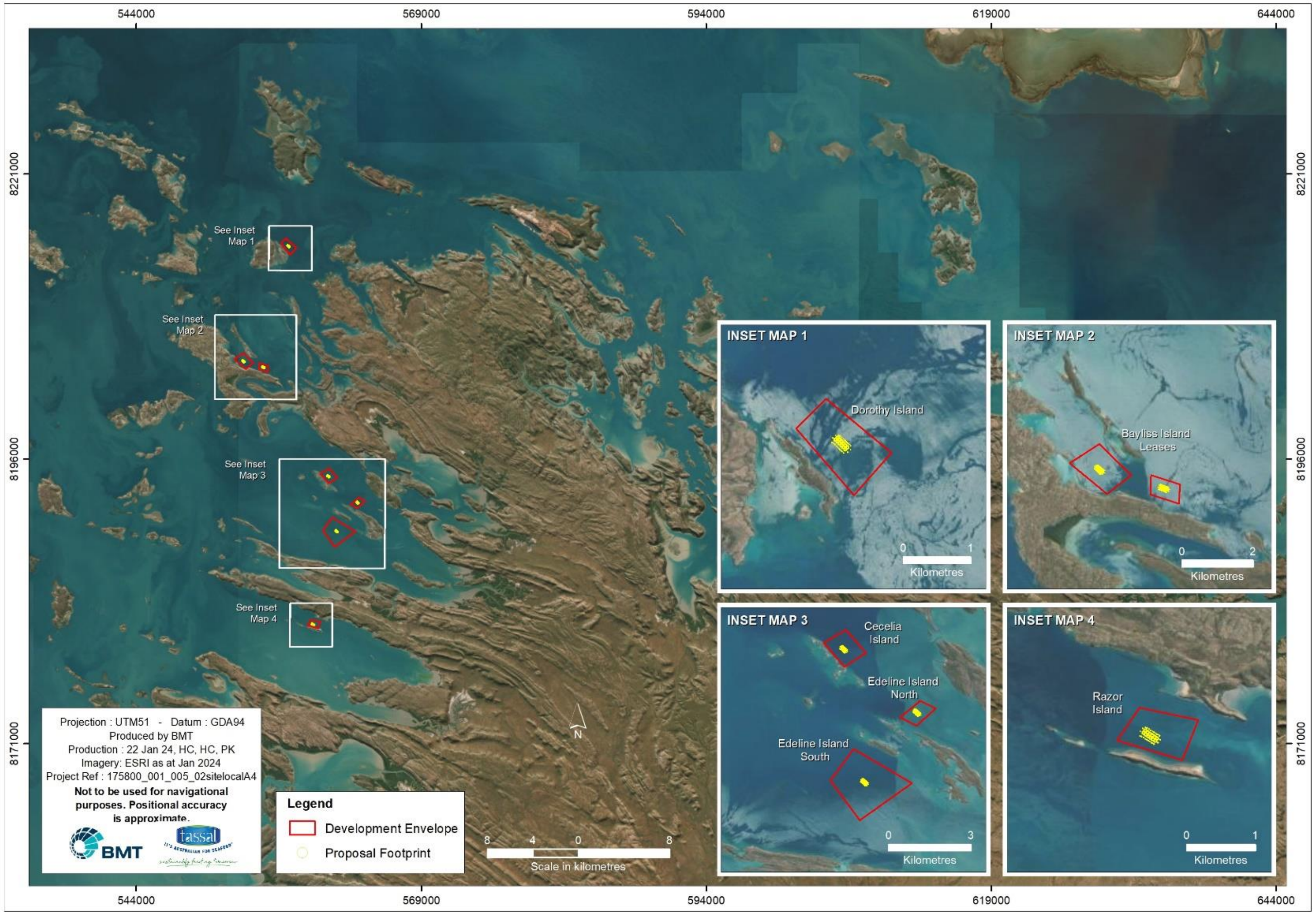


Figure 1.3 Proposed development envelope/footprint of the seven sites

1.7 Site selection and optimisation

1.7.1 Proposal alternatives

It is very clear that Tassal could not continue operations as is within Cone Bay and would potentially have to cease operations if an alternative such as this Proposal was not possible. As such, a detailed site selection process was undertaken to ascertain suitable locations for the planned expansion. The final set of seven proposed sites were decided as the most appropriate for development after several years of exploration and assessment.

Alternative options for expansion of Cone Bay barramundi farming operations within the existing KADZ were assessed initially. An option to use the north-east site of the aquaculture lease for expansion was explored. Bathymetry and metocean data collected at the north-east region of the existing lease indicated that establishing operations at this location would be challenging. A pilot study, including installation of pens north-east of the existing pens, confirmed that the current speeds of up to 18 knots experienced in this area were too strong to keep the pens in place with the mooring-grid system, and no other mooring system would be feasible in this situation either. Furthermore, the current speeds would also be too strong to efficiently grow barramundi or any other alternative finfish species. This is due to the fish having to constantly swim against the current to maintain their position in the pen and avoid being pushed up against the edge of the pens in the direction of the prevailing current.

After it was determined no suitable location within the existing KADZ for the development could be found, alternative sites across the Buccaneer Archipelago were assessed in detail. In total, 15 alternative sites were explored, of which seven remain as the Proposal. Initial baseline water and sediment quality data as well as hydrodynamic data was collected at all these locations to begin characterising the environmental conditions and ascertain whether they would be suitable for sea-pen aquaculture. However, during the development of the expansion plan, these were all eventually removed from the final proposal for one of or a combination of the following reasons:

- Proximity to sensitive environmental and/or cultural heritage values and/or areas (particularly within Strickland Bay)
- Inappropriate current speeds for sea-pen aquaculture (either too high or too low)
- Inappropriate depths (too shallow)
- Logistical constraints in servicing the sites due to distance from other Tassal operations

At the conclusion of this assessment, it was decided to reduce the expansion plan to the final set of seven which form the Proposal.

1.7.2 Environmental criteria for site selection

Offshore site selection

The Buccaneer Archipelago has been chosen as the area for Tassal's expansion project for several reasons. Areas closer to population centres, such as Derby, are not feasible for several reasons. Firstly, King Sound near Derby has very low flushing rates, which is linked with very high turbidity within the Sound. Secondly, riverine inputs into King Sound result in elevated nutrient levels and algal blooms at certain times of the year, which pose a risk to the health of barramundi. The water quality in the Buccaneer Archipelago on the other hand has low nutrient levels and a low likelihood of algal blooms associated with riverine inputs or high nutrient levels. Deeper waters in the Archipelago also allow for greater flushing rates which further maintain water quality at a level suitable for barramundi. The Archipelago provides a balance in terms of flushing rates versus current speeds, such that there is enough movement of water to maintain water quality without strong current speeds which would be too fast to allow for appropriate securing of the sea-pens.

The proposed sites for the expansion have been located to avoid sensitive benthic communities and habitats as much as practicable while still providing suitable current speeds for finfish farming that will not exceed the safety limits of the sea-pens or prevent the fish from growing efficiently. Though sites could be located in deeper waters further offshore within the Archipelago, the logistical constraints with pens located further away than those proposed would significantly reduce the profitability of the expansion, limiting its commercial feasibility. Several proposed sites have already been removed/re-configured in this final Proposal as they were found to be too near sensitive marine habitats or cultural heritage values.

The alternatives explored in Cone Bay were not feasible for a variety of reasons nor would they have resulted in better environmental outcomes if they were. For example, Tassal can produce up to the maximum limit of 15,000 tonnes production at their current Cone Bay site, as per their existing licence. However, the alternative suggested in this Proposal whereby Tassal's operations are spread across a much broader footprint, means that though the maximum production is at 17,500 tonnes the overall environmental outcomes on a per site basis are improved substantially. In summary, not only will the Proposal help Tassal meet anticipated market demand for high-quality barramundi, but it will also allow them to implement several operational improvements that will improve the sustainability and environmental footprint overall.

The proposed increase in the size of sea-pens will reduce the overall stocking density at each farm (from a maximum of 45 kg/m^3 to 35 kg/m^3), reducing the concentration of fish and feed waste in the receiving environment, further mitigating environmental impacts at each location. Lower stocking density, greater distance between pens, and stocking of only a single age class within each pen also significantly reduces the risk of pathogen transmission. Furthermore, the new sites are in deeper waters where the clearance between the bottom of the pens and the benthic substrate will be at least 13 m, increasing dilution/diffusion of nutrients resulting from fish/feed waste, in comparison to only 2 m of clearance in some instances within the KADZ. No other technologies/options are currently available that would help significantly enhance production or profitability in the KADZ, hence the requirement for the expansion.

Economic viability of the project

Once fully operational, the Proposal is expected to employ ~140 FTE positions in the Kimberley region. There is considerable anticipated market demand for high-quality barramundi product both nationally and internationally, and as such both the short and long-term economic feasibility of the Proposal is only expected to increase.

As the Proposal proceeds, social benefits to the local region in the form of direct and indirect employment and spending will increase. Not only will the Proposal diversify the local economy, it will also support employment opportunities within the local communities, encouraging residents to stay and work within the region rather than leaving for greater opportunities elsewhere.

1.8 Local and regional context

1.8.1 Physical and ecological characteristics of the marine environment

Marine ecology

The marine environment along the northwest of Australia is a unique area characterised by a combination of extreme physical conditions and limited anthropogenic stressors (Halpern *et al*. 2008).

Organisms growing in the Buccaneer Archipelago must deal with extreme physical conditions including large tidal ranges (up to 12 m), high water temperatures (35 to 40 °C in shallow intertidal habitats), and high turbidity during the wet season (Hovey *et al*. 2015; Pedersen *et al*. 2016). The success of benthic primary producers throughout this region contribute to regional primary productivity and ecosystem services, which form the basis of the trophic structure that supports the highly diverse marine fauna.

The diversity of seagrass meadows in the Kimberley region includes 12 tropical species evenly distributed between two families: Hydrochaitaceae and Cymodoceaceae (Kendrick *et al*, 2016). More than 270 species of macroalgae have been recorded in the Kimberley, most of which are small, epiphytic red algae (Huisman and Sampey 2014). Species of the genus *Sargassum* are particularly abundant in inshore areas and act as important habitat and food sources (Huisman and Sampey 2014).

Conservation Areas

Multiple areas of conservation significance have been defined in the Buccaneer Archipelago. Three state marine parks have been legislatively enacted. These are the Bardi Jawi Gaarra Marine Park, the Mayala Marine Park and the Lalang-gaddam Marine Park, which encompass the Buccaneer Archipelago and the northern part of the Dampier Peninsula. The Mayala Marine Park includes the entirety of the proposed sites, though the sites are within the proposed general use zone designation of the marine parks which allows for aquaculture activity. However, it is noted that some sites are in close proximity to sanctuary or special purpose zones as defined under the Mayala Marine Park Management Plan (DBCA 2022a). These zones have been demarcated to protect areas of particular environmental (sanctuary) and/or cultural (special purpose) value (DBCA 2022a). Furthermore, the same area is defined as the Mayala Country Indigenous Protected Area (IPA), which protects the land and sea territory within Mayala's Native Title Determination Area. The leases also fall within the West Kimberley National Heritage Place, as declared under the EPBC Act. No World Heritage Areas, Ramsar wetlands or other state or federally legislated conservation areas are present in the vicinity of the Proposal. Figure 1.6 shows the relevant conservation areas in vicinity of the Proposal.

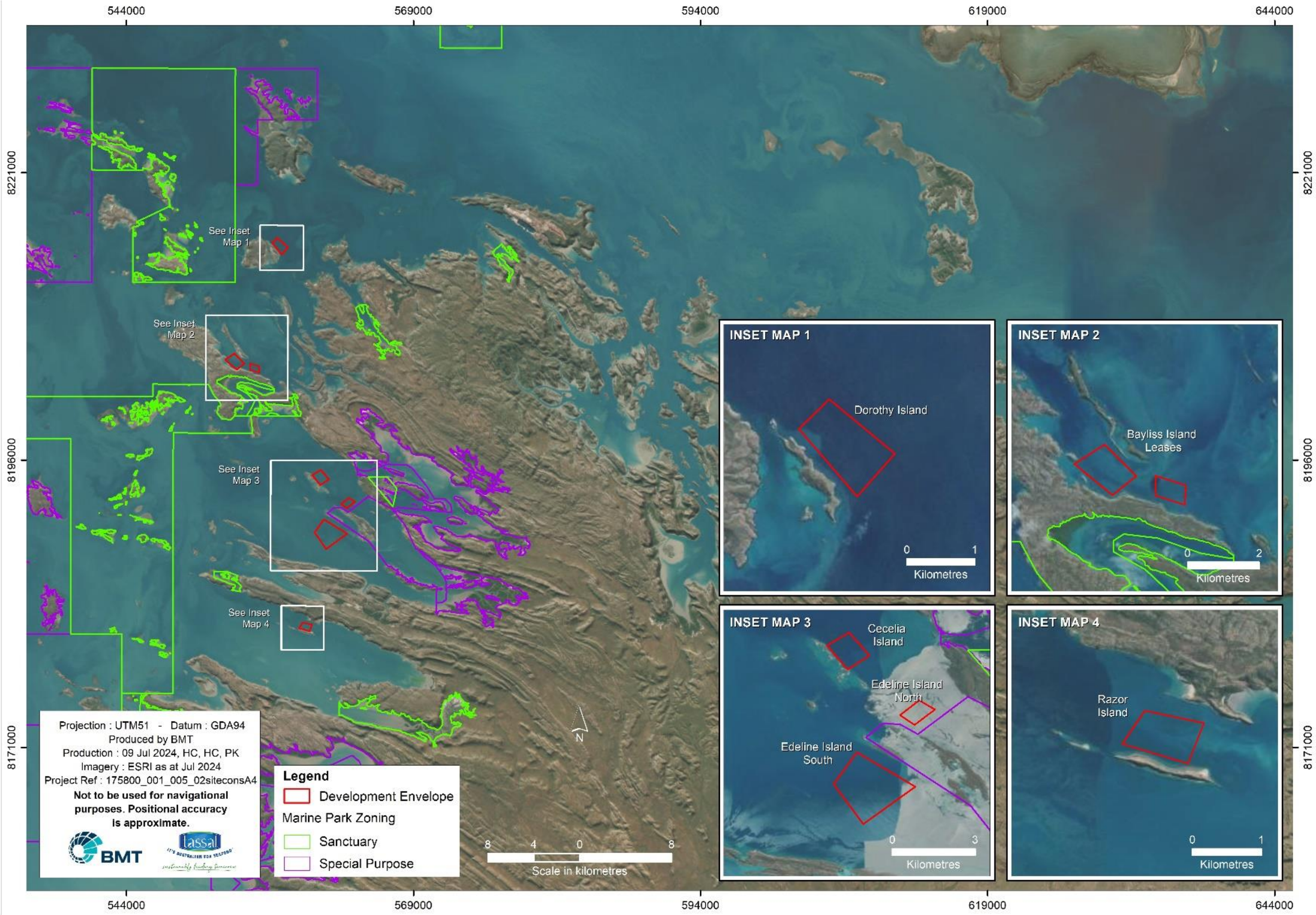


Figure 1.4 Areas of conservation significance in proximity to the proposed sites

Tides, currents and water conditions

The Buccaneer Archipelago on the Australian North West Shelf is highly complex with thousands of islands subjected to an extreme 12 m macrotidal regime (Wilson 2013). Currents around the islands are multidirectional and can exceed 1 m/s, producing unique ocean conditions including whirlpools and standing waves (Cresswell & Badcock 2000, Wilson 2013, Lowe *et al*. 2015). Modelling results from this study, based off current data collected in field, indicated that current speeds varied between 20-50 cm/s at the surface and 10-30 cm/s at the seabed throughout the Archipelago (Figure 1.5 and Figure 1.6). The annual mean circulation consisted of rotating eddies interacting with the semi-enclosed structures at the shorelines of Razor Island as well as in the offshore area southwest of Cone Bay. In general, the currents in the sites are mostly influenced by the bathymetric features and eddies shedding-off the islands. Local currents are heavily influenced by tide, which override the broader scale, outer continental shelf currents (Condie & Andrewartha 2008). The strong tidal influence means nearshore intertidal marine organisms that inhabit inshore locations can be exposed to direct sunlight for up to 3 hours at a time (Richards et al. 2015). This region is also periodically exposed to extreme environmental forces (e.g. cyclones) that don't necessarily fit into the seasonal or annual patterns.

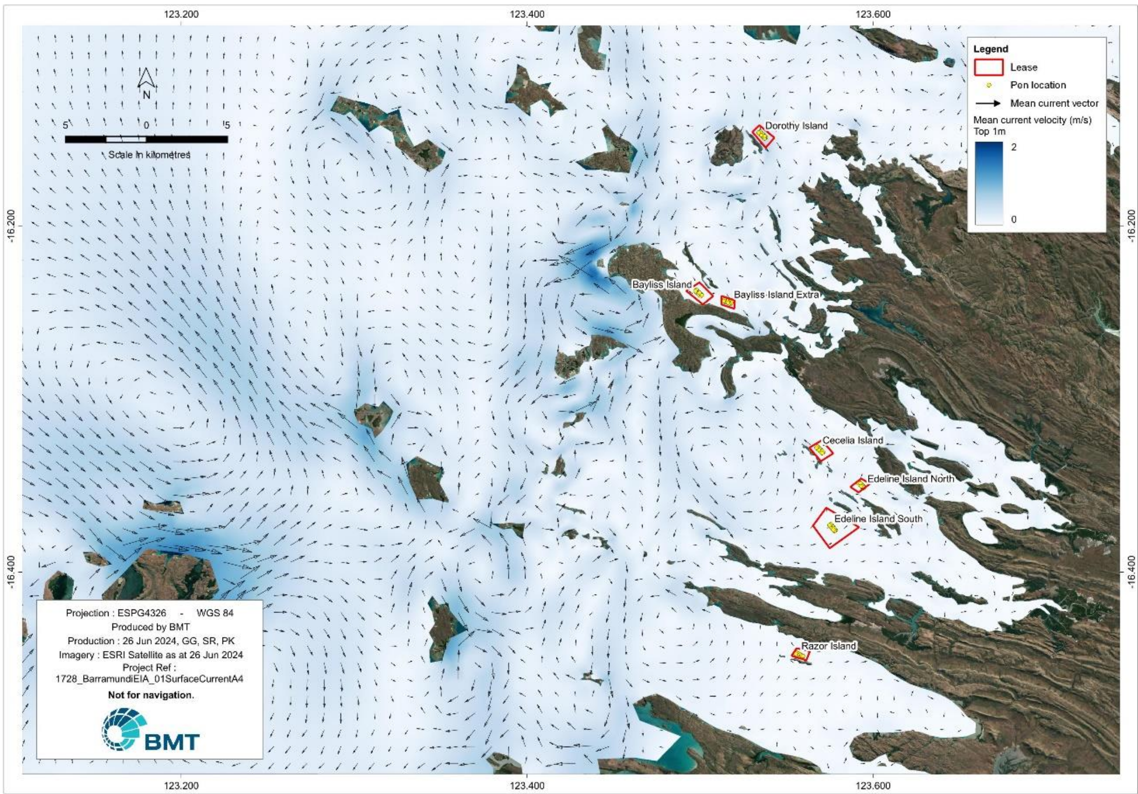


Figure 1.5 Annual mean surface velocities showing circulation patterns around the proposed sites

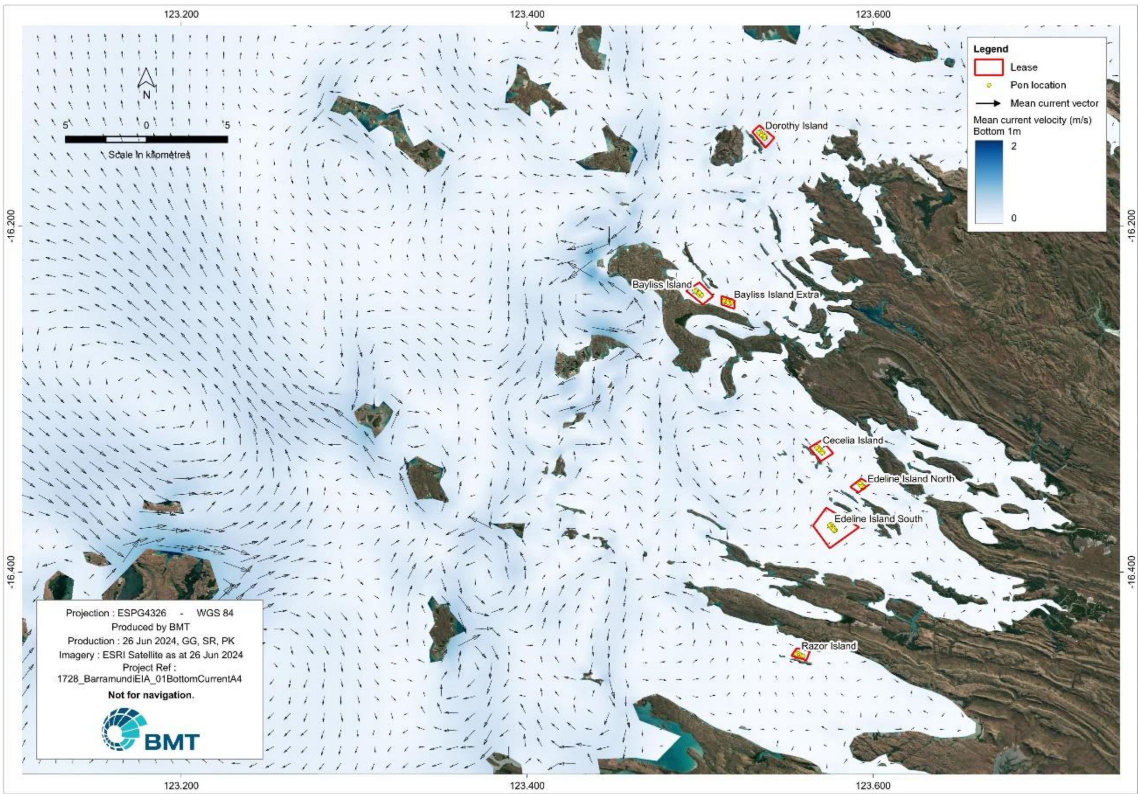


Figure 1.6 Annual mean bottom velocities showing circulation patterns around the sites

The Kimberley has distinct wet (November to March) and dry seasons (April to October). The wet season is characterised by increased freshwater inputs into coastal marine environments, increasing sediment loads and decreasing light availability (Hovey et al. 2015). Low light availability typically reduces the photosynthetic capacity of benthic primary producers, with subsequent effects on productivity and distribution, especially for groups such as seagrasses that typically have high light requirements. In nearshore regions of the Archipelago in proximity to riverine inputs high turbidity is common, particularly during the wet season. The water quality at the offshore islands on the other hand is significantly different, being far closer to oligotrophic conditions where background nutrient and microalgal concentrations are low (DBCA 2022a). The significant movement of water due to tidal fluxes potentially helps replenish water quality in these areas, particularly in the deepwater channels which are common throughout the Archipelago (Brocx & Semeniuk 2011; DBCA 2022a).

Sediments

The sediments of the Archipelago are not well studied, however for the most part, what is known is that they are a mixture of silt and fine sands, primarily from the fluvial inputs of riverine systems. Coarse sediments such as gravel are not generally as common (this study). Other studies in Cone Bay indicate similar results, with soft sediments predominating throughout Cone Bay, particularly in areas close to where there is input from river systems. See Section 5.3.2 for further details.

Fauna

The Buccaneer Archipelago includes habitats for a variety of marine fauna of conservation significance. Several cetacean species, including humpback whales (*Megaptera novaeangliae*), dugongs (*Dugong dugon*), snubfin (*Orcaella heinsohni*) and humpback dolphins (*Sousa sahulensis*). These species either migrate through or live in the Archipelago year-round, with humpback whale mother and calf pairings residing in Camden Sound between June-September. Six marine turtle species (green, olive ridley, flatback, hawksbill, loggerhead and leatherback) are also known to forage within the waters or lay their eggs on the shoreline of the Buccaneer Archipelago and Dampier Peninsula (DAWE 2017). Other species of significance include estuarine crocodiles which inhabit the estuaries and coastal areas of the Archipelago, while several sawfish species are also known to be present in the region. For further details, see Section 7.

1.8.2 Physical and ecological characteristics of the terrestrial environment

Climate

The Buccaneer Archipelago, part of the West Kimberley region, experiences a warm tropical monsoon climate with two distinct wet and dry seasons. The wet season is characterised by high temperatures, significant rainfall and increased occurrence of cyclones, while the dry season reflects very stable weather conditions of clear skies and warm days. The climate is described by comparing data from the last 30 years (1991 – 2020) from a weather station site at Cockatoo Island in the Buccaneer Archipelago (BoM 2021). The average rainfall for the area is 959 mm per annum, with the majority falling in months during the wet season from January – March. Atmospheric temperatures are highest during April and lowest in July. The region experiences monthly mean maximum temperatures ranging from 28.7 °C in July to 33.4 °C in April. Monthly mean minimum temperatures range from 22.1 °C in July to 27.6 °C in December.

The wind regime in the Buccaneer Archipelago is driven by low-pressure systems along the monsoonal belt during the wet season, and stable conditions during the dry season (Wilson 2013). During the warmer months from November to March, westerly rain-bearing winds dominate with speeds between 30-45 km/h and there is a high probability of tropical cyclones occurring due to higher landmass temperatures causing low-pressure zones. The dry season is dominated by light easterly trade winds and the low-pressure zones of the monsoonal belt disappear, resulting in calm and stable conditions. Wind stresses are lowest and unsteady in directionality during the transitional months between the wet and dry seasons (Wilson 2013).

Geomorphology

The natural geomorphology of the Buccaneer Archipelago is characterised by a distinctive coastline ria, a zone of submerged river systems, hills and ridges due to rising seas forming complex coastal features and isles (Brocx and Semeniuk 2011). The islands vary in elevation and diversity of vegetation, from sparse spinifex to patches of low forest and fringing mangrove systems (DPIRD 2020). Elevations vary from 20 m to 40 m with some island cliffs and headlands reaching 80 – 100 m, reflecting the continuation of high relief formations on the mainland.

Three shoreline assemblages dominate the area (Brocx and Semeniuk 2011):

- Headlands and islands or rias, most showing minor embayment's with tidal flat or salt flat development
- Beachrock and adjacent fringing reefs with some beach formation between headlands
- Beachrock with limited tidal flat development and sand ridges.

Geology

The geology of the Buccaneer Archipelago is described as one of the most dramatic land-seascapes of the Australian coastline (Wilson 2013). The area is dominated by rocky sandstone islands and adjacent coastline dating back to the pre-Cambrian age (2500 – 1800 million years ago) (Brocx and Semeniuk 2011). Coastal features also include volcanic rocks and ironstones of the King Leopold Orogen, which adjoin with the southern section of the Proterozoic Kimberley Basin where they form outcrops and peninsulas projecting seaward from the coast (Brocx and Semeniuk 2011). The western end of the orogen proximate to the Buccaneer Archipelago is intensely folded by tectonic activity, giving rise to complex features that characterise the area including the rocky ria coast with high relief, major gulfs and inlets and nearshore rocky islands (Wilson 2013).

Hydrogeology

The Buccaneer Archipelago is located at the intersection of the Canning and Kimberley basins via the King Leopold Orogen. The Canning basin is the second largest sedimentary basin in Australia, comprising sandstone and basalt sediments up to 15 km thick with two major aquifers (Gov. of WA 1978). The Kimberley Basin is a shallow marine basin with total thickness around 2 km, perhaps the most unexplored and least understood given its remote and mostly offshore location. The King Leopold Orogen is a belt of folded sedimentary and metamorphic rocks along the south-west margin of the Kimberley Basin (Brocx and Semeniuk 2011).

The key aquifers in the area are the Wallal sandstone confined aquifer and the shallow Callawa formation (Gov. of WA 1978). The rocks and sandstone sediments function as aquifers to a range of water bodies (Mathews et al. 2011). Fractured sandstone overlying relatively less permeable weathered basalt results in seepage of freshwater along the basalt/sandstone interface and in the development of habitats for Kimberley rainforests (McKenzie et al. 1991). Groundwater from both the Wallal and Callawa aquifers flows towards the coast and discharges into scree via seepage and into the ocean via surface or subsurface discharge onto tidal flats (Mathews et al. 2011). Freshwater discharging also occurs from rivers, creeks, and rivulets, as waterfalls directly into the sea and are nationally significant features (Brocx and Semeniuk 2011). Recharge occurs primarily through direct percolation from rainfall at a rate of around 3 – 6% (Gov. of WA 1978).

Soils and topography

The coastal geology of the Buccaneer Archipelago is defined by two distinct regions overlapping with the Canning and Kimberley basins. The Kimberley basin is characterised by Proterozoic sandstone and basic intrusive rock, which comprises the numerous islands and outcrops in the Buccaneer Archipelago that rise steeply to elevations of 20 – 100 m (Brocx and Semeniuk 2011). The coastal geology shifts at the intersection of the King Leopold Orogen into Mesozoic sandstone with diverse sedimentary structures associated with the coastal dunes and tidal flats of the Canning basin (Brocx and Semeniuk 2011). The coastline surrounding Cone Bay is mostly rocky, with mangrove-fringed sections of rocky shoreline in some areas and only a small proportion of sand forming beaches of up to 500 m maximum length (Short 2019). The beaches are generally composed of coarse, carbonate-rich sand and each have distinct variations in sediment texture that is typical of the Kimberley coast (Short 2011). There are several streams that drain to the coast, but major rivers are not present, and it is likely the combination of extreme tidal ranges with the lack of fluvial sedimentary deposition is the driving factor behind the lack of sand forming beaches in the region (Short 2011).

Flora and vegetation

The coastline of the Buccaneer Archipelago features extensive tropical mangrove systems that occupy most sheltered embayment’s and inlets, as well as lower energy sections of the rocky shore that dominates the region (Short 2011). There are various species of mangroves present in habitat-specific assemblages, from rocky cliff shores to tidal creeks and flats with such topographic variations made evident by this variation in the occurrence of mangrove species (Cresswell and Semeniuk 2011). The complexity of mangrove habitats that are evident along the Kimberley Coast and their relationship to the ria coastal environment surrounding the Buccaneer Archipelago make them a globally unique feature, as ria coasts are not common and most do not exhibit tropical mangrove communities (Cresswell and Semeniuk 2011). The area also exhibits a small proportion of beach ridges and dunes that offer habitat for coastal dune flora, including various coastal grasses, low shrubs and a dense shrub community of diverse plants growing on hind dunes (Short 2011).

Avifauna

The Kimberley region of Western Australia exhibits numerous islands which support at least 179 species of birds (Pearson, Cowan and Caton 2013). The avifauna of the region show a closer affinity to the tropical areas of the Northern Territory and North Queensland than they do to the rest of Western Australia, with surprisingly little geographic differentiation of bird taxa between the distinct tropical locations (Johnstone and Storr 1998). A 1957 survey of Cockatoo Island identified 40 species of birds on or around the island (Warham 1957). There are no known seabird sites of importance on or around Koolan Island, which holds little intertidal or mangal habitats (Masini, Sim and Simpson 2009). However, an extensive earlier study found Koolan Island to have the highest diversity of avifauna among the Kimberley islands with 116 species recorded over 10 years (McKenzie et al. 1995). An average of 56 bird species were observed at each of three other islands surveyed in the Buccaneer Archipelago: namely Lachlan, Long and Hidden Islands (Pearson, Cowan and Caton 2013). These islands were observed to have a suite of species associated with drier woodlands or grasslands (Pearson, Cowan and Caton 2013). A search of the EPBC Protected Matters Search tool lists the region as being a Biologically Important Area for the Roseate Tern, Red-footed Booby, Lesser Frigatebird and the Greater Frigatebird; further information on avifauna is provided in Section 7.

No bird species or subspecies were found to be endemic or confined to the Kimberley Islands, and many of the documented species are migratory birds that arrive annually to utilise the extensive mudflats of the Kimberley region during the north Asian winter (Johnstone 1990). The Kimberley Islands are known to be on a major flightway of migratory species including Palaearctic birds and Australian bird species moving between the mainland and the Lesser Sunda Islands during the summer months (Pearson, Cowan and Caton 2013).

1.8.3 Socio-economic

Buccaneer Archipelago

The major population centres near to the Buccaneer Archipelago are Broome and Derby, with several smaller towns and communities present on the Dampier Peninsula to the west of the Archipelago. The major industries of the region are primarily mining or mineral resource related, with some contribution from pearling and commercial fishing, though these operations are generally small in scale. Tourism is increasing in the region, although it is largely based out of Broome, with day trips by boat or scenic flights being the most common way to access the marine environment. Some small-scale eco-tourism or fishing lodges exist on the Dampier Peninsula.

There are 15 different State-managed commercial fisheries operating within the North Coast Bioregion (Pilbara/Kimberley), 6 of which operate within or adjacent to the Buccaneer Archipelago (DPIRD 2017). A variety of finfish and invertebrate species are targeted by both commercial and recreational sectors within the North Coast Bioregion. Targeted pelagic/offshore species caught with demersal line and net methods, trawling, diving and potting methods include sharks, tropical snappers, cods, coral and coronation trout, trevally, tuskfish, tunas, mackerels and billfish. Nearshore-based methods such as seine-netting, near-shore gillnetting, hand-hauled nets, and shore-based line fishing are used to capture barramundi, tropical emperors, mangrove jack, trevallies, sooty grunter, threadfin, cods and catfish, and invertebrate species including blue swimmer crabs, mud crabs and squid (DPIRD 2017). The region is also used for both shore and boat-based recreational fishing. The fisheries and target species relevant to the Proposal project area, and the likelihood of interaction with the Proposal, are summarised in Table 1.4 and Table 1.5. Pearl aquaculture is also a major industry in the region, with pearl farms shown in Figure 1.7.

Table 1.4 Western Australian fisheries relevant to the Proposal area

Fishery	Commercial or recreation use	Target species	Operation use, vessels/licences and closure periods
North West Slope Trawl Fishery	Commercial	Scampi (*Metanephrops australiensis*)	Located in deep water from the coast of the Prince Regent National Park to Exmouth between the 200 m depth contour to the outer limit of the Australian Fishing Zone. There are ~4 commercial vessels that operate within this fishery. Operates 12-month of the year (AFMA 2012, Chambers & Larcombe 2015).
Western Skipjack Fishery	Commercial	Indian Ocean Skipjack Tuna (*Katsuwonus pelamis*)	Located between the coastline to 200 nm offshore from Western Australia. There are 14 Western Skipjack Tuna Fishery permits, however no Australian boats currently fish for skipjack tuna since 2009. Typically fished using purse seine fishing (Patterson & Mobsby, 2020).
Western Tuna and Billfish Fishery	Commercial	Bigeye Tuna (*Thunnus obesus*), Yellowfin Tuna (*Thunnus albacares*), and Striped Marlin (*Kajikia audax*)	Operates in Australia's Exclusive Economic Zone and high seas of the Indian Ocean. Fishing efforts in this fishery is conducted through pelagic longline, with low levels of minor-line fishing. There are ~2 pelagic longline vessels, and ~2 minor-line vessels that operate within the fishery (AFMA 2015, Williams et al, 2020).
Aquaculture Pearl Oyster Fishery	Commercial	Pearl Oysters (*Pinctada maxima*)	Pearl leases are located mainly along the Kimberley coast, particularly in the Buccaneer Archipelago, in Roebuck Bay and at the Montebello Islands (DPIRD 2017). Wild pearl oysters are also collected by divers in the nearshore areas of the Archipelago to be grown out at the pearl leases.
Trochus Fishery	Commercial / Native title holders	Sea Snail (*Trochus niloticus*)	A small fishery based on a single target species (*trochus niloticus*) and has no by-catch because they are harvested by hand. The annual harvest in the past decade has ranged between 2-15 tonnes. The fishery is managed under Ministerial exemption and arrangements include restricted areas of harvest, two community-initiated closures within the Native Title areas, seasonal closures from June to October and size limits to protect breeding stock (DPIRD 2017).
Kimberley Gillnet and Barramundi Managed Fishery	Both	Barramundi (*Lates calcarifer*) Threadfin Salmon (*Polydactylus macrochir*)	Operates in nearshore and estuarine zones from the Northern Territory border to the top end of Eighty Mile Beach, south of Broome. Fishery is managed with seasonal area closures and gear restrictions. Recreational fishers take only a small amount of barramundi, estimated at between two and eight per

Fishery	Commercial or recreation use	Target species	Operation use, vessels/licences and closure periods
			cent of the overall barramundi catch in WA. Recreational fishing is managed through bag and size limits and gear restrictions (DPIRD 2017).
Shore-based and Demersal Finfish Resources	Recreational	100+ demersal/pelagic species inhabiting marine water between 1-250 m in the North Coast Bioregion	Recreational shore-based fishing operates 12 months of the year throughout the North Coast Bioregion. However, owing to the high tidal range, much of the angling activity is boat-based, with beach fishing limited to periods of flood tides and high water. There are ~123,000 recreational licence holders in WA. The numerous creek systems, mangroves, rivers, beaches, offshore islands and coral reef systems provide recreational fishing opportunities for numerous target species (DPIRD 2017).

Table 1.5 Distribution, key life strategies and habitat association of commercially and recreationally important species in the North Coast Bioregion

Species	Distribution/key life strategies	Habitat associations
Barramundi (*Lates calcarifer*)	Found north from Exmouth Gulf though most abundant in the Kimberley region. Most common in rivers and creeks with large catchments with a slow continuous flow and water temperatures above 20°C. Shows a preference for submerged logs, rock ledges and other structures in the water. Lifecycle includes freshwater, estuarine and marine phases. Larvae typically reside in mangrove or tidal habitats, before migrating into rivers and freshwater billabongs as juvenile fish. When the fish become sexually mature (at three to five years of age) they migrate back to the saltwater to spawn (DPIRD 2013).	Streams, rivers, lakes, billabongs, estuaries, and coastal waters
Bigeye Tuna (*Thunnus obesus*),	A pelagic migratory species swimming continuously over large distances. Found to depths of 250 metres. Juveniles and sub-adults usually school at or near the surface with other tuna species. Peak spawning periods in the southern hemisphere are between summer and autumn. Females may spawn every 2-3 days during the spawning season (AFMA 2021a).	Pelagic
Indian Ocean Skipjack Tuna (*Katsuwonus pelamis*)	A pelagic migratory species which travels long distances and can be found to depths of 260 metres. Juveniles are generally found in shallower surface waters and move into deeper water as they mature. Spawning occurs throughout the year in tropical waters, with females able to spawn almost daily (AFMA 2021b).	Pelagic
Pearl Oysters (*Pinctada maxima*)	Found in northern coastal waters as far south as Shark Bay but is not commercially fished south of North West Cape. A sedentary bottom-dweller commonly found between 0-50 metres in areas where the seabed has crevices that allow the young animals to	Sand and rocky substratum

Species	Distribution/key life strategies	Habitat associations
	settle into a protected environment and a hard substratum for them to attach. The seabed is typically a flat basement rock with very little relief. Fine sediment accumulates on it to a depth of a few millimeters, obscuring the underlying rock surface (Fletcher et al, 2006).	
Scampi (*Metanephrops australiensis*)	A benthic species that inhabits the continental shelf off Australia's west coast, mainly off Port Hedland. They can usually be found on Globigerina ooze at depths of 420-500 metres. Scampi prefer a firm substrate, and build less extensive burrows, than other similar species. They may spend considerable periods of time outside their burrows. Timing of spawning is uncertain but is thought to occur annually (AFMA 2021c).	Soft mud, clay, and sand
Sea Snail (*Trochus niloticus*)	Juveniles live in shallow areas on intertidal reef flats, while adults prefer atoll reefs along the reef crest or on reef slopes at depths of 0 to 20 m. These gastropods feed on very small plants and filamentous algae grazed on coral and rocks. Breeding period occurs during spring tides with nocturnal spawning (Colquhoun 2001).	Intertidal reefs and atoll reefs
Striped Marlin (*Kajikia audax*)	A pelagic migratory species which travels long distances and can be found to depths of ~290 metres. Rarely seen in coastal waters, except where sharp drop-offs to deep water occur. Spawning occurs in summer with 4-41 spawning events occurring over the spawning season (AFMA 2021d)	Pelagic
Threadfin Salmon (*Polydactylus macrochir*)	Found from Exmouth in Western Australia through the tropics to the Brisbane River on the east coast of Australia. King threadfin occur in shallow, turbid waters such as coastal waters, estuaries, mangrove creeks, and mangrove-lined rivers, over sandbanks and mud substrates, similar to Barramundi (Shultz & Lee 2015)	Rivers, estuaries, mangroves and coastal waters
Yellowfin Tuna (*Thunnus albacares*)	A pelagic migratory species swimming continuously over large distances. Found to depths of 250 metres. Spawning occurs throughout the year in tropical waters. The peak spawning period in the southern hemisphere occurs in summer. In tropical waters females spawn almost daily. Spawning occurs almost entirely at night (AFMA 2021e).	Pelagic

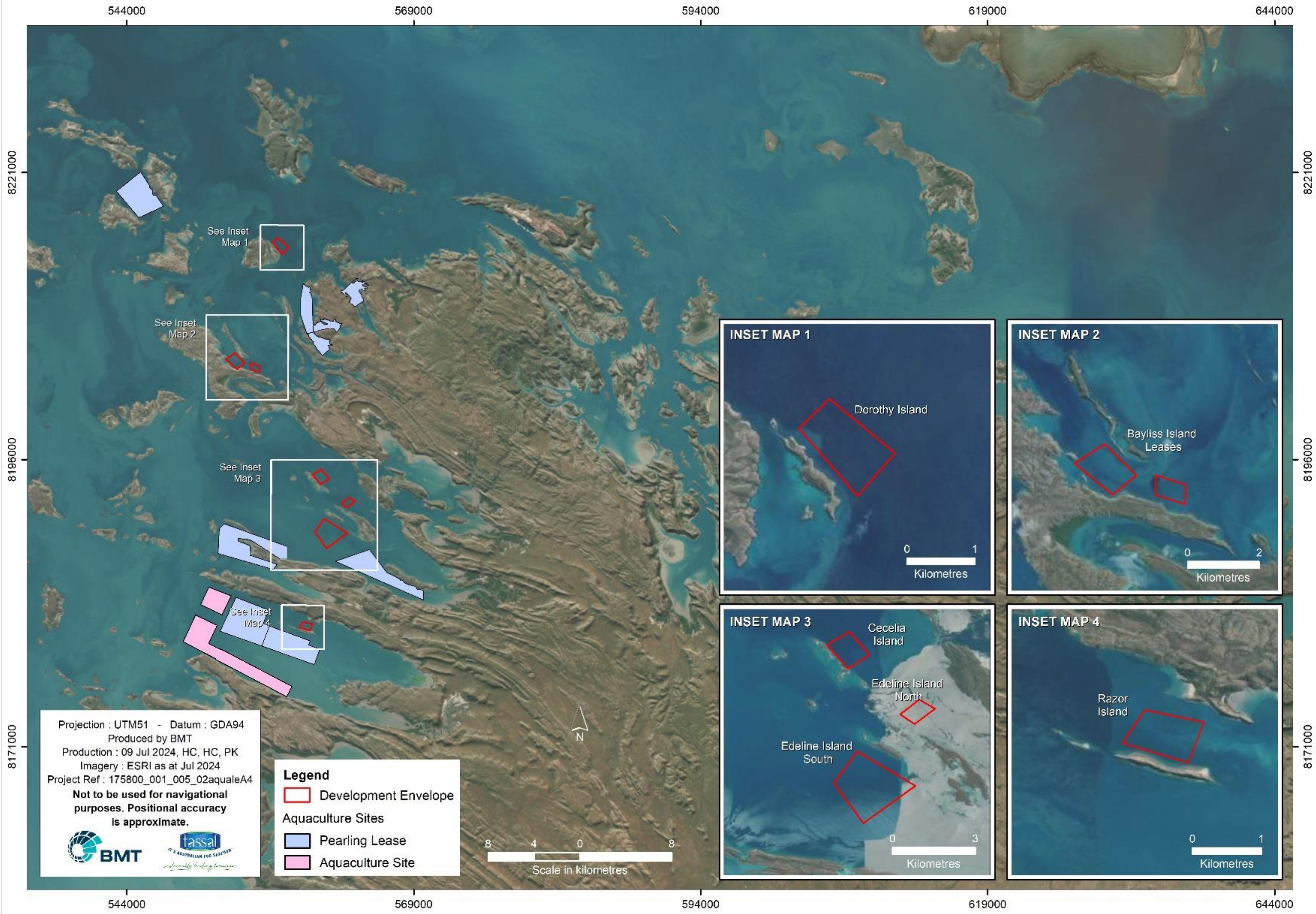


Figure 1.7 Aquaculture sites (KADZ) and pearling leases in proximity to the Development Envelope of the Proposal

Heritage

The entire West Kimberley, which includes the whole of the Buccaneer Archipelago, has been listed as a National Heritage Place, and is thus classified as a Matter of National Environmental Significance (MNES) under the EPBC Act. This is because it contains several values for both human and natural heritage. Some details are provided below, with further information provided in Section 9 and the PER developed by Stantec.

Indigenous heritage

The West Kimberley has been listed as it contains numerous values of importance for Aboriginal Traditional Owners in the region, including flora and fauna, sites of previous habitation, rock art and artefacts among others. The respective Mayala and Dambimangari Traditional Owners in the region have strong cultural associations with the area surrounding the proposed sites. The peoples of these groups hold deep and spiritual connections to Country and have been and will continue to practice their culture and maintain their Country for thousands of years.

Landscapes and geology

The ancient geology of the region serves to promote the West Kimberley as a unique landscape globally. The Oscar, Napier, Emmanuel and Pillara Ranges are the remains of a vast coral reef that existed nearly 400 million years ago, similar in scale to the Great Barrier Reef. The Gogo fish fossils present in the area provide insight into the development of live birth and represent some of the earliest four limbed vertebrates. Dinosaur footprints are also present on the west coast of Dampier Peninsula, along with fossilised human footprints which are significant for being one of only three documented human track sites in Australia and the only evidence of tracks on the west coast.

Pearling

Aboriginal people collected *Pinctada maxima* pearl shell for use in ceremonies and rituals. It is the most widely distributed item in Aboriginal Australia, having been traded across two-thirds of the continent. European pearling became well established in the region after the discovery of the world's largest pearl oyster shell in Roebuck Bay in 1861.

1.8.4 Other Land Uses

There are other land uses and tenure within the region which could interact with the Proposal, which are summarised in Section 2.

2 Legislative and Planning Context

2.1 Purpose and scope

Tassal has referred the Proposal under Part IV, Section 38 of the *Environmental Protection (EP) Act 1986* and the EPBC Act. Under the EP Act, Tassal must demonstrate that the Proposal meets the EPA's key environmental factors and objectives. A pre-referral meeting with representatives of the Department of Primary Industries and Regional Development (DPIRD) and the Department of Water and Environmental Regulation (DWER) was held on 26 May 2020 and a follow-up meeting with DWER technical specialists on the 18 June 2020. The intent of the 18 June meeting was to agree on the type and extent of technical studies needed to support Tassal's referral. The outcomes of the technical studies are expected to provide evidence the Proposal is manageable under the EPA's Environmental Quality Management Framework. The Proposal was submitted to the EPA on the 5th of May 2022. After initial assessment of the Proposal and its supporting documentation, the EPA submitted a formal Request for Additional Information under Section 40(2)(a) of the EP Act to MPA (now Tassal) on the 6th October 2022. The intent of this revised referral document is to include the relevant information requested to allow for the EPA's assessment.

Furthermore, on the 8/04/2024 Tassal submitted a request under Section 43(a) of the EP Act to change the submitted Proposal. The changes made to the Proposal were the removal of the nurseries located on the Dampier Peninsula, as well as 6 of the 13 proposed ocean-based sites put forward in 2022. This submission was accepted by the EPA on the 13th June 2024. Subsequently, all reference to the nurseries, as well as the Environmental Factors which are no longer relevant, have since been removed from the supporting documentation including this report.

A series of pre-lodgement meetings have also been held with the Department of Climate Change, Energy, the Environment and Water (DCCEEW; formerly the Department of Agriculture, Water and the Environment [DAWE]) to understand their primary assessment requirements. The project was subsequently referred to DCCEEW under the EPBC Act, with a formal request for a Public Environmental Report (PER) provided to Tassal. The PER covers all relevant matters for DCCEEW, and hence all information pertaining to the EPBC Act is located in the PER (Stantec 2024a). A summary of relevant information is provided in Section 12.

2.2 Proponent

2.2.1 Tassal proponent overview and relevant history

Tassal Group is the largest vertically integrated seafood producer in Australia. Tassal currently operates several salmon farming leases in Tasmania, as well as prawn farms in Queensland. Tassal seek to provide high-end barramundi products in an environmentally sustainable manner, with the following protocols:

- rigorous site selection to ensure sites have clean, oxygen-rich water as well as strong currents to help with dilution of material
- wildlife protection through stringent internal protocols to ensure fauna are not impacted by farming infrastructure
- predominantly plant-based feed formula
- internal vaccination program to minimise disease

Regarding the Cone Bay sites, Tassal (then operating as MPA) began operating in the Kimberley in 1999 at the current Cone Bay sites. The Proponents details are provided in Table 2.1.

Table 2.1 Proponent contact details

Proponent Contact Details	
Company	Tassal Operations Pty Ltd
ABN/CAN	ACN 106 324 127
Address	GPO Box 1645 Hobart, Tasmania, 7001, Australia
Key contact	**Jude Tyzack – Senior Manager, Projects & Growth** **Telephone:** 1300 827725 **Email:** jude.tyzack@tassal.com.au

2.2.2 Cone Bay operations

MPA (now Tassal) has operated barramundi production with sea-pen aquaculture in Cone Bay since 1999 under various iterations of Aquaculture Licence 1465, pursuant to Section 97 of the FRM Act. The production of barramundi was approved under Part IV of the EP Act in 2009 (Ministerial Statement [MS] 798), with an increased production of barramundi from 1000 tonnes per annum (tpa) to 2000 tpa approved in 2012 under MS 885. The EPA recommended submission of a revised Environmental Monitoring and Management Plan (EMMP; Oceanica 2011) as a condition for environmental referral.

The 2012 proposed Cone Bay barramundi production expansion under MS 885 coincided with a commitment made by the Western Australian Government to develop a sustainable marine aquaculture industry and establish marine aquaculture zones pursuant to Section 101A(2A) of the FRM Act. As part of this commitment, a strategic proposal to develop finfish aquaculture within the KADZ was approved under MS 966. The KADZ covers an area of 2,00ha and allows for a maximum production of 20,00t.

The existing Tassal barramundi sea-pen aquaculture falls within the KADZ. Tassal has since had phase II and III of the Cone Bay aquaculture operations accepted as Derived Proposals under the KADZ, as it conformed with its objectives and requirements. The Phase II Cone Bay aquaculture proposal was implemented in place of the Proposal subject to MS 885 and the Phase III expansion included an extended aquaculture lease with additional production capacity not to exceed 8010 tpa.

Though the Cone Bay lease run by Tassal will remain operating for a short period while the expansion occurs, the Cone Bay operations do not form part of this referral. This is because this Proposal does not fall within the KADZ, and as such requires a whole new assessment at both state and federal level considering it is not therefore a Derived Proposal. The intent of this document is to only refer to Cone Bay operations where valuable information with regards to the expansion may be included, not to assess those operations itself.

2.3 Experience, capability and track record

MPA (now Tassal) has operated in Cone Bay since 2004 at its current lease. Tassal is the first aquaculture operator in Australia to have sea-pen grow-out of barramundi and has provided barramundi products to the Australian market since their inception. Over their time in Cone Bay, Tassal have sought to follow the technological developments in sea-pen farming which has helped to improve their environmental footprint.

Tassal has operated since 1986 when the first farm site was established in Tasmania. Since then, Tassal have acquired further sites in Tasmania, as well as prawn farming operations in Queensland

and the barramundi farming operations in Cone Bay, as well as attracting expertise from a wide variety of industry sectors such as fish health (vaccinations), sustainable packaging, and genetics and husbandry practices for in-house processing. With this expertise Tassal seeks to ensure their products are environmentally sustainable throughout the product life cycle (i.e. from the farms all the way to the when the products are consumed).

Tassal is not currently subject to proceedings under any law for the protection of the environment or the conservation and sustainable use of natural resources. Other entities within TOPL have previously been subject to proceedings (i.e. infringement notices under the Environmental Management and Pollution Control Act 1994 [EMPCA], Letters of Warning) as follows for the previous five years:

- Infringement notices for contraventions of an environmental licence (two notices)
- Diesel spill at Margate (two notices)
- Formal warning notices issued (four notices)

TOPL have twenty-one prior convictions arising from infringement notices recorded under other state legislation relating to marine debris (x18), a missing International Association of Lighthouse Authorities (IALA) mark, revocation of a mooring permit, and identification of a mooring buoy. Despite these convictions, they have been appropriately managed by Tassal and relevant regulators. No fines were received by any member of TOPL in the previous five years in connection with proceedings under any law for the protection of the environment or conservation and sustainable use of natural resources.

2.4 Environmental impact assessment process

The key environmental impact assessment legislative requirements of relevance to the Proposal comprise formal assessment under:

- Part IV of EP Act; and
- Section 87 of the EPBC Act.

2.4.1 Western Australian Environmental impact assessment process

The *Environmental Protection Act 1986* (EP Act) is the primary legislative instrument for environmental assessment in Western Australia. It specifies procedures for assessment and appeal processes, including responsibilities and functions of the Western Australian Minister for the Environment and the (EPA). Under Part IV of the EP Act, the EPA is responsible for providing advice to the Minister for significant proposals assessed under Part IV of the EP Act.

This document has been prepared in accordance with the EPA's instructions on how to prepare an Environmental Review Document (EPA 2024b) to support referral of the Proposal under the Section 38 of the EP Act.

In accordance with Section 3.1.3 of the Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2021, this document has been prepared to provide sufficient information for the EPA (and referral agencies) to assess the Proposal.

Consultation with Decision-Making Authorities (DMAs) has substantially commenced to support the Proposal.

2.4.2 Western Australian standards, guidelines and policies

Assessment of the environmental impacts of the Proposal is based on various Western Australian Position Statements and Guidance Statements. Standards, guidelines and policies related to specific environmental factors or individual aspects of the Proposal are identified in Section 2.5 and discussed in the individual sections relevant to the environmental factor being addressed.

2.4.3 Australian Government environmental impact assessment process

The EPBC Act is the Australian Government's key piece of environmental legislation. Detailed assessment is required under the EPBC Act for projects that are likely to have a significant impact on MNES defined under the EPBC Act, or in Commonwealth Waters.

Potentially relevant MNES for the Proposal in State Waters are summarised below. Full details on MNES are provided in the PER (Stantec 2024a), with a summary of pertinent information provided in Section 12.

- Listed threatened and/or migratory species–including protected marine fauna.
- National Heritage Place – West Kimberley

2.5 Other approvals and regulations

Table 2.2 lists other key approvals required for various proposal activities that are identified at this time, including the relevant DMAs. Other approvals or DMAs may be identified through the referral and assessment process. Works may not commence until any other downstream approvals are gained.

2.5.1 Department of Primary Industries and Regional Development

DPIRD, under the FRMA have direct management of Tassal's aquaculture lease that will cover the operation of the proposed seven sites. Under the FRMA, DPIRD will be responsible for those items specifically listed in Table 2.2, which will include monitoring and management of Tassal's operations that fall under the jurisdiction of the FRMA (such as biosecurity control), which will be managed under a Monitoring and Environmental Management Plan (MEMP). DPIRD will not however be responsible for management of Tassal's environmental monitoring requirements, which will fall under the management of DWER, under an Environmental Monitoring and Management Plan (EMMP; Annex A). This includes the management of any chemical therapeutants that may be used as part of Tassal's operations (see Annex A for details).

Table 2.2 Decision Making Authorities, legislation and approvals relevant to the Proposal

Agency / Decision Making Authority	Legislation or agreement regulating the activity	Approval required	Whether and how statutory decision-making process can mitigate impacts on the environment?
State			
Department of Water and Environmental Regulation (DWER) / Minister for Environment	*Environmental Protection Act 1986 (Part IV)*[1] [Environmental Protection Authority Services]	EPA Approval (Ministerial Statement)	Yes, the relevant EPA objectives identified in this document will be met
		Relevant proposal elements: • Sea-pen operations	• Through the provision of a comprehensive Environmental Review Document (this document) and its subsequent review and assessment by the EPA
Department of Mines, Industry Regulation and Safety	*Dangerous Goods Safety Act 2004*	Dangerous goods licence	No EPA factor objective is relevant in this case
		Relevant proposal elements: • Sea-pen operations (storage of diesel fuel)	• The proponent will need approval to keep dangerous goods on site in an appropriate and safe area
Department of Biodiversity, Conservation and Attractions (DBCA)	*Conservation and Land Management Act 1986*	Sampling permits to undertake monitoring activities within DBCA managed jurisdiction (i.e. marine parks)	Yes, the sampling permits will ensure all monitoring activities undertaken by Tassal are in line with the CALM Act

Agency / Decision Making Authority	Legislation or agreement regulating the activity	Approval required	Whether and how statutory decision-making process can mitigate impacts on the environment?
		Relevant proposal elements: • Sea-pen operations (sampling)	• The proponent will acquire relevant permits from DBCA prior to undertaking sampling within the bounds of the DBCA managed jurisdictions in the region.
	Biodiversity Conservation Act 2016	Stakeholder consultation must be considered, no direct approval under the Act.	Yes, the EPA factor objective for social surroundings and its requirements for stakeholder consultation will be met
		Relevant proposal elements: • Sea-pen operations	• The proponent has completed thorough stakeholder consultation in the planning of the Proposal. Though the Bardi Jawi Gaarra, Mayala and Lalang-gaddam Parks either contain or are in close proximity to the proposed sites, these parks will be administered by DBCA and traditional owner JMBs, who will specify management of ecological, cultural, social and economic values of the marine park. • Any sampling that Tassal undertakes as part of their operations, beyond the borders of each site, will require approval under a Regulation 4 Authority, which authorises Tassal to access DBCA managed areas.

Agency / Decision Making Authority	Legislation or agreement regulating the activity	Approval required	Whether and how statutory decision-making process can mitigate impacts on the environment?
Department of Transport	Navigable Waters Regulations 1958	Approval including a Notice to Mariners (temporary and permanent allowances)	Yes, the EPA factor objective for social surroundings will be met
		Relevant proposal elements: • Sea-pen operations (installation of objects within navigable waters)	• The application for installation of objects in navigable waters will ensure all relevant parties, including the public, are aware of the location of the sea-pens and will avoid interacting with them.
Department of Primary Industries and Regional Development (DPIRD)	*Aquatic Resources Management Act 2016* *Fish Resources Management Act 1994*	Approval from DPIRD's biosecurity group	Yes, the EPA factor for marine fauna will be met
		Relevant proposal elements: • Sea-pen operations (potential for construction and operational vessels to result in introduced marine species [IMS], risk of stock with pathogens, different genetic traits escaping into the wild)	• DPIRD's biosecurity group will require testing of the vessels used in construction and operations to reduce the risk of IMS introduction • DPIRD's biosecurity group will require testing of all fish stock before they are transferred to the sea-pens as detailed in DPIRD's translocation policy. The management of this is detailed in a separate Management and Environmental Monitoring Plan (MEMP) that is authorised and managed by DPIRD. No environmental monitoring is

Agency / Decision Making Authority	Legislation or agreement regulating the activity	Approval required	Whether and how statutory decision-making process can mitigate impacts on the environment?
			prescribed under this plan, as DWER will manage all environmental monitoring aspects. The MEMP will refer to the EMMP for the Proposal directly when it comes to reporting and assessment • DPIRD will be responsible for managing the sea-pen operations under an aquaculture licence, prescribed under the FRMA. DPIRD is also an informal joint management partner for the Mayala Marine Park for items pertaining to aquaculture (i.e. this Proposal), fisheries and pearling.
Department of Planning, Lands and Heritage	*Land Administration Act 1997*	Section 91 licence or easement Relevant proposal elements • Sea-pen operations	No environmental impacts relevant to this process.
Commonwealth			
Department of Climate Change, Energy, the Environment and Water (DCCEEW)	*Environmental Protection and Biodiversity Conservation Act 1999*[1]	DCCEEW approved action as under Section 87 of the EPBC Act of a controlled action requiring the protection of Matters of National Environmental Significance (MNES)	Yes, this legislation will be complied with.
		Relevant proposal elements • Sea-pen operations (potential interaction with	• The potential impacts of sea-pen operations on threatened marine fauna will be mitigated through the

Agency / Decision Making Authority	Legislation or agreement regulating the activity	Approval required	Whether and how statutory decision-making process can mitigate impacts on the environment?
		threatened/migratory marine fauna; West Kimberley National Heritage Place)	strategies outlined in the PER (Stantec 2024a)
Department of Agriculture, Fisheries and Forestry (DAFF)	*Biosecurity Act 2016*	No approval required, just consideration under the EP Act and EPBC Act	Yes, the EPA objectives relevant in this case will be met
		Relevant proposal elements: • Sea-pen operations (introduction of IMS from vessels)	• Appropriate environmental management plans will mitigate the risk of the introduction of biosecurity hazards
Department of Infrastructure, Transport, Regional Development and Communications	*Protection of the Sea (Prevention of Pollution from Ships) Act 1983*	No approval required, just consideration under the EP Act (international convention aimed at the prevention of pollution from ships caused by operational or accidental cause)	Yes, this legislation will be complied with.
		Relevant proposal elements: • Sea-pen operations (pollution from operational vessels including barges)	• Appropriate Environmental Management Plans will mitigate the risk of pollution from vessels

Notes:

1. Primary environmental impact assessment and approvals

2.5.2 Tenure

Tenure for each element of the Proposal is summarised in Table 2.3 and Figure 2.1 and Figure 2.2, while existing leases (i.e. mining exploration or aquaculture leases) in the area surrounding the Proposal is detailed in Table 2.4. Tassal is currently negotiating with DBCA and DPIRD to negotiate tenure of the proposed aquaculture lease (made up of the seven sites).

A number of native title determinations have also been made over the proposal elements, as illustrated in Figure 2.1 and Figure 2.2.

Table 2.3 Tenure for each element of the Proposal

Proposal element	Holder	Purpose	Tenure requirements
Razor Island, Edeline Island South, Edeline Island North, Cecelia Island, Bayliss Islands, Dorothy Island sites (as one aquaculture lease)	Crown Land	State waters and marine park.	Lease arrangements currently sit under Crown Land

Table 2.4 Other land-uses / leases or licences in the area surrounding the Proposal

Land-use / Tenure type	Holder	Description / extent
Exploration Licence / Mining Lease	Koolan Island Iron Ore Pty Ltd	Exploration licence for area surrounding Koolan Island Mining Lease for Koolan Island
Exploration Licence	Atom Minerals Pty Ltd.	Exploration licence for marine area north-west of Koolan Island
Exploration Licence	Auscan Exploration Pty Ltd	Exploration lease for terrestrial and nearshore areas of Buccaneer Archipelago
Exploration Licence	Silver Gull Iron Ore Pty Ltd	Exploration licence in marine waters surrounding Cockatoo Island
Exploration Licence	Pluton Resources Limited	Exploration licence in marine waters south of Cockatoo Island
Exploration Licence	Cockatoo Island Mining Pty Ltd	Exploration licence on Cockatoo Island
Mining Lease	Cockatoo Island Mining Pty Ltd	Mining lease for Irvine Island
Exploration Licence	Pluton Mining Pty Ltd	Exploration Licence for area west of Irvine Island
Exploration Licence	Regal Mining Pty Ltd	Exploration Licence for area north of Irvine Island
Exploration Licence	William Robert Richmond	Exploration licence south-east end of Cone Bay

Land-use / Tenure type	Holder	Description / extent
Exploration Licence	Buxton Resources Ltd	Exploration south-east end of Cone Bay and area surrounding Derby
Aquaculture Leases	Various	Pearl farming leases throughout the Archipelago in proximity to the proposed sites. See Figure 1.9

Notes:
1. Tenure for mining and exploration leases sourced from the Government of Western Australia Department of Mines, Industry, Regulation and Safety.

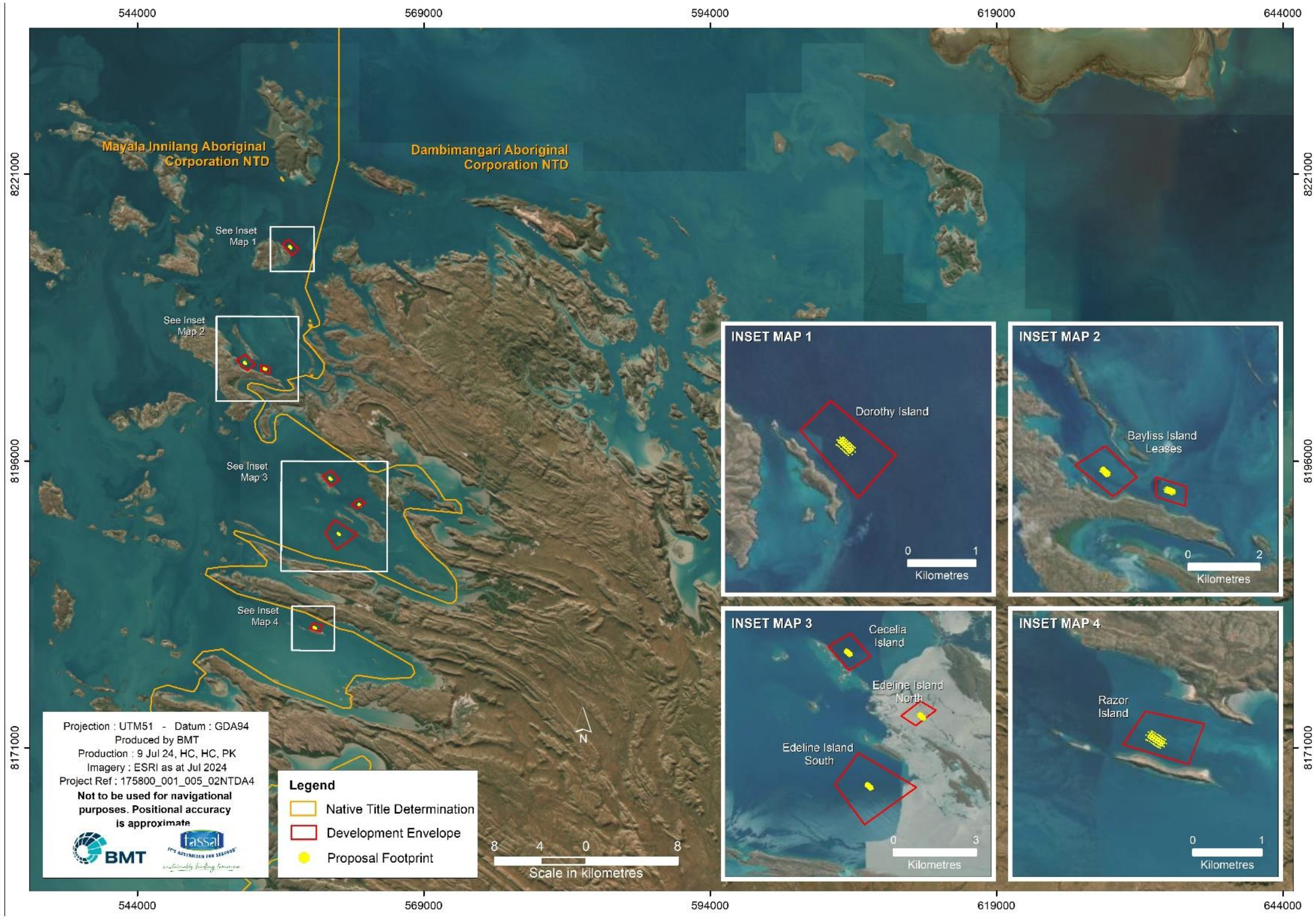


Figure 2.1 Native title determination in the vicinity of the proposed sites

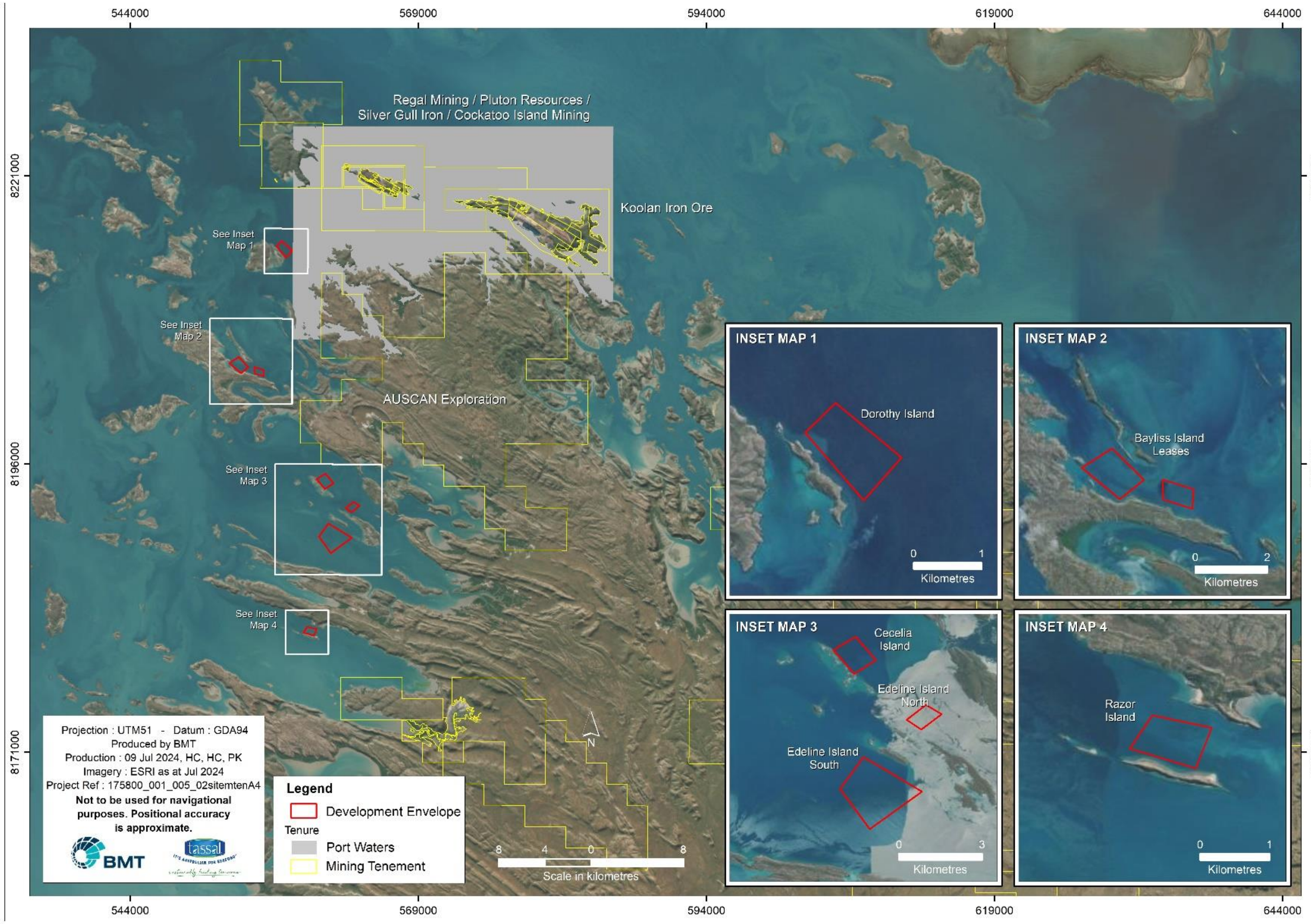


Figure 2.2 Tenements and port waters in the vicinity of the proposed sites

3 Stakeholder Engagement

The key objectives of stakeholder engagement have been to consult key stakeholders of the proposed expansion plan and ensure that the final proposed project successfully integrates Traditional Owner, community and government considerations while also meeting Tassal's project requirements. Tassal has facilitated stakeholder consultation through its established networks across the West Kimberley region and State from its existing Cone Bay operations. Tassal has also looked to expand its stakeholder consultation through a broadened stakeholder analysis process considering its footprint will expand across a broad area of the Buccaneer Archipelago which multiple stakeholders operate within.

Tassal has been a participant in the design and development of the creation of the marine parks in the Buccaneer Archipelago, comprised of the Mayala Marine Park, Bardi Jawi Gaarra Marine Park and Lalang-gaddam Marine Park. The plan includes recognition that aquaculture projects will be permitted within the General Use zone areas of the Marine Parks. The formulation of the marine parks has included extensive consultation managed by the Department of Biodiversity, Conservation and Attractions (DBCA) including co-design workshops with Traditional Owners and targeted consultation with different community and industry groups. The plans have also incorporated extensive broader public consultation processes which note the anticipated expansion of aquaculture operations within the marine parks given the exceptional conditions for aquaculture operations. Tassal has been an active participant in the Marine Park development and consultation processes, making presentations and providing updates on multiple occasions to the broader stakeholder group coordinated by DBCA.

Tassal has adopted key principles of stakeholder consultation focused on open, honest and transparent communication during the development of the proposal and subsequently into its development. These key principles are:

- **Communication** – Communication must be open, accessible, clearly defined, two-way and appropriate.
- **Transparency** – The process and outcomes of community and stakeholder engagement should, wherever possible, be made open and transparent, agreed upon and documented.
- **Collaboration** – A co-operative and collaborative approach to seek mutually beneficial outcomes is considered key to effective engagement.
- **Inclusiveness** – Inclusiveness involves identifying and involving communities and stakeholders early and throughout the process, in an appropriate manner.
- **Integrity –** Community and stakeholder engagement should establish and foster mutual trust and respect.

3.1 Key stakeholders

Key stakeholders identified in relation to the Proposal by Tassal are summarised in Table 3.1. All these stakeholders have been engaged by Tassal throughout the Proposal planning phase to ensure any key stakeholder concerns have been addressed in a manner approved by all parties.

Table 3.1 Key stakeholders identified and engaged with by Tassal, following the IAPP2 public participation spectrum

Stakeholder	Stakeholder Type	Level of engagement
DWER	State Government	Consult
DPIRD	State Government	Involve
DBCA	State Government	Involve
DPLH	State Government	Consult
DCCEEW	Commonwealth Government	Consult
Kimberley Ports Authority	State Government	Consult
Kimberley Development Commission	State Government	Consult
Shire of Derby-West Kimberley	Local Government	Consult
Shire of Broome	Local Government	Consult
Kimberley Development Commission	Regional Development Corporation	Consult
Bardi Jawi Niimidiman Aboriginal Corporation	Registered Native Title Body Corporate	Consult
Dambimangari (Dambeemangarddee) Aboriginal Corporation	Registered Native Title Body Corporate	Consult
Mayala Inninalang Aboriginal Corporation RNTBC (MIAC)	Registered Native Title Body Corporate	Consult
Nyul Nyul PBC Aboriginal Corporation	Registered Native Title Body Corporate	Consult
Nyamba Buru Yawuru LTD	Registered Native Title Body Corporate	Consult
Ardyaloon Aboriginal Community	Aboriginal Community Organisation	Consult
Djarindjin Aboriginal Community	Aboriginal Community Organisation	Consult
Kimberley Land Council	Aboriginal Representative Organisation	Consult
Environs Kimberley	Environmental Advocacy Group	Inform
PEW Charitable Trust	Environmental Advocacy Group	Inform
Conservation Council of WA	Environmental Advocacy Group	Inform
Cygnet Bay Pearls	Private Business	Inform
Arrow Pearling Base	Private Business	Consult
Mary Island Fishing Club	Community Group	Inform

Stakeholder	Stakeholder Type	Level of engagement
Broome Chamber of Commerce and Industry	Industry Group	Inform
Derby Chamber of Commerce and Industry	Industry Group	Inform

3.2 Stakeholder engagement process

The project location falls within the Native Title Determination boundaries for the MIAC and lies adjacent to the Native Title Determination for the Dambimangari Aboriginal Corporation. Tassal has focused on developing a strong relationship with both these groups (amongst others) with the signing of an Indigenous Land Use Agreement (ILUA) with the MIAC. Engagement with representative bodies has been a particular focus for consultation throughout the lifetime of the proposal so far, considering the proximity of areas of cultural significance to some aspects of the proposal and the potential employment benefits to members of local Aboriginal communities.

The general strategy for engagement with the three key stakeholder categories is summarised below:

- Marine Park Consultation Groups: active participation in providing information and input into the design and development of the Buccaneer Marine Parks including open presentations and Q&A sessions with the broader stakeholder reference groups established by DBCA (when the Proposal was managed by MPA prior to Tassal's acquisition of the Proposal)
- Government agencies: discuss requirements and approvals as indicated by government agencies, following relevant legislation (EP Act for State, EPBC Act for Commonwealth).
- Native Title Groups: consult throughout development and commissioning phase of the project
  - involve Traditional Owners in the project
  - discuss and explore employment opportunities
  - share environmental impact findings
  - understand heritage values and potential impacts to them
  - adjust zoning of development envelope if key values intersect
  - keep native title groups updated with project progress.
- Community and Industry groups: Share project plans and progress and be available to listen to any questions or concerns.

The step-by-step process Tassal followed in engaging with stakeholders involved the following actions:

- Initial video presentation of project overview to key groups;
- Delivery of brochure of project overview for stakeholders' reference;
- Face-to-face or online stakeholder meetings;
  - Pre-referral meetings with DWER;
  - Pre-referral meetings with DAWE;
  - Attending Aboriginal Prescribed Body Corporate board meetings, as well as organising scope specific meetings with PBCs to discuss the Proposal;
  - Organising on country site visits with representatives from the MIAC; and
  - Meetings with TOs, DBCA and DPIRD regarding the marine parks in the Buccaneer Archipelago

- Written communication and distribution of project updates;
- Telephone discussions; and
- Organising tours of the project area

3.3 Stakeholder consultation outcomes

The table below summarises engagement undertaken and the key outcomes through the consultation. A major outcome of the consultation process with the refinement of the proposed sites in response to the cultural associations and value particular locations have to the Traditional Owners. A number of sites were moved or relocated entirely to avoid these areas, with the revised locations being generally supported by Traditional Owners through revised consultation. Other key themes which emerged through the consultation include:

- Ensuring ongoing communication as the project progresses through the approvals process
- Emphasising engagement and consultation with Traditional Owners
- Developing opportunities to maximise local employment and business procurement opportunities

Table 3.2 Stakeholder consultation outcomes

Stakeholder group	Date	Type of consultation	Topic	Key concern / issue	Outcomes
DWER	26-05-2020 22-03-2022	Pre-referral meetings	General project summary Application process	The initial meeting identified the technical studies likely required to support Tassal's (then MPA) application for the original Proposal. The follow-up meeting described the results of these technical studies.	DWER recommended several technical studies to be completed to support the proposals application. These included a modelling study, benthic habitat mapping study, and assessment of interactions with marine fauna. DWER recommended some changes to the delivery / analysis conducted in the technical studies prior to final submission. These have been followed within the original document submission.
	June 2022-January 2023	Official letter Email Virtual meetings	Assessment pathway Request for Additional Information	The Proposals likely assessment pathway with the information provided	After initial assessment of the referral, DWER informed Tassal (then MPA) that the Proposal would be assessed by the EPA. Subsequently, to support the assessment, DWER provided a notice Requiring Information for Assessment under Section 40(2)(a) of the EP Act to Tassal (then MPA), dated the 6/10/22. Tassal subsequently engaged with DWER to confirm the type and delivery of the additional information. In consultation with DCCEEW, it was determined that, though the Proposal could not be assessed under the bilateral pathway, the timing of the assessments could be aligned as

Stakeholder group	Date	Type of consultation	Topic	Key concern / issue	Outcomes
					much as possible to assist in keeping it as an efficient process.
	2023-present	Post-referral meetings to discuss revised application, requests for additional information	Revised application post proponent change	Upon acquiring MPA in July 2023, Tassal needed to submit a Section 43a to reflect a new amended Proposal with them as the proponent	After discussions with DWER, DPIRD and DCCEEW, it was confirmed that the nurseries originally included within the Proposal could likely be removed, considering that they could be managed directly by DPIRD under the FRMA. Subsequent discussions were held in late 2023 to confirm the passing of the Proposal from MPA to Tassal, as well as the removal of 6 of the 13 sites originally proposed. When Tassal became the Proponents of the project, further discussions were had to inform DWER of the change including change in contact details. Tassal submitted a Section 43(a) Form to amend the Proposal as noted above. This amendment was accepted on 13th June 2024. Tassal then held a revised referral meeting with DWER to discuss the updated Proposal on the 14/08/2024; and a final pre-lodgement meeting with DWER on the 03/12/2024.
DPIRD	2020-2022	Ministerial meetings	General discussion of the proposal and its feasibility	Tassal (as MPA) have engaged with DPIRD throughout the lifetime of the Proposal to discuss the Proposals feasibility, its major components as well	The state government recognises the significance of the Proposal and DPIRD is appreciative of the continued approach.

Stakeholder group	Date	Type of consultation	Topic	Key concern / issue	Outcomes
				as any assistance which DPIRD could provide.	DPIRD provided a series of actions with regards to the Proposal initially, which were followed through by Tassal (then MPA).
	2023-present	Site visits Meetings Email	Revised proposal	Post referral, and the change in Proponent to Tassal, discussions have continued regarding the revised Proposal	After discussions with DWER, DPIRD and DCCEEW, it was confirmed that the nurseries originally included within the Proposal could likely be removed, considering that they could be managed directly by DPIRD under the FRMA. DPIRD will continue to provide guidance as to the Proposal, particularly its application under the FRMA and the provision of an aquaculture licence for approval of the Proposal. Tassal has continuously liaised and engaged with DPIRD regarding the Proposal, particularly elements of the Proposal which have changed since the original submission by MPA. This engagement has been managed via phone calls, face-to-face and online meetings, and email. DPIRD continue to provide Tassal with the requisite regulatory information to assist in the referral of the revised Proposal.
DCCEEW	10-08-2020 23-03-2022	Pre-referral meetings Email Virtual meetings	General project summary Assessment pathway	The initial meeting identified the technical studies likely required to support Tassal's (than as MPA) application for the original Proposal.	Similarly to DWER, DCCEEW recommended a number of technical studies/aspects which must be covered off within the technical studies. These included MNES such as the West Kimberley National Heritage Place among others. The technical studies

Stakeholder group	Date	Type of consultation	Topic	Key concern / issue	Outcomes
				The follow-up meeting described the results of these technical studies	recommended were similar/same as those recommended by DWER.
	June 2022-January 2023	Email Virtual meetings	Assessment pathway	DCCEEW's assessment decision and how that would align with DWER's assessment.	On 16/08/22, DCCEEW informed Tassal (then MPA) that the Proposal would be assessed following the provision of a Public Environment Report. On 31/10/2022, DCCEEW released the draft PER Guidelines for review. In consultation with DWER, it was determined that, though the Proposal could not be assessed under the bilateral pathway, the timing of the assessments could be aligned as much as possible to aid in efficiency of the assessment.
	2023-present	Email Virtual meetings	Assessment process Revised proposal	Post referral, and the change in Proponent to Tassal, discussions have continued regarding the revised Proposal, including the assessment pathway	After discussions with DWER, DPIRD and DCCEEW, it was confirmed that the nurseries originally included within the Proposal could likely be removed, considering that there were no MNES of relevance for the BTAP facility. An amended variation of the Proposal was accepted by DCCEEW on 05/07/2024 under Section 156a of the EPBC Act.
DBCA	2020-2022	Marine park design workshops Meetings	Proposal intersection with the marine parks in the Buccaneer Archipelago	Consultation centred on the draft zoning for the marine parks and aquaculture and fishing industry use within the marine parks	There were two sites, Irvine Island and Bathurst Island, that were located in areas proposed to be designated as special purpose zones for cultural protection in the (then) future marine park. Traditional Owners expressed concern regarding their location.

Stakeholder group	Date	Type of consultation	Topic	Key concern / issue	Outcomes
					During the second round of consultation with the DBCA and traditional owners, Tassal (then MPA) were advised that the special purpose zone for cultural protection in Strickland Bay expanded to Edeline Island, in proximity to or covering the proposed Edeline Island North and East sites. The locations of the respective sites have been reassessed, with the removal of Irvine Island, Bathurst Island and Edeline Island East. These sites were replaced with three new sites, Bayliss Island Extra, Conilurus Island Extra and Crocodile Creek Extra and the slight re-arrangement of Edeline Island North to not impinge on the special purpose zone in Strickland Bay.
	June 2022-January 2023	Official review/letters	Draft management plan for the ocean-based sites	Review of the draft management plan, with several comments on the monitoring recommended	DBCA provided several comments on the draft MEMP as required under the FRMA. These comments have subsequently been addressed within this revised EMMP as well as the MEMP (BMT 2024).
	August 2023-Present	Meetings, emails	Tassal acquisition of Proposal, revised Proposal, ongoing engagement with MIAC	Provision of update Proposal information to DBCA including how the Proposal would be limited to the Mayala Marine Park / Mayala Country IPA	Tassal presented to DBCA representatives alongside MIAC at the recent MIAC Family roadshows held in July 2024. This included a detailed description of the revised project scope, monitoring and sampling program and methodology, post-approval implementation and growth/staging proposal. A final pre-lodgement meeting was held with DBCA on the 03/12/2024 to discuss the

Stakeholder group	Date	Type of consultation	Topic	Key concern / issue	Outcomes
					revised proposal and provide DBCA opportunity to comment. DBCA indicated they will provide formal comment through the referral process.
Kimberley Ports Authority	2020-2022 2023	Meetings	Discussion of sites and their intersection with Port boundaries (current and proposed)	Some of the proposed sites intersected with the Kimberley Port Authority waters in Yampi Sound	Confirmation sites are acceptable, and appropriate tenure can be granted for the proposed sites partially located in the proposed Port boundaries. Upon acceptance of the revised proposal, KPA were informed that the proposed sites would no longer intersect with Port boundaries
	2024	Meetings	Revised Proposal and new Proponent	Intersection of Proposal with KPA waters	Tassal held a meeting with KPA on the 9/07/2024 confirming the approved change in Proposal Scope, outlining that the proposed sites no longer intersect with KPA waters. Tassal attended a KPA board meeting on the 25/10/2024 to provide a further Proposal update.
Kimberley Development Commission	2020-2022	Email	Project Briefing and Project Update	Noted	Requested to be informed on project progress.
	2024	Meetings	Revised Proposal and new Proponent	Revised Proposal Development Opportunities	Tassal has held several meetings in 2024 with the Kimberley Development Commission regarding the revised Proposal, as well as exploring potential initiatives regarding mortality utilisation and circular economy opportunities

Stakeholder group	Date	Type of consultation	Topic	Key concern / issue	Outcomes
Shire of Derby-West Kimberley	2020-2022	Meetings	General project summary	Community consultation, linkages with other significant projects in the region	General support from the Shire, who encouraged ongoing communication which can facilitate broader community consultation as the primary source of information for much of the community Encouraged engagement and participation with Traditional Owners Noted the importance of other significant projects in the Archipelago such as the Cockatoo Island Multi-user Supply Base
	2024	Meetings	Revised Proposal and new Proponent	Revised Proposal Development Opportunities	Tassal held a meeting with the Shire President in May 2024 to discuss the changes to the Proposal.
Shire of Broome	2020-2022	Meetings	General project summary	Employment and housing challenges present in Broome currently which may be exacerbated by the Proposal	General support from the Shire, who like the Shire of Derby-West Kimberley encouraged continued communications to aid in community consultation. Noted that the Proposal may result in cumulative increase on employment and housing demand challenges currently being experienced in Broome.
	2024	Meetings	Revised Proposal and new Proponent	Revised Proposal Development Opportunities	Tassal held a meeting with the Shire President in July 2024 to discuss the changes to the Proposal.
Bardi Jawi Niimidiman Aboriginal Corporation	2020-2023	Marine park design workshops Board meetings	General project summary, particularly focused on proposed Ardyaloon nursery via	The siting of the Ardyaloon nursery and the potential interactions with the local community	The Corporation noted that Tassal (then MPA) would need to approach the council to present the final nursery siting plan for the Ardyaloon nursery once complete.

Stakeholder group	Date	Type of consultation	Topic	Key concern / issue	Outcomes
			marine park design workshops and board meetings		Discussed the potential for employment and training opportunities where Traditional Owners are able to work and live on country
	November 2023-present	Emails Virtual meetings	Revised Proposal and new Proponent	Discussion of the revised Proposal, noting the proposed removal of the Ardyaloon nursery	Bardi Jawi were informed by Tassal of the plans to remove the Ardyaloon nursery from the Proposal. However, reaffirmed that Bardi Jawi remain regional stakeholders and as such any opportunities for future projects should be explored. MIAC have further met with Bardi Jawi to express their support for the Proposal, and to hear of any concerns from Bardi Jawi.
Dambimangari (Dambeemangarddee) Aboriginal Corporation	19-10-2021 2022-2023	Marine park design workshops Board meetings Email	Consultation and information sharing for 13 ocean-based aquaculture sites (5 sites are located in Dambimangari non-exclusive native title).	The location of the proposed sites and any interactions with Traditional Owner activities	The Corporation noted the final preferred changes to the location of the proposed sites and had no objections. Sought clarification on freedom of navigation within the sites, where Tassal advised that access to any areas within the proposed sites will not be hindered. Noted that the Corporation is seeking to increase the number of permanent and visiting destinations on Country including Yalloon, Silvergull Creek, Coppermine Creek and Koolan Island. Opportunities for employment in the expanded operations and enhanced cooperation between Tassal and the Corporation could enable more people to more regularly return to or permanently reside on Country.

Stakeholder group	Date	Type of consultation	Topic	Key concern / issue	Outcomes
					Ongoing engagement in the Proposal and continuous consultation through the approvals process was encouraged, including on cultural associations, employment and economic opportunities.
	November 2023 – August 2024	Emails Virtual meetings	Revised Proposal and new Proponent	Discussion of the revised Proposal, noting the proposed removal of the sites within Dambimangari Native Title Determination, and subsequently the ending of the move towards a negotiation protocol, ILUA, heritage agreement at this time.	Dambimangari were informed by Tassal of the plans to remove those sites which lay within Dambimangari Native Title Determination from the Proposal. However, Tassal reaffirmed that Dambimangari remain regional stakeholders and as such any opportunities for future projects should be explored. Tassal further provided invitation to attend surveys on country, as well as an invite to visit operations of other Tassal facilities in Tasmania/Queensland. DAC confirmed that they would still like to visit Tassal operations elsewhere and participate in surveys on country. MIAC have further met with DAC to discuss the Proposal (23/08/24), and to hear of any concerns from DAC. As a result of that meeting, DAC requested a negotiation workshop with Tassal and the opportunity to engage the advice of MIAC's independent environmental consultant.
	August 2024 - present	Face-to-face meetings	DAC engagement within Proposal	Discussion with DAC regarding the potential for their engagement with the Proposal.	Tassal attended the DAC board meetings on the 23/10/2024 and 04/12/2024. Tassal proposed several initiatives to address DAC concerns including a visit for the DAC

Stakeholder group	Date	Type of consultation	Topic	Key concern / issue	Outcomes
					Board to Tasmania to inspect salmon operations, an ongoing contract with the DAC Rangers to assist with shoreline clean-ups, and ongoing information sharing regarding monitoring and management starting with a workshop to review and understand the EMMP provisions for maintaining marine environmental quality particularly in the sanctuary and special purpose zones of the marine park.
Mayala Inninalang Aboriginal Corporation RNTBC	2020-2022	Marine park design workshops Meetings	Proposal intersection with the marine parks in the Buccaneer Archipelago (with reference to Mayala Sea Country)	Consultation centred on the draft zoning for the marine parks and aquaculture and fishing industry use within the marine parks	There were two sites, Irvine Island and Bathurst Island, that were located in areas proposed to be designated as special purpose zones for cultural protection in the (then) future marine park. Traditional Owners expressed concern regarding their location. During the second round of consultation with the DBCA and traditional owners, Tassal (then MPA) were advised that the special purpose zone for cultural protection in Strickland Bay expanded to Edeline Island, in proximity to or covering the proposed Edeline Island North and East sites. The locations of the respective sites have been reassessed, with the removal of Irvine Island, Bathurst Island and Edeline Island East. These sites were replaced with three new sites, Bayliss Island Extra, Conilurus Island Extra and Crocodile Creek Extra and the slight re-arrangement of Edeline Island

Stakeholder group	Date	Type of consultation	Topic	Key concern / issue	Outcomes
					North to not impinge on the special purpose zone in Strickland Bay.
	12-05-2021 19-08-2021 Ongoing consultation in 2022	Marine park design workshops Board meetings Email	Consultation and information sharing for 13 ocean-based aquaculture sites (8 sites fall within Mayala sea country).	During the first consultation it was not clear to the MIAC what the size and layout of the sites would be. MIAC sought further information on the size and layout of the sites	The information, such as an example farm layout and size including rough pen designs to give an idea of what it would look like when a site is in production has been shared. The Corporation noted the final preferred changes to the proposed sites with no objections raised. The Corporation noted the importance of maintaining communication on the referral and approvals process including notification on public consultation period. Encouraged Tassal to seek opportunities to progress social, economic and employment outcomes.
	November 2023	Emails Virtual meetings	Revised Proposal and new Proponent	Discussion of the revised Proposal, noting the remaining sites are all still within Mayala Native Title, and hence negotiations are necessary	Tassal informed Mayala of the change in proponent from MPA to Tassal; while confirming that the revised proposal would still remain within Mayala Native Title and hence there would be a need to finalise negotiations
	Ongoing consultation in 2024	Emails Virtual and face-to-face meetings On country site visits	Heritage agreements, ILUAs, negotiation protocols, on site surveys	Organisation of the requisite heritage agreements and negotiation protocols with a move towards an ILUA, including requirement for on country site surveys	Tassal has finalised a negotiation protocol with Mayala Inninalang Aboriginal Corporation RNTBC, as of November 2023, and Heritage Agreement as of March 2024. On country surveys were carried out in May 2024, with the outcomes documented in Section 9.

Stakeholder group	Date	Type of consultation	Topic	Key concern / issue	Outcomes
					An environmental workshop was conducted alongside MIAC on the 1-3/07/2024. Family meetings with MIAC were conducted post the environmental workshop. Scheduled meeting to for negotiation of the ILUA to be held on 6/09/24. Aim to reach agreement on Drafting for an October Annual General Meeting and Authorisation Meeting. ILUA has been authorised by the MIAC as of the 20/11/2024. ILUA has been submitted for registration with the Native Title Tribunal as of February 2025.
Nyul Nyul PBC	2020	Board meeting	General project summary	Awareness of the cultural significance associated with barramundi and naming	The Corporation noted there is a lack of knowledge/awareness surrounding cultural significance associated with barramundi and the naming of such.
Ardyaloon Aboriginal Community	2020-2022	Meetings Emails	General project summary Lease negotiations for the nursery at Ardyaloon	Siting and arrangements surrounding the Ardyaloon nursery	The Ardyaloon Council and Community are supportive of the proposal to construct a nursery facility in the community and wish to progress with construction. Noted the potential to establish a site on land located within the community's aquaculture zone already present. Site discussions will continue to progress as the project moves through the approvals process.
	2024	Meetings	Revised Proposal and new Proponent	Discussion of the revised Proposal, noting the nurseries were removed from the Proposal, and	Tassal informed Ardyaloon of the change in proponent from MPA to Tassal; while confirming that the revised proposal would no longer contain the nursery at Ardyaloon.

Stakeholder group	Date	Type of consultation	Topic	Key concern / issue	Outcomes
				hence the negotiations were no longer necessary for operations at Ardyaloon.	However, reaffirmed that Ardyaloon remain regional stakeholders and as such any opportunities for future projects should be explored. Tassal regularly hold meetings with the CEO of the Ardyaloon community regarding project updates.
Djarindjin Aboriginal Community	2022	Meeting Email	General project summary	Employment opportunities	The Djarindjin Community noted they are supportive of the Proposal and encourage further engagement on employment and business opportunities
Environs Kimberley	2022	Phone conversations Email	General project summary, with a particular focus on environmental outcomes	Results of the environmental technical studies	Noted the results of the technical studies, and that these will be considered through the EPA referral process. Requested that ongoing communication/consultation occur, and that transparency is given regarding the Proposal. Encouraged consultation with Traditional Owners
PEW Charitable Trust	2022	Phone conversations Email	General project summary, with a particular focus on environmental outcomes	Results of the environmental technical studies	Noted that the results of the technical studies will be considered through the formal referral process. Encouraged engagement with Traditional Owners
Conservation Council of WA	2022	Phone conversations Email	General project summary, with a particular focus on	Results of the environmental technical studies	Noted that the results of the technical studies will be considered through the formal referral process.

Stakeholder group	Date	Type of consultation	Topic	Key concern / issue	Outcomes
			environmental outcomes		Encouraged engagement with Traditional Owners
Cygnet Bay Pearls	2020-2022	Meetings Email Phone conversations	General project summary	Noted	Generally supportive of the Proposal
	2024	Meetings Email Phone conversations	Revised Proposal and new Proponent	Revised Proposal Development Opportunities	Tassal have held regular meetings with Cygnet Bay Pearls regarding details on the revised Proposal. Cygnet Bay Pearls have reiterated they are supportive of the Proposal.
Maxima Pearls	2024	Meetings Email Phone conversations	Revised Proposal and new Proponent	Revised Proposal Development Opportunities	Tassal have informed Maxima Pearls on the revised Proposal and new Proponent.
Kimberley Land Council	2022	Meetings Phone conversations	General project summary Engagement regarding Native Title Representative support	Effective engagement with Traditional Owners	Encourage ongoing engagement and transparency with Traditional Owners and opportunities to strengthen relationships and partnerships.
	2024	Meetings Phone conversations	Revised Proposal and new Proponent	Revised Proposal Development Opportunities	Tassal have engaged with KLC to discuss the changes to the Proposal and particularly it’s reduction such that it remains only within MIAC Native Title. KLC have also been provided the opportunity to comment on the MIAC ILUA.

Stakeholder group	Date	Type of consultation	Topic	Key concern / issue	Outcomes
Arrow Pearling Base	2020-2022	Meetings Email Phone conversations	General project summary, siting of the proposed nursery adjacent to the Arrow Pearling Base	Siting of the nursery adjacent to the Arrow Pearling Base	Supportive of the Proposal. A lease agreement for the proposed nursery has been executed.
	2024	Meetings	General project update	Discussion of the revised Proposal, noting the nurseries were removed from the Proposal, and hence the negotiations were no longer necessary for operations at Arrow Pearling.	Tassal informed Arrow Pearling of the change in proponent from MPA to Tassal; while confirming that the revised proposal would no longer contain the nursery at Arrow Pearling.
Mary Island Fishing Club	2020-2022	Informal meetings Phone conversation	General project summary	Location of the sites	Encouraged ongoing engagement with the Club and requested a meeting with the Club committee.
	2024	Informal meetings Phone conversation	Revised Proposal and new Proponent	Revised Proposal Development Opportunities	Tassal have briefed the President of the Mary Island Fishing Club on the revised Proposal. The Club have requested Tassal attend a committee meeting to provide further updates. Tassal are awaiting a proposed date for attendance.
Broome Chamber of Commerce and Industry	2022	Phone conversation Emails	General project summary	Nil	Supportive of the Proposal. Encouraged ongoing engagement with the business community regarding procurement opportunities

Stakeholder group	Date	Type of consultation	Topic	Key concern / issue	Outcomes
	2024	Phone conversation Emails	Tassal acquisition of Proposal, revised Proposal	Revised Proposal Development Opportunities	Tassal have held several discussions with the Chamber of Commerce to discuss the revised Proposal, as well as planning for a Chamber networking function to be held on Tassal premises.
Derby Chamber of Commerce and Industry	2022	Phone conversation Emails	General project summary	Nil	Supportive of the Proposal. Encouraged ongoing engagement with the business community regarding procurement opportunities
	2024	Phone conversation Emails	Tassal acquisition of Proposal, revised Proposal	Revised Proposal Development Opportunities	Tassal have held several discussions with the Chamber of Commerce to discuss the revised Proposal, as well as planning for a Chamber networking function to be held on Tassal premises.

3.4 Ongoing consultation

Tassal is committed to ongoing consultation with relevant stakeholders including Traditional Owners, DBCA, other government agencies, local communities, interested parties and organisations throughout the progression and implementation of the Proposal. Tassal has developed a plan for ongoing engagement and communication moving forward (Table 3.3). In summary the following consultation will be undertaken during the approvals and operations:

- Regular updates and briefings to relevant Native Title Groups
- Continue to liaise with relevant state and local government authorities
- Notify key stakeholders of any public consultation associated with the Proposal approvals, commencement, and completion of operations

Table 3.3 Summary of ongoing consultation to be undertaken throughout the lifetime of the Proposal

Stakeholder Group	Objective	Method	Timeframe
MIAC	Ensure on-going consultation with MIAC inline with the ILUA Ensure all concerns are identified and addressed during the environmental approvals process	Meetings Briefings Notifications of any public consultation associated with the Proposal	Move to ongoing consultation and negotiation following the signed ILUA.
Traditional Owners	To ensure on-going consultation with Native Title groups are in place in accordance with legislative requirements All concerns are identified and addressed during the environmental approvals process	Meetings Briefings Notifications of any public consultation associated with the Proposal	Regular update – progress on environmental approval process Project preparation, operations and completion notifications under relevant legislative requirements. Further engagement under MOU agreements where appropriate or as required.
State and Local Government Agencies	To ensure consistent periodic communication with State and Local Government.	Meetings, Briefings Notifications	Periodic update - progress on environmental approval process. Notification of commencement (start date) of the Project activities - two weeks prior to the first mobilisation to the site. Notification within two weeks of the demobilisation from site. Periodic update - results and plan forward.
Community and Industry Groups, Aboriginal Communities,	To ensure the local community is informed on the project activities.	Meetings Presentations Notifications	Periodic update - progress on environmental approval process is reported on the Proponent's website to ensure transparency for

Stakeholder Group	Objective	Method	Timeframe
Environmental Advocacy Organisations and Private Businesses			all stakeholders including regional communities.

4 Environmental Factors and Principles

4.1 Identification of key factors and their significance

The EPA lists a number of environmental factors which need to be considered in the EIA process (EPA 2021a). The key factors relevant to this Proposal are considered in Table 4.1, with those listed as a key environmental factor if it has been determined that the Proposal will potentially have a significant impact on that factor, either directly or indirectly as part of its development or operation. Consideration of significance is given as per section 6 in EPA (2021a).

Table 4.1 Key environmental factors, their significance and relationship to the Proposal

EPA theme	EPA factor	Significance	Relationship to Proposal
Sea	Benthic Communities and Habitats	Key environmental factor	Benthic communities and habitats can be impacted by nutrient enrichment from sea-pen operations, as well as smothering impacts from waste material which enters the water column. Sediment infauna can be impacted by a change in sediment chemistry as a result of finfish wastes or uneaten food particles
	Coastal Processes	Other environmental factor	Coastal processes are unlikely to be significantly impacted by the Proposal.
	Marine Environmental Quality	Key environmental factor	Marine environmental quality can be impacted by nutrient enrichment from sea-pen operations, with wastes from finfish as well as excess feed entering the water column and potentially changing the concentration of nutrients as well as increasing the likelihood of algal blooms
	Marine Fauna	Key environmental factor	Marine fauna (cetaceans, crocodiles, sharks) may be impacted by the Proposal, with the sea-pens providing an obstacle in the water column while also attracting predators.
Land	Flora and Vegetation	Other environmental factor	Terrestrial flora and vegetation are unlikely to be impacted by the Proposal.
	Landforms	Other environmental factor	Landforms are unlikely to be impacted by the Proposal
	Subterranean Fauna	Other environmental factor	Subterranean Fauna are unlikely to be impacted by the Proposal
	Terrestrial Environmental Quality	Other environmental factor	Terrestrial environmental quality is unlikely to be impacted by the Proposal
	Terrestrial Fauna	Other environmental factor	Terrestrial environmental quality is unlikely to be impacted by the Proposal
Water	Inland Waters	Other environmental factor	Terrestrial environmental quality is unlikely to be impacted by the Proposal

EPA theme	EPA factor	Significance	Relationship to Proposal
Air	Greenhouse Gas Emissions	Other environmental factor	The Proposal will result in some greenhouse gas emissions, primarily from the operation of vessels and diesel powered gensets, though the total emissions are minor in quantity.
	Air Quality	Other environmental factor	Air quality is unlikely to be impacted by the Proposal
People	Social Surroundings	Key environmental factor	Areas of significance for Aboriginal cultural heritage are in proximity to all proposed sites. Considerable stakeholder consultation has been completed in relation to these areas to ensure stakeholders concerns are well understood.
	Human Health	Other environmental factor	The storage and use of chemicals may have impacts on human health; however, these chemicals will be in low quantities and as such pose no significant risk to human health.

4.2 Consistency with environmental principles

The EP Act identifies a series of principles for environmental management. The environmental principles are the highest assessment level that a Proposal or scheme must meet in order to be found environmentally acceptable by the EPA. The proponent has considered these principles in relation to the development and implementation of the Proposal (Table 4.2).

Table 4.2 EPA Act principles and object

Principle	Consideration
The precautionary principle Where there are threats of serious irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, decisions should be guided by: careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and an assessment of the risk-weighted consequences of various options.	Comprehensive biological surveys and technical studies have been undertaken by specialist scientists to inform the assessment of the Proposal. The data yielded by these technical assessments have been used in the refinement of the sites selected for the Proposal. Where residual environmental impacts have been identified, the risks of these impacts being significant has been evaluated and mitigation measures have been, and will continue to be, incorporated into the design and management of the Proposal.
The principle of intergenerational equity The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	The Proposal is an excellent example of an aquaculture development that has the potential to provide significant environmental, social and economic benefits to future generations. Food security is a major issue as the global population continues to grow, and aquaculture is a key area of growth which will be vitally important to meet that demand.

Principle	Consideration
	The Proposal will make a major and sustained contribution to Western Australia's economy, within a setting that is currently underutilised for other economic land use. These intergenerational benefits can be delivered with the loss of less than 1% of the benthic communities and habitats within the development envelope, including avoidance or effective mitigation of impacts on species and communities of conservation significance.
The principle of the conservation of biological diversity and ecological integrity Conservation of biological diversity and ecological integrity should be a fundamental consideration.	Selection of sites took account of major ecological constraints, resulting in the avoidance of the majority of the direct impacts that may have otherwise arisen from for example direct removal of habitats due to moorings. Comprehensive biological surveys and technical studies were then undertaken by specialists to inform the assessment of the Proposal. The data yielded by these assessments have been used both to reconfirm that the sites selected will avoid direct impacts on species and communities of conservation significance.
Improved valuation, pricing and incentive mechanisms Environmental factors should be included in the valuation of assets and services. The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement. The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste. Environmental goals, having been established, should be pursued in the most cost-effective way, by establishing incentive structures, including market mechanisms, which benefit and/or minimise costs to develop their own solutions and responses to environmental problems.	The proponent acknowledges and endorses the need for improved valuation, pricing and incentive mechanisms and has aimed to pursue these principles wherever practicable in the development of the Proposal. This has included: Environmental factors have played a central role in the site selection process and in the improved operational model Any waste that is generated from the Proposal will be managed directly by the proponent with no requirement for other bodies to manage or pay for that waste The cost of decommissioning of the project will be covered by the proponent even if they are unable to do so themselves through the provision of a bond under DPIRD licencing.
The principle of waste minimisation All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.	The proponent's approach to waste management and minimisation will follow the standard hierarchy, comprising: • Avoid and reduce at waste stream sources; • Reuse and recycle where practicable; and • Treat and/or dispose of in accordance with regulated requirements. The proponent will also reduce the amount of waste discharged into the environment through its feeding regime where feed is only input into sea-pens when stock are actively feeding.

Principle	Consideration
Object of the EP Act The object of the EP act provides for "the prevention, control and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with the foregoing"	The proponent has sought to meet the object of the EP act by preventing, controlling and abating potential environmental harm wherever possible in the design and implementation of the Proposal. Specifically, the Proposal provides for a new operational model for sea-pen farming which will have a reduced environmental impact in comparison to the current operational model, while sites have been selected to avoid habitats and vegetation as much as possible.

4.3 Relevant policy and guidance

Assessment of the environmental impacts of the Proposal is based on various Western Australian position statements and guidance statements. Standards, guidelines and policies related to specific environmental factors or individual aspects of the Proposal are listed and discussed in the individual sections relevant to the environmental factor being addressed. The documents generally considered relevant to assessment by the EPA for the Proposal are listed in Table 4.3.

Table 4.3 EPA policy and guidelines relevant to the Proposal

Environmental Protection Authority Policy or Guideline	Relevant Proposal aspect
Statement of Environmental Principles, Factors and Objectives (EPA 2021a)	Significance assessment of potential environmental impact.
Environmental Factor Guideline – Benthic communities and habitats (EPA 2016b) Environmental Factor Guideline – Coastal Processes (EPA 2016c) Environmental Factor Guideline – Marine environmental quality (EPA 2016d) Environmental Factor Guideline – Marine Fauna (EPA 2016e) Technical Guidance – Benthic communities and habitats (EPA 2016f) Technical guidance – EIA of Marine Dredging proposals (EPA 2021e) Technical Guidance – Protecting the quality of Western Australia's marine environment (EPA 2016g) Perth's Coastal Waters Environmental Values and Objectives (EPA 2000)	Potential impacts on the marine environmental quality, benthic communities and habitats and marine fauna through the operation of sea-pen aquaculture at the proposed sites.
Factor Guideline – Air Quality (EPA 2016h)	Potential emission of diesel fumes from the operation of vessels and diesel gensets during sea-pen operations
Factor Guideline – Greenhouse Gas Emissions (EPA 2019)	Potential impact from scope 1 and 2 greenhouse gas emissions during operation of the sea-pens.

Environmental Protection Authority Policy or Guideline	Relevant Proposal aspect
Environmental Factor Guideline – Social Surroundings (EPA 2023a) Technical Guidance EIA of Social Surroundings – Aboriginal Cultural Heritage (EPA 2023b) Environmental Factor Guideline – Human Health (EPA 2016i)	Potential impact associated with Aboriginal and cultural values.
Australian and New Zealand guidelines for fresh and marine water quality (ANZG 2018)	Sets water quality objectives.

5 Marine Environmental Quality

5.1 EPA objective

The EPA objective for marine environmental quality is to maintain the quality of water, sediment and biota so that environmental values are protected.

5.2 Policy and guidance

The relevant EPA policies and guidelines for marine environmental quality and the scope of each of these as relevant to the Proposal are outlined in Table 5.1.

Table 5.1 Policies and guidelines

Policy or guidance	Consideration
Environmental Quality Criteria Reference Document for Cockburn Sound (EPA 2017)	The thresholds examined by the modelling were generally derived from EPA (2017), which provides comprehensive advice regarding the setting of triggers, even when the area of interest is outside of Cockburn Sound. EPA advised this approach is necessary to use for the Proposal. Other thresholds are as per ANZG (2018).
Factor Guideline – Marine Environmental Quality (EPA 2016c)	EPA (2016c) provides guidance on Marine Environmental Quality, including factors which can impact the marine environment. Marine Environmental Quality is assessed based on levels of contaminants in water, sediments or biota, or to changes in the physical or chemical properties of waters and sediments relative to a natural state.
Technical Guidance – Protecting the quality of Western Australia's Marine Environment (EPA 2016g)	EPA (2016g) provides guidance on the environmental quality management frameworks for protecting Western Australia's marine environment and defines the environmental values and objectives for ecosystem health, fishing and aquaculture, recreation and aesthetics, industrial water supply and cultural and spiritual values, as well as the approach to setting levels of ecological protection. The studies executed in support of the Proposal, including hydrodynamic and water quality modelling, were designed and executed in the context of EPA (2016g).
Technical Guidance – Environmental Impact Assessment of marine dredging proposals (EPA 2021b)	EPA (2021b) provides guidance on the appropriate process for assessing environmental impacts associated with marine dredging proposals. The thresholds used in interrogating the model results are derived from the annexure to this technical guidance.
Other policy or guidance	

Policy or guidance	Consideration
Bardi Jawi Gaarra, Mayala and Lalang-gaddam Marine Park Management Plans	The Bardi Jawi Gaarra, Mayala and Lalang-gaddam Marine Park Management Plans dictate how aspects of marine environmental quality within the parks are managed.
Mayala Country Plan (MIAC 2019)	The Mayala Country Plan sets out the biocultural heritage and relationship Mayala people have with Country. It further dictates Mayala's strategic approach and priorities for Country, including relations with external projects on Mayala Country, such as this Proposal.
Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018)	These documents and the assessments of impacts contained herein are based on guidance in the relevant EPA documents (cited above), which are in turn based on the high-level guidance provided in ANZECC & ARMCANZ (2000) and ANZG (2018).

Western Australia's coastal waters are managed under the EPA's Environmental Quality Management Framework (EQMF). The EQMF is based on the National Water Quality Management Strategy (ANZG 2018), which represents an agreed, Australia-wide approach to protecting water quality and associated environmental values.

EPA (2017) sets out the Environmental Quality Plan (EQP) for Western Australia's coastal waters, which includes four environmental values (EVs) and seven environmental quality objectives (EQOs) (Table 5.2). A specifically defined EQP for this Proposal has been defined as per Section 5.4.5.

Table 5.2 Environmental values and Environmental Quality Objectives as per EPA (2017)

Environmental Values	Environmental Quality Objectives
Ecosystem health	There are four levels of ecological protection: • Maintain ecosystem integrity at a maximum level of ecological protection. • High level of ecological protection. • Moderate level of ecological protection. • Low level of ecological protection.
Recreation and aesthetics	Water quality is safe for primary contact recreation (e.g. swimming and diving). Water quality is safe for secondary contact recreation (e.g. fishing and boating). Aesthetic values of the marine environment are protected.
Fishing and aquaculture	Seafood (caught or grown) is of a quality safe for eating. Water quality is suitable for aquaculture purposes.
Industrial water supply	Water quality is suitable for industrial use.
Cultural and spiritual values	Cultural / spiritual values are protected

5.3 Receiving environment

The Buccaneer Archipelago is highly complex with thousands of islands subjected to an extreme 12 m macrotidal regime (Wilson 2013). Currents around the islands are multidirectional and can exceed 1 ms^{-1}, being heavily influenced by tides, which override the broader scale, outer continental shelf currents (Condie & Andrewartha 2008). The region is periodically exposed to extreme environmental forces (e.g. cyclones) that don't necessarily fit into the seasonal or annual patterns, which can impact marine environmental quality. Nearshore areas of the region, particularly those near river mouths, can be particularly turbid with minimal flushing occurring, often resulting in elevated nutrient levels and algal blooms. Most of the proposed sites however are distanced from riverine areas and are interspersed throughout the Archipelago.

With a lack of industrial or agricultural developments in the Buccaneer Archipelago, the surrounding water quality is generally considered to be of high quality. However, as noted above periodic events such as cyclones and riverine inputs particularly in the wet season can at times lead to very turbid waters in some areas. Baseline data has been collected to inform the assessment and gain a better understanding of existing water quality, as is detailed below.

5.3.1 Baseline study - methods

The original baseline water and sediment quality monitoring program was conducted between February-August 2021, which was a 'typical' year whereby the environmental conditions generally were similar to conditions expected in any given year, though the monitoring period did not capture any extreme events which are known to occur. Additional data was conducted between January-March 2024 to supplement the original baseline. The purpose of the baseline program was to effectively capture the seasonal and spatial variability in the collected parameters across the area of interest. This has provided a comprehensive baseline to set the boundary conditions of the water quality and particle tracking models, and allow comparison against the EPA's criteria for high, moderate and low ecological protection. Field work associated with the program was undertaken by specialist scientists in conjunction with Tassal staff, with data analysis and interpretation undertaken by BMT. A summary of the program and its results for key parameters is given below, with full results provided in Annex E.

Program design

Water samples were originally taken at a total of 29 monitoring locations, comprising of 16 lease locations and 13 reference locations either on the outer (oceanic) or inner (nearshore) boundary of the Buccaneer Archipelago in proximity to the proposed sites (Table 5.4). Sediment samples were collected at the 16 lease locations. The number of monitoring locations was revised for the additional baseline program after Tassal reduced the scale of the Proposal (as per the approved Amendment under Section 43(a) of the EP Act), while further reference locations were included. The revised baseline dataset as such comprises a total of 27 monitoring locations, consisting of 7 lease locations, 7 reference locations and 13 model-boundary reference locations. The analysis presented here focuses only on the locations relevant to the revised proposal.

Locations were positioned to provide coverage of all the proposed sites, while also providing an indication of any gradients in water quality from offshore to nearshore regions, which may affect baseline conditions. The additional reference locations were also selected to be near the lease locations, but distant enough such that they are not predicted to be impacted by any activities associated with the Proposal or any other operations. In addition to the water quality samples collected, physical spot samples of water temperature and dissolved oxygen at the seabed were also collected using a CTD profiler.

The water and sediment quality parameters that were collected in this program are detailed in Table 5.3.

Table 5.3 Water and sediment quality parameters collected for chemical analysis

Water quality parameters	Sediment quality parameters
Chlorophyll-a	Copper
Phaeophytin-a	Zinc
Particulate Organic Carbon	Total Kjeldahl Nitrogen
Ortho-phosphate (PO_4-P)	Total Phosphorous
Ammonia (NH_4-N)	Total Organic Carbon
Nitrate and Nitrite (NO_x-N)	Particle Size Distribution
Total Nitrogen	Infauna
Total Phosphorous	
Silicate	
Total suspended solids	

Water samples were collected using an electric submersible pump 0.5 m below the surface, at each of the 27 water quality locations. Once retrieved, the water samples were divided into the aliquots required for each analysis and placed into the respective sample bottles which were then put into an esky with ice or ice bricks. Once back on land, samples were appropriately stored prior to transportation to the laboratory.

Sediment samples were collected using a sediment corer. At each location, four cores (equating to four replicate samples) were collected of which the top 5 cm of each core was used to form a combined and homogenised sample. Each sample was placed either into sample bags or jars and placed into an esky with ice or ice bricks. Once back on land samples were appropriately stored prior to transportation to the laboratory.

Infauna samples were collected using a Petite Ponar grab. Four replicate grabs were collected at each site. The content of each grab was carefully rinsed through a series of graded sieves (to a minimum of 1 mm). Any material greater than 1 mm was fixed in formalin prior to transportation to the laboratory. Infauna were carefully picked from the samples and retained for identification to species level.

The schedule for the collection of the baseline dataset was designed such that sampling events provided coverage for two primary sources of temporal variation; a) neap and spring tidal events, and b) wet and dry seasons. Tidal variation is extreme within the Kimberley region, and as such it has a major impact on the natural variation in water quality. The Kimberley region also experiences two major seasons, the wet and the dry. These two seasons peak in February and June/July respectively, as such capturing data across this period generally captures the greatest level of temporal variation in any given year for the region.

The original baseline dataset captured six sampling events in the wet and dry respectively between February-August 2021. The additional baseline dataset captured seven sampling events between January-April 2023, and a further seven sampling events between October 2023-March 2024. The water quality baseline dataset comprises of a total of 26 individual sampling events, providing coverage of both natural tidal variation and natural seasonal variation for the region. The recommendation in ANZG (2018) for the collection of two years of monthly baseline data results in a total of 24 individual sampling events. However, this recommendation is typically for temperate environments where natural temporal variation is primarily driven by changes between the four seasons of summer, autumn, winter and spring; and not by tides or by variation between two seasons (wet vs dry). For the Kimberley region, two years of monthly data would not capture the natural variation associated with changes between neap and spring tides. As such, though the baseline dataset here does not technically comprise of two years of continuous monthly data, it does provide coverage for the two key drivers of temporal variation for the region.

The gap in the additional dataset was a result of a change in the Proposal owner, and not part of the initial design of the sampling campaign.

Table 5.4 Water and sediment quality sampling program schedule

Year	2021												2023											2024		
Month	Feb	Feb	Mar	Mar	Apr	Apr	Jun	Jun	Jul	Jul	Aug	Aug	Jan	Feb	Feb	Mar	Mar	Mar	Apr	Oct	Nov	Dec	Dec	Feb	Feb	Mar
Sample Event	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Water quality parameters																										
Dissolved Oxygen (in-situ)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Temperature (in-situ)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Chlorophyll 'a'	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Phaeophytin-a	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Particulate Organic Carbon	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ortho-phosphate (PO_4-P)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ammonia (NH_4-N)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Nitrate and Nitrite (NO_x-N)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Year	2021												2023											2024		
Month	Feb	Feb	Mar	Mar	Apr	Apr	Jun	Jun	Jul	Jul	Aug	Aug	Jan	Feb	Feb	Mar	Mar	Mar	Apr	Oct	Nov	Dec	Dec	Feb	Feb	Mar
Sample Event	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Water quality parameters																										
Total Nitrogen	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Total Phosphorous	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Silicate	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sediment quality parameters																										
Copper	✓							✓								✓										
Zinc	✓							✓								✓										
Total Kjeldahl Nitrogen	✓							✓								✓										
Total Phosphorous	✓							✓								✓										
Total Organic Carbon	✓							✓								✓										
Particle Size Distribution	✓							✓								✓										
Infauna	✓							✓								✓										

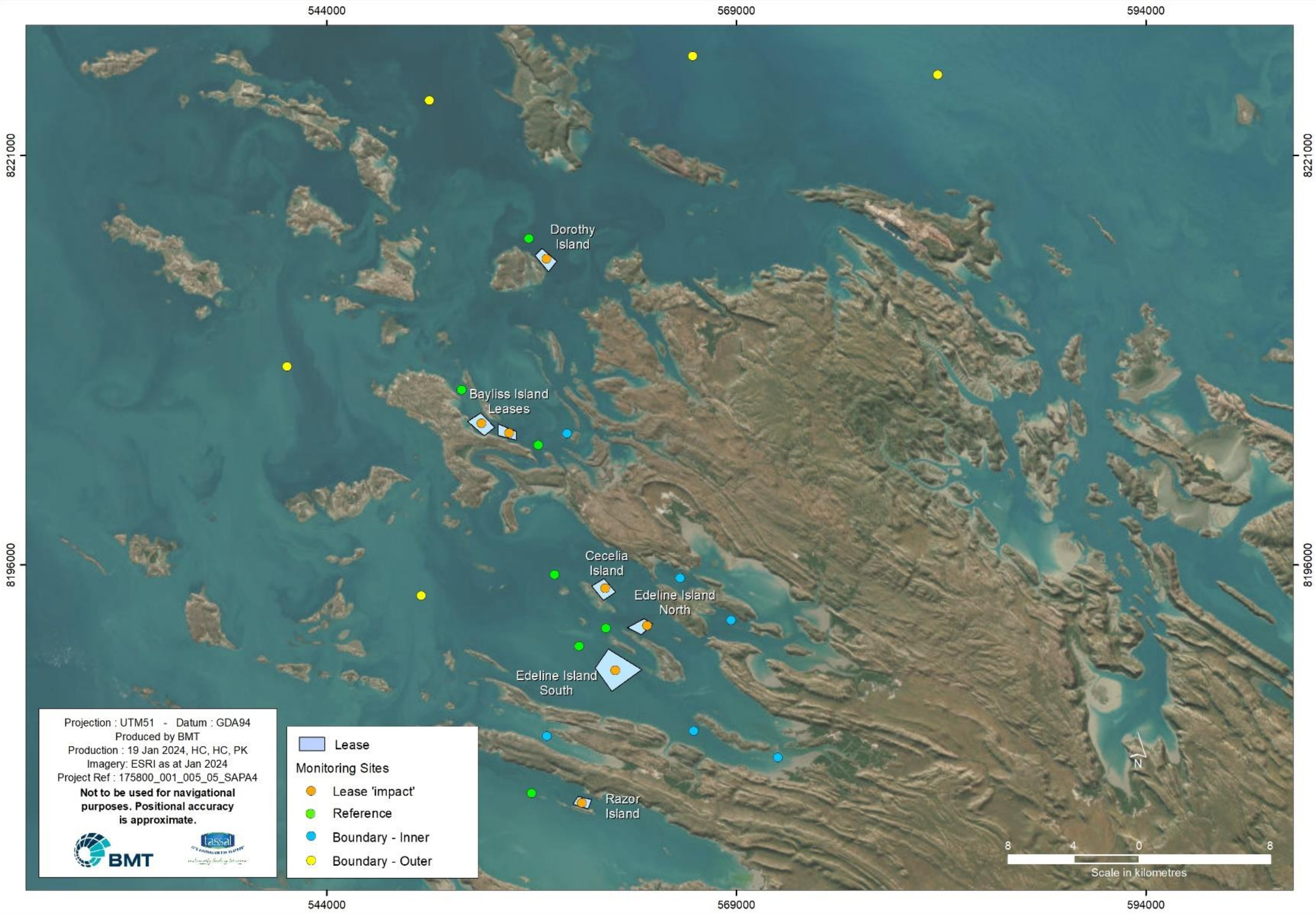


Figure 5.1 Baseline water and sediment quality sampling locations

Statistical analyses – methods

The following section describes the statistical procedures used to analyse the baseline dataset. It includes a technical overview of the approaches to the transformation, interrogation and interpretation of the data. The description is necessarily technical to ensure the approaches used are as transparent as possible.

Water quality

The median concentrations within water samples were compared to the IMCRA mesoscale bioregions (Australia) default guideline values for physical and chemical (PC) stressors for the Kimberley region, where available (ANZG 2018). To derive guideline values for impact assessment, the 80th and 95th percentiles for each parameter were also calculated using the baseline data. For samples with concentrations below the laboratory Level of Reporting (LoR), values were assumed to be equivalent to the LoR in order to calculate the 80th and 95th percentile.

Multivariate analyses tested the difference in overall environment characteristics between the various sites. A Euclidean resemblance matrix was applied on untransformed data prior to analysis with PERMANOVA (non-parametric analysis of variance, Version 7.0.21, Primer-E Ltd) (Anderson et al. 2008). Post-hoc pair wise comparisons were then used to test for differences among locations.

This testing was required to verify how similar the environmental characteristics at each lease location, as well as each reference location, were to each other. The reasoning for this was two-fold. Firstly, testing was conducted to determine whether the data for any of the lease locations could be pooled. The EQC for the impact assessment would subsequently be calculated from each set of pooled data and applied to the particular geographical area or region where the PERMANOVA testing has verified that the baseline environmental conditions are not statistically significantly different. Secondly, testing was conducted to verify that the reference locations are not statistically significantly different from the lease locations that they would be suitable for comparison for ongoing monitoring within the EMMP (Annex A).

Sediment

The 95th percentile of dissolved metal and ammonia concentrations within sediment samples were compared to the ANZG (2018) default guideline values (DGVs) for 99% species protection for a high ecological/conservation area. For samples with concentrations below the LoR, values were halved in order to calculate the 95th percentile. Sediment analyte concentrations were compared to ANZG (2018) DGVs for non-toxicant analytes.

Infauna

For the analysis of infauna, a two-factor statistical design was used: (1) Season (fixed factor, two levels [wet & dry]); (2) Location (fixed factor). The benthic infauna assemblage (multivariate dataset) were first sorted to species level, before being consolidated to the phyla level due to the generally low diversity recorded at a class or family level. Multivariate assemblage data were square-root transformed to down-weight the contribution of dominant infauna and to allow intermediate or rarer groups to play a part in the analyses (Clarke 1993). A Bray-Curtis dissimilarity matrix was generated, and the data were analysed using PERMANOVA.

Results of multivariate analysis were presented graphically using non-metric multidimensional scaling plots (nMDS). This enabled the top benthic infauna phyla that had the strongest correlations with the patterns in the multivariate data to be determined. For univariate analyses of infauna abundance and family richness, a Euclidean distance measure was applied on untransformed data, allowing PERMANOVA to return an equivalent test statistic to a standard ANOVA (Anderson et al. 2008). Post-hoc pair wise comparisons were used to test for differences among levels within significant factors. Results from family richness and abundance analyses were presented using bar graphs of means and standard errors for each location.

To examine the relationship between infauna community assemblage and sediment parameters (grain sizes, trace metals, nutrients), a nMDS plot of the community assemblage were graphed with vectors overlayed on the nMDS plot of sediment parameters. This enabled the top sediment parameters that had the strongest correlations with the patterns in the multivariate infauna data to be determined.

5.3.2 Baseline study – results

Water Quality

Only a subset of the water quality data analysis is presented here, focusing on the key parameters that form part of the impact assessment. For full results of the water quality baseline data collection program, see Annex E.

Pooling Data

Results of the PERMANOVA testing for the pooling of location data are summarised in Table 5.5 and Table 5.6. The only lease location which reported a significant difference in overall environmental characteristics, as defined by the collected water quality parameters, to the other lease locations was Razor Island and its respective reference location. No other lease location reported a significant difference to any other lease location. This supports the pooling of the baseline data across the remaining lease locations, excluding Razor Island, for the derivation of water quality thresholds for use in the modelled impact assessment.

Testing of the reference locations also found that none of the selected reference locations showed a significant difference to the lease location they would be compared to, under ongoing monitoring. This supports the selection of these reference locations and provides evidence that they are appropriate for comparison to the lease locations in the EMMP. Some of the proposed reference locations did show a significant difference to other reference locations, however, as reference location data is not being pooled this is of no consequence.

Table 5.5 Results of a one factor PERMANOVA examining differences among locations across all water quality parameters

Source	Df	MS	P(perm)
Location	**27**	**23.748**	**0.0001**
Residual	922	8.422	
Total	949		

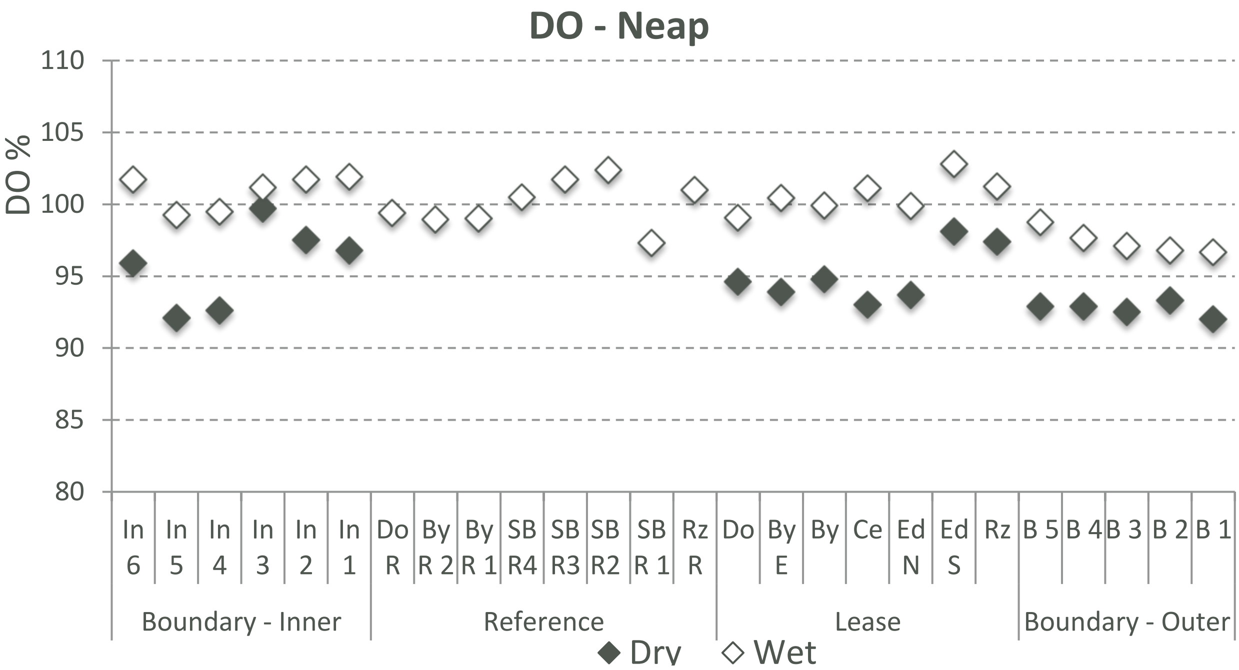
Table 5.6 Results of PERMANOVA pairwise comparisons examining differences among locations across all water quality parameters

	By	Ce	Do	EIN	EIS	Rz	By E	SB R 1	SB R 2	SB R 3	SB R 4	By R 1	By R 2	Do R 1
Ce	0.266													
Do	0.277	0.0624												
EIN	0.5199	0.9185	0.1734											
EIS	0.2788	0.4267	0.7173	0.396										
Rz	**0.0016**	**0.0321**	**0.0452**	0.0502	0.5017									
By E	0.9361	0.5428	0.1939	0.4528	0.1485	**0.0032**								
SB R 1	0.32	0.0623	0.9537	0.2708	0.6032	**0.044**	**0.0419**							
SB R 2	0.2079	0.5372	0.4592	0.6043	0.4839	0.3081	0.2524	0.3219						
SB R 3	0.2665	0.2798	0.6145	0.3911	0.8909	0.917	0.1091	0.4055	0.6453					
SB R 4	0.3125	0.9358	0.444	0.8753	0.5717	0.1721	0.3827	0.1836	0.9755	0.5591				
By R 1	0.3823	0.087	0.4917	0.0931	0.1692	**0.0014**	0.2269	0.0981	0.3559	0.0486	0.1529			
By R 2	0.3366	0.3061	0.4174	0.2276	0.2333	**0.0178**	0.4588	0.0532	0.8189	0.1955	0.5986	0.6167		
Do R 1	0.0667	0.0012	0.8904	0.0111	0.1008	**0.0005**	**0.0081**	0.4627	0.1179	**0.031**	**0.0216**	0.3515	0.0638	
Rz R 1	0.0521	0.0189	0.6969	0.0753	0.6699	0.3591	**0.0061**	0.6019	0.2402	0.7281	0.1118	**0.0058**	**0.0146**	**0.0384**

Notes:
1. By = Bayliss, Ce = Cecelia, Do = Dorothy, EIN = Edeline Island North, EIS = Edeline Island South, Rz = Razor, E = Extra, Str = Strickland, R = Reference
2. **Bold =** p-values with alpha < 0.05

Dissolved oxygen

Median dissolved oxygen saturation ranged between 96.65% to 102.79% in the wet season, and 84% to 100.2% in the dry season (Figure 5.2). Concentrations were generally lower during the spring tides compared to neap tides. Dissolved oxygen saturation was lowest particularly at the inner and outer boundary locations; however, this was only the case during the dry season, with saturation otherwise consistent during the wet season across most locations. Table 5.7 summarises median dissolved oxygen concentrations across the lease and reference locations, with a split between the Razor Island locations and the others noting the results of the PERMANOVA testing for pooling of the baseline dataset.



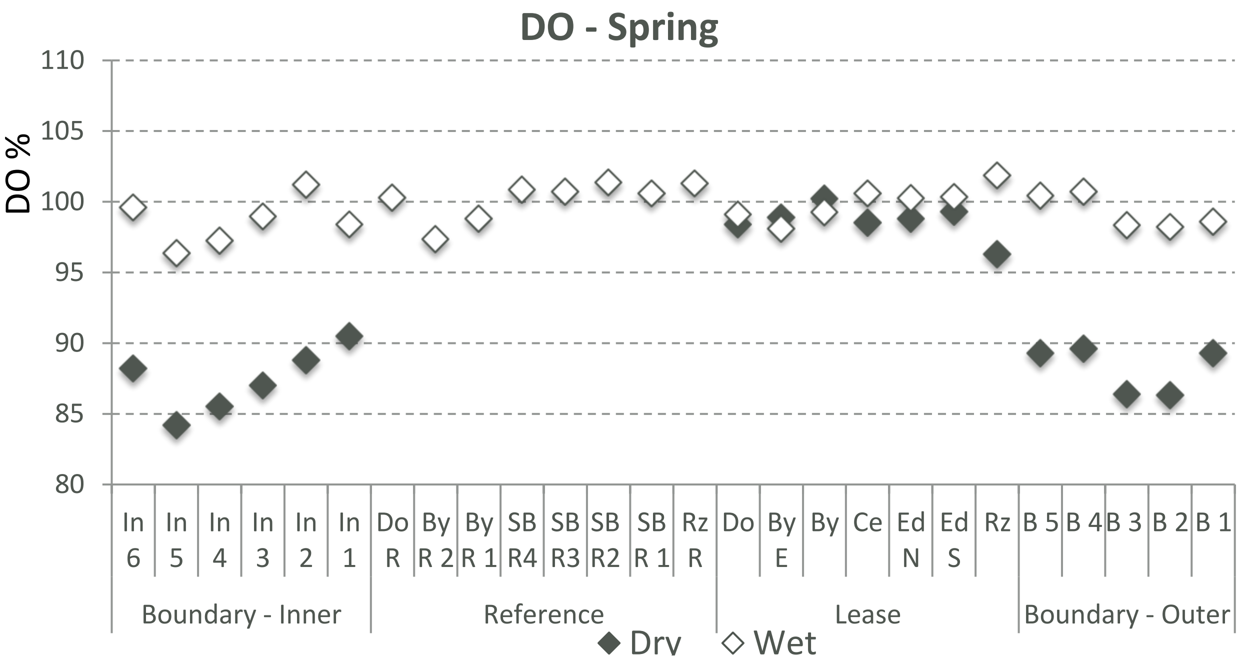


Figure 5.2 Median dissolved oxygen saturation (depth-averaged) across boundary (inner and outer), lease and reference locations for wet and dry seasons and neap and spring tides

Table 5.7 Median dissolved oxygen concentrations (%) across all lease and reference locations between wet and dry seasons

Location	Wet	Dry
Razor Island	100.50	96.85
Razor Island Reference	101.00	-
80th Percentile - Razor Island	103.78	99.20
95th Percentile - Razor Island	105.38	104.00
80th Percentile - Razor Island (across seasons)	103.70	
95th Percentile - Razor Island (across seasons)	105.50	
Edeline South	100.60	98.60
Edeline North	99.45	95.35
Cecelia Island	100.60	94.00
Strickland Bay Reference 1	98.10	-
Strickland Bay Reference 2	101.07	-
Strickland Bay Reference 3	100.34	-
Strickland Bay Reference 4	99.25	-
Bayliss Islands	99.60	96.10
Bayliss Islands Extra	99.80	94.35
Bayliss Islands Reference 1	-	98.30
Bayliss Islands Reference 2	-	97.65
Dorothy Island	98.45	94.80
Dorothy Island Reference	99.15	-
80th Percentile - Other leases	102.04	99.30
95th Percentile - Other leases	104.62	101.70
80th Percentile - Other leases (across seasons)	101.68	
95th Percentile - Other leases (across seasons)	104.36	

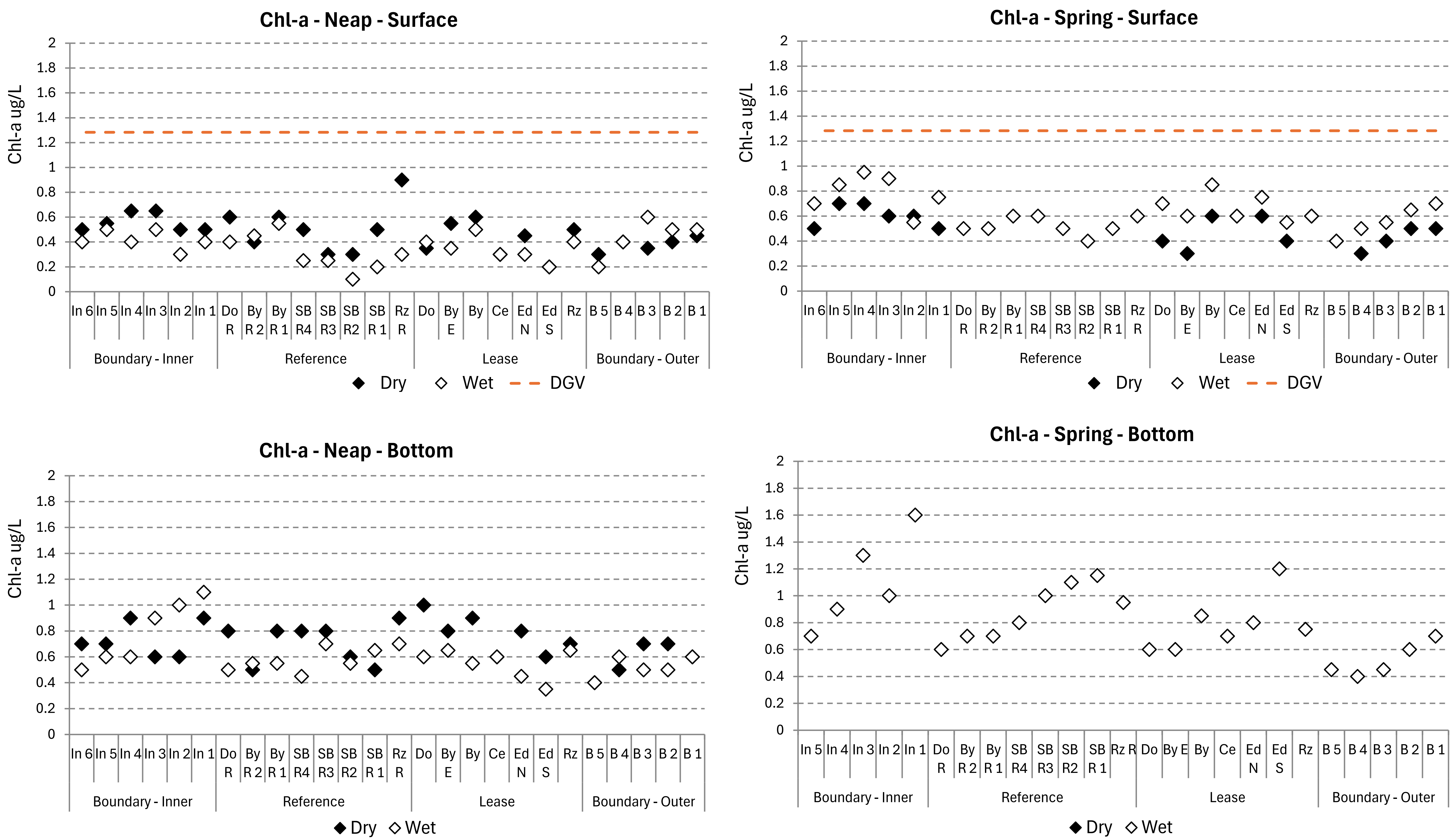
Chlorophyll-a

Median chlorophyll-a concentrations were below the ANZG (2018) default guideline value (averaged across seasons) for all locations in all seasons (Figure 5.3). At the surface, median concentrations ranged between 0.1 ug/L to 0.95 ug/L in the wet season, and 0.2 ug/L to 0.9 ug/L in the dry season. Concentrations were substantially greater in the bottom of the water column across all seasons and both tidal cycles, potentially due to resuspension of material with tidal fluctuations. Concentrations were generally higher during the spring tides compared to neap tides across all locations no matter the depth.

At an area level, the inner locations closest to the nearshore regions of the Archipelago tended to report higher median chlorophyll-a concentrations than the other locations, particularly during spring tides.

Concentrations at the reference and lease locations were relatively consistent. Boundary locations reported the lowest median concentrations overall.

Table 5.8 summarises median chlorophyll-a concentrations across the lease and reference locations, with a split between the Razor Island locations and the others noting the results of the PERMANOVA testing for pooling of the baseline dataset.



Note: In = Inner, R = Reference, B = Boundary, Do = Dorothy, By = Bayliss, By E = Bayliss Extra, Ce = Cecelia, Ed N = Edeline North, Ed S = Edeline South, Rz = Razor, SB = Strickland Bay

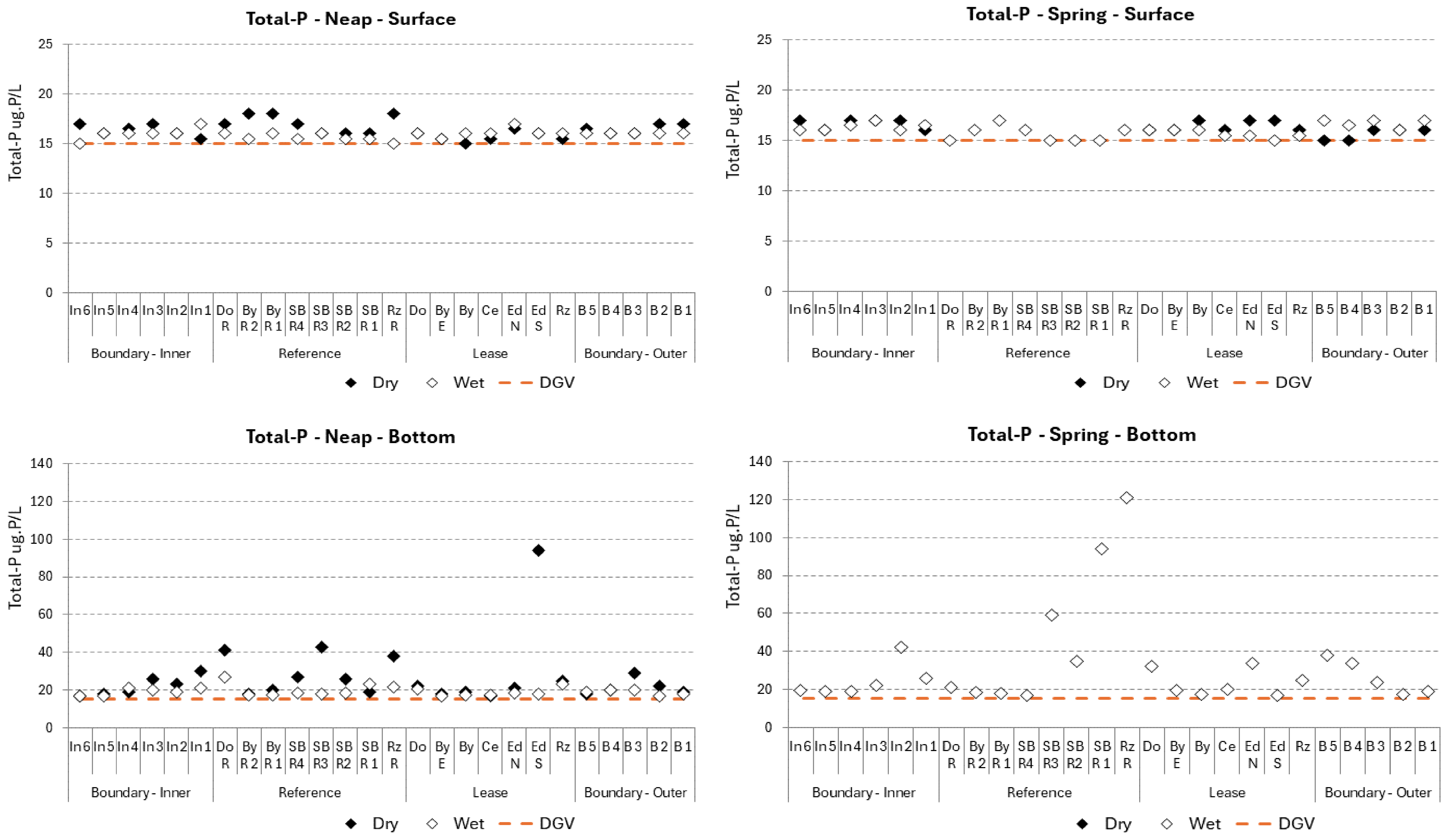
Figure 5.3 Median surface and bottom chlorophyll-a concentrations across boundary (inner and outer), lease and reference locations for wet and dry seasons and neap and spring tides, against the default guideline value for chlorophyll-a for the Kimberley region for surface waters (averaged across seasons; ANZG 2018)

Table 5.8 Median chlorophyll-a concentrations (ug/L) across all lease and reference locations between wet and dry seasons

Location	Wet	Dry
Razor Island	0.60	0.60
Razor Island Reference	0.70	0.90
80th Percentile - Razor Island	**0.80**	**0.90**
95th Percentile - Razor Island	**1.10**	**0.90**
80th Percentile - Razor Island (across seasons)	**0.90**	
95th Percentile - Razor Island (across seasons)	**1.10**	
Edeline South	0.40	0.30
Edeline North	0.60	0.60
Cecelia Island	0.60	0.55
Strickland Bay Reference 1	0.60	0.50
Strickland Bay Reference 2	0.50	0.45
Strickland Bay Reference 3	0.55	0.55
Strickland Bay Reference 4	0.50	0.65
Bayliss Islands	0.60	0.70
Bayliss Islands Extra	0.60	0.55
Bayliss Islands Reference 1	0.60	0.70
Bayliss Islands Reference 2	0.50	0.45
Dorothy Island	0.55	0.40
Dorothy Island Reference	0.50	0.70
80th Percentile - Other leases	**0.90**	**0.78**
95th Percentile - Other leases	**1.20**	**0.80**
80th Percentile - Other leases (across seasons)	**0.80**	
95th Percentile - Other leases (across seasons)	**1.20**	

Total Phosphorous

Median total phosphorous concentrations exceeded the ANZECC ARMCANZ (2000) default guideline value (averaged across seasons) across all locations, seasons and tides (Figure 5.4). At the surface, median concentrations ranged between 15.5 ug.P/L to 17 ug.P/L in the wet season, and 15.5 ug.P/L to 18 ug.P/L in the dry season. Concentrations were substantially greater in the bottom of the water column across all seasons and both tidal cycles, with the highest reported median of 121 ug.P/L at the Razor Island Reference location in the wet season. Concentrations were generally higher during the neap tides compared to spring tides across all locations no matter the depth.



Note: In = Inner, R = Reference, B = Boundary, Do = Dorothy, By = Bayliss, By E = Bayliss Extra, Ce = Cecelia, Ed N = Edeline North, Ed S = Edeline South, Rz = Razor, SB = Strickland Bay

Figure 5.4 Median surface and bottom total phosphorous concentrations across boundary (inner and outer), lease and reference locations for wet and dry seasons and neap and spring tides, against the default guideline value for total phosphorous for the Kimberley region (averaged across seasons; ARMCANZ & ANZECC 2000)

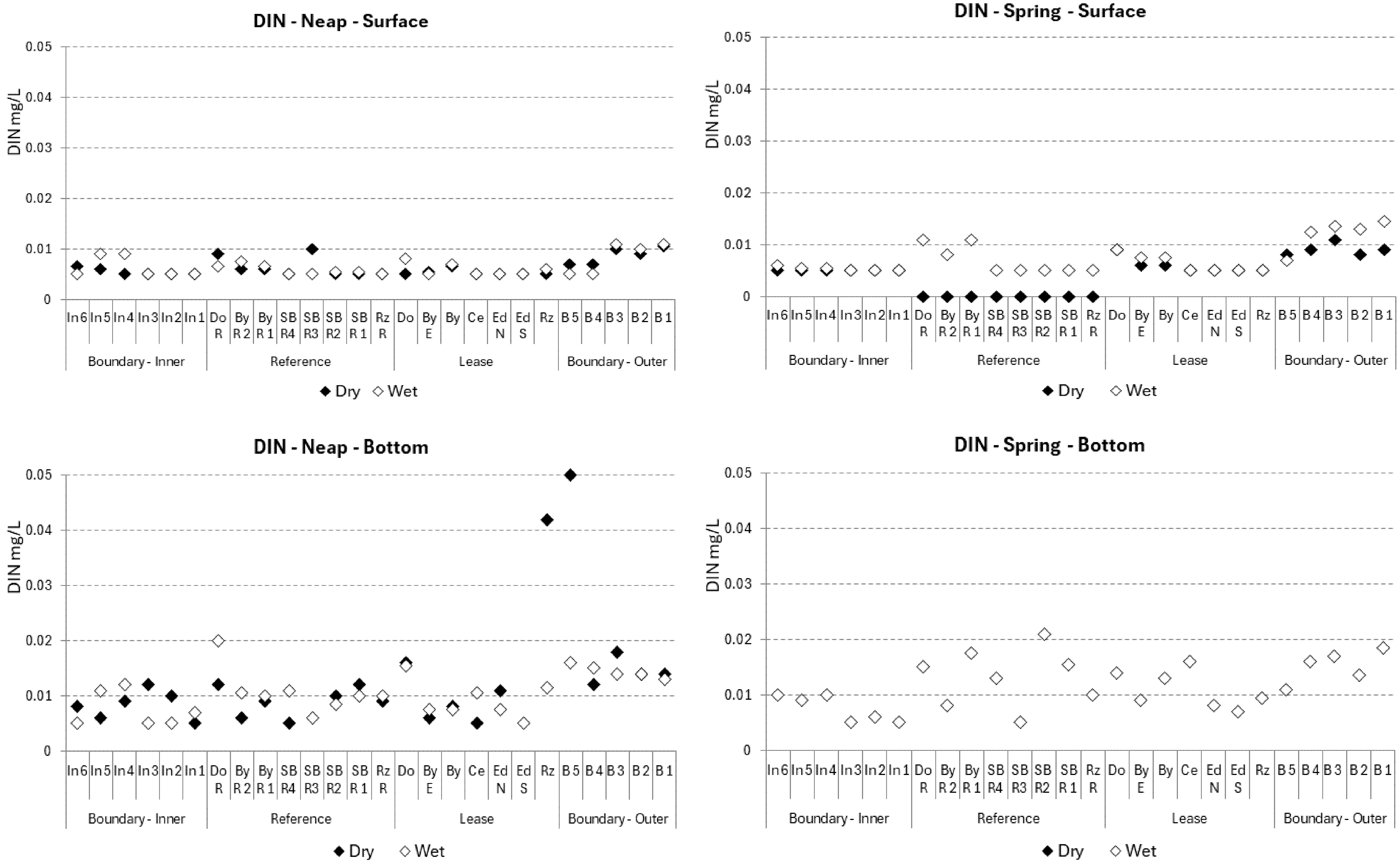
Table 5.9 Median total phosphorous concentrations (ug.P/L) across all lease and reference locations between wet and dry seasons

Location	Wet	Dry
Razor Island	17.00	16.00
Razor Island Reference	17.00	28.00
80th Percentile - Razor Island	24.00	19.40
95th Percentile - Razor Island	150.00	32.15
80th Percentile - Razor Island (across seasons)	24.00	
95th Percentile - Razor Island (across seasons)	135.50	
Edeline South	16.00	16.50
Edeline North	17.00	17.00
Cecelia Island	16.50	16.00
Strickland Bay Reference 1	16.50	17.50
Strickland Bay Reference 2	16.50	21.00
Strickland Bay Reference 3	16.50	29.50
Strickland Bay Reference 4	17.00	22.00
Bayliss Islands	17.00	16.50
Bayliss Islands Extra	16.00	16.00
Bayliss Islands Reference 1	17.00	19.00
Bayliss Islands Reference 2	16.00	18.00
Dorothy Island	16.50	16.00
Dorothy Island Reference	18.00	29.00
80th Percentile - Other leases	20.00	18.00
95th Percentile - Other leases	52.00	26.95
80th Percentile - Other leases (across seasons)	19.00	
95th Percentile - Other leases (across seasons)	43.85	

Dissolved Inorganic Nitrogen

Median dissolved inorganic nitrogen concentrations at the surface ranged between 0.005 mg/L to 0.015 mg/L in the wet season, and 0.005 mg/L to 0.011 mg/L in the dry season. Median concentrations were substantially greater in the bottom of the water column across all seasons and both tidal cycles. Median concentrations were generally greater during the spring than neap tides across all locations no matter the depth.

Table 5.10 summarises median dissolved inorganic nitrogen concentrations across the lease and reference locations, with a split between the Razor Island locations and the others noting the results of the PERMANOVA testing for pooling of the baseline dataset.



Note: In = Inner, R = Reference, B = Boundary, Do = Dorothy, By = Bayliss, By E = Bayliss Extra, Ce = Cecelia, Ed N = Edeline North, Ed S = Edeline South, Rz = Razor, SB = Strickland Bay

Figure 5.5 Median surface and bottom dissolved inorganic nitrogen concentrations across boundary (inner and outer), lease and reference locations for wet and dry seasons and neap and spring tides

Table 5.10 Median dissolved inorganic nitrogen concentrations (mg/L) across all lease and reference locations between wet and dry seasons

Location	Wet	Dry
Razor Island	0.007	0.005
Razor Island Reference	0.006	0.007
80th Percentile - Razor Island	0.007	0.012
95th Percentile - Razor Island	0.027	0.031
80th Percentile - Razor Island (across seasons)	0.010	
95th Percentile - Razor Island (across seasons)	0.036	
Edeline South	0.005	0.005
Edeline North	0.007	0.005
Cecelia Island	0.008	0.005
Strickland Bay Reference 1	0.008	0.009
Strickland Bay Reference 2	0.006	0.008
Strickland Bay Reference 3	0.005	0.037
Strickland Bay Reference 4	0.007	0.005
Bayliss Islands	0.008	0.007
Bayliss Islands Extra	0.007	0.006
Bayliss Islands Reference 1	0.011	0.008
Bayliss Islands Reference 2	0.008	0.006
Dorothy Island	0.010	0.007
Dorothy Island Reference	0.014	0.011
80th Percentile - Other leases	0.015	0.009
95th Percentile - Other leases	0.023	0.014
80th Percentile - Other leases (across seasons)	0.014	
95th Percentile - Other leases (across seasons)	0.022	

Sediment quality

Nutrients

Nutrient concentrations were similar across sediment sites (Table 5.11). Phosphorus concentrations ranged from 0.37-0.56 mg.P/g. Total Kjeldahl nitrogen (TKN) ranged from 0.3-1.3 mg.N/g. Total organic carbon content ranged from 0.2-0.9%. There are no ANZG (2018) DGVs for nutrients in sediments. No north-south gradient was reported in total nutrient concentrations across the lease locations.

Table 5.11 Nutrient concentrations in sediment samples at lease locations

Location	TKN (mg.N/g)	Total Phosphorous (mg.P/g)	TOC (%)
Wet season (February 2021)			
Cec. Is.	1.00	0.56	0.30
Ede. Is. North	1.20	0.41	0.70
Ede. Is. South	0.60	0.37	0.70
Dor. Is.	1.20	0.43	0.60
Bay. Is.	0.30	0.43	0.40
Bay. Is. Ex.	-	-	-
Raz. Is.	1.00	0.40	0.40
Dry season (June 2021)			
Cec. Is.	0.30	0.57	0.20
Ede. Is. North	1.00	0.43	0.70
Ede. Is. South	1.20	0.43	0.80
Dor. Is.	1.20	0.46	0.80
Bay. Is.	0.60	0.40	0.40
Bay. Is. Ex.	1.00	0.51	0.60
Raz. Is.	1.00	0.40	0.40
Wet season (February 2023)			
Cec. Is.	0.5	0.52	0.4
Ede. Is. North	0.7	0.43	0.5
Ede. Is. South	0.6	0.37	0.8
Dor. Is.	1	0.46	0.8
Dor. Is. Ref Site 1	1.3	0.45	0.9
Bay. Is.	0.6	0.45	0.4
Bay. Is. Ref Site 1	0.6	0.35	0.7
Bay. Is. Ref Site 2	0.8	0.38	0.5
Bay. Is. Ex.	0.9	0.44	0.6
Raz. Is.	0.5	0.41	0.3
Raz. Is. Ref Site 1	0.7	0.43	0.5
Str. Bay Ref Site 1	0.9	0.49	0.6
Str. Bay Ref Site 2	1.1	0.41	0.7
Str. Bay Ref Site 3	1.1	0.41	0.8
Str. Bay Ref Site 4	0.3	0.72	0.2

Notes:

1. Bay = Bayliss, Cec = Cecelia, Is = Island, Dor = Dorothy, Ede = Edeline, Raz = Razor, Ex = Extra, Str = Strickland, Ref = Reference

Trace Metals

Trace metals of copper and zinc were variable temporally and spatially (Table 5.12) particularly zinc, however both were in relatively low concentrations throughout (well below ANZG guidelines of 65 mg/kg and 200 mg/kg for copper and zinc respectively). Wet season data reported for zinc were marginally higher than for dry season. There was no clear north to south gradient in trace metal concentrations.

Table 5.12 Metal concentrations in sediment samples at lease locations

Location	Total Cu (mg/kg)	Total Zn (mg/kg)
Wet season (February 2021)		
Cec. Is.	3.20	14.00
Ede. Is. North	10.00	31.00
Ede. Is. South	11.00	33.00
Dor. Is.	8.70	24.00
Bay. Is.	6.20	19.00
Bay. Is. Ex.	-	-
Raz. Is.	6.30	21.00
Dry season (June 2021)		
Cec. Is.	3.30	10.00
Ede. Is. North	9.30	26.00
Ede. Is. South	11.00	30.00
Dor. Is.	10.00	25.00
Bay. Is.	5.10	15.00
Bay. Is. Ex.	8.80	24.00
Raz. Is.	6.30	21.00
Wet season (February 2023)		
Cec. Is.	4.70	14.00
Ede. Is. North	6.90	19.00
Ede. Is. South	11.00	28.00
Dor. Is.	8.50	21.00
Dor. Is. Ref Site 1	10.00	26.00
Bay. Is.	5.30	15.00
Bay. Is. Ref Site 1	16.00	32.00
Bay. Is. Ref Site 2	6.10	17.00

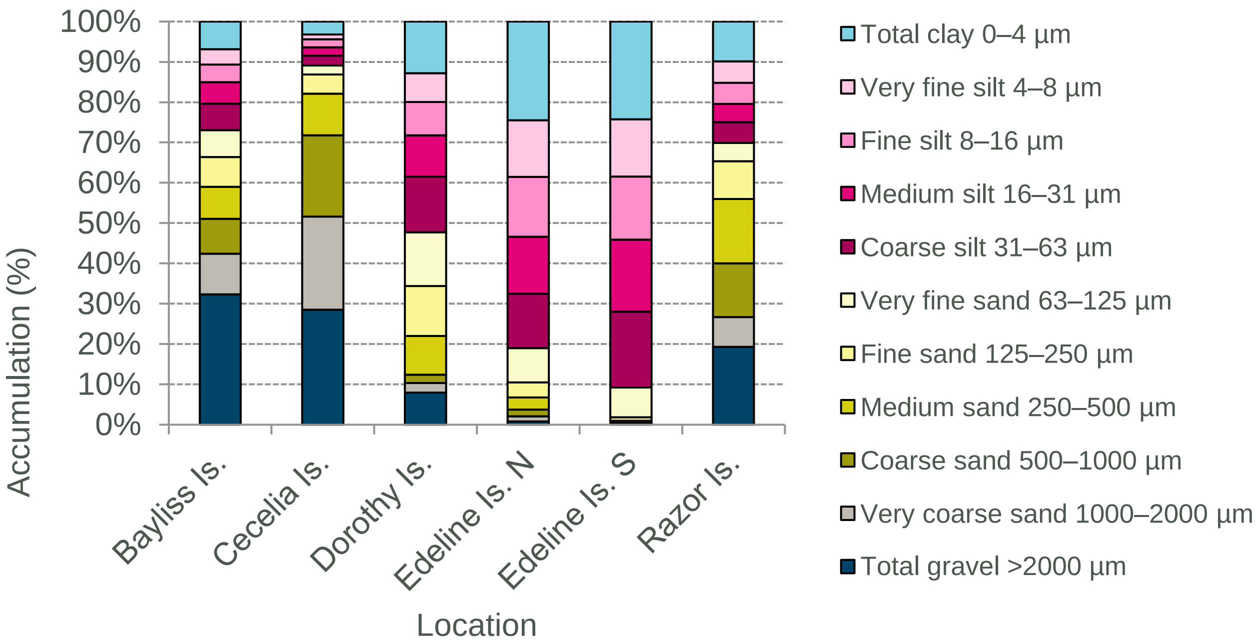
Bay. Is. Ex.	9.00	23.00
Raz. Is.	5.10	18.00
Raz. Is. Ref Site 1	7.80	24.00
Str. Bay Ref Site 1	8.50	26.00
Str. Bay Ref Site 2	11.00	27.00
Str. Bay Ref Site 3	12.00	32.00
Str. Bay Ref Site 4	2.90	11.00

Notes:

1. Bay = Bayliss, Cec = Cecelia, Is = Island, Dor = Dorothy, Ede = Edeline, Raz = Razor, Ex = Extra, Str = Strickland, Ref = Reference

Particle size distribution

Results for particle size distribution indicated that there were no overall differences between season but clear separation in distribution between some locations (Table 5.13; Figure 5.7, Figure 5.8). For example, Bayliss Island, Cecelia Island and Razor Island were characterised by higher concentrations of gravel and coarse sand. All other locations reported no gravel or coarse sand and were predominantly made up of silt or fine sand. This is the case for both wet and dry seasons. The nMDS plot also showed no clear separation between seasons.



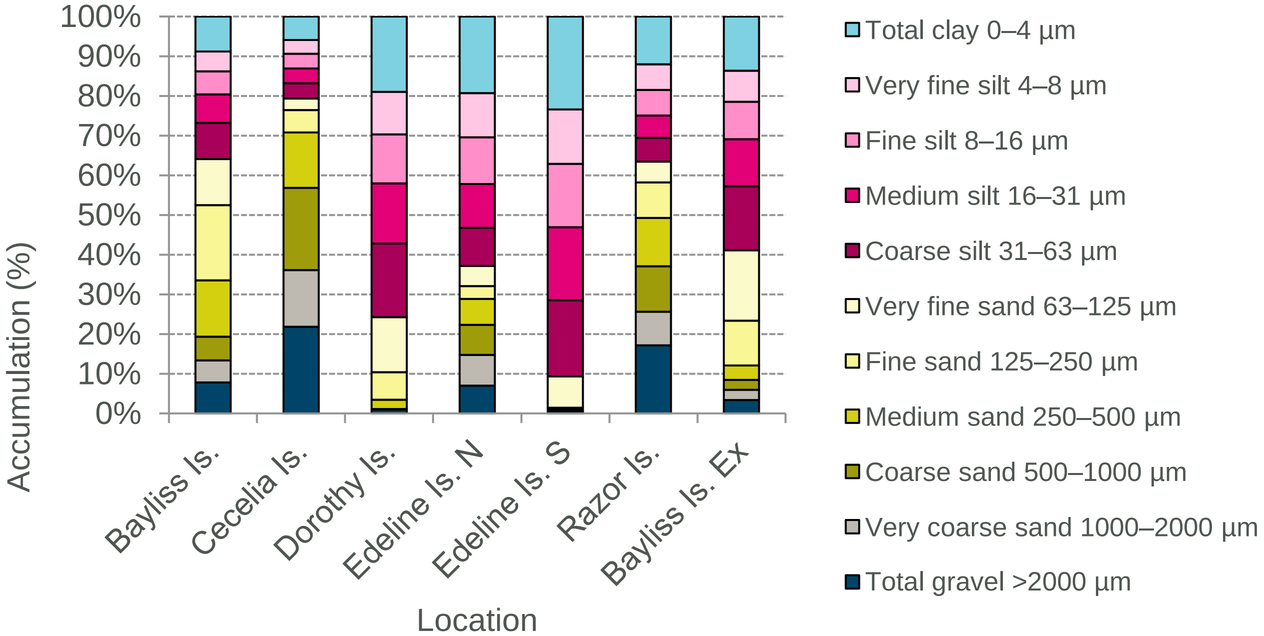


Figure 5.6 Particle size distribution results for all locations for wet and dry seasons (2021)

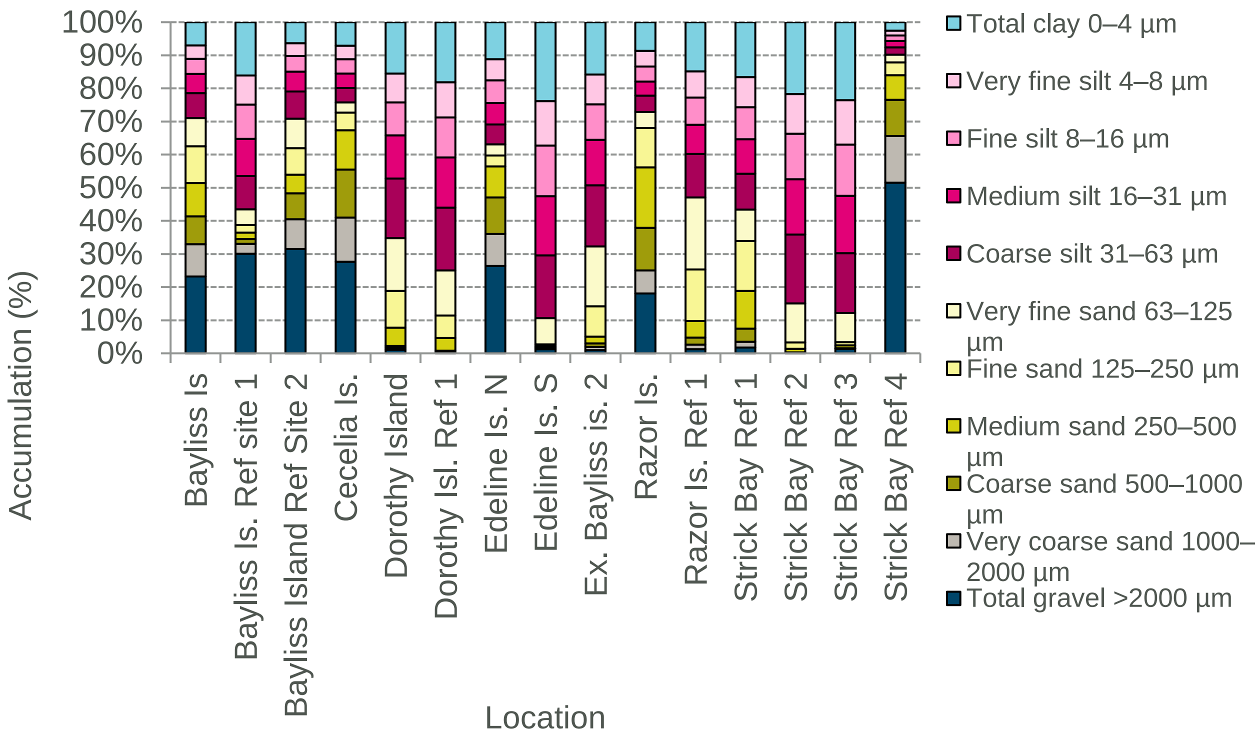
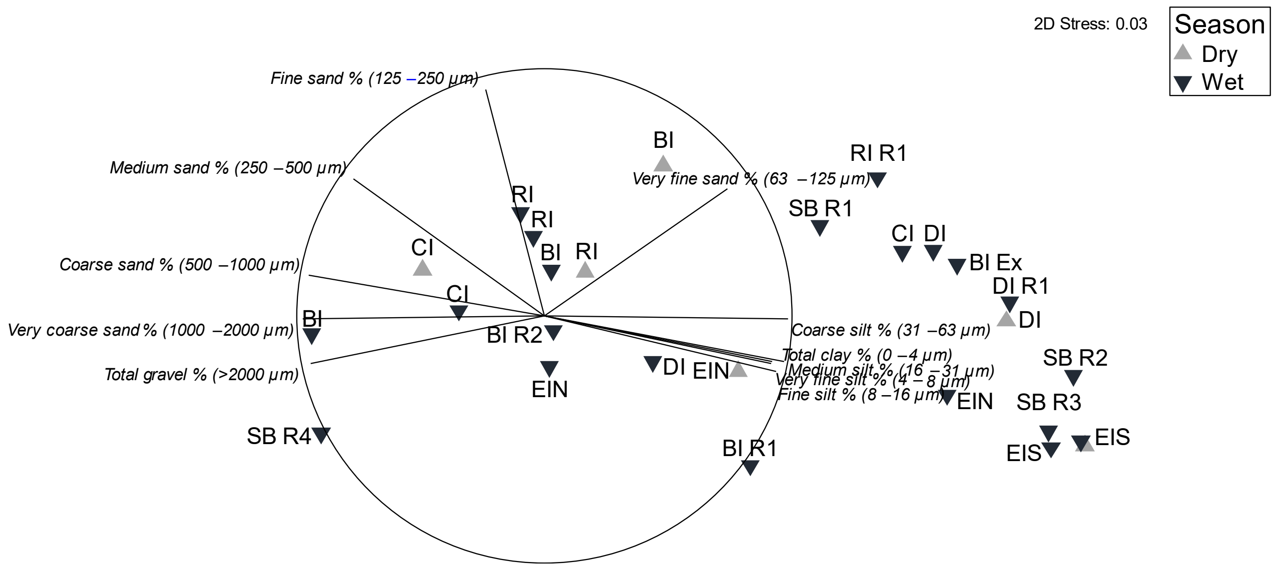


Figure 5.7 Particle size distribution results for all Locations for wet season (2024)



Notes:

1. In nMDS, differences between locations are represented by the relative distance between points
2. 2D stress is a representation of the dimensionality of the ordination i.e. how much can be interpreted from constraining the ordination onto 3 or in this case 2 dimensions: stress <0.05 gives an excellent representation; stress <0.1 corresponds to a good ordination with no real prospect of a misleading interpretation; stress <0.2 gives a potentially useful 2–dimensional ordination, though for values at the upper end of this range, too much reliance should not be placed on the detail of the plot
3. Black line vectors indicate the relative importance of the individual trace metals in driving the separation between Sites.
4. EIN = Edeline Island North, EIS = Edeline Island South, RI = Razor Island, BI = Bayliss Island, CI = Cecelia Island, DI = Dorothy Island, SB = Strickland Bay, R = Reference

Figure 5.8 Non-Metric multidimensional scaling plot showing ordination of locations with overlay of particle size distribution

Table 5.13 Multivariate PERMANOVA results for particle size distribution of sediments

Source	Df	MS	P(perm)
Location	14	524.91	0.0884
Season	1	19.173	0.8152
Location x Season	5	119.51	0.7823
Residual	6	176.82	
Total	26		

Notes:

1. Df = Degrees of freedom, MS = Mean square

Infauna

Outcomes of univariate analyses of infauna abundance and species richness indicated no differences between season but a significant difference between locations for species richness (Table 5.13 5.9, Figure 5.10). At a location level, Razor Island, Bayliss Island and Cecelia Island recorded the highest abundance and species richness overall. Dorothy Island recorded lower abundances but higher species richness during the wet season and the opposite in the dry season.

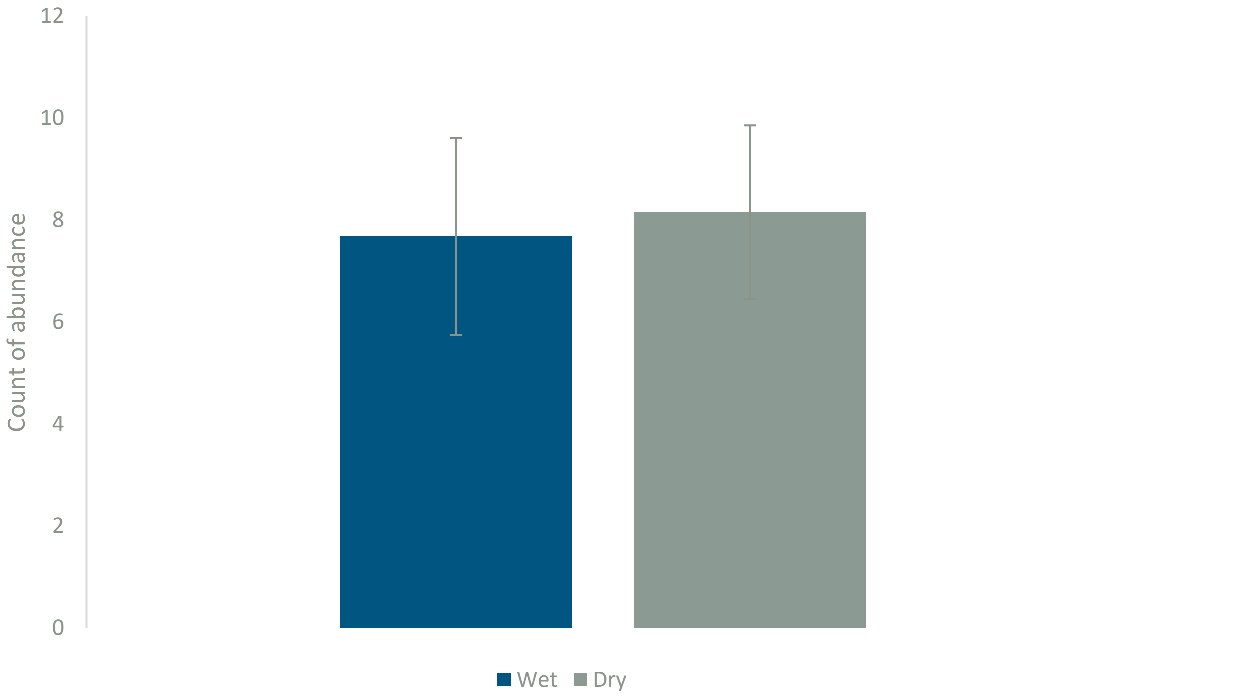


Figure 5.9 Mean (± Standard Error) abundance of infauna taxa recorded across all locations for wet and dry season

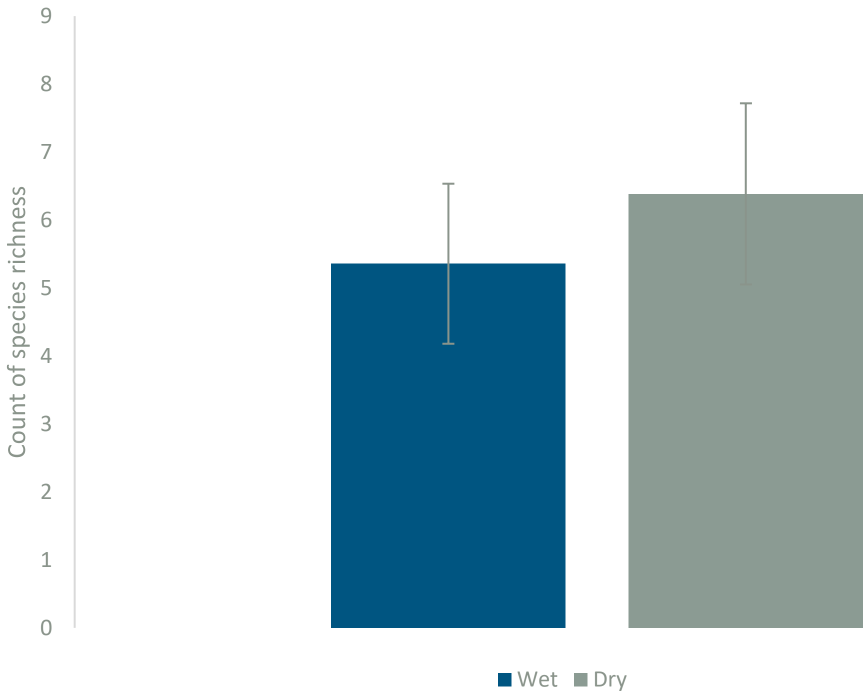


Figure 5.10 Mean (± Standard Error) counts of species richness across all locations for wet and dry seasons

Table 5.14 Results of a two-factor PERMANOVA for the community assemblage of infauna for all locations

Source	Df	MS	P(perm)
Location	**9**	**2107.3**	**0.1541**
Season	1	1024.2	0.6005
Location x Season	9	1114.8	0.7968
Residual	9	1486.7	
Total	28		

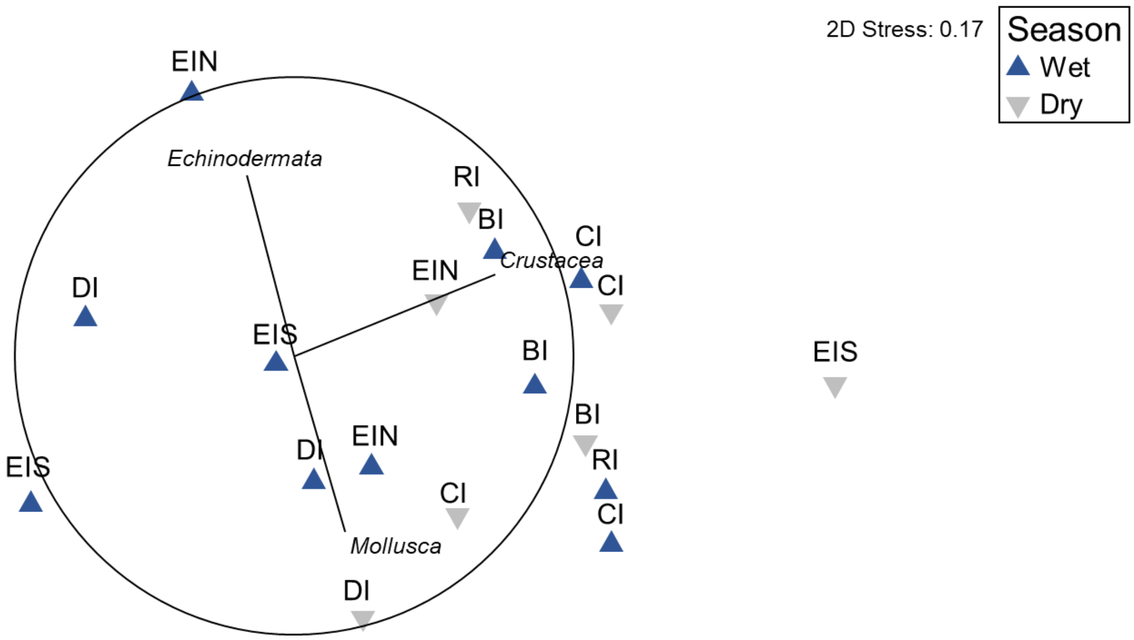
Notes:
1. Df = Degrees of freedom, MS = Mean square

Multivariate analyses of infauna data revealed a diverse community, represented by 10 phyla (Annelida, Chaetognatha, Chordata, Crustacea, Echinodermata, Mollusca, Nemertea, Porifera, Sipuncula) and 69 families. Sampling recorded 31 families of polychaetes (accounting for 35% of the infauna sampled), 35 families of crustaceans (accounting for 44% of the infauna sampled), 8 families of molluscs (accounting for 5% of the infauna sampled), 3 families of echinoderms (accounting for 5% of the infauna sampled) and 2 families of porifera (accounting for 3% of the infauna sampled). The PERMANOVA analysis indicated no significant variation of community assemblage between locations or seasons (Table 5.15). These results are mirrored in the nMDS which shows some variation at the location level, but no clear separation between seasons. Overall, polychaetes were more abundant in wet season samples, while crustaceans were more abundant in dry season samples. All other phyla had relatively similar abundances and representation in both seasons. At a location level, Bayliss Island and Cecelia Island reported the highest abundances and greatest diversity due to greater representation of polychaetes and crustaceans.

Table 5.15 Results of a two-factor PERMANOVA for the community assemblage of infauna for all sites

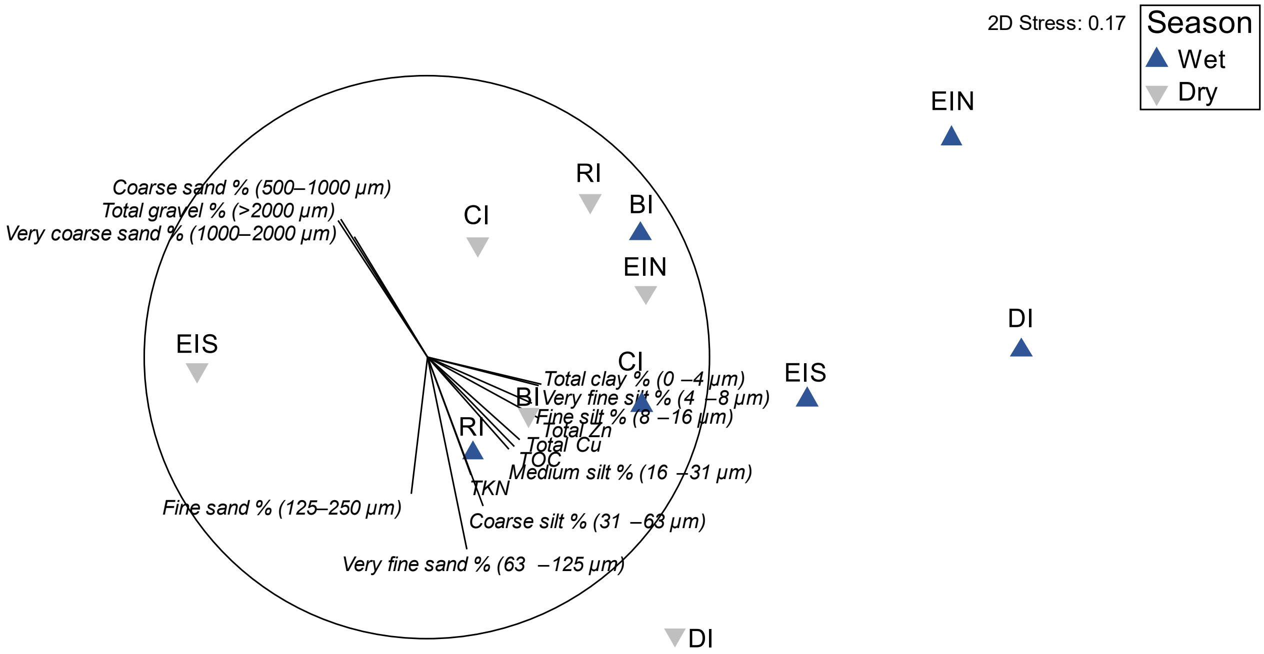
Source	Df	MS	P(perm)
Location	**9**	**2105.2**	**0.0465**
Season	1	929.09	0.5155
Residual	9	1188.4	
Total	19		

Notes:
1. Df = Degrees of freedom, MS = Mean square



Notes:
1. In nMDS, differences between locations are represented by the relative distance between points
2. 2D stress is a representation of the dimensionality of the ordination i.e. how much can be interpreted from constraining the ordination onto 3 or in this case 2 dimensions: stress <0.05 gives an excellent representation; stress <0.1 corresponds to a good ordination with no real prospect of a misleading interpretation; stress <0.2 gives a potentially useful 2–dimensional ordination, though for values at the upper end of this range, too much reliance should not be placed on the detail of the plot
3. Black line vectors indicate the relative importance of the individual trace metals in driving the separation between Locations.
4. EIN = Edeline Island North, EIS = Edeline Island South, RI = Razor Island, BI = Bayliss Island, CI = Cecelia Island, DI = Dorothy Island

Figure 5.11 nMDS ordination of infauna ordination of infauna community assemblage among seasons by location with vector overlays



Notes:

1. In nMDS, differences between location are represented by the relative distance between points
2. 2D stress is a representation of the dimensionality of the ordination i.e. how much can be interpreted from constraining the ordination onto 3 or in this case 2 dimensions: stress <0.05 gives an excellent representation; stress <0.1 corresponds to a good ordination with no real prospect of a misleading interpretation; stress <0.2 gives a potentially useful 2–dimensional ordination, though for values at the upper end of this range, too much reliance should not be placed on the detail of the plot
3. Black line vectors indicate the relative importance of the individual trace metals in driving the separation between locations.
4. EIN = Edeline Island North, EIS = Edeline Island South, RI = Razor Island, BI = Bayliss Island, CI = Cecelia Island, DI = Dorothy Island

Figure 5.12 nMDS ordination of infauna community assemblage among seasons with vector overlay of predominant sediment characteristics

Vector overlays of the sediment parameters onto the infauna nMDS ordination plot showed that the infauna assemblage at the northern part of the Archipelago (Crocodile Creek, Conilurus Island, Dorothy Island) which included generally lower counts of infauna overall inhabited fine or very fine sediments or silt with higher TKN and TOC content. Polychaetes and crustaceans, which were found in greater abundance at Bayliss Island, Cecelia Island, inhabited coarse or gravelly sediments (500->2000 um).

5.4 Potential impacts

5.4.1 Approach

Potential impacts to marine environmental quality have been considered for both the construction and operation of the sites. Predictive modelling was only conducted for the operation of the sites, not the construction, as the impacts from construction are likely to be localised, short term and for the most part non-significant. The relevant criteria used to assess impacts from the operation of the sites are detailed in Section 5.6. Potential impacts were derived based off understanding of the cause-effect pathways for each pressure resulting from the Proposal.

The impact of other operations in the area nearby the proposed leases, including commercial and industrial operations, on marine environmental quality are also considered to ensure the total cumulative impacts are well understood.

Impacts have been defined as summarised below.

- Major – E.g. Results in permanent changes or long lasting (> 5 years recovery) impacts to marine environmental quality over a broad extent
- Moderate – E.g. Results in semi-permanent changes (< 5 years recovery) impacts to marine environmental quality generally some way beyond the immediate footprint i.e. lease boundaries, but not widespread
- Minor – E.g. Results in short-term changes to marine environmental quality which are immediately remedied if the pressure is removed, and are generally confined to the immediate footprint
- Insignificant – no impacts to marine environmental quality are expected.

5.4.2 Pressure-response relationships

To understand the potential risks posed by the Proposal, the types of pressure, their magnitude and their likely effect needed to be appreciated. This understanding was subsequently used to identify the key cause-effect-response pathways and to interpret the model results.

Cause-effect-response pathways

Cause-effect-response pathways were developed following the step-wise approach of Gross (2003). This approached developed two models: a control model and a stressor model. Control models are hierarchical (5.16), with the stressors and their sources shown in the upper layers and the indicators (receptors) and effects shown in the middle to bottom layers. The control model makes no attempt to account for the magnitude and/or the duration of the stress.

The stressor model is a refined version of the control model focussing on the cause-effect pathways of most concern. It details relationships between stressors, ecosystem components, effects and biological receptors and accounts for the major cause effect pathways, from which the indicators and thresholds were ultimately derived. Stressor models were developed for both construction and operation related impacts from the Proposal.

The objective of this approach was to identify the cause-effect-response pathways most likely to be affected by the Proposal, and those likely to exhibit measurable changes in response to stressor inputs. The understanding gained by this process was used to identify the thresholds described in Section 5.6.

Figure 5.13 Hierarchical control model showing stressors and key cause-effect-response pathways

5.4.3 Integrated model

To assess the potential impacts of the Proposal on marine environmental quality, an integrated hydrodynamic, particle transport, water quality and sediment diagenesis model was used to simulate a total of four fish production scenarios as per the criteria detailed in Section 5.5. Figure 5.14 summarises the key components of the integrated model, which comprises hydrodynamic, fish waste, particle transport, water quality and biogeochemical (diagenesis) components. The fully integrated model was capable of resolving the regional hydrodynamics, the deposition and dispersal of wastes from sea-pens, the effects of these wastes on the marine environment, and the rate of environmental recovery following cessation and/or relocation of the aquaculture activities.

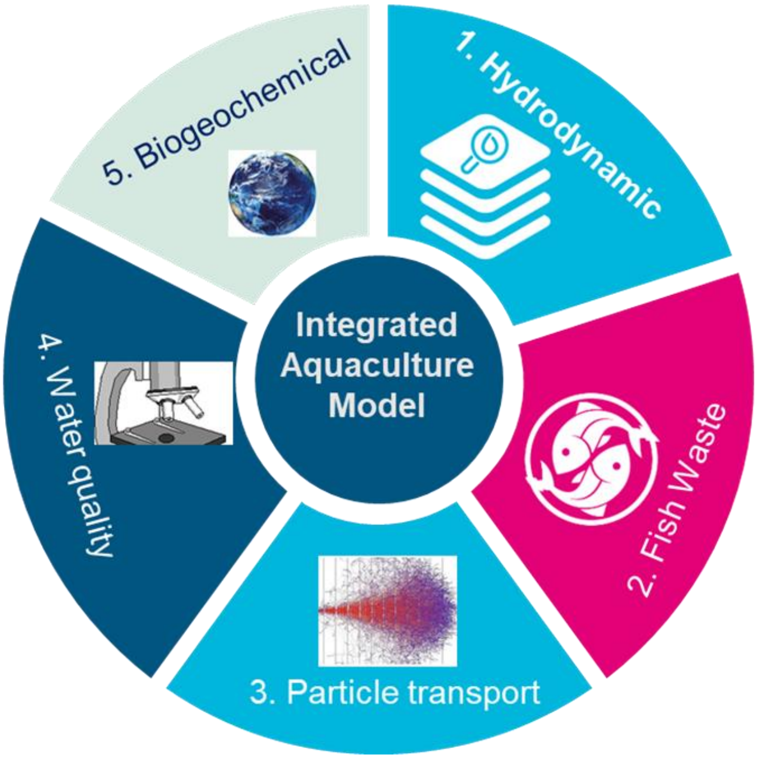


Figure 5.14 Components of the integrated model developed for the study

The approach to integrating the individual modelling components is detailed in Annex B and Annex D. Details on the results of the modelling are detailed in Section 5.5.

5.4.4 Identified Pressures

Physical presence of sea-pens

The physical presence of the sea-pens, either during construction or once operational, may affect local hydrodynamics. The scientific literature has shown that the presence of sea-pens restricts water flow and reduces the velocity in the surface layer occupied by the pens, while enhancing the water velocity in the bottom layer beneath the pens, which may result in scouring of the sea-bed. Subsequent increases in bottom current speeds are dependent on the distance between the bottom of the sea-pens and the seafloor, generally being maximised where the height of the pens is approximately half the maximum water depth (Wu et al. 2014). At the current Cone Bay sites, scouring is known to occur beneath the sea-pens as a result of this relationship. It is expected that the potential for scouring at the new proposed sites will be minimised considering the far greater distance between the bottom of the sea-pens and the seabed.

Organic wastes

Organic wastes are a key pressure generated by the Proposal on the surrounding water and sediment quality. Sea-pen aquaculture can impact the surface sediment layer when organic wastes settle beneath, or in close proximity to, the sea-pens (Mazzola et al. 2000, Carroll et al. 2003). The deposition of organic material can result in local organic enrichment or potentially eutrophication depending on the characteristics of the surrounding environment. In this sense, if waters are stratified, there is no mixing of the water column and as such no replenishment of oxygen in the water column, which may be depleted as total community respiration increases in response to increased organic loads on surface sediments (Gray 1992, Baden et al. 1990, Schaffner et al. 1992). Hypoxia may cause local loss of benthic populations (Gaston & Edds 1994), reduced growth rates of benthic fauna (Forbes & Lopez 1990, Forbes et al. 1994) and changes in benthic communities (Pearson & Rosenberg 1978, Josefson & Jensen 1992, Hargrave et al. 2008; Hargrave 2010). For benthic communities, any changes are generally characterised by rare and more sensitive species disappearing first, followed by other more resilient species. Some species are able to resist hypoxic or near-hypoxic conditions, and as such may be found in greater relative abundances in these areas (Pearson & Rosenberg 1978, Gray 1992, Dauer et al. 1992).

Infauna are widely regarded as sensitive indicators of environmental degradation and restoration in marine sediments (Clarke & Green 1988, Austen et al. 1989, Warwick et al. 1990, Weston 1990, Dimitriadis & Koutsoubas 2011). Several studies have demonstrated a correlation between the level of organic enrichment and the extent of infauna community degradation (Pearson and Rosenberg 1978, Hargrave 2010). Deposition rates >700 g C/m^2/yr are widely believed to represent a critical value, such that sediments exposed to this rate of deposition are considered degraded, i.e. diversity of benthic fauna is significantly reduced (Cromey et al. 1998). Although useful in terms of predicting the magnitude of effect of infauna, these thresholds give no indication of recovery times (also known as remediation) following removal of the contaminant source.

Case studies of finfish aquaculture systems in Tasmania and Europe found that impacts are generally restricted to within 10–100 m of sea-pens and that the magnitude of impact depended largely on the depth of the water and the rate of water movement through the site (Carroll et al. 2003, Crawford 2003, Borja et al 2009). Average current velocities through the Proposal region were modelled to be between 20-50 cm/s at the surface and 10-30 cm/s at the benthos (Table 5.16). This range of average current speeds is conducive to conditions described as either 'moderately' or 'not sensitive' to impact. Currents speeds >10 cm/s are widely considered 'ideal' for sea-pen aquaculture, and current speeds <6 cm/s are generally considered 'not ideal' for sea-pen aquaculture.

Table 5.16 Increasing suitability of potential aquaculture sites based on current speed

Suitability	Current speed (cm/s)	Reference
Not sensitive to impact / desirable	10-25	Carroll et al. (2003)
	>15	Borja et al. (2009)
	13–77	Benetti et al. (2010)
	5–20	Halide et al. (2009)
	10–60	Beverage (2004)
Moderately sensitive to impact	5–15	Borja et al. (2009)
Sensitive to impact / unsuitable	3–6	Carroll et al. (2003)
	<5	Borja et al. (2009)

Inorganic nutrients

Finfish aquaculture in open water sea-pens does result in the input of inorganic nutrients (e.g. Ammonia from fish excretion) which may cause deterioration in local water quality. Inorganic nutrients in the form of ammonia, nitrite + nitrate and orthophosphate may lead to adverse environmental effects via a number of cause-effect pathways, all of which contain BCH as key receptors. As such, the cause-effect-response pathways which include inorganic nutrients are a key part of this as assessment.

Habitat studies in the Proposal area have revealed an array of benthic habitats, particularly in nearshore areas, including the presence of fringing coral reefs and macroalgal communities (Section 6). Macroalgae and corals in particular are known to be sensitive to sources of inorganic nutrients whereby in enriched areas, living corals may be slowly replaced by macroalgae in what is known as a phase shift. Some studies have suggested that phase shifts are dependent on the degree of herbivory on a reef system (e.g. Littler & Littler 1984, Jackson et al. 2001, Bellwood et al. 2004, Hughes et al. 2010, Rasher et al. 2012), as in areas where herbivores are absent, algae have been able to proliferate even at low nutrient concentrations (~1 µmol/L).

Metals and other contaminants

Metals and other contaminants can cause toxic effects on marine organisms if concentrations reach threshold levels or accumulate via biomagnification (Parsons 2012). Sources of metals include contaminated sites, agricultural and urban runoff, discharges from sewage treatment plants, and copper-based antifoulants sometime used on sea-pen infrastructure (Parsons 2012).

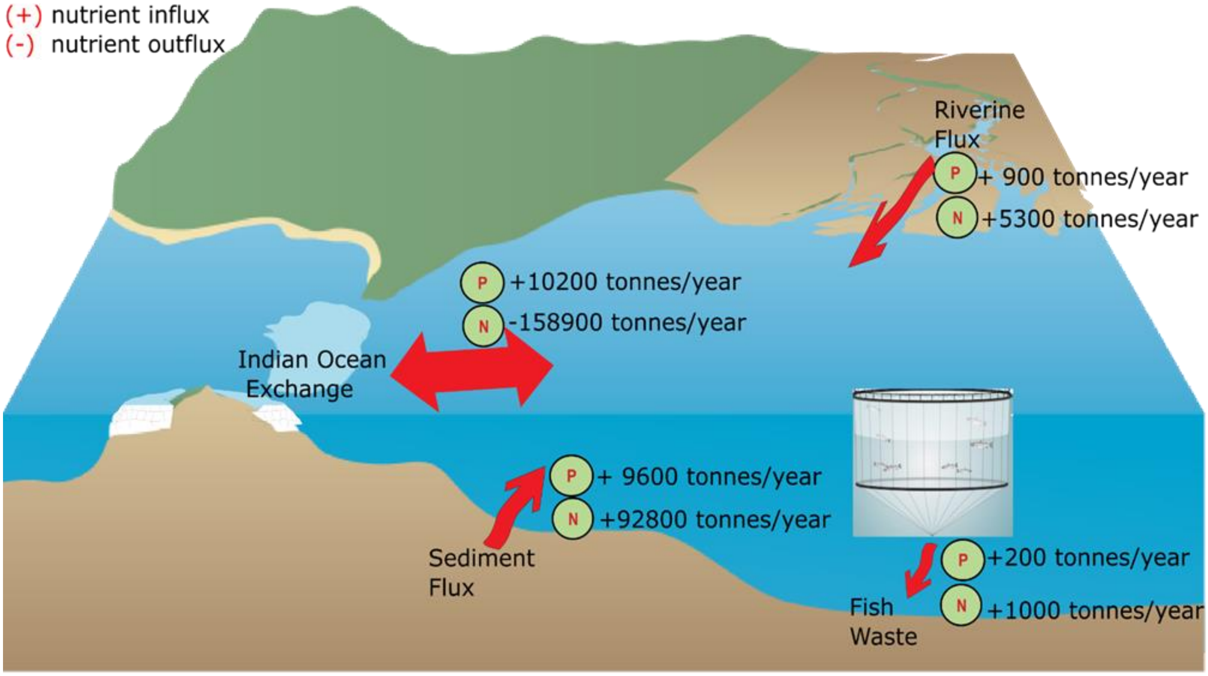
Metals form a small part of commercial aquaculture feeds as trace elements, whereby the metals are consumed by finfish and excreted in the faeces. Previous studies have found that Zinc and Iron were present in the highest concentrations within sediments below sea-pens, with relatively low proportions of copper (Moccia et al. 2007). Despite the very low concentrations in commercial feeds, monitoring in Tasmanian waters has recorded copper and zinc sediment values at concentrations higher than the ANZECC/ARMCANZ (2000) ISQG-low and ISQG-high guideline values at some sea-pen sites (DPIPWE 2011). Ongoing compliance monitoring for the existing Cone Bay aquaculture sites however has not recorded any exceedance of the ANZG (2018) guideline values for zinc or copper.

Chemical therapeutants are occasionally used to treat disease occurring in farmed finfish. Their usage is very rare however due to the widespread implementation of vaccination programs. Chemical therapeutants are only used as a last resort, and there are strict requirements around their usage. See Annex A for further details.

Ecosystem nutrient budget

As it is relatively underdeveloped, the nutrient budget of the Buccaneer Archipelago generally only comprises advective oceanic and sediment nutrient fluxes, as well as riverine inputs in the wet season. The oceanic and sediment nutrient fluxes are relatively small resulting in oligotrophic conditions (i.e. low nutrient) around the vast majority of the Archipelago. In some areas near to river mouths however there is a greater input of nutrients which can result in natural algal bloom events, as occurred in Cone Bay in early 2019 (DHI 2019). These natural algal blooms are relatively commonplace in the region, particularly in Cone Bay.

The addition of the nutrient inputs generated by the Proposal adds both an immediate nutrient load to the water column (via waste and feed excess) and a delayed load via impacted sediment nutrient remineralisation. A graphical representation of existing and impacted conditions, with approximate annual nutrient fluxes is included in Figure 5.15. Fluxes have been computed from measurements and model predictions.



Notes:

1. Biomass flux includes both solid and liquid waste nitrogen and phosphorus
2. Sediment flux is the background flux for the Buccaneer Archipelago region; sediment flux is based upon the average sediment nutrient content measured during the baseline sampling program
3. Oceanic flux is the total nutrient flux in and out of the Buccaneer Archipelago
4. Cage flux is based off outputs from Scenario 1 of the integrated model

Figure 5.15 Conceptual diagram of the baseline and operations nutrient budget

5.4.5 Environmental Quality Plan

The Buccaneer Archipelago, where the Proposal is situated, does not have a pre-defined regional Environmental Quality Plan (EQP), and there are no other EQPs for other projects or developments in the area that could subsequently be aligned with. As such, a specific EQP for this Proposal has been defined for this assessment.

The overarching objective of the EQP is to ensure the marine environment is managed to achieve the Environmental Values (EVs) and Environmental Quality Objectives (EQOs) as outlined in Table 5.2. The environmental factor for Marine Environmental Quality is closely aligned with the EV for Ecosystem Health. The EV for Ecosystem Health recognises that there are areas (such as around sea-pen aquaculture) where a high level of ecosystem protection cannot be maintained. These areas are assigned a moderate level of ecological protection (EPA 2016g), each of which has specific limits of acceptable change (Table 5.17). The framework recognises the competing environmental, social and industrial uses of the marine environment, and allows for small, localised effects, while aiming to maintain overall environmental integrity (EPA 2016g). This is important in the context of this document, which includes strategies to manage the expected reduction in environmental quality immediately adjacent to the sea-pens and proposed sites.

Table 5.17 Levels of ecological protection as defined by EPA (2017)

Level of ecological protection	Limits of acceptable change
Low	To allow for large changes in the quality of water, sediment and biota (e.g. large changes in contaminant concentrations causing large changes beyond natural variation[1] in the natural diversity of species and biological communities, rates of ecosystem processes and abundance/biomass of marine life, but which do not result in bioaccumulation/biomagnification in near-by high ecological protection areas).
Medium	To allow moderate changes in the quality of water, sediment and biota (e.g. moderate changes in contaminant concentrations that cause small changes beyond natural variation in ecosystem processes and abundance/biomass of marine life, but no detectable changes from the natural diversity of species and biological communities).
High	To allow small changes in the quality of water, sediment or biota (e.g. small changes in contaminant concentrations with no resultant detectable changes beyond natural variation* in the diversity of species and biological communities, ecosystem processes and abundance/biomass of marine life).
Maximum	All activities to be managed so that there are no changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota.

Notes:
1. Detectable change beyond natural variation nominally defined by the median of a test site parameter being outside the 20th and 80th percentiles of the measured distribution of that parameter from a suitable reference site

The EQP is set-out in Table 5.18 and Figure 5.16. As the Proposal is situated within the Mayala Marine Park, areas of special value (i.e. sanctuary zones, special purpose zones) as designated by this marine park must achieve a Maximum Level of Ecological Protection. All other areas within general use zones, beyond the immediate vicinity of the proposed sites, must achieve a High Level of Ecological Protection. Areas within close proximity to the sites, where impacts to marine water or sediment quality are predicted, must achieve a Moderate Level of Ecological Protection. The designation of the areas which fall within the high and maximum levels of ecological protection are intended such that the Environmental Values for both ecosystem integrity, as well as aesthetics, recreational use, and fishing and aquaculture are all maintained. Even though these other EV's do not use the LEP approach specifically, the particular stressors which may impact these values are all associated with marine environmental quality.

The Environmental Value of Spiritual and Cultural value (Table 5.2) is more difficult to measure impacts against, noting that these values, though linked, go beyond the intrinsic ecological health or aesthetic appeal of these areas. Some protection to these specific values is provided with the assignation of 'Special Purpose Zones (Cultural Protection)' under the Mayala Marine Park zoning framework, such that they have a Maximum Level of Ecological Protection. These areas have been identified previously through engagement associated with the development of the marine park, as well as further engagement with Traditional Owners subsequently after the designation of these zones. Predicted impacts to this EV are directly linked with the EPA Factor Social Surroundings, and as such key impacts are addressed specifically within Section 9.

Table 5.18 Environmental Quality Plan for this Proposal

Level of ecological protection	Designated areas
Low	NA
Moderate	Areas within the Development Envelope, where increases to dissolved inorganic nitrogen and chlorophyll-a and/or enrichment / contamination of soft sediments and subsequent effects on infauna as a result of sea-pen aquaculture are possible.
High	All areas beyond the development envelope of the sites within the general use zones of the Mayala Marine Park and Lalang-gaddam Marine Park
Maximum	All areas defined as special purpose zones or sanctuary zones within the scope of the Mayala Marine Park and Lalang-gaddam Marine Park.

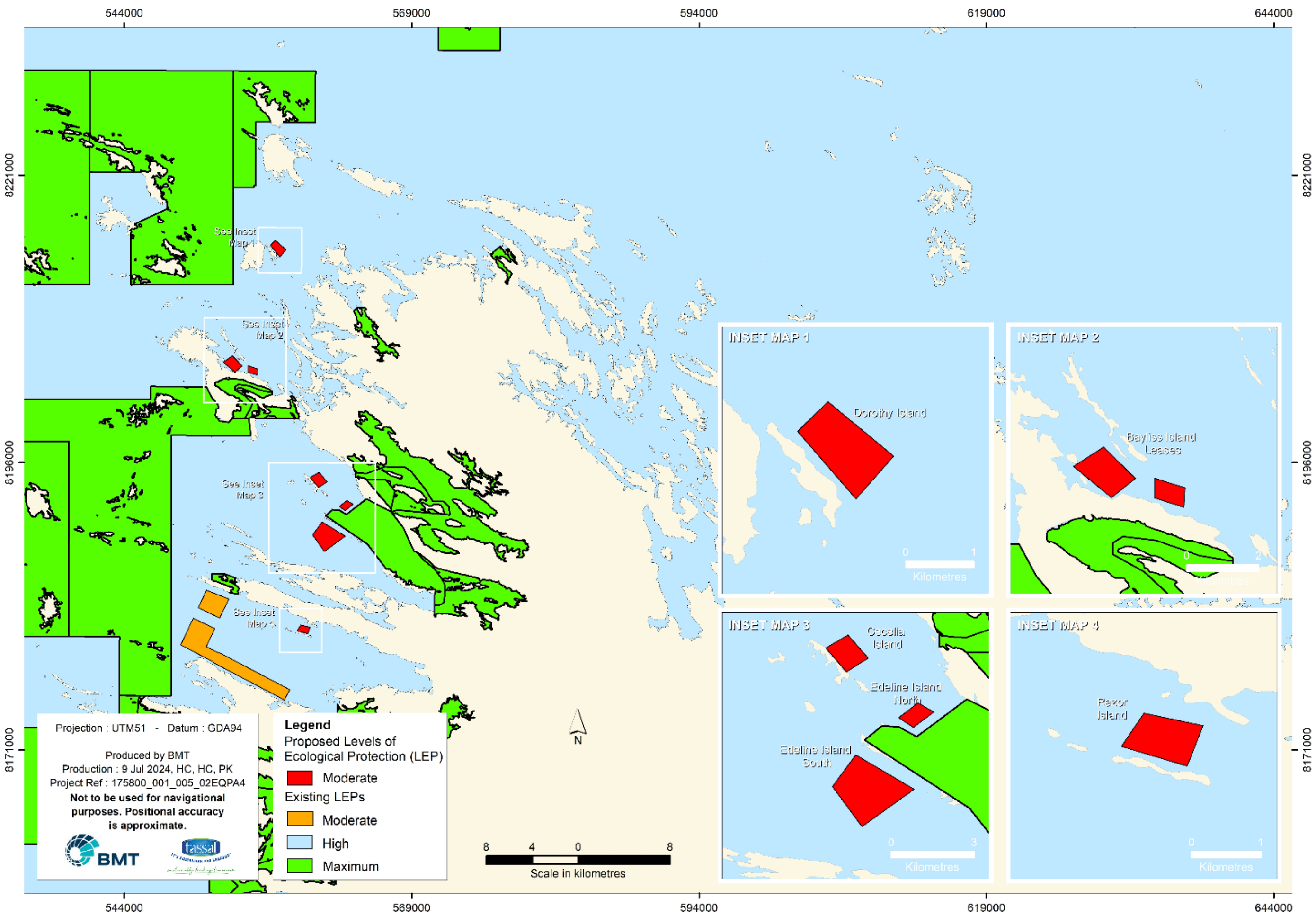


Figure 5.16 Proposed Environmental Quality Plan (EQP) for the Ocean Barramundi Project, with proposed and existing levels of ecological protection (LEPs)

5.4.6 Potential construction impacts

The relevant cause-effect pathways for the construction of the sites are summarised in Figure 5.17. The majority of the cause-effect pathways revolve around elevated total suspended solids as a result of anchoring, as well as the presence of construction vessels / equipment which result in hydrocarbon spills / waste generation. The potential impacts are summarised in Table 5.19.

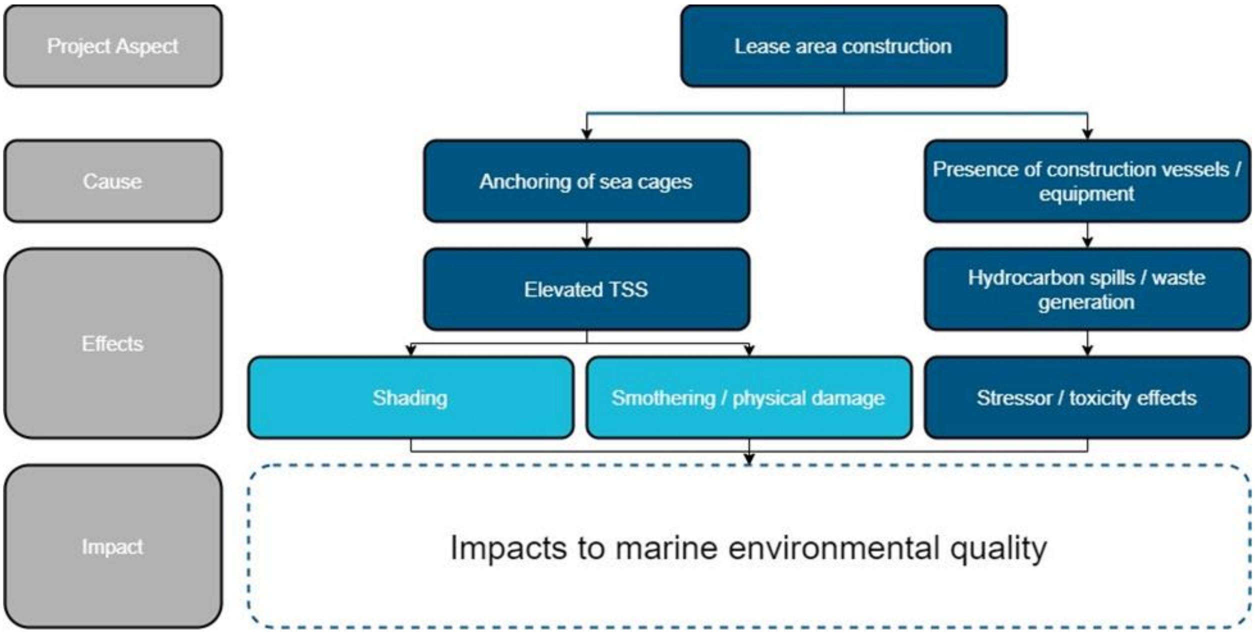


Figure 5.17 Cause-effect pathways associated with construction of the sea-pens at the sites

Table 5.19 Potential construction impacts to marine environmental quality from construction of sites

Development type	Potential impacts	Impact	Context and assessment	Extent	Duration	Significance of Impacts (prior to the application of mitigation measures)
Leases	Reduced light (Increased total suspended solids)	Direct	There is potential for periodic elevations in turbidity and associated reductions in light penetration generated via the anchoring of the sea-pens.	Limited (impact likely only possible in areas close to the anchorages)	<1 day at a time during construction	2-Minor
Leases	Toxicity (Hydrocarbon spills and waste generation)	Direct	Marine construction activities include the use of a barge and support vessels, presenting potential risks due to hydrocarbons spills and waste generation.	Limited (construction vessels are only small and as such do not contain a significant amount of fuel)	<1 week for a spill to occur and be cleaned up	2-Minor

5.4.7 Potential operational impacts

The relevant cause-effect pathways for the operation of the sites are summarised in Figure 5.19 and Table 5.20. The relevant thresholds used to determine the potential impacts of the operation of the sites on marine environmental quality are summarised in Section 5.6. The potential impacts themselves are summarised in Table 5.19.

Aquaculture scenarios chosen for modelling

Modelling scenarios were agreed in consultation with Tassal. Scenarios were based on a conservative assessment of the proposed farming methods Tassal is looking to implement for the expansion project, as described in Table 5.19.

Table 5.20 Aquaculture infrastructure assumptions

Infrastructure Component	Details
Pen diameter (m)	36
Pen circumference (m)	120
Pen depth – anti predator netting (m)	13-16
Pen depth – fish netting (m)	10-13
Pen volume (m^2)	~12,600
Other assumptions	12 pens per site Simultaneous production in every site Continuous release of feed and associated wastes

The scenarios chosen for modelling are summarised in Table 5.21. Scenarios 1 and 2 both modelled an increasing standing biomass ranging from 1,570 tonnes to a maximum of 4,500 tonnes per lease, with Food Conversion Ratios (FCRs) varying between 1.5 and 2.3 for scenarios 1 and 2 respectively. FCRs are important in determining the amount of particulate and dissolved wastes excreted from farmed fish and are based on determining how much of the feed is converted to waste material. The lower the FCR, the less waste produced by the farmed fish.

The modelling included an associated increase in feed and waste outputs throughout the model period as biomasses increased. The standing biomass of 4,500 tonnes was selected in consultation with Tassal, with this value equating to the absolute maximum biomass that will be present on a given site prior to harvesting. Scenario 1 is representative of the most likely operating conditions for the Proposal, with Tassal committing to a target FCR of 1.5, while scenario 2 is provided to indicate worst-case impacts.

Each site was modelled to have the same biomass throughout. Though this doesn't completely match with the approach discussed in Section 1.5.3, it does provide a conservative estimate of impacts at any given site over a production cycle, which is more useful to determine the total maximum extent of potential impacts particularly for those sites that are distant from each other. This latter point means the predicted impacts at any point in time are over estimated, considering that Tassal will not stock all sites with the same biomass at the same time, rather there will be some sites distant from each other that have a high biomass and are either close to or ready for harvest, while those closest to these sites will have little to no stock.

Across each scenario a 12-month period was modelled, representing annual variation with seasonality. For each scenario, only the 12 months where biomasses increased from month 7 to month 18 was modelled, so as to represent the maximum potential environmental impact of the Proposal. Though Tassal is planning on implementing a minimum 1-month complete fallowing period after the cessation of harvesting, this part of the production cycle was not modelled directly. Figure 5.18 summarises the modelled increase in fish biomass through time for the scenarios.

Table 5.21 Modelled production scenarios

Scenario No.	1	2
Starting standing biomass (tonnes)	1570	1570
Ending standing biomass (tonnes)	4500	4500
FCR	1.5	2.3
Model period (months)	12	12
No. pens per site	12	12

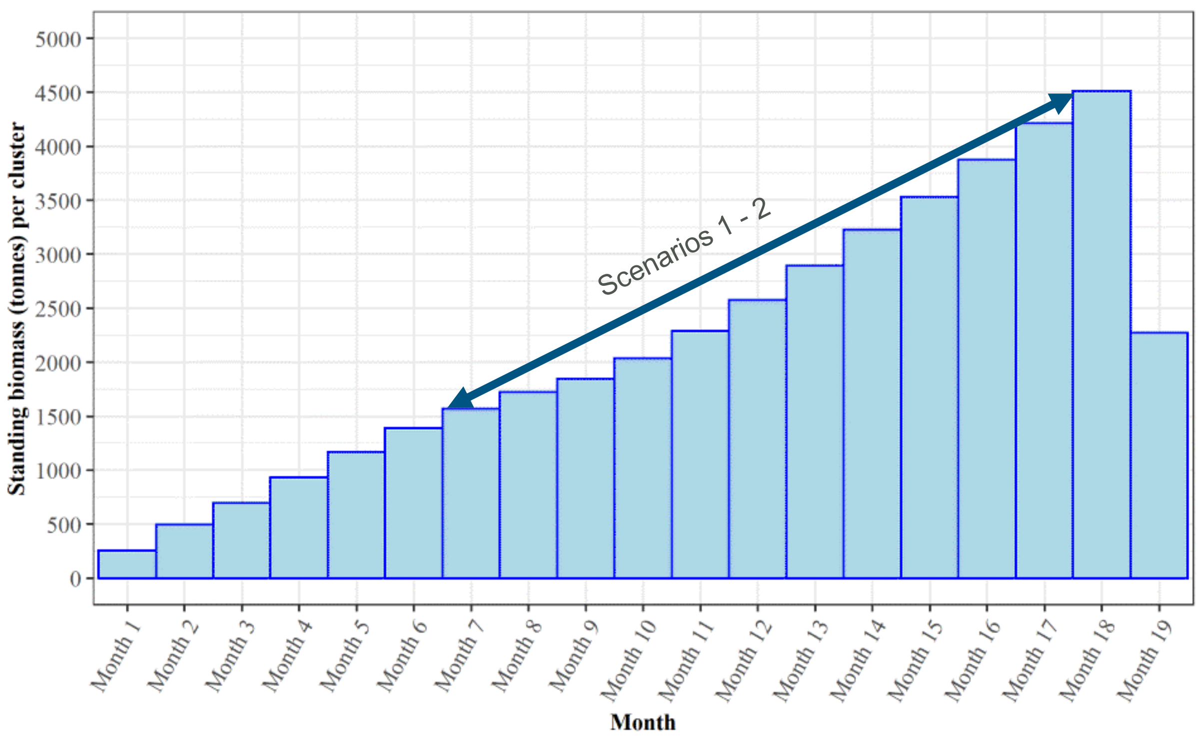


Figure 5.18 Operational standing biomass per cluster

Thresholds for model interrogation – water quality

Recovery of the water column to baseline levels could not be modelled directly in lieu of the uncertainty regarding the lethal and sub-lethal thresholds of endemic species, and equal uncertainly regarding their timing of recovery, particularly following exposure to aquaculture stressors (i.e. organic material and inorganic nutrients). Thresholds for water column oxygenation, algal growth potential and nutrient enrichment are based on EPA (2017). For each parameter, an overarching threshold for the entire year, rather than a season specific threshold, was applied. The predicted impact footprint for each parameter is compared to the proposed EQP as defined in Section 5.4.5.

As discussed in Section 5.3.2, the baseline values for the physical and chemical water quality parameters at Razor Island were found to be statistically significantly different to those at the other proposed sites. As such, a separate set of criteria were applied to the impact assessment for Razor Island than for the other sites, to reflect this variation in the baseline condition.

Oxygenation

The thresholds for oxygenation (dissolved oxygen; DO) are based on EPA (2017). The thresholds are equivalent to the Environmental Quality Guidelines (EQG) for achieving moderate and high levels of ecological protection (Table 5.22), which require that DO levels are maintained at 80% and 90% saturation respectively for a period greater than six weeks duration.

Algal growth potential and nutrient enrichment

Thresholds for inorganic nutrients were developed to address the effects of algal growth potential and nutrient enrichment (Table 5.22). The thresholds for algal growth potential and nutrient enrichment are based on the 95th and 80th percentile values obtained during baseline studies, with a separate set of values applied for Razor Island than for the other sites (Section 5.3). In this context, the 80th percentiles are in alignment with the criteria used for a high level of ecological protection; and the 95th percentiles, a moderate level of protection.

Table 5.22 Water quality thresholds

Parameter	Moderate ecological protection	High ecological protection
Oxygenation[1]	DO saturation in the bottom half of water column not to fall below 80% for a period exceeding 6 weeks	DO saturation in the bottom half of water column not to fall below 90% for a period exceeding 6 weeks
Algal growth potential[2] Razor Island	DIN concentration not to exceed 0.035 mg/L more than 50% of the time	DIN concentration not to exceed 0.01 mg/L more than 50% of the time
Algal growth potential[2] Remaining sites[3]	DIN concentration not to exceed 0.022 mg/L more than 50% of the time	DIN concentration not to exceed 0.014 mg/L more than 50% of the time
Nutrient enrichment[2] Razor Island	Chlorophyll-a not to exceed 1.1 µg/L more than 50% of the time	Chlorophyll-a not to exceed 0.9 µg/L more than 50% of the time
Nutrient enrichment[2] Remaining sites[3]	Chlorophyll-a not to exceed 1.2 µg/L more than 50% of the time	Chlorophyll-a not to exceed 0.8 µg/L more than 50% of the time

Notes:
1. Thresholds are based respectively on the EPA's EQGs for moderate and high ecological protection (EPA 2017). Threshold assumes continuous exceedance for a period exceeding six weeks.
2. Thresholds are based on the EPA's EQGs for moderate (95th percentile baseline data) and high (80th percentile baseline data) ecological protection (EPA 2017).
3. Remaining sites = Edeline Island South, Edeline Island North, Cecelia Island, Bayliss Island, Bayliss Island Extra, Dorothy Island

Thresholds for model interrogation - sediment quality

The potential for the Proposal to impart adverse effects on the benthic marine environment (particularly soft sediments) were described in the context of EPA (2016f). The criteria used here are based on concentrations for physico-chemical stressors (dissolved oxygen and hydrogen sulphide) as it is believed that referencing the end point impacts to sediment infauna, following the approach of Hargrave et al. (2008), allows for a more accurate prediction of impacts to sediment quality when it comes to direct nutrient enrichment. Similar criteria are used by other environmental agencies globally when assessing potential impacts of marine finfish farms on soft sediments and can be considered best-practice (EPA Tasmania 2022).

Oxygenation

Impacts to soft sediments are predicted based on sediment chemical conditions, represented by the concentration and depth of oxygenation and hydrogen sulphide (Table 5.23). Levels of ecological protection were defined based on threshold criteria (defined in more detail in Annex D). This included consideration of oxygen and sulphide concentrations within the top 5 cm of sediment. Areas were designated as falling within the MEPA where conditions of hypoxia are possible, and the HEPA when sediments received waste material, but not in proportions substantial enough to alter the sediment chemistry.

Chemical indicators (i.e. oxygenation/hydrogen sulphide content) were used over biological indicators (i.e. infauna species richness), as its trajectory is more reliable, and it has readily identifiable beginning and end points. Biological indicators, in contrast, may show more subtle changes, considering guilds of infauna inhabiting similar ecological niches may replace each other, leading to subtle differences in post remediation community structures – meaning the extent of impacts at the end point is difficult to quantify.

Metals

Thresholds for metals were based on whether sediment metal concentrations exceeded the EPA's Environmental Quality Guideline (EQG) trigger values (EPA 2017). Areas were designated as falling within the MEPA/HEPA where the EQGs for copper and zinc, the two metals found most commonly within finfish feed, were exceeded, noting that the EQGs for high and moderate protection are the same in this particular case (as per Table 3; EPA 2017).

Table 5.23 Thresholds applied to soft sediments

Parameter	MEPA	HEPA
Hydrogen sulphide Oxygenation	Conditions of hypoxic stress, resulting in potential reductions of species richness of infauna taxa of no more than 50%. This occurs when the upper 2 cm H_2S concentration remains within the 100-300 µM L-1 range.	Where the rate of deposition is sufficiently low so as not to contribute material affects to sediment chemistry and/or infauna species richness. Following Hargrave et al. (2008) this category requires that H_2S remains below 100 µM L-1 Top 5 cm of sediment remain oxygenated
Metals (Zn and Cu)[1]	Sediment concentrations of Zn and Cu exceed the EPA EQGs[2,3]	Sediment concentrations of Zn and Cu exceed the EPA EQGs[2,3]

Notes:
1. Zinc (Zn) and Copper (Cu) are the metals present in feeds in the highest proportion and those with EPA (2017) triggers.
2. EQG = Environmental Quality Guideline
3. Per EPA (2017), the values for high/moderate protection are the same

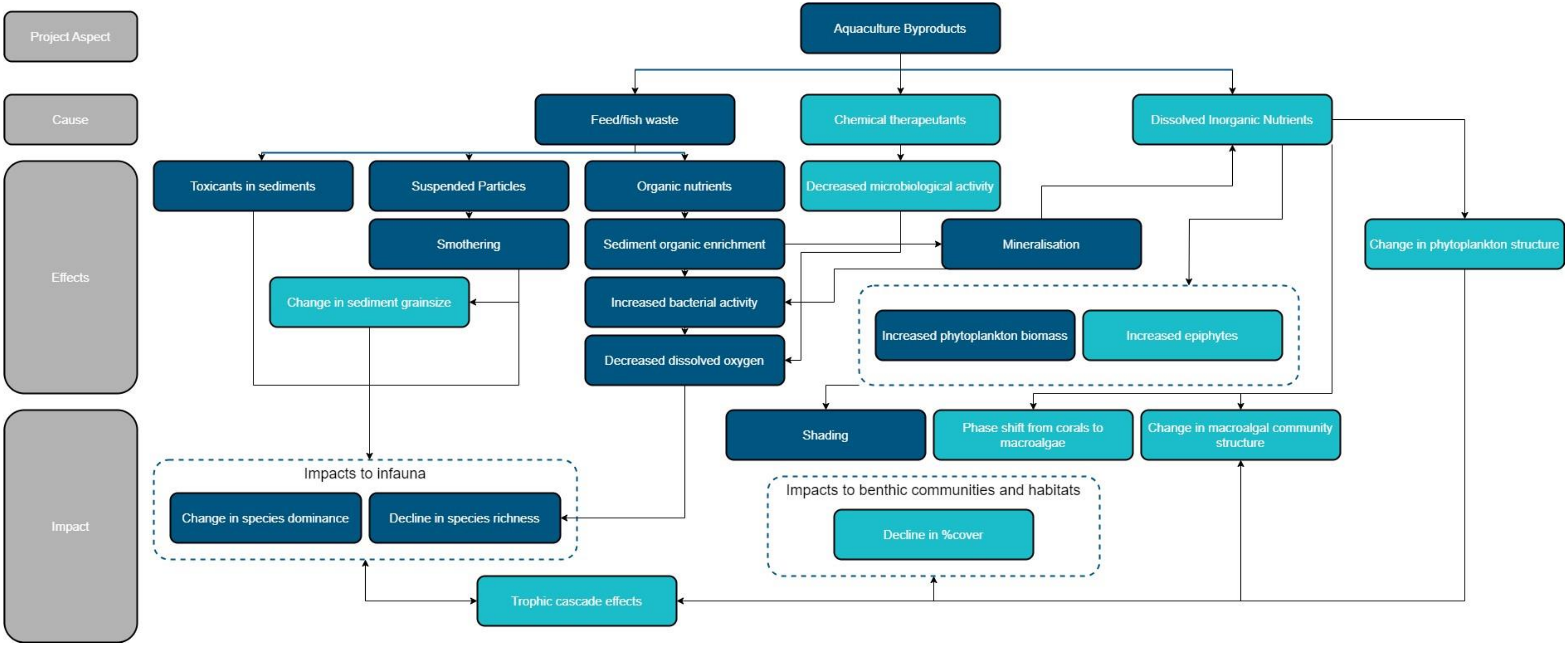


Figure 5.19 Cause-effect pathways associated with the operation of sites

Modelled impact assessment – water quality

Oxygenation

The potential for deoxygenation of the water column beneath and near the sea-pens was investigated using the integrated hydrodynamic, water and sediment diagenesis model. Simulations focused on the bottom half of the water column. Median dissolved oxygen concentrations at the edge of the continental shelf were lower than 80% saturation. Oxygen concentrations maintained normal levels across the scenarios, with no evidence of significant oxygen drawdown. Results of the sediment diagenesis model, however, point to high levels of biological oxygen demand (BOD) at the sediment water interface (Annex C). Under the anoxic sediment conditions predicted by the model, waters at the sediment water interface (and in some cases, the layers above the sediment water interface) are likely to experience some oxygen drawdown. However, the extent of water movement through the system is such that the level of drawdown is unlikely to be of any ecological consequence, as oxygen levels are quickly resupplied by new seawater inputs.

Algal growth potential (DIN)

The spatial extent and concentration of DIN released from sea-pen infrastructure was investigated for each scenario. Concentrations of DIN near the sea-pens increased with increasing biomass. The decrease in DIN with distance from the sea-pens was driven partly by far-field dilution processes and partly by biological assimilation, both processes simulated in the integrated model.

Concentrations of DIN only exceeded the moderate ecological protection criterion (95th percentile of background) within the waters adjacent to the sea-pens for scenario 2 within the Bayliss Island site. No other exceedances of the moderate ecological protection criterion are predicted for DIN (Figure 5.20, Figure 5.21, Figure 5.22, Figure 5.23). DIN concentrations exceeding the high protection criterion were predicted to occur beyond the borders of the sites in Strickland Bay, at the Bayliss Islands and for Razor Island within Cone Bay for scenario 2. The exceedance on the south-eastern side of the Edeline Island North lease intersects with the special purpose zone (cultural heritage) of the Mayala Marine Park, however no other intersection of exceedances of the DIN criterion occur with other sanctuary or special purpose zones throughout the Proposal area. Modelling for scenario 1 predicted no exceedances of the high protection criterion beyond the borders of any of the proposed sites. In areas where current speeds are generally greater, there was little to no predicted change (e.g. at Dorothy Island).

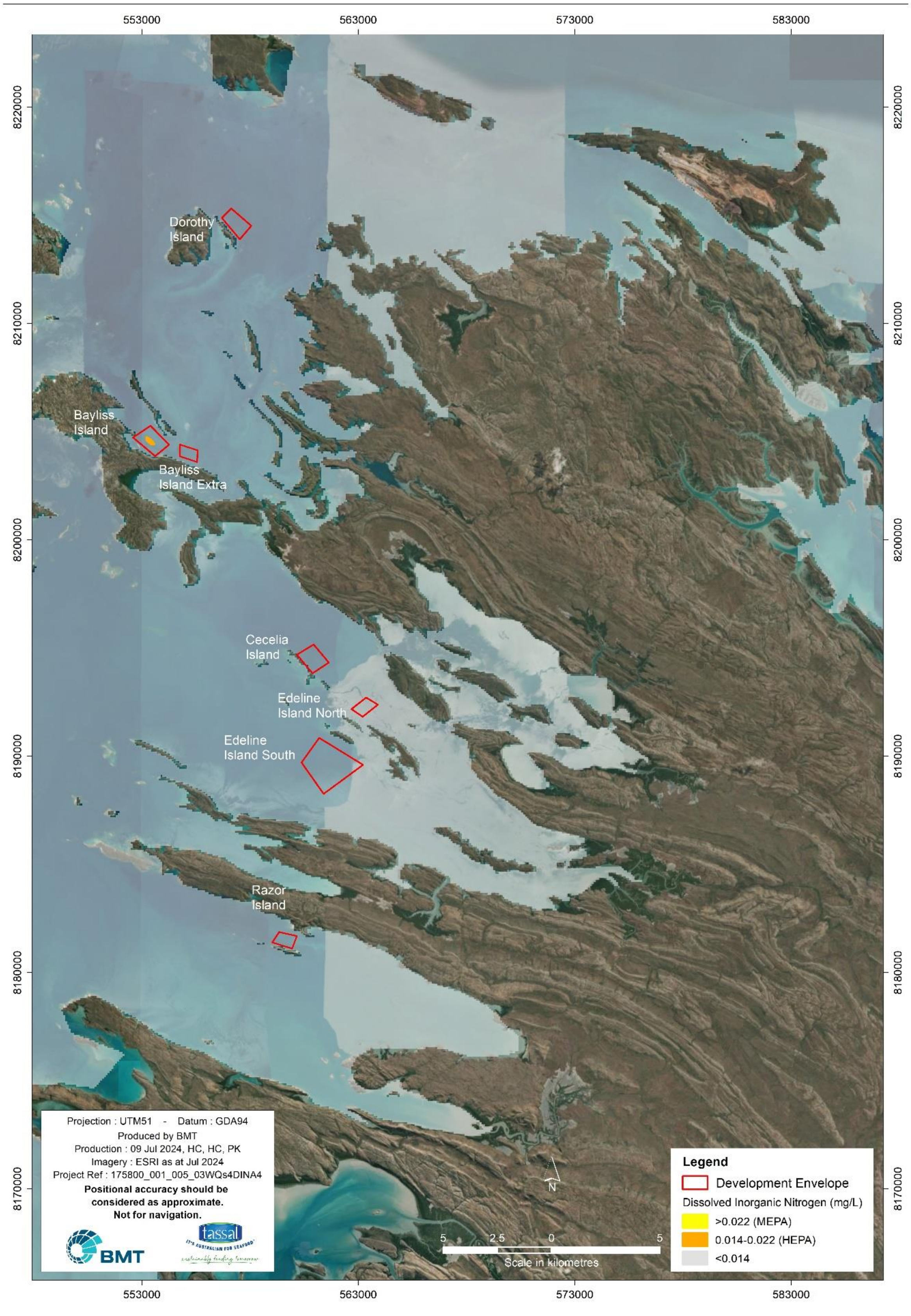


Figure 5.20 Predicted dissolved inorganic concentrations in the water column under scenario 1 – Strickland Bay, Bayliss Islands, Dorothy Island

Figure 5.21 Predicted dissolved inorganic nitrogen concentrations in the water column under scenario 1 – Razor Island

Figure 5.22 Predicted dissolved inorganic nitrogen concentrations in the water column under scenario 2 – Strickland Bay, Bayliss Islands, Dorothy Island

Figure 5.23 Predicted dissolved inorganic nitrogen concentrations in the water column under scenario 2 – Razor Island

Nutrient enrichment (chlorophyll-a)

A natural gradient of chlorophyll-a was detected between deeper waters and nearshore waters, with sites in deep offshore waters tending to have lower chlorophyll-a values under each of the modelled scenarios. In the northern part of the Archipelago, modelled chlorophyll-a values generally did not exceed the moderate or high ecological protection criteria, except for some inshore areas where it is likely material becomes entrapped. Strickland Bay and Cone Bay however had elevated chlorophyll-a values particularly in nearshore areas depending on the scenario. This is also likely a reflection of hydrodynamics as well as the natural gradient of chlorophyll-a between deeper and shallow waters.

Under scenario 2, chlorophyll-a values exceed the 95th percentile criteria in much of the nearshore region of Strickland Bay as well as the majority of Cone Bay (Figure 5.26, Figure 5.27). The 'footprint' is significantly reduced under scenario 1. The 80th percentile criteria is also exceeded in Cone Bay in both scenarios 1 and 2, extending beyond the 'footprint' for the 95th percentile criteria. However, it is critical to note that the 80th and 95th percentile criteria used here, which are derived from the baseline samples collected for the purposes of this study, are very stringent. For example, the 95th percentile criteria is triggered at 0.9 or 0.8 ug/L (varies between Razor Island and the other sites, see Section 5.3.2 for details), which is still reflective of an oligotrophic marine system which generally have a chlorophyll-a concentration of ~1 ug/L (Sri Endah Purnamaningtyas & Mujiyanto 2021). Furthermore, under scenario 1 and 2, chlorophyll-a values are predicted to be less than 1.3 ug/L throughout the model domain. As such, though chlorophyll-a may be elevated above background at these levels it is unlikely there would be any subsequent significant impacts on marine fauna or other biota. This is reinforced by the fact that the model did not predict significant deoxygenation at the sediment interface, which would normally be expected to occur if chlorophyll-a was reaching concentrations reported during an algal bloom.

Overall, the modelling indicates that chlorophyll-a exceedances are not expected in the areas near to the sites for the most part, rather they are elevated in nearshore areas where hydrodynamic flushing is reduced and the potential for the build-up of organic material is increased. Furthermore, these areas naturally record higher baseline chlorophyll-a concentrations than the areas where the sites are sited (see Annex E for details). For example, the nearshore areas of Strickland Bay and Cone Bay periodically experience naturally elevated algal values with significant inflow of riverine inputs during the wet season. A significant algal bloom occurred in 2019 in Cone Bay, with a follow-up investigation finding that the bloom was likely due to elevated riverine inputs during the wet season, rather than any potential enrichment from the Cone Bay operations (DHI 2019). The observed chlorophyll-a values for this study were found to be peak at more than 25 ug/L, with concentrations above 5 ug/L observed for several days in the lead up to and post the peak of the algal bloom (DHI 2019). Furthermore, monitoring conducted within Cone Bay has found that there is a natural gradient of chlorophyll-a and total organic carbon (TOC) from nearshore to offshore areas, with nearshore areas consistently recording higher concentrations of both parameters particularly during the wet season (Stantec 2022b).

The elevations that occur in nearshore regions of Strickland Bay and Cone Bay do intersect with the special purpose or sanctuary zones of the Lalang-gaddam Marine Park and Mayala Marine Park, however, as stated above these areas periodically have naturally higher elevations of algal concentrations. Noting that the management of these areas under the zoning of the marine park requires no change to background condition, the prescriptive monitoring specified in the EMMP (Annex A) will ensure that these areas are maintained, in line with the defined EQP (as per Section 5.4.5).

Figure 5.24 Predicted chlorophyll-a concentrations under scenario 1 – Strickland Bay, Bayliss Islands, Dorothy Island

Figure 5.25 Predicted chlorophyll-a concentrations under scenario 1 – Razor Island

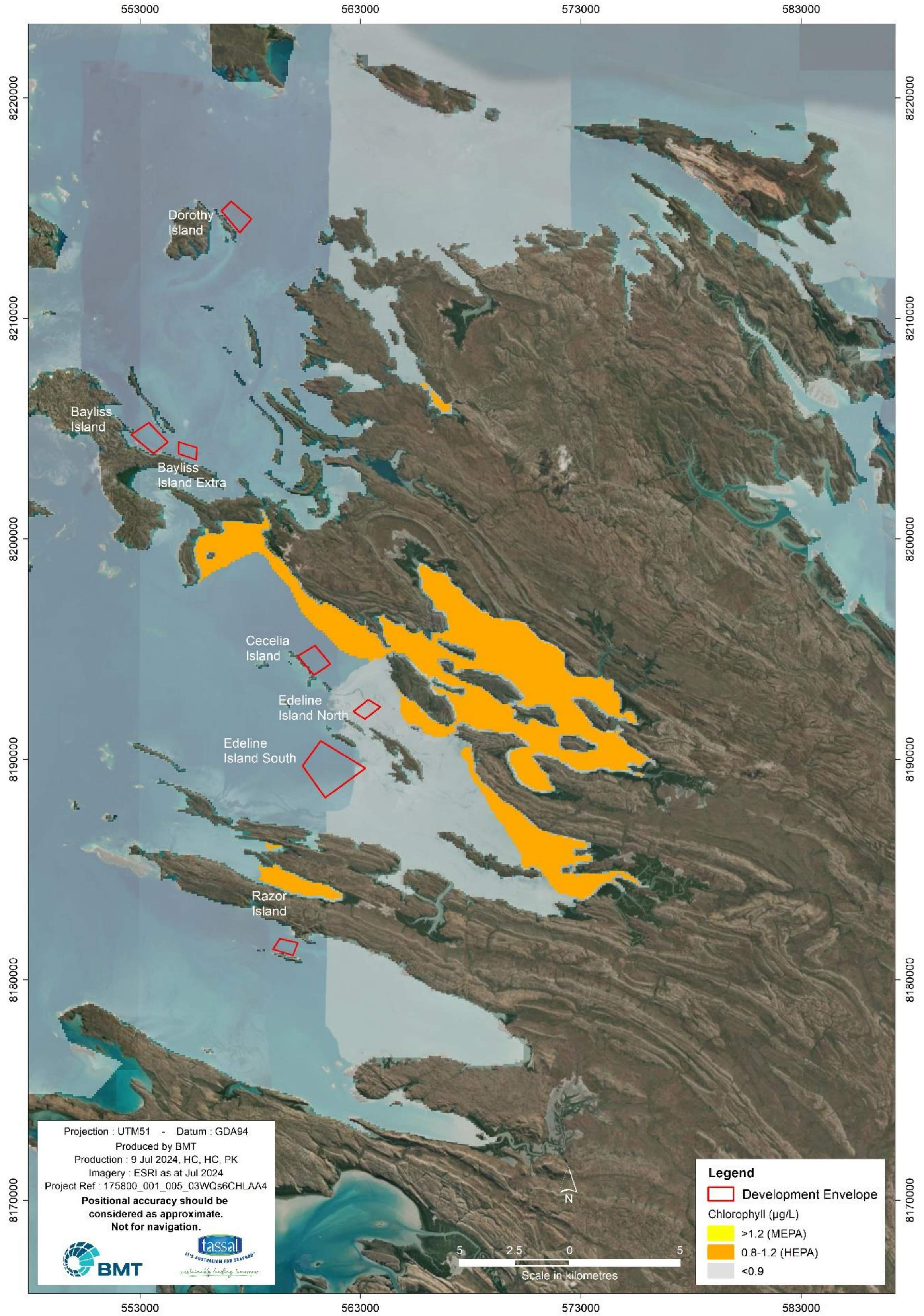


Figure 5.26 Predicted chlorophyll-a concentrations under scenario 2 – Strickland Bay, Bayliss Islands and Dorothy Island

Figure 5.27 Predicted chlorophyll-a concentrations under scenario 2 – Razor Island

Modelled impact assessment – sediment quality

Inputs of organic waste (carbon)

An integrated hydrodynamic, particle transport, water quality and sediment diagenesis model was used to determine the trajectory, settlement and impacts of organic wastes leaving the sea-pens, which may result in an increase in total suspended solids in the water column. For modelling purposes, inputs of organic waste to the seafloor were termed deposition footprint (waste area density in g/m^2/year). Deposition was used as a proxy for organic enrichment, and as an indicator of potential secondary effects, including deoxygenation and accumulation of sulphides. Deposition data are reported here for contextual purposes only.

Figure 5.28 and Figure 5.29 show the predicted rate of deposition to the seafloor under scenarios 1 and 2 after twelve months of continuous finfish production. Deposition levels greater than background were detectable beneath and near to the sea-pens in each of the modelled scenarios. Accumulation of organic material occurred under each scenario and commenced rapidly following beginning of production. The highest deposition was concentrated immediately below the sea-pens, with areas beyond the sea-pens by contrast maintaining similar levels of deposition even with different FCRs. These is indicative of a highly concentrated effect, whereby the deposition of organic waste is centred on the area of seafloor immediately under the sea-pens. In some areas deposition was present beyond the boundaries of sites, however these were generally at rates very close to background.

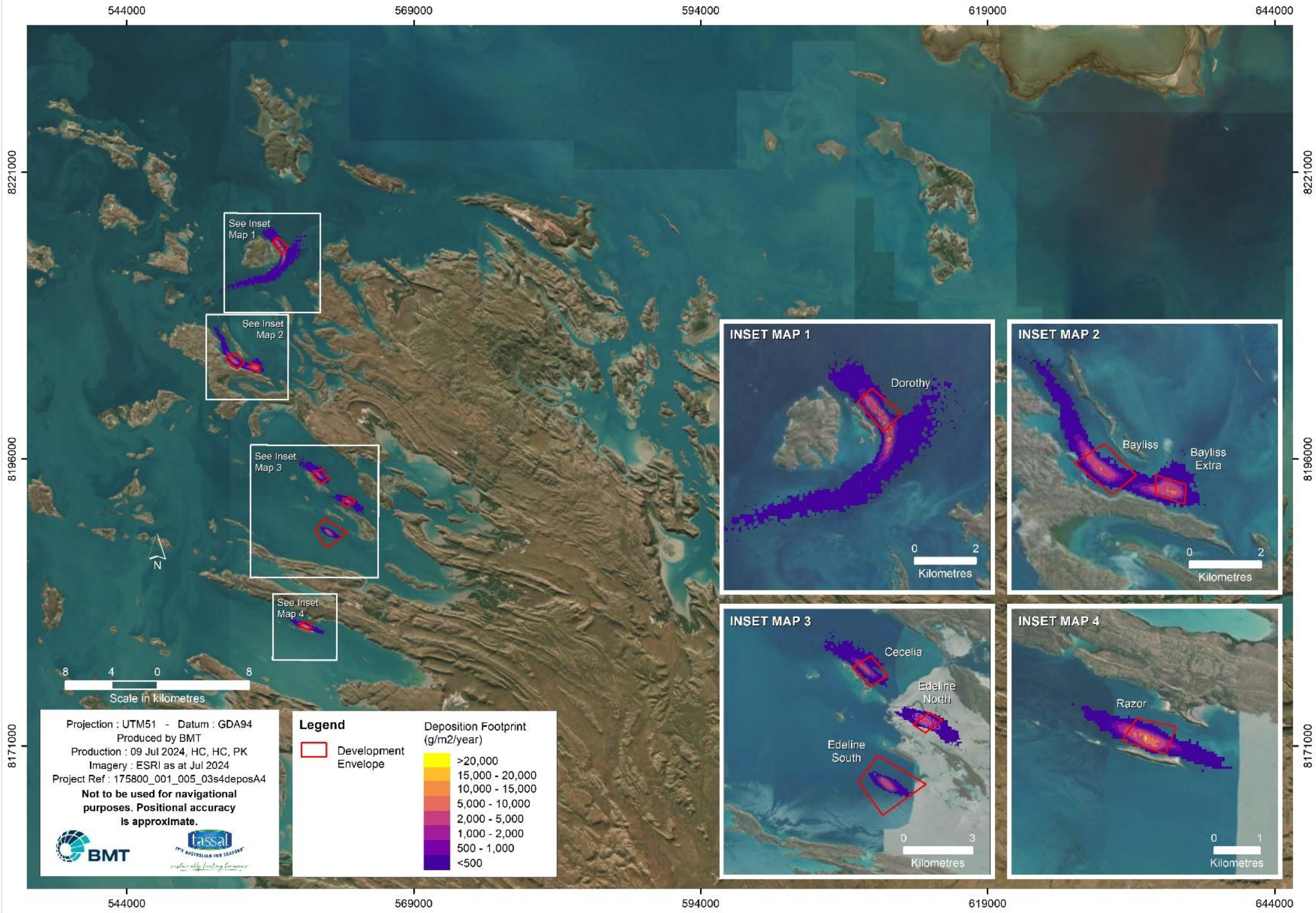


Figure 5.28 Deposition footprint at the proposed sites under scenario 1

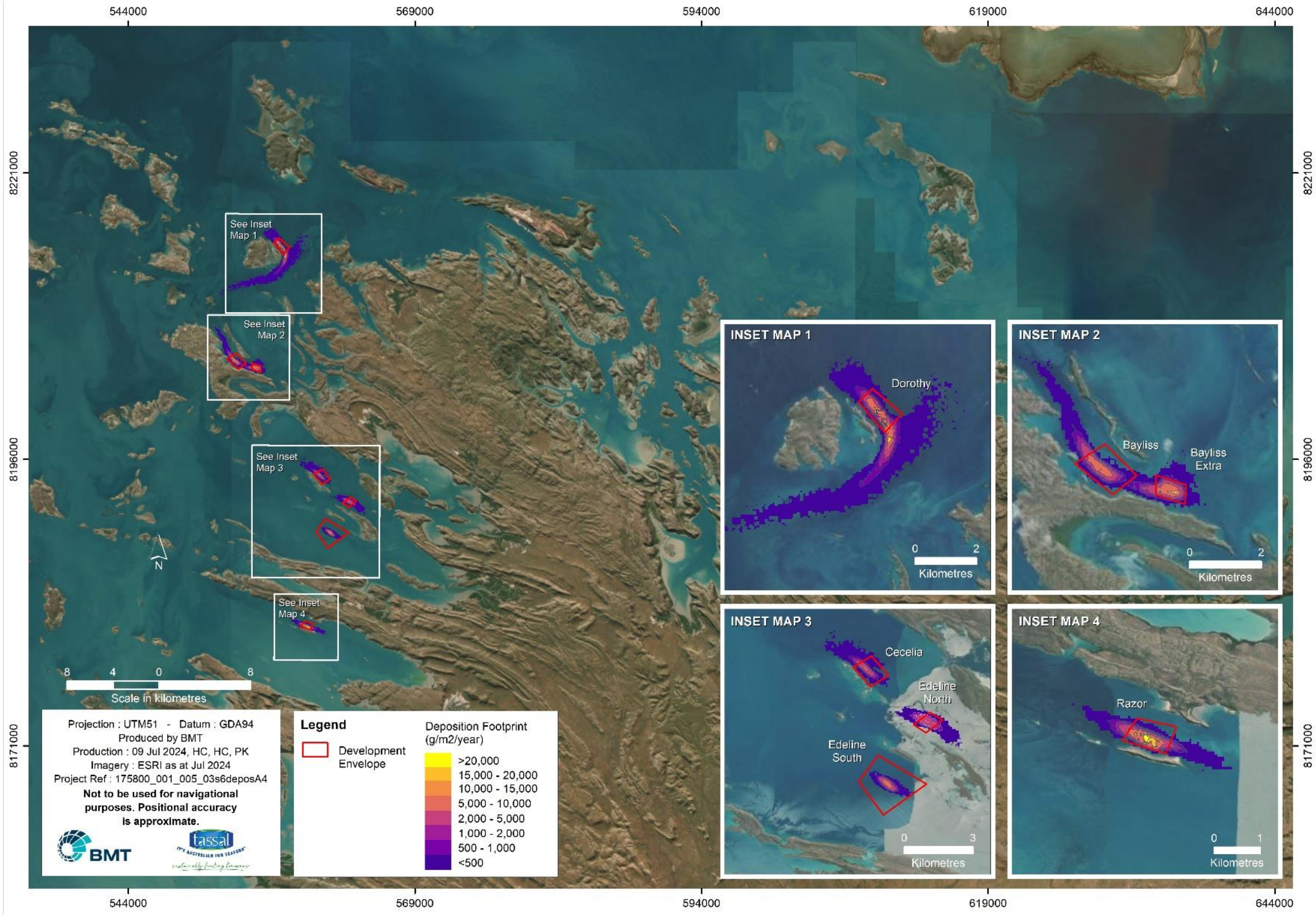


Figure 5.29 Deposition footprint at the sites under scenario 2

Soft sediments (dissolved oxygen and sulphide content)

Figures 5.30 to 5.32 show the projected extent of changes to dissolved oxygen and sulphide content in soft sediments as a result of deposition from the finfish pens; after one, two and five years of continuous (i.e. assuming no fallowing) operations respectively. Major increases in hydrogen sulphide content and subsequent decreases in dissolved oxygen content are generally only predicted to occur directly beneath the sea-pens. Some moderate changes are predicted at the edges of the proposed limits and beyond for a subset of the sites. This is particularly the case for those sites which are situated in areas of significant hydrodynamic flushing, such as Dorothy Island or Bayliss Islands, where depositional material will be distributed over a large area. A small area of intersection of the deposition impact footprint with the Garrooggoorrod Special Purpose Zone (cultural protection) south-east of the Edeline Island North site does occur, however this is limited in area (maximum intersection of 0.14 km^2).

For the most part, the predicted extent of impacts does not change substantially between one and two years of operations, with only small changes in the extent of impacts predicted after operations for five years.

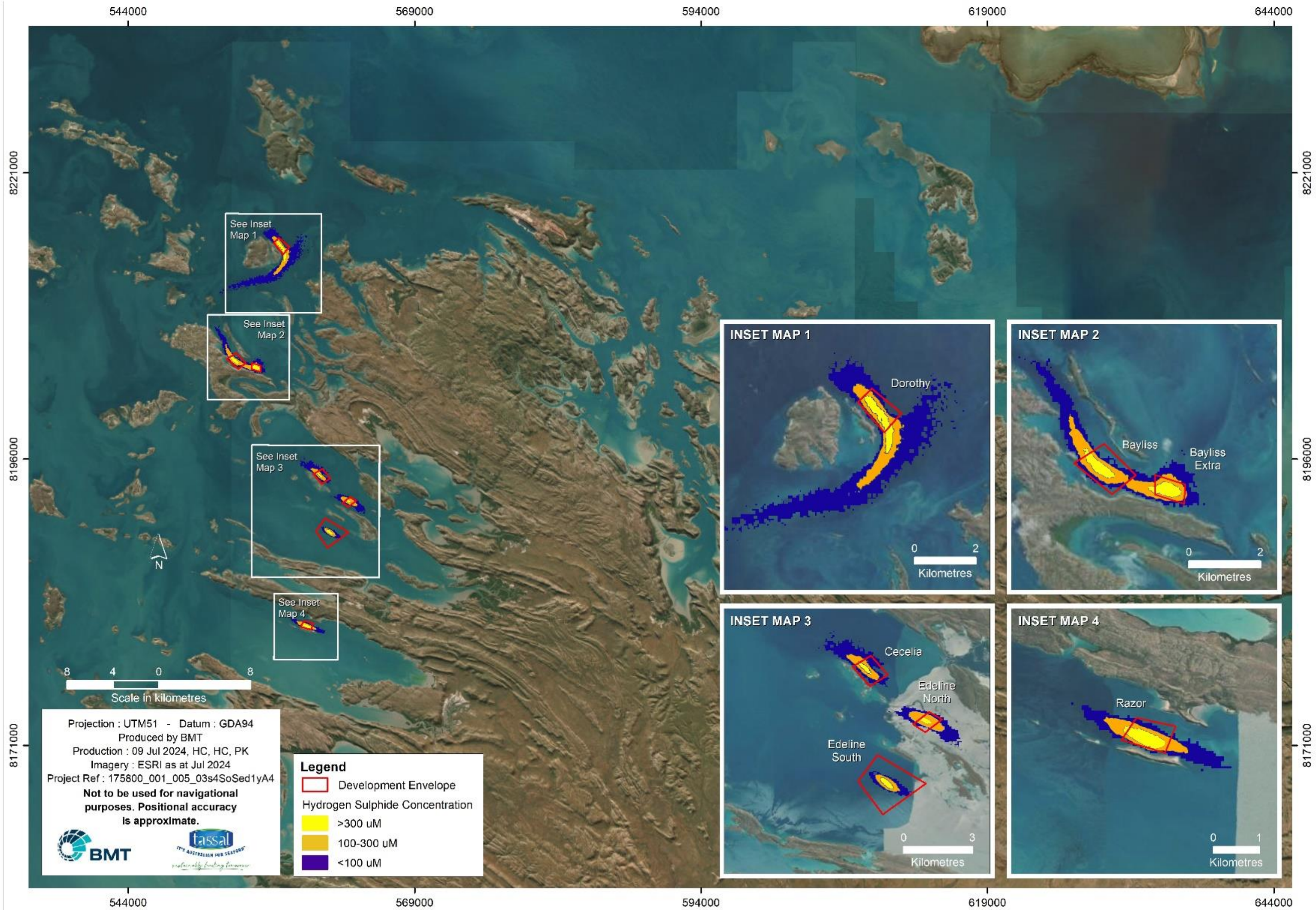


Figure 5.30 Soft sediment impact footprints after 1 year of operations under scenario 1

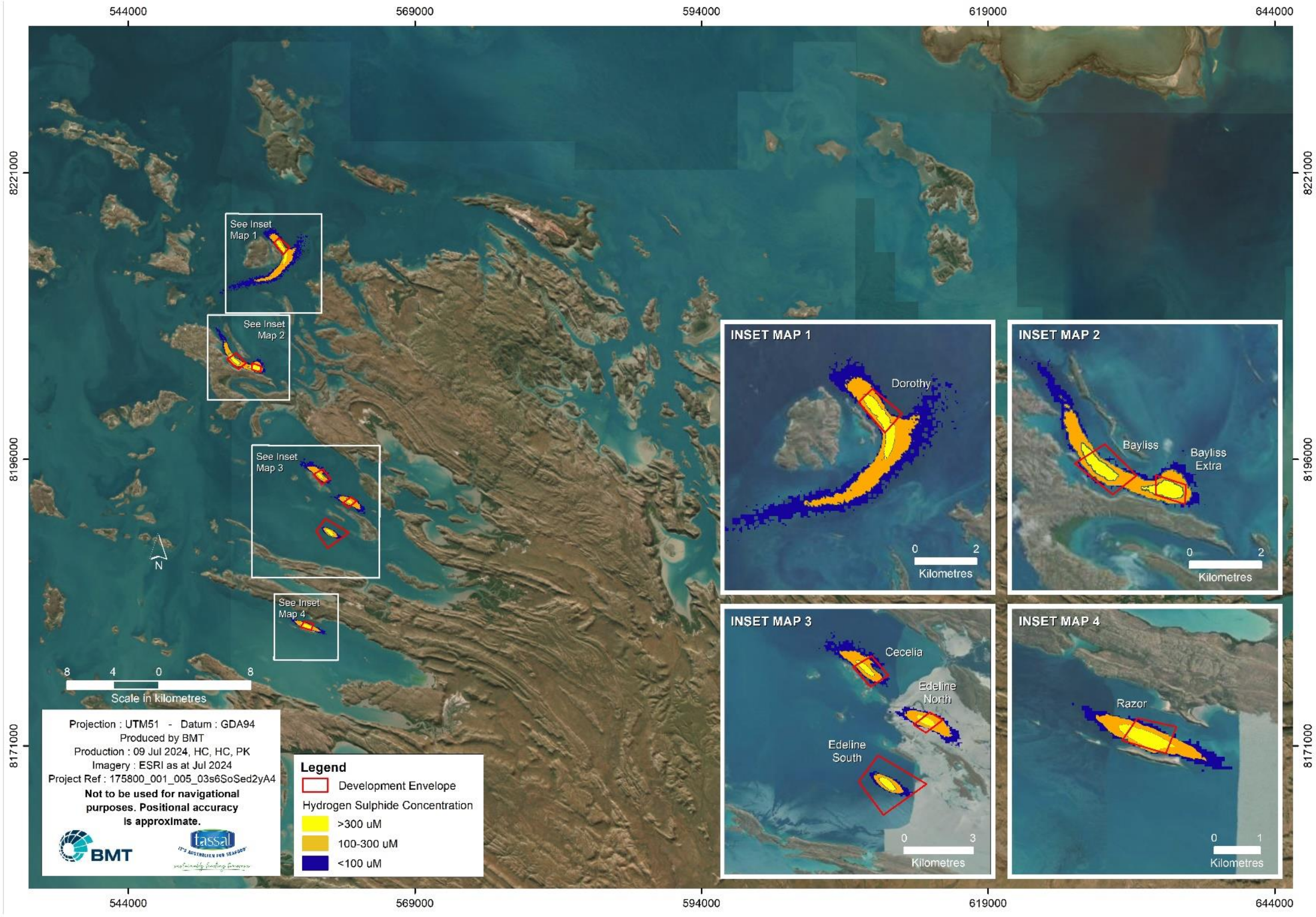


Figure 5.31 Soft sediment impact footprints after 2 years of operations under scenario 1

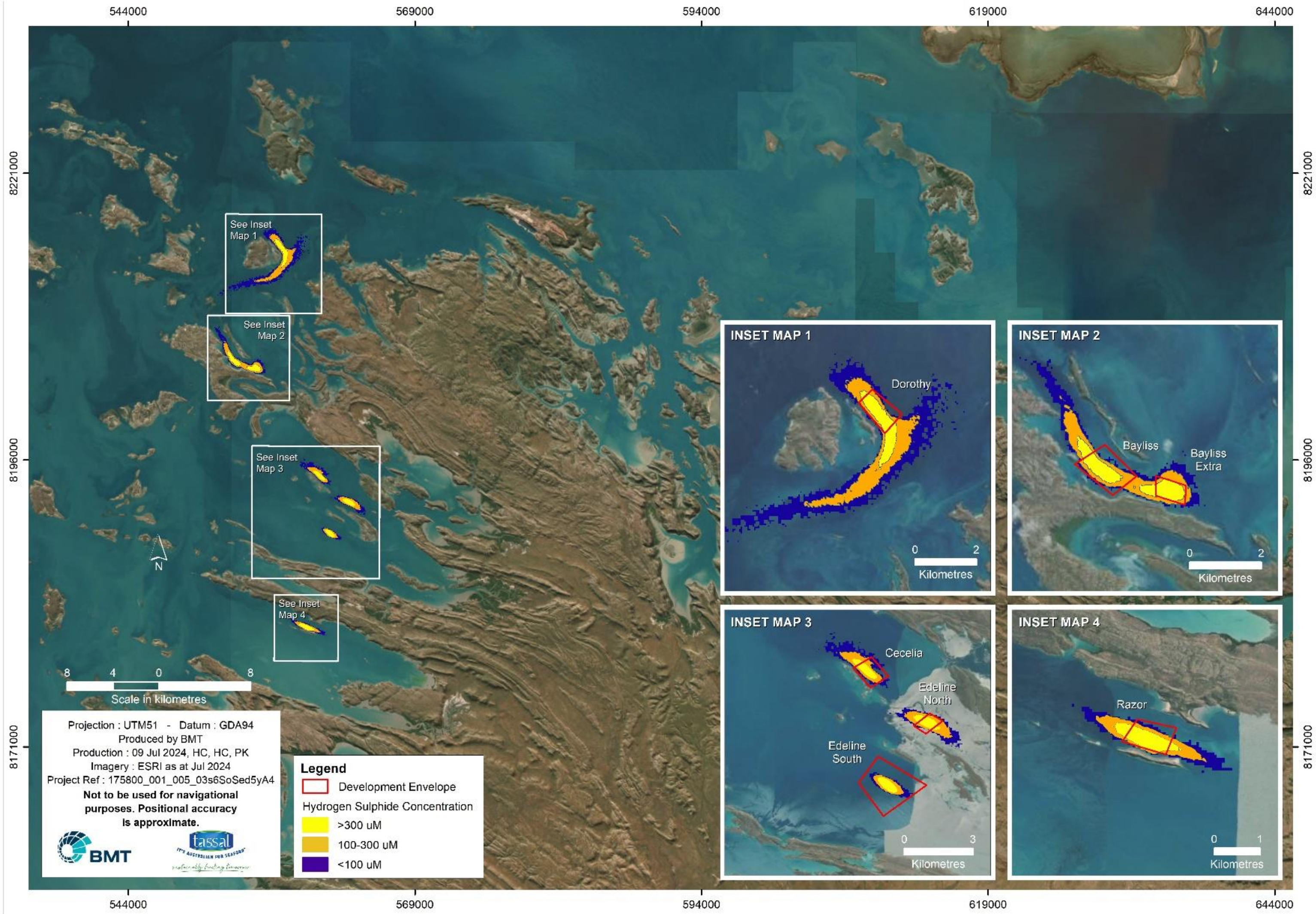


Figure 5.32 Soft sediment impact footprints after 5 years of operations under scenario 1

Sediment toxicity (heavy metals)

The sediment diagenesis model was used to determine the time taken for sediments to recover following inputs of waste, including trace elements (zinc and copper), which are present in commercial finfish feeds. Triggers were set following the EPA's EQGs for high/moderate ecological protection (EPA 2017). Results indicate that for the targeted FCR of 1.5 with an increasing biomass through time (scenario 1), neither zinc nor copper accumulated to levels above the trigger values (Table 5.24). In scenario 2, zinc did accumulate to levels above the trigger, however this was only directly beneath the sea-pens and only in a limited number of sites. At the boundary of the sites, zinc and copper accumulation was less than the triggers for all scenarios.

Table 5.24 Trace metal contamination in sediments

Scenario	Underneath sea-pens		At site boundary	
	Zinc	Copper	Zinc	Copper
1	Does not exceed threshold	Does not exceed threshold	Does not exceed threshold	Does not exceed threshold
2	Exceeds threshold			

5.4.8 Summary of Potential Impacts

Table 5.25 shows the potential operational impacts to marine environmental quality, prior to the application of mitigation measures.

Table 5.25 Potential operational impacts to marine environmental quality from the operation of the sites (without mitigation)

Development type	Potential impacts	Impact	Context and assessment	Extent	Duration	Significance of Impacts (prior to the application of mitigation measures)
Leases	Nutrient enrichment (aquaculture wastes)	Direct	Finfish and excess feed wastes will breakdown and potentially result in nutrient enrichment both of the water column and of the sediments where waste particles settle	Broad (nutrient enrichment may extend to a regional scale)	Lifetime of project (except when sites are fallowed)	4-Major
Leases	Increase in total suspended solids	Direct	Waste particles will increase the concentration of total suspended solids in the water column	Broad (elevated TSS may occur beyond the borders of the sites), however mostly limited to the sea-pen extent	Lifetime of project (except when sites are fallowed)	3-Moderate
Leases	Increased phytoplankton biomass	Indirect	Nutrient enrichment as a result of the breakdown of waste products may subsequently enhance phytoplankton biomasses	Broad (increased biomasses may occur beyond the borders of the sites)	Lifetime of project (particularly wet season when nutrients are naturally higher)	3-Moderate
Leases	Deoxygenation	Indirect	Oxygen levels both in the water column and in the sediments may	Limited (generally only in close	Lifetime of project	2-Minor

Development type	Potential impacts	Impact	Context and assessment	Extent	Duration	Significance of Impacts (prior to the application of mitigation measures)
			reduce due to an increase in microbial activity to breakdown the elevated nutrients polluted into the environment	proximity to the sea-pens)		
Leases	Toxicity (ammonia)	Indirect	Ammonia wastes produced by the farmed finfish may concentrate to a toxic level	Broad (nutrient enrichment may extend to a regional scale)	Lifetime of project	2-Minor
Leases	Toxicity (chemical therapeutants)	Indirect	Chemical therapeutants may be used in extreme case to manage disease outbreaks, and subsequently pose a very low risk of contamination to marine environmental quality.	Limited (limited to directly beneath the sea-pens)	Lifetime of project	2-Minor
Leases	Change to hydrodynamic conditions	Direct	The installation of the sea-pens may change the local hydrodynamics around the sites	Limited (immediate vicinity of the sea-pens)	Lifetime of project	2-Minor

5.4.9 Cumulative impacts

The cumulative direct and indirect impacts of other operations ongoing or proposed in the vicinity of the development envelopes for the sites are summarised in Table 5.26. Though pearl farming leases operate in close vicinity to the proposed sites, there are no potential cumulative impacts on marine environmental quality, other than that the farmed pearls may help remove some of the waste material from the sea-pens before it reaches the seabed, depending on the hydrodynamics of the specific area (there is minimal chemical usage on these farms while wastes produced are also low to nil).

A search of the Environment Online database for other referred significant proposals, as well as current or ongoing projects, was undertaken to confirm the potential cumulative impacts in the vicinity of the Proposal. The only two identified were the Cockatoo Island Multi-supply User Base and the Koolan Island Iron Ore Mine. Cockatoo Island is a distance of ~9.46 km from the closest point of the Proposal (site at Dorothy Island), while Koolan Island is a distance of ~20.5 km from Dorothy Island. Though both projects have the potential to impact on marine environmental quality, as described in Table 5.26, these impacts are very unlikely to interact with any potential impacts from the Proposal (as shown by the modelling results in Section 5.4.7). The impacts from the Proposal can subsequently be viewed as first impact to the area in which the Proposal is located, noting that all other project impacts are distant from the development envelope of the Proposal, and do not present a significant cumulative impact to MEQ.

Table 5.26 Impacts from other ongoing and proposed operations in vicinity of the development envelope for the sites

Development type	Phase	Approved / Operational / Referred	Potential impacts	Impact	Context and assessment
Cockatoo Island Multi-user Supply Base	Construction / operations	Referred	Waste generation	Indirect	During construction and operations, a number of solid and liquid wastes will be generated, including but not limited to sewage, bilge waters, colling waters, deck drainage, lubricating oils, hydraulic oils and excess concrete and asphalt which if released into the marine environment could affect water quality.
Cockatoo Island Multi-user Supply Base	Construction / operations	Referred	Increase in total suspended solids	Indirect	Pile driving required for port activities may increase total suspended solids on a localised scale. Unlikely to interact with site.
Koolan Island Iron Ore Mine and Port Facility	Operations	Operational	Toxicity / increase in turbidity	Direct	Sediment runoff from stormwater poses a risk of introducing toxic materials or wastes into the surrounding marine environment if waste dumps, stockpiles, pits and roads are not managed appropriately.

5.5 Mitigation

Tassal has applied the mitigation hierarchy to the Proposal to protect marine environmental quality, and to meet the EPA's environmental quality objective for ecosystem integrity. Management procedures proposed to minimise impacts to marine environmental quality from the Proposal are summarised below in accordance with EPA's mitigation hierarchy.

5.5.1 Construction

Appropriate avoidance measures have been taken where possible to limit the impact of the construction of the sites on marine environmental quality (Table 5.27).

Table 5.27 Mitigation strategies for reducing construction related impacts at the sites following EPA's mitigation hierarchy

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets
Reduced light (Increased total suspended solids)	NA	• Tassal will only use low-profile mooring blocks or anchors for anchoring their sea-pens, meaning no pile driving or drilling is required to secure them. The installation of these anchors does not result in significant re-suspension of sediments, and any material that is re-suspended is expected to settle in less than a day.	NA	NA	NA	NA
Toxicity (Hydrocarbon spills and waste generation)	• Limited volumes of hydrocarbons or other major wastes will be kept at site or on construction vessels	• A hydrocarbon spill kit will be kept on board all vessels during construction to be used to reduce the extent of a spill in the event one occurs	• All waste generated during construction of the sites will be kept on-board the vessels and disposed of appropriately at a waste facility	NA	NA	NA

5.5.2 Operations

Appropriate avoidance measures have been taken where possible to limit the impact of the operation of the sites on marine environmental quality (Table 5.28).

Environmental monitoring and management for the operational phase is outlined in the EMMP in Annex A. The plan provides guidance on operational activities and the details in relation to the following:

- Detailed monitoring and management requirements
- Timing/frequency of monitoring and management commitments
- Responsibilities for monitoring and management commitments
- Contingency planning/measures in the event of an environmental or safety issue
- Reporting requirements to government and environmental regulators.

The major impacts on marine environmental quality from the Proposal are associated with nutrient enrichment. One of the main mitigation strategies that Tassal can implement is the rate of feeding, where cessation of feeding is possible as an option amongst a variety of other feed management related responses. The cessation/reduction of feed will immediately reduce the nutrient inputs into the system. Through this strategy, Tassal will be able to ensure they do not have the predicted level of impact as indicated by the modelling as their mitigation responses will occur before marine environmental quality reaches the condition predicted.

Table 5.28 Mitigation strategies for reducing operations related impacts on MEQ from the Proposal following EPA's mitigation hierarchy

Impact	Avoidance	Minimisation	Management	Monitoring	Rehabilitate	Offset
Nutrient enrichment (wastes from sea-pens)	• Placement of pen infrastructure in a naturally highly energetic, well mixed environment to assist with dilution • Maintenance of stocking densities, feed inputs and target FCRs (1.5) to minimise nutrient inputs to the local environment • Use of floating/sinking feed in combination with video surveillance to cease feeding as soon as stock cease eating	• At the conclusion of each 18-month grow-out cycle, the sites will be fallowed for a period of a minimum of 1 month, allowing time for the sediment conditions to recover. • Reduced stocking density (in comparison to current operations in Cone Bay) leading to a reduction in the concentration of wastes	Implementation of a EMMP (Annex A), with the following specific strategies: • If nutrient levels exceed the respective criteria, then Tassal will instigate an appropriate management action to reduce the effect and restore environmental quality. These measures could include the review of feeding and stock biomass loading, or the immediate cessation of feeding to reduce nutrient inputs into the system	• Nutrient and measurements at fixed distances up and downcurrent of the sea-pen installation and at appropriate reference sites, with at least some of the fixed sites positioned at the MEPA/HEPA boundary.	NA	NA
Increase in total suspended solids	• Placement of pen infrastructure in a naturally highly energetic, well mixed environment.	• Reduced stocking density (in comparison to current operations in Cone Bay) leading to a	Implementation of a EMMP (Annex A).	• Total suspended solid measurements at fixed distances up and downcurrent of the sea-pen	NA	NA

Impact	Avoidance	Minimisation	Management	Monitoring	Rehabilitate	Offset
	• Maintenance of stocking densities, feed inputs and target FCRs to minimise nutrient inputs to the local environment • Use of floating/sinking feed in combination with video surveillance to cease feeding as soon as stock cease eating	reduction in the concentration of wastes		installation and at appropriate reference sites, with at least some of the fixed site positioned at the MEPA/HEPA boundary.		
Increased phytoplankton biomass	• Placement of pen infrastructure in a naturally highly energetic, well mixed environment. • Maintenance of stocking densities, feed inputs and target FCRs to minimise nutrient inputs to the local environment • Use of floating/sinking feed in combination with	In the event of a bloom, Tassal may stop feeding stock.	Implementation of a EMMP (Annex A), with the following specific strategies: • If chlorophyll-a levels exceed the respective criteria, then Tassal will instigate an appropriate management action to reduce the effect and restore environmental quality. These measures could include the review	• Nutrient and chlorophyll-a measurements at fixed distances up and downcurrent of the sea-pen installation and at appropriate reference sites, with at least some of the fixed site positioned at the MEPA/HEPA boundary. • Additional chlorophyll-a sites will be included in nearshore areas	NA	NA

Impact	Avoidance	Minimisation	Management	Monitoring	Rehabilitate	Offset
	video surveillance to cease feeding as soon as stock cease eating • Deeper pens will allow Tassal to encourage stock to move to the bottom of the pens if harmful algal are present. Fresh, highly oxygenated water can also be pumped into the pens to push algae out of the sea-pen in a process known as venturation		of feeding and stock biomass loading	where modelling indicated phytoplankton biomasses might increase.		
Deoxygenation	• Maintenance of stocking densities, feed inputs and target FCRs to minimise nutrient inputs to the local environment • Use of floating/sinking feed in combination with video surveillance to cease feeding	• At the conclusion of each 18-month grow-out cycle, the sites will be fallowed for a period of a minimum of 1 month, allowing time for the sediment conditions to recover. Reduced stocking density (in comparison to current operations	Implementation of a EMMP (Annex A).	• Oxygen measurements at fixed distances up and downcurrent of the sea-pen installation and at appropriate reference sites, with at least some of the fixed site positioned at the MEPA/HEPA boundary.	NA	NA

Impact	Avoidance	Minimisation	Management	Monitoring	Rehabilitate	Offset
	as soon as stock cease eating • Deeper pens will allow Tassal to encourage stock to move to the bottom of the pens if harmful algal are present. Fresh, highly oxygenated water can also be pumped into the pens in a process known as venturation to replenish dissolved oxygen concentrations	in Cone Bay) leading to a reduction in the concentration of wastes		• Videos of sediment condition will be taken to confirm absence of spontaneous outgassing of hydrogen sulphide and/or observations of bacterial mats (Beggiatoa spp.)		
Toxicity (Ammonia)	• Maintenance of stocking densities, feed inputs and target FCRs to minimise nutrient inputs to the local environment • Use of floating/sinking feed in combination with video surveillance to cease feeding	• Reduced stocking density (in comparison to current operations in Cone Bay) leading to a reduction in the concentration of wastes	Implementation of a EMMP (Annex A).	• Ammonia measurements at fixed distances up and downcurrent of the sea-pen installation and at appropriate reference sites, with at least some of the fixed site positioned at the MEPA/HEPA boundary.	NA	NA

Impact	Avoidance	Minimisation	Management	Monitoring	Rehabilitate	Offset
	as soon as stock cease eating					
Toxicity (chemical therapeutants)	• All stock will be tested for disease prior to transfer to the sites. Vaccination programs will be operated, and health surveillance will be carried out throughout the life cycle to minimise the need for therapeutants to be utilised as much as possible	• Therapeutant dosages are to be specified by a qualified veterinarian prior to their introduction	Implementation of a EMMP (Annex A).	NA	NA	NA

5.6 Assessment and significance of residual impacts

The residual impacts of the Proposal are summarised in Table 5.29 where present. Overall, the project does pose a risk to marine environmental quality if mitigation measures apply, particularly with the introduction of nutrient loading in the vicinity of the sea-pens. For the most part, these impacts are in close proximity to the sea-pens, however some changes are expected beyond the development envelope of the project with potential for nutrient enrichment. As described in Section 5.5, the monitoring and associated mitigation actions required as part of the EMMP will help ensure the Proposal does not pose more than a moderate risk to marine environmental quality. Specifically, the ability for Tassal to immediately cease feeding if nutrient or chlorophyll-a associated criteria are exceeded, which significantly reduces nutrient inputs into the marine system, means Tassal can respond rapidly to any incidences of nutrient enrichment and mitigate it before impacts as predicted by the integrated model occur. If nutrient enrichment continues once normal operations begin, Tassal can explore alternate production models on particular sites (which have reduced feeds, different standing biomasses etc) to help reduce nutrient inputs in areas where monitoring is showing it is a problem.

Table 5.29 Residual impacts on Marine Environmental Quality

Impact	Phase	Assessment	Residual impact
Reduced light (Increased total suspended solids)	Construction	The anchoring of the sea-pens may re-suspend sediments in the immediate vicinity of the anchoring / securing; however, any re-suspended materials will be minimal and are expected to settle within a day	1-Insignificant
Toxicity (hydrocarbon spills and waste generation)	Construction	The risk of hydrocarbon spills from vessels during construction will be no more than from any other vessels operating in the area, while all vessels will contain spill kits on board in the event a spill does occur. Any wastes generated will be kept to the vessel and disposed of appropriately at a waste management facility.	1-Insignificant
Nutrient enrichment (aquaculture wastes)	Operations	Nutrient enrichment from aquaculture wastes may occur without mitigation, however it will be significantly reduced through the mitigation strategies implemented by Tassal, as well as the direction to achieve an FCR of 1.5. Any potential for nutrient enrichment long-term will be monitored and managed under the EMMP to verify that Tassal's operations do not pose a risk of nutrient enrichment beyond the site boundaries. This includes the monitoring of nutrient conditions in proximity to and beyond the sea-pens, with management actions ready to be implemented in the event of an exceedance of the relevant criteria. In this way, Tassal are able to respond to any nutrient enrichment and mitigate it before it has a significant impact beyond sea-pens, including those areas of the Mayala and Lalang-gaddam Marine Parks that are zoned such that no change from background condition is allowed within these zones.	3-Moderate

Impact	Phase	Assessment	Residual impact
Reduced light (increase in total suspended solids)	Operations	The potential for increase in total suspended solids is expected to be kept within the vicinity of the sites, with only minor reduction of light levels in comparison to baseline conditions.	2-Minor
Increased phytoplankton biomass	Operations	Increased phytoplankton biomasses are predicted in nearshore areas of Strickland Bay and Cone Bay in particular, without mitigation. The extent of these increases is significantly reduced with the commitment to an target FCR of 1.5. The potential for long-term increases in phytoplankton biomasses (as well as discrete algal bloom events) will be monitored and managed under the EMMP. This includes additional monitoring sites in nearshore areas where modelling predicted elevated chlorophyll-a concentrations. Tassal's management actions, in the event that elevated phytoplankton biomasses are recorded, will help reduce nutrient loading into the system and reduce the potential for phytoplankton increases. This will ensure that no change to background condition occurs particularly in the sanctuary and special purpose zones of the Lalang-gaddam and Mayala Marine Parks. Monitoring of phytoplankton will be particularly important during the wet season when riverine inflows increase nutrient loading in nearshore areas. Particular management of the timing of feeding etc during these seasons will help further reduce the risk of elevated phytoplankton biomasses and the risk of algal blooms.	3-Moderate
Deoxygenation	Operations	Modelling results indicated that dissolved oxygen levels, even in close proximity to the sediments, remained relatively consistent between scenarios and between baseline conditions. Because dissolved oxygen is key to the survival of the stocked fish, it will be monitored on location at all sites every single day, in addition to the monitoring required under the EMMP. As such, any time low oxygen levels are recorded management actions will be immediately implemented to help increase oxygen levels.	2-Minor
Toxicity (Ammonia)	Operations	Dissolved inorganic nitrogen levels are not expected to approach EPA's guideline values for toxicity for Ammonia.	2-Minor
Toxicity (chemical therapeutants)	Operations	The need for therapeutants will be reduced as much as feasible through Tassal's biosecurity measures as well as a proactive animal health programme.	1-Insignificant
Change to hydrodynamic conditions	Operations	Though minor changes to hydrodynamic conditions are expected as a result of the Proposal, this is only modelled to occur in the immediate vicinity of the sea-pens and is not expected to pose a long-term change to current speeds or directions.	1-Insignificant

5.7 Predicted outcome

Considering the mitigation strategies implemented by this proposal, and the little to no cumulative impacts from other proposals or projects, there is only a moderate to minor risk of changes to marine environmental quality in the vicinity of the sites. This is specifically associated with the potential for nutrient enrichment, and subsequent potential increases in phytoplankton biomasses. Both of these parameters, as well as a range of others, will be monitored and managed under the EMMP. Though some elevations were projected within sanctuary / special purpose zones of the Mayala and Lalang-gaddam Marine Parks, this is before mitigation actions are accounted for. With the monitoring specified in the EMMP, and the associated actions required if exceedances of relevant triggers are recorded, it is expected that the EPA's objective for Marine Environmental Quality can be met, and no impact to the values of the Mayala and Lalang-gaddam Marine Parks will occur.

6 Benthic communities and habitats

6.1 EPA objective

The EPA objective for the Benthic Communities and Habitats factor is to protect benthic communities and habitats so that biological diversity and ecological integrity are maintained.

6.2 Policy and guidance

The relevant EPA policies and guidelines for benthic communities and habitats and the scope of each of these as relevant to the Proposal are outlined in Table 6.1.

Table 6.1 Policies and guidelines

Policy or guidance	Consideration
Environmental Quality Criteria Reference Document for Cockburn Sound (EPA 2017)	The thresholds examined by the modelling were generally derived from EPA (2017), which provides comprehensive advice regarding the setting of triggers, even when the area of interest is outside of Cockburn Sound. Other thresholds are as per ANZG (2018).
Factor Guideline – Benthic Communities and Habitats (EPA 2016a)	EPA (2016a) provides guidance on Benthic Communities and Habitats, including factors which can impact the benthic marine environment. Benthic communities and habitats are assessed based on potential impacts to biological diversity and ecological integrity of either benthic communities such as algae, seagrass or corals, and habitats which are the substrate benthic communities grow in. Specifically, the EPA focuses on the extent, severity and duration of potential impacts, and subsequently whether any consequential losses to benthic communities and habitats are permanent or temporary.
Technical Guidance – Protecting benthic Communities and Habitats (EPA 2016e)	EPA (2016e) provides guidance on the environmental quality management frameworks for protecting Western Australia's benthic communities and habitats and defines the environmental values and objectives for ecosystem health, fishing and aquaculture, recreation and aesthetics, industrial water supply and cultural and spiritual values, as well as the approach to setting levels of ecological protection. The studies executed in support of the Proposal, including particle tracking modelling and habitat mapping, were designed and executed in the context of EPA (2016e).
Other policy or guidance	

Policy or guidance	Consideration
Bardi Jawi Gaarra, Mayala and Lalang-gaddam Marine Park Management Plans	The Bardi Jawi Gaarra, Mayala and Lalang-gaddam Marine Park Management Plans dictate how benthic communities and habitats present within the parks are managed.
Mayala Country Plan (MIAC 2019)	The Mayala Country Plan sets out the biocultural heritage and relationship Mayala people have with Country. It further dictates Mayala's strategic approach and priorities for Country, including relations with external projects on Mayala Country, such as this Proposal.
Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018)	These documents and the assessments of impacts contained herein are based on guidance in the relevant EPA documents (cited above), which are in turn based on the high-level guidance provided in ANZECC & ARMCANZ (2000) and ANZG (2018).

6.3 Receiving environment

6.3.1 Environmental Values

The environmental conditions within the Buccaneer Archipelago and broader West Kimberley region, particularly the presence of tidal exchanges greater than 10m, has a major influence on the extent and distribution of BCH. However, there is limited published information on the distribution, biomass, and productivity of BCH throughout the Buccaneer Archipelago. Key environmental values which are known to be present include fringing coral reefs and bombies, particularly in the waters adjacent to the Archipelagos islands, ephemeral meadows of seagrass (*Halophila ovalis)* in the nearshore regions, as well as sponge gardens.

Corals

The coral reefs of the Archipelago are of particular environmental value. Two types of reef are generally present; low intertidal reefs which develop narrow, horizontal or gently sloping flats at the mean low water mark for spring tides, and high intertidal reefs which develop coralline algal-dominated flats between the low water and high mark for neap tides. These high intertidal reefs are unique in that most coral reefs grow vertically until they reach sea level, at which point they then alternate their growth direction and spread out laterally into deeper water. The intertidal reefs present here on the other hand keep growing vertically such that the flats can be above the tidal mark for half the time (Richards and O'Leary 2015). The predominant species of coral in the Archipelago are varied, with *Acropora* dominating in sheltered areas of fringing reefs alongside *Fungiid* corals, which make way for a *Porites* dominated zone at 10-15 metres depth. *Porites* bommies are also present within the subtidal inner reef flats. Research indicates that the species present at the inshore fringing reefs are highly divergent from the offshore 'oceanic' populations present, indicating that they are independent in an ecological and evolutionary sense (Richards et al 2017).

These reefs are unique considering their ability to withstand bi-diurnal tidal fluxes of up to 10 m, which is the largest of any coral reef system in the world, which exposes the reefs to high temperatures, wind and sunlight at levels far above those experienced by reefs elsewhere on the globe. For example, the bleaching threshold for Kimberley corals for temperature is approximately 32°C, while for most other corals they are stressed if exposed to prolonged periods of temperatures over 29°C. This resilience was exhibited during the 2010-2011 marine heatwave on the WA coastline, where the inshore Kimberley reefs were some of the only reefs to show no evidence of widespread bleaching and mortality.

In addition to exposure when the water mark drops below the corals, the majority of the corals in the nearshore regions also experience high turbidity due to the influx of sediment-filled freshwater during the wet season. As such, light levels are reduced significantly at this time of year, which reduces coral's ability to photosynthesise. To counter-act this, many scleractinian (hard corals) species have adapted to filter organic particles from the water column. Smothering due to settlement of suspended particles in the water column is another challenge these species have adapted to deal with. Many species actively remove sediment with their tentacles or excrete a protective layer of mucus, while others have adapted a morphology which prevents particles from settling.

Seagrasses

Twelve species of seagrass have been recorded in the Kimberley, with turtle grass (*Thalassic hemprichii*) and paddle weed (*Halophila ovalis*) the most common species found in the region (McMahon et al. 2017). Subtidal meadows are generally short-lived and dominated by species with fast turnover times and high reproduction rates, often disappearing during the wet season (Kendrick et al. 2017). Little detailed study has been conducted on seagrasses within the Archipelago, however the Sunday Island Group which is adjacent to the Archipelago contains particularly extensive and diverse meadows with eight species being recorded in the raised lagoons of the islands (Kendrick et al. 2017). With the proximity of the Group to the Archipelago it is expected that similar levels of diversity may be present.

Macroalgal communities

Across the Kimberley region more than 270 species of macroalgae have been recorded, the majority of which are red algae (Huisman and Sampey 2014). *Sargassum* species are abundant in the inshore habitats of the Archipelago, providing important shelter for juvenile fish.

Sediment macrofauna

Little information on benthic filter feeding communities exists within the Archipelago. A survey conducted within the Lalang-gaddam / Camden Sound recorded abundant and diverse sponges, crustaceans, echinoderms and soft corals in localised areas with hard substrate, while areas of sand or silt were sparse in biota (Heyward et al. 2018). The areas of highest diversity were generally associated with seabed channels from the Holocene transgression reflecting former river channels and drowned valleys which create rapid changes in depth, slope and aspect over relatively short distances. It is likely similar patterns of benthic communities is present within the Archipelago.

Sediment infauna

There is limited published data available for sediment infauna within the Buccaneer Archipelago. Available data suggests a relatively diverse infauna assemblage within Cone Bay for example, where a total of 91 different families across ten phyla (Arthropoda, Echinodermata, Mollusca, Platyhelminthes, Phoronida, Sipuncula, Nematoda, Nemertea, Annelida and Helichordata) were identified. The most abundant families comprised polychaetes (28 families, 53.3% of total infauna) and amphipods (ten families, 28.8% of total infauna) (Oceanica 2013a). Greater diversity is generally present within soft sediments. Results from studies conducted for this Proposal, as detailed in Section 5.4, indicate a relatively less diverse assemblage in comparison across the broader Archipelago in deeper waters where samples were collected.

Mangroves

Significant diversity of mangroves are present throughout the islands of the Buccaneer Archipelago, with all 18 species of mangroves in Australia found in the Kimberley region, 10 of which are only found in the Kimberley (Pendretti and Paling 2001). Though the mangroves of the Archipelago have not yet been mapped directly, a similar suite of species could be expected.

6.3.2 Overview of studies

Benthic mapping study

Benthic habitat mapping was undertaken by BMT to characterise the extent of benthic habitats within and adjacent to the development envelopes of the Proposal area (Annex F). Four preliminary local assessment units (LAU) were defined based on the extent of the proposed sites and has since been altered to capture the relative extent and area of influence of the Proposal (based on modelling described in Section 5), to ensure alignment with the EPA *Technical Guidance: Protection of Benthic Communities and Habitats* (EPA 2016b) (Figure 6.1). The LAUs are unique in that the Proposal is non-contiguous, i.e. the zones of impact are generally limited to a constrained area at or adjacent to the sites (Section Figure 5.12, Figure 5.30 to Figure 5.32). As such, habitat mapping has only been conducted for areas within the zones of impact, as well as for nearshore areas where there are known significant environmental values (e.g. fringing coral reefs). This means there are some habitats, between the zones of impact and the nearshore fringing reefs, within the LAUs which were not mapped. This was seen to be the most appropriate approach to ensure understanding of benthic habitats in proximity to the sites while still providing information on the proximity of significant habitats (fringing coral reefs) to the Proposal.

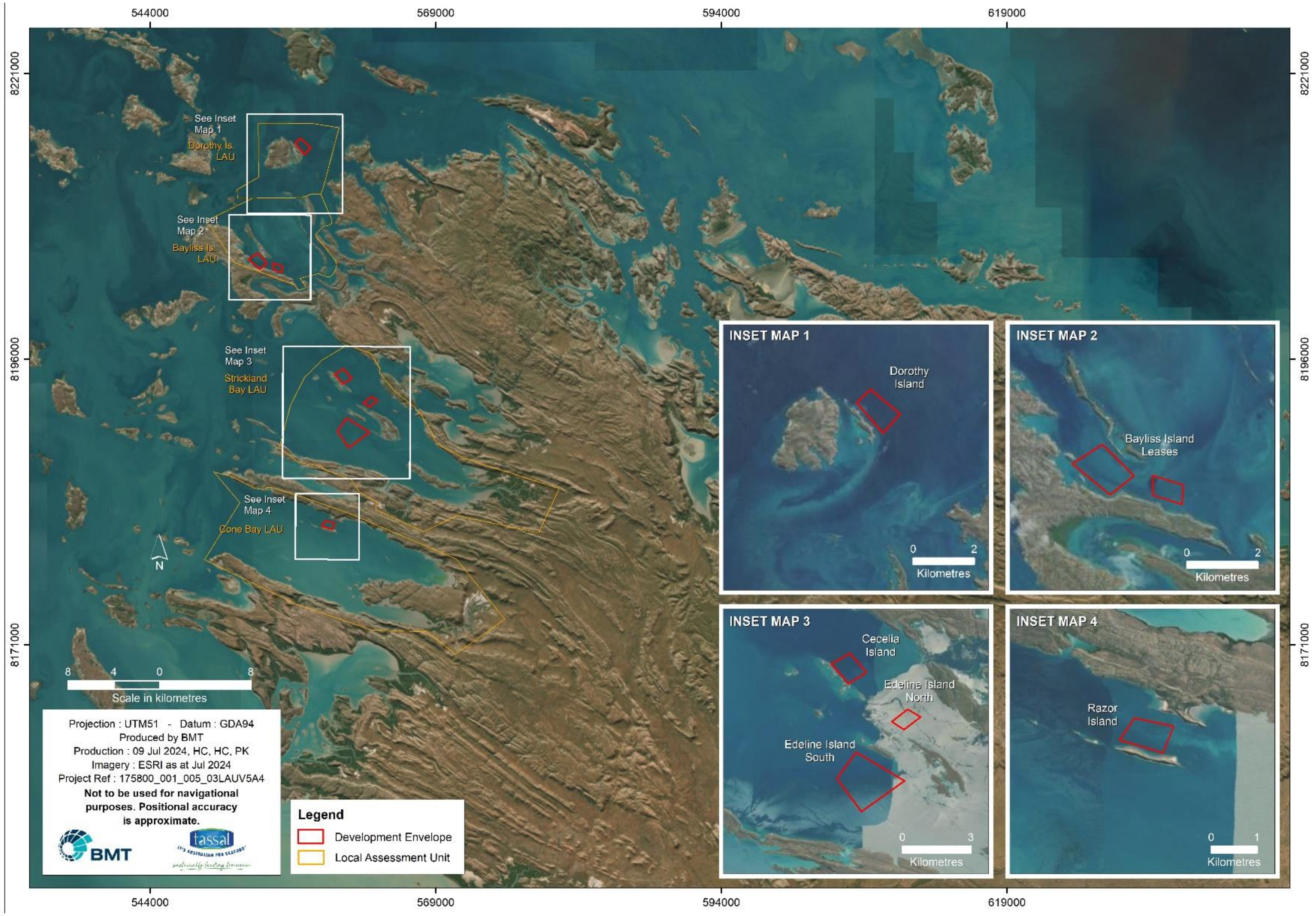


Figure 6.1 Local Assessment Units

Details on the methods and survey types are given in Annex F, with a summary given below of the information used in creating the habitat maps for this Proposal:

- Satellite imagery
- Side-scan data collected by Tassal at the sites
- Ground-truthing video collected by Tassal on pre-defined waypoints
- Additional side-scan, bathymetry and multi-beam data collected in areas beyond the sites
- Original habitat mapping conducted for the KADZ in Cone Bay

Habitats were categorised to general substrate type (i.e. coral, sand). The category for coral is conservative, as it includes any fringing reef which may contain live or dead coral tissue.

Habitat analysis – results

Sand, sand with rock (rubble) and sand with silt were the dominant benthic substrates found across the LAUs (total cover of 42%, 18% and 23% respectively; Table 6.2, Figure 6.2). The dominant habitat types within the sites themselves, as well as the deep waters adjacent to the sites, also were soft sediments either of silt or sand. Coral were found for the most part in nearshore areas on fringing reefs. Overall, coral made up 6% of the habitats identified. Other vegetated habitats, such as macroalgae, totalled less than 5% all together across the Archipelago. Mangroves were also identified on some of the islands or along the shoreline, totalling <1% of the habitats identified. A very small patch of seagrass was identified from previous mapping in Cone Bay, though this represented less than 0.01% of habitats across the entire Archipelago. This is unsurprising considering most of the habitats mapped are in deep waters beyond the depth limitations of the majority of seagrass species present in the region.

Between the LAUs, there was a clear difference between those in the north of the Archipelago and those in the south. The LAUs in Strickland Bay and around Razor Island were dominated by sand or sand with rubble habitats, with little to no silty sediments identified. Deep water habitats in the Bayliss LAU and the Dorothy Island LAU however were predominantly silt or silt and sand. The composition of the nearshore areas in terms of coral reef habitats in comparison to sandy shorelines were relatively similar.

Table 6.2 Extent of benthic habitat categories in mapped area across the Archipelago within each respective LAU

Habitat	Cone Bay LAU		Strickland Bay LAU		Bayliss Islands LAU		Dorothy Island LAU	
	Area (km^2)	Proportion (%)	Area (km^2)	Proportion (%)	Area (km^2)	Proportion (%)	Area (km^2)	Proportion (%)
Mangrove	0.03	<1	0.09	1	0.04	1	0.15	1
Filter Feeders	0.09	<1	0.00	0	0.00	0	0.00	0
Coral	0.76	7	0.75	6	0.50	8	0.51	5
Rock (Rubble)	0.13	1	0.44	3	0.21	4	0.32	3
Rock (Rubble) and Macroalgae	0.00	0	0.03	2	0.02	0	1.51	15
Sand	10.48	90	5.19	36	1.02	17	0.38	4
Sand and Macroalgae	0.10	0	0.13	1	0.11	2	0.00	0
Sand and Rock (Rubble)	0.00	<1	6.22	52	0.69	12	0.22	2
Sand and silt	0.00	0	0.00	0	2.79	47	6.41	64
Sand and silt (LC)	0.00	0	0.00	0	0.57	10	0.04	<1
Seagrass	<0.01	<1	0.00	0	0.00	0	0.00	0
Silt	0.00	0	0.00	0	0.00	0	0.41	4
Total	11.6	100	12.87	100	5.96	100	9.95	100

Figure 6.2 Habitat map for all sites

Water and sediment quality study

To assess impacts of the Proposal on benthic habitats, a water and sediment quality study, as summarised in Section 5, was conducted. The relevant aspects of that study to benthic communities and habitats are the impacts on sediments, as well as the level of deposition and association with shading and smothering of benthic habitats.

6.4 Potential impacts

The potential for impacts to benthic communities and habitats resulting from construction and operation of the Proposal are summarised in Table 6.3 and Table 6.4. Potential impacts categorised as major or moderate are explored further below. Potential impacts listed as minor are not considered any further in this document.

6.4.1 Approach

Potential impacts to benthic communities and habitats have been considered for both the construction and operation of the sites. Predictive modelling, using the integrated model described in Section 5, was only conducted for the operation of the sites, not the construction of both, as the impacts from construction are likely to be acute and insignificant given the minimal level of disturbance. The relevant criteria used to assess impacts from the operation of the sites are detailed in Section Figure 5.12, and were derived based off understanding of the cause-effect pathways for each pressure resulting from the Proposal.

The impact of other operations in the area nearby the proposed sites, including commercial and industrial operations, on benthic communities and habitats are also considered to ensure the total cumulative impacts are well understood.

Impacts have been defined as summarised below:

- Major – E.g. Results in permanent changes or long lasting (> 5 years recovery) impacts to BCH, either through smothering impacts or changes to sediment characteristics as a result of nutrient enrichment
- Moderate – E.g. Results in semi-permanent changes (< 5 years recovery) impacts to BCH, either through smothering impacts or changes to sediment characteristics as a result of nutrient enrichment
- Minor – E.g. Results in short-term changes to BCH which are immediately remedied if the pressure is removed
- Insignificant – no impacts to BCH are expected

The same pressure-response relationships as those detailed in Section 5 were explored to identify the relevant thresholds for assessing impacts of the Proposal on BCH.

6.4.2 Potential construction impacts

The relevant cause-effect pathways for the construction of the sites are summarised in Figure 5.17. The potential impacts are summarised in Table 6.3.

Table 6.3 Potential impacts to Benthic Communities and Habitats from construction of the sites

Development type	Potential impacts	Impact	Context and assessment	Extent	Duration	Significance of Impacts (prior to the application of mitigation measures)
Leases	Removal	Direct	Direct removal of BCH through construction activities (placement, anchoring, etc.). The marine infrastructures, i.e. the sea-pen and barge anchorages, will be installed on the seafloor. Direct losses of BCH will therefore be limited to the maximum size of the anchorages for the 120 m sea-pens, each of which has a footprint of ~4 m^2. With ~28 anchorages per site for the sea-pens, as well as 8 anchors of the same size for the barges, this equates to a total footprint of approximately 0.12 ha for the 120 m sea-pens across all seven leases. This is greater than the footprint expected from the anchorages required for the 80 m pens, as the anchorages themselves are expected to be smaller.	Limited (only where infrastructure is present)	Lifetime of project	2-Minor
Leases	Shading / smothering	Indirect	The anchoring of the sea-pens may result in elevated TSS at a local scale, potentially resulting in shading or smothering effects on BCH	Limited (only in close proximity to the infrastructure)	<1 day	2-Minor

6.4.3 Potential operational impacts

The relevant cause-effect pathways for the operation of the sites are summarised in Figure 5.19, but are limited to potential effects from shading and smothering of BCH as well as deposition resulting in changes to the oxygenation of the seabed sediment. The potential impacts themselves are summarised in Table 6.5. Thresholds for impact assessment are provided below.

Thresholds for model interrogation

The zone of impact approach, as defined in EPA 2021e and provided below, was followed to interrogate the model results, with some adjustments to consider the fact that the approach is difficult to apply to continuous aquaculture activities (see details below). There are three levels associated with these definitions; zone of high impact (ZoHI), zone of moderate impact (ZoMI) and zone of influence (ZoI):

- Zone of high impact – the area where serious damage to benthic communities is predicted or where impacts are predicted to be irreversible. The term *serious damage* means 'damage to benthic communities and/or their habitats that is effectively irreversible or where any recovery, if possible, would be unlikely to occur for at least 5 years'.
- Zone of moderate impact – the area within which predicted impacts on benthic organisms are sub-lethal, and/or the impacts are recoverable within a period of five years
- Zone of influence – the area within which changes in environmental quality associated with the Proposal are predicted and anticipated during operations, but where these changes would not result in a detectible impact on benthic biota. These areas can be large, but at any point in time impacts are likely to be restricted to a small portion of the ZoI.

These definitions were developed to assess the impacts of capital dredging activities to benthic habitats in WA's northwest, and its application to aquaculture EIA is relatively new (see DHI 2013, BMT Oceanica 2015). The ZoMI in particular is difficult to apply to aquaculture activities, as it requires the impacts within the zone to be 'recoverable' within a defined period of five years. Aquaculture activities however are continuous, apart from intermittent fallowing events where all aquaculture activities within the area cease. As such, only two zones (ZoHI and ZoI) have been applied for this assessment, following feedback and guidance provided by the EPA. This is a conservative measure, whereby areas that would otherwise have been classified within the ZoMI have been included within the ZoHI instead. Actual impacts within the ZoHI would not extend continuously to the whole area (except for where the anchorages of the sea-pens are located) but represent the outer border at which impacts associated with the Proposal to BCH are predicted which may occur at some point during the lifetime of the Proposal.

The thresholds used are summarised in Table 6.4, with further information on potential impacts to the receiving BCH provided below.

Soft sediments – deposition

The cause-effect pathways which impact the condition of soft sediments are the same which have subsequent impacts on infauna communities present within the sediment layer, as detailed in Section 5.4.7. The assessment thresholds used to determine the level of impact the Proposal will have on soft sediments are therefore necessarily similar.

These thresholds have been applied to the entirety of the project footprint, except for areas where coral habitats have been mapped, considering coral habitats are more susceptible to changes in environmental conditions than BCH associated with soft sediments. Though the benthic habitat mapping for the Proposal did indicate the presence of filter feeders (e.g. sponges, whips) in some areas of soft sediment, these were very sparse, non-contiguous, and represented less than 1% of the total area of soft sediments mapped. As such, the soft sediment thresholds have been applied over these areas, rather than applying a secondary set of thresholds for these very limited and isolated areas.

Corals – smothering / shading

Operational aquaculture activities have the potential to impact on corals via smothering and shading effects. Particulate waste material (i.e. uneaten feed and faecal waste) can smother any coral on the benthos, with the coral unable to clear deposited material once a certain threshold has been exceeded. This particulate waste material may also reduce light availability at the benthos, resulting in shading effects. Indirect shading effects from increases in algal biomasses associated with increases in nutrient availability as a result of finfish excretion and the breakdown of uneaten feed are also possible. Finally, the sea-pen infrastructure can directly shade any habitats present underneath or in the immediate vicinity of the sea-pens.

The thresholds for smothering / shading effects used in this assessment are based on those developed within the WAMSI Dredging Science Node and provided in the appendices of EPA 2021e. This particular set of thresholds for corals have been selected based on feedback from the EPA (Notice requiring information for assessment; EPA 2022) and provide a conservative assessment for potential impacts to corals of the Kimberley, noting the thresholds have been developed using data collected from projects based in the offshore Pilbara region. Natural conditions in the offshore Pilbara (and as such the environmental tolerances of the coral species' endemic there) are different to those of the inshore Pilbara and Kimberley region which experience high periods of turbidity associated with tidal fluctuations and riverine inflows during the wet season. The specific thresholds used have been taken from Table A3 (EPA 2021e), considering only a ZoHI is being used to assess impacts of this Proposal. Though the thresholds presented in Table A3 delineate effect areas of likely significant levels of mortality / serious damage, their application to areas of the Kimberley which have corals known to be resilient to these particular cause-effect pathways (i.e. shading, suspended sediment, deposition) is likely more suitable than using more conservative thresholds derived from Table A2 of EPA 2021e.

Assessment of impacts to corals using both smothering and shading thresholds focused on the areas where modelling predicted the fate of particulate waste material from the sea-pens would intersect with mapped coral habitats. However, consideration of potential shading impacts to coral in areas beyond the particulate waste footprints, due to increases in algal biomass and associated reductions in light availability was also given.

Table 6.4 Threshold criteria for model interrogation associated with impacts to BCH

Effect	Relevant BCH	Major impact (ZoHI)		No / low impact (ZoI)	
		Criteria	**Description**		
Smothering[1]	Corals	Sediment deposition exceeds >20 mg cm^{-1} d^{-1} at any time during the modelled period	Changes are detectable in the field and are likely to be related to complete habitat loss. Major impacts are likely to have secondary influences on other ecosystems.	Sediment deposition <20 mg cm^{-1} d^{-1} across modelled period	No impacts expected to occur.
Shading[1]	Corals	DLI <0.1 at any time during the modelled period		DLI >0.1 across modelled period	
Deposition and subsequent changes to oxygen and hydrogen sulphide content	Infauna (soft sediments)	H_2S concentration in the upper 2 cm of sediment exceeds 100 µM L^{-1}.[2]	Where the rate of deposition results in conditions of persistent anoxia, with a corresponding mean reduction in infauna species richness greater than 50%.	Following Hargrave et al. (2008) this category requires that H2S remains below 100 µM L^{-1} Top 5 cm of sediment remain oxygenated	Where the rate of deposition is sufficiently low so as not to contribute material affects to sediment chemistry and/or infauna species richness

Notes:
1. Thresholds based on thresholds provided in Table A3 of EPA (2021b)
2. Based on an adjustment to thresholds developed in Hargrave et al. (2008), to reflect the lack of a ZoMI applied to this Proposal.

Modelled impact assessment

This modelled impact assessment presents a best-case and worst-case scenario (scenarios 1 and 2 as per Section 5.4.3) of the Proposal's operations. Zones of impact presented are based off the extent of effects expected after 5 years of continuous operations for both scenarios, with no fallowing. A single set of zones of impact are presented in Figure 6.3 and Figure 6.4, encapsulating impacts associated with smothering / shading on corals as well as impacts to infauna living within soft sediments.

Smothering / shading

The potential for impacts from smothering / shading was investigated using the hydrodynamic model coupled to the particle transport model. Corals were chosen because they exhibit poor tolerance to sedimentation particularly in conjunction with reductions in light availability (EPA 2021e), thus providing for a conservative assessment. They are also the primary BCH present that may be at risk of loss due to smothering / shading effects.

For smothering, rates of sediment deposition were calculated on a square meter basis over a 12-month period and averaged over a 365-day period. Effects of shading, where they are considered in areas beyond the modelled particulate waste footprint, focused on comparing conditions in the baseline scenario to the modelled scenarios. This is because the majority of the study area is in deep water where light availability is naturally ~1 DLI or less, and coral growth as such is limited to nearshore fringing reefs in waters <10 m deep (BCH reference).

Modelling predicted that small areas of coral at some nearshore fringing reefs would fall within the ZoHI as a result of smothering and/or shading effects associated with particulate waste from the sea-pens, under both scenarios 1 and 2. This occurred at the coral reefs immediately adjacent to the Razor Island, Cecelia Island, Bayliss Islands and Dorothy Island sites (Figure 6.3 and Figure 6.4). No coral were predicted to be impacted from operations at the Edeline Island North and South sites. There was only minor variation between scenarios 1 and 2 for these predictions, noting that the total extent of the particulate waste footprint (and as such the potential to intersect with coral habitats), does not change substantially with different food conversion ratios.

Though reductions in photosynthetic active radiation (PAR; required for photosynthetic organisms to produce energy) of ~2.7% and ~7% were respectively observed immediately under the sea-pens and to a distance of 100 m from the sea-pen perimeter, there were no significant declines in PAR in areas beyond the footprint of particulate waste material which would have the capacity to shade coral to the degree that the thresholds in Table 6.4 would be exceeded (as a result of increases in phytoplankton). The response of phytoplankton to the varying inputs of nitrogen, as simulated across the range of scenarios, is discussed further in Section 5.

Deposition and subsequent changes to oxygen and hydrogen sulphide content

As per the classification (Table 6.4), no areas of moderate impact were modelled noting that recovery of impacts from continuous aquaculture activities is uncertain. Areas expected to receive waste, but not in concentrations great enough to alter the sediment chemistry and subsequently impact infauna communities, were designated zones of influence. Areas classified as ZoI are expected to maintain sediment oxygen and sulphide levels equivalent to unimpacted sites located beyond the influence of aquaculture activities, and subsequently result in no changes to infauna communities. As such, only a ZoHI and a ZoI are indicated in the model results.

Results predicted that the ZoHI (as combined with the ZoMI) extended beyond the boundaries of all sites, except at Edeline Island South. For example, waste material from Dorothy Island is modelled to disperse south-west into a deep-water channel, extending up to ~3 km from the southern border of the site. The ZoHI between Bayliss Island and Bayliss Island Extra is also predicted to be contiguous. All other sites show clear separation between each other, with there being significantly less dispersion of material. This is likely a result of the higher current speeds in the northern part of the Archipelago, which when simulated in the model, imparted a strong influence on particle transport and resuspension–both processes which affected the retention of organic material near the sea-pens. Particles tended to disperse under higher current speeds, but tended to sink, deposit and remain close to the sea-pens under lower current speeds. The ZoI was the largest (in area) and the most dispersed of the impact categories. In the northern area of the Archipelago, the higher current speeds acted to increase the dispersion of organic particles, which in turn increased the area occupied by the ZoI.

Direct comparisons between the scenarios highlights that there is a marked difference in the extent of the ZoHI across all sites between scenarios 1 and 2, suggesting that managing FCRs will have a significant effect on the level of expected impacts to soft sediments and infauna communities. Though the extent of the ZoHI is significant, it should be noted that this is primarily due to the inclusion of the ZoMI within the ZoHI classification. Furthermore, the assessment presented here focuses on predicted impacts after 1-5 years of continuous operations. In reality, Tassal will fallow sites after each production cycle which will reduce inputs of finfish waste and feed material to nil during these periods. As such, this modelled impact assessment is conservative, and the full extent of impacts is likely to be less than that predicted.

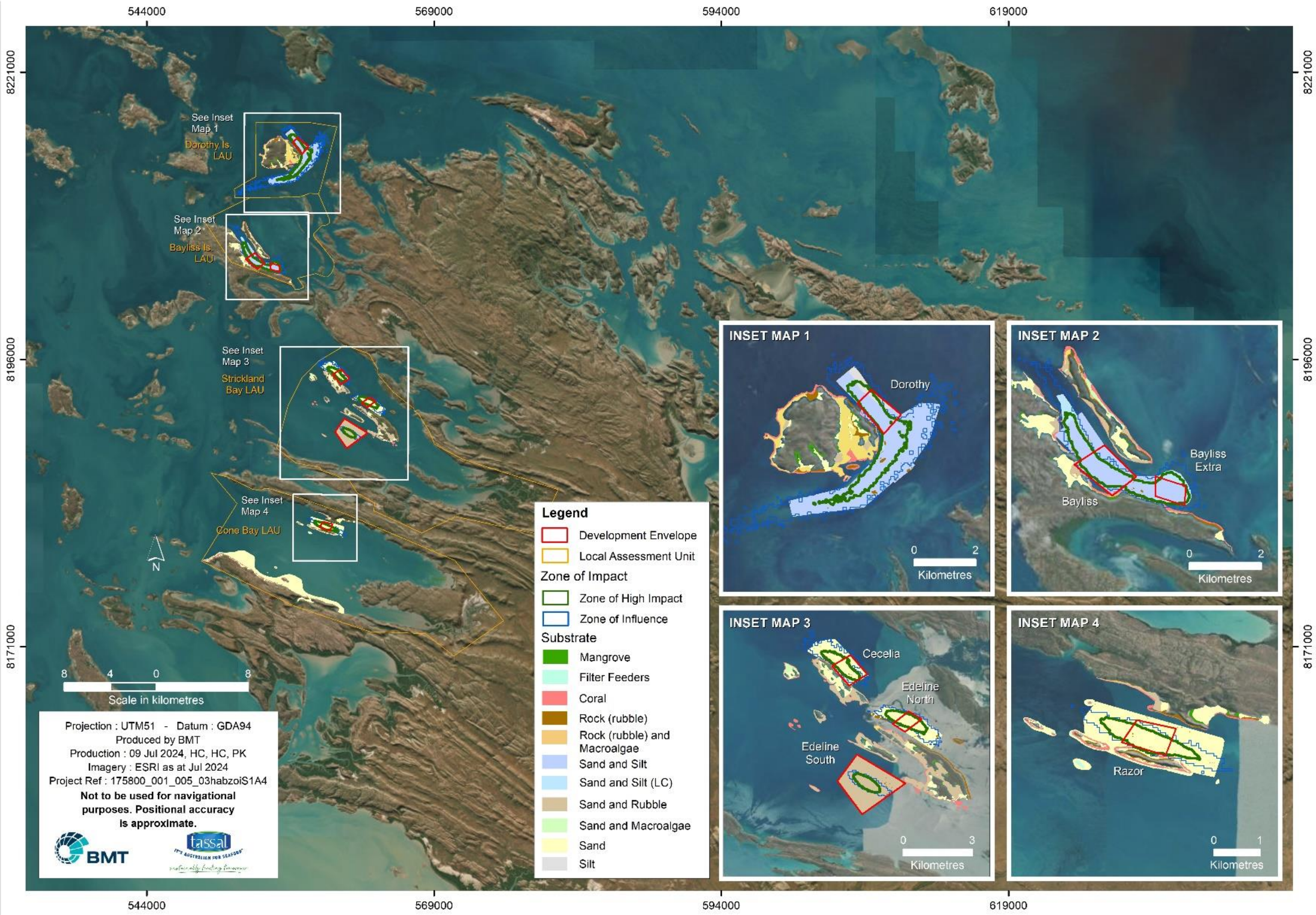


Figure 6.3 Zones of impact after 5 year of operations under scenario 1

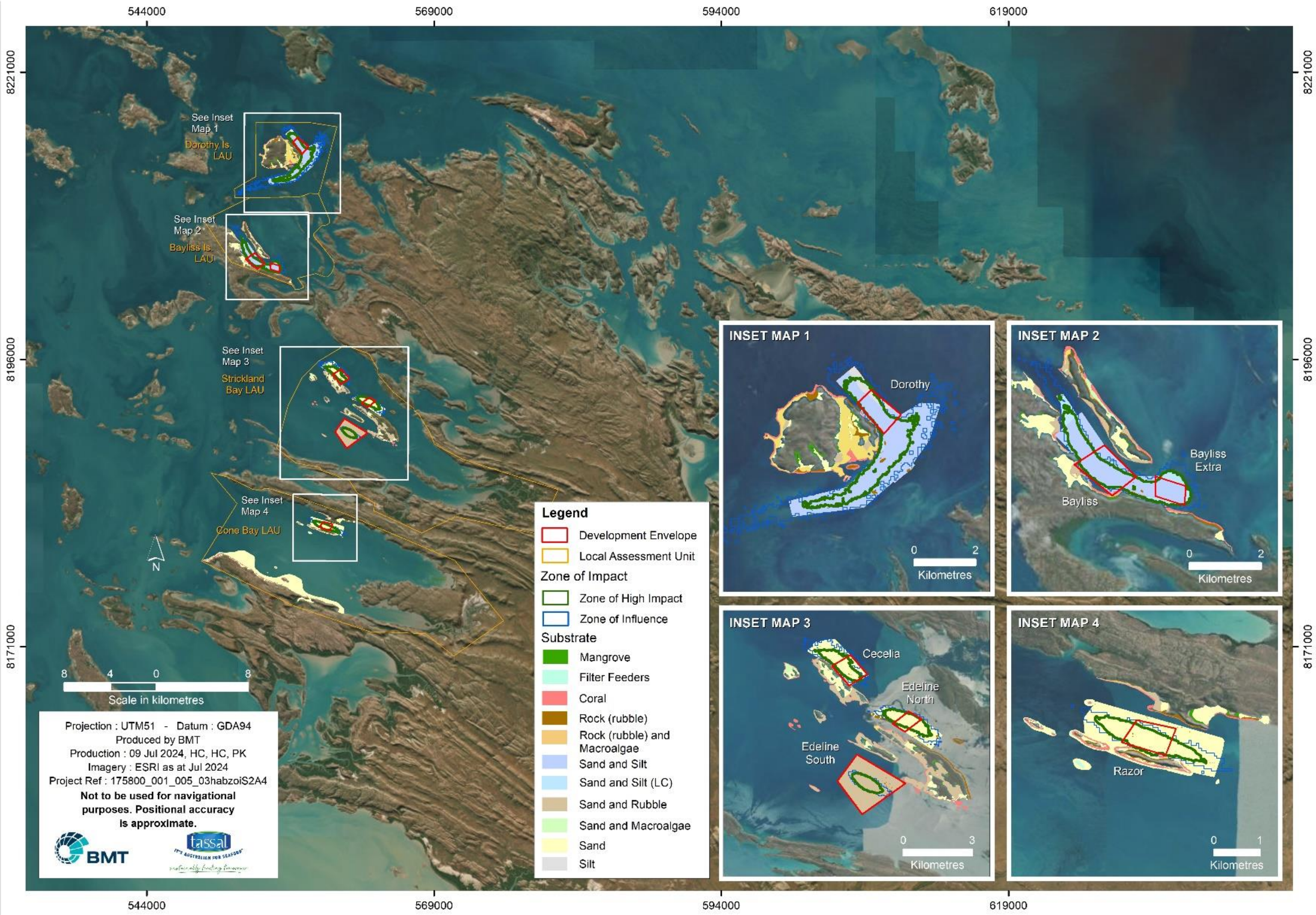


Figure 6.4 Zones of impact after 5 years of operations under scenario 2

Comments on the zone of influence

The spatial extent of the ZoI, and particularly its outer limits of distribution, was driven largely by the dispersion of the smallest faecal fraction (see Section 5.4.3). Particles may travel this distance from the pens through resuspension, but they are unlikely to accumulate in the densities shown in the Figures because the model understates dispersive processes at very low deposition rates.

The model does not simulate every single particle released during operations, as to do so would exceed hardware limits such as memory and disk space. Instead, multiple particles are packaged together in a single discrete unit of 10 kg, which means that the lowest deposition rate that can be resolved is 10 kg/year. This 'package' will have all the physical characteristics of the particles it is representing (e.g. settling velocities, resuspension dynamics, density) but using it greatly reduces computational overhead. At high deposition rates (e.g. in the vicinity of pens), packaging particles in this manner will not change overall model results, but in areas with low deposition rates (e.g. areas at the extent of Dorothy Island) deposition will be overstated if only a few packages are deposited at the same location.

Mapping of benthic habitats has, as such, been conducted across the entire area of the ZoHI as well as the majority of the ZoI. Some areas at the furthest extent of the ZoI have not been mapped, noting the above.

Algal growth potential (DIN)

As discussed in Section Figure 5.12, the model predicts some minor increases in DIN in nearshore areas where fringing reefs are present. An increase in DIN has the potential to allow for increases in macroalgal growth, which may result in harm to coral habitats. Though the modelling did predict there to be some minor elevations, it is not clear as to whether these increases would directly result in the loss of coral habitats, and as such losses associated with algal growth potential have not been calculated directly.

Summary of potential operational impacts

Table 6.5 summarises the potential operational impacts to BCH, prior to the application of mitigation measures.

Table 6.5 Potential impacts to Benthic Communities and Habitats from operation of the sites

Development type	Potential impacts	Impact	Context and assessment	Extent	Duration	Significance of Impacts (prior to the application of mitigation measures)
Leases	Shading (sea-pen infrastructure)	Direct	The sea-pen infrastructure will increase light attenuation at the seafloor directly underneath the pens, resulting in shading effects on any BCH present.	Limited (immediately below the sea-pens)	Lifetime of project	3-Moderate
Leases	Shading (elevated TSS)	Indirect	Wastes from sea-pens may increase TSS in the water column, further increasing light attenuation at the seafloor.	Limited (immediately below the sea-pens)	Lifetime of project	3-Moderate
Leases	Shading (Increase in phytoplankton biomass)	Indirect	An increase in phytoplankton biomass due to elevated nutrient inputs from aquaculture wastes may result in increased shading effects on BCH.	Moderate (phytoplankton biomasses may increase in areas beyond the boundaries of the sites)	Lifetime of project	3-Moderate
Leases	Smothering	Direct	The deposition of aquaculture waste products (finfish feed, faecal wastes) may smother BCH.	Moderate (depositional material may disperse beyond boundaries of the sites)	Lifetime of project, except while sites are fallowed	4-Major

Development type	Potential impacts	Impact	Context and assessment	Extent	Duration	Significance of Impacts (prior to the application of mitigation measures)
Leases	Sediment toxicity (deoxygenation, increases to hydrogen sulphide content)	Indirect	The deposition of aquaculture waste products (finfish feed, faecal wastes) may result in a change to sediment chemistry, including the creation of anoxic zones, potentially impacting BCH present	Moderate (depositional material may disperse beyond boundaries of the sites)	Lifetime of project, except while sites are fallowed	3-Moderate
Leases	Nutrient enrichment (aquaculture wastes – algal growth potential)	Indirect	An increase in nutrient concentrations in the water column may result in a phase shift from coral habitats to macroalgae.	Broad (nutrient enrichment may occur well beyond boundaries of the sites in some areas)	Lifetime of project	3-Moderate

6.4.4 Cumulative impacts

The cumulative direct and indirect impacts of other operations ongoing or proposed in the vicinity of the development envelopes for the sites are summarised in Table 6.6. A search of the Environment Online database for other referred significant proposals, as well as current or ongoing projects, was undertaken to confirm the potential cumulative impacts in the vicinity of the Proposal. As for MEQ, the other relevant projects were limited to the Cockatoo Island Multi-user Supply Base and the Koolan Island Iron Ore Mine. Impacts to BCH from these two projects are limited to the direct footprints in close proximity to both islands, and do not come close to intersecting with the LAU's defined for the Proposal. As such, there is no likely interaction of impacts on BCH from the Proposal and from these two projects. Regionally, BCH is relatively unimpacted from anthropogenic sources across the Archipelago. This is especially the case for BCH in the region of the Proposal, with all industrial activities having taken place on Cockatoo Island or Koolan Island at a substantial distance from the nearest Proposal element (i.e. at least ~9.5 km from Dorothy Island). As such, the Proposal presents the likely first potential impact to BCH from anthropogenic sources in the region and does not present a significant cumulative impact to BCH.

Though not listed as actual proposed projects, the establishment of the Mayala, Lalang-gaddam and Bardi Jawi Garri Marine Parks have the potential to result in a number of positive impacts for BCH in the region, with key benefits listed below:

- Increase targeted research and monitoring on the health and condition of BCH in the marine parks
- Establish guidelines by which BCH and marine environmental quality, which BCH is influenced by, are protected and maintained

Table 6.6 Impacts from other ongoing and proposed operations in vicinity of the development envelope for the sites

Development type	Phase	Approved / Operational / Referred	Potential impacts	Impact	Context and assessment
Cockatoo Island Multi-user Supply Base	Construction / operations	Referred	Waste generation	Indirect	During construction and operations, a number of solid and liquid wastes will be generated, including but not limited to sewage, bilge waters, colling waters, deck drainage, lubricating oils, hydraulic oils and excess concrete and asphalt which if released into the marine environment could affect BCH.
Cockatoo Island Multi-user Supply Base	Construction / operations	Referred	Increase in total suspended solids	Direct	Pile driving required for port activities may remove any BCH present in that area.
Cockatoo Island Multi-user Supply Base	Construction / operations	Referred	Increase in total suspended solids	Indirect	Pile driving required for port activities may increase total suspended solids on a local scale
Koolan Island Iron Ore Mine and Port Facility	Construction / operations	Operational	Removal	Direct	The construction of the seawall and the port facility on the southern part of Koolan Island will / has resulted in the direct loss of 1.3 and 2.3 ha of reef flats respectively.
Koolan Island Iron Ore Mine and Port Facility	Operations	Operational	Toxicity / increase in turbidity	Direct	Sediment runoff from stormwater poses a risk of introducing toxic materials or wastes into the surrounding marine environment if waste dumps, stockpiles, pits and roads are not managed appropriately, which could have toxic effects on BCH.
Pearl leases (managed by DPIRD)	Operations	Operational	Shading	Direct	Pearl farm surface longlines have the potential to cause direct shading effects on any benthic habitats directly beneath the longlines. The small size of the lines and baskets in which the pearls are grown-out mean these effects are negligible

6.4.5 Estimated losses of BCH

The proportion of BCH within the ZoHI (permanent loss has been determined based on EPA (2016f) *Technical Guidance – Protection of Benthic Communities and Habitats*.

The Buccaneer Archipelago has had little to no development since European colonisation. The only historical impacts to BCH to consider were associated with the Koolan Island Iron Ore mine, which constructed a sea wall and port facility (impacting approximately 1.3 and 2.3 hectares of reef flat habitat respectively) (EPA 2005). These impacts however are limited to the southern part of the Island, which is beyond the LAUs of this study. Impacts from the Cockatoo Island User Supply Base were well beyond the LAUs defined for this study. Though aquaculture operations have been operating within Cone Bay under Marine Produce Australia since 2004, there is no evidence of loss of habitats as a result of these operations. As such, with no other significant developments within the LAUs which have affected BCH, it was assumed that there were no historical losses to consider.

Areas of potential habitat loss within the LAUs are all within general purpose zones of the Mayala Marine Park, except for an area of 0.14 km^2 of soft sediment on the south-eastern side of the Edeline Island North site. This 0.14 km^2 within the ZoHI intersects with the Garrooggoorrod Special Purpose Zone (cultural protection), however this is entirely limited to soft sediment areas and no coral habitats within the special purpose zone are predicted to be impacted. No losses to BCH are therefore predicted to intersect with other sanctuary or special purpose zones of the Mayala Marine Park. Therefore, potential small-scale loss as a result of aquaculture operations are not anticipated to result in a significant impact to the ecological values of the Buccaneer Archipelago. This small potential habitat loss is also not expected to result in loss of habitat critical for survival of threatened and migratory marine fauna in the region (Section 7).

To determine the estimated losses of BCH associated with this project, the zone of impact criteria listed for the cause-effect pathways associated with the deposition of material from the sea-pens, and subsequent potential changes to the oxygen and hydrogen sulphide content of the sediments in addition to shading / smothering effects on coral, were used. Shading effects associated with elevations of chlorophyll-a were not considered as under no scenario was this cause-effect pathway predicted to shading effects to result in any losses of BCH.

The calculations are based off the results predicted under scenario 1 and 2 after 5 years production, which reflects the most conservative estimate of impacts for the production scenario most likely to be met in this Proposal.

Though the benthic footprint of the anchorages used in securing the sea-pens and barges would result in impacts to BCH, the ZoHI as predicted by the integrated model completely covers this area, and as such the anchorage footprint was considered within the ZoHI regardless.

Table 6.7 Anticipated cumulative permanent and temporary benthic habitat loss for the Proposal under scenario 1

Benthic habitat type	Area mapped (km^2)	Historical loss (km^2)	Area of permanent loss (ZoHI) (km^2)	Total area impacted (km^2)	Proportion of total mapped, cumulative loss (%)	Proportion of permanent and recoverable Project loss (%)
Cone Bay LAU						
Mangrove	0.03	0.00	0.00	0.00	0	0
Filter Feeders	0.09	0.00	<0.01	<0.01	2.2	2.2
Coral	0.76	0.00	0.01	0.01	1.3	1.3
Rock (Rubble)	0.13	0.00	<0.01	<0.01	<1	<1
Rock (Rubble) and Macroalgae	0.00	0.00	0.00	0.00	0	0
Sand	10.48	0.00	0.68	0.68	NA[1]	NA[1]
Sand and Macroalgae	0.00	0.00	0.00	0.00	0	0
Sand and Rock (Rubble)	0.10	0.00	0.00	0.00	0	0
Sand and Silt	0.00	0.00	0.00	0.00	NA[1]	NA[1]
Seagrass	<0.01	0.00	0.00	0.00	0	0
Silt	0.00	0.00	0.00	0.00	NA[1]	NA[1]
Strickland Bay LAU						
Mangrove	0.09	0.00	0.00	0.00	0	0
Filter Feeders	0.00	0.00	0.00	0.00	0	0
Coral	0.75	0.00	<0.01	<0.01	1.3	1.3
Rock (Rubble)	0.44	0.00	0.02	0.02	4.5	4.5
Rock (Rubble) and Macroalgae	0.03	0.00	0.00	0.00	0	0
Sand	5.19	0.00	1.52	1.52	NA[1]	NA[1]
Sand and Macroalgae	0.13	0.00	0.00	0.00	0	0
Sand and Rock (Rubble)	6.22	0.00	0.46	0.46	7.39	7.39
Sand and silt	0.00	0.00	0.00	0.00	NA[1]	NA[1]
Seagrass	0.00	0.00	0.00	0.00	0	0
Silt	0.00	0.00	0.00	0.00	NA[1]	NA[1]
Bayliss Islands LAU						
Mangrove	0.04	0.00	0.00	0.00	0	0
Filter Feeders	0.00	0.00	0.00	0.00	0	0
Coral	0.50	0.00	0.08	0.08	16	16
Rock (Rubble)	0.21	0.00	<0.01	<0.01	<1	<1
Rock (Rubble) and Macroalgae	0.02	0.00	0.00	0.00	0	0
Sand	1.02	0.00	0.00	0.00	NA[1]	NA[1]

Benthic habitat type	Area mapped (km²)	Historical loss (km²)	Area of permanent loss (ZoHI) (km²)	Total area impacted (km²)	Proportion of total mapped, cumulative loss (%)	Proportion of permanent and recoverable Project loss (%)
Sand and Macroalgae	0.11	0.00	0.00	0.00	0	0
Sand and Rock (Rubble)	0.69	0.00	<0.01	<0.01	<1	<1
Sand and silt	2.79	0.00	1.98	1.98	NA[1]	NA[1]
Seagrass	0.57	0.00	0.00	0.00	0	0
Silt	0.00	0.00	0.00	0.00	NA[1]	NA[1]
Dorothy LAU						
Mangrove	0.15	0.00	0.00	0.00	0	0
Filter Feeders	0.00	0.00	0.00	0.00	0	0
Coral	0.51	0.00	0.03	0.03	5.8	5.8
Rock (Rubble)	0.32	0.00	0.02	0.02	6.3	6.3
Rock (Rubble) and Macroalgae	1.51	0.00	0.00	0.00	0	0
Sand	0.38	0.00	0.00	0.00	NA[1]	NA[1]
Sand and Macroalgae	0.00	0.00	0.00	0.00	0	0
Sand and Rock (Rubble)	0.22	0.00	0.00	0.00	0	0
Sand and silt	6.45	0.00	2.36	2.36	NA[1]	NA[1]
Seagrass	0.00	0.00	0.00	0.00	0	0
Silt	0.41	0.00	0.15	0.15	NA[1]	NA[1]

Notes:
1. Sand or silt are unvegetated habitats, so no BCH are lost

Table 6.8 Anticipated cumulative permanent and temporary benthic habitat loss for the Proposal under scenario 2

Benthic habitat type	Area mapped (km²)	Historical loss (km²)	Area of permanent loss (ZoHI) (km²)	Total area impacted (km²)	Proportion of total mapped, cumulative loss (%)	Proportion of permanent and recoverable Project loss (%)
Cone Bay LAU						
Mangrove	0.03	0.00	0.00	0.00	0	0
Filter Feeders	0.09	0.00	<0.01	<0.01	2.2	2.2
Coral	0.76	0.00	0.01	0.01	1.3	1.3
Rock (Rubble)	0.13	0.00	<0.01	<0.01	<1	<1
Rock (Rubble) and Macroalgae	0.00	0.00	0.00	0.00	0	0
Sand	10.48	0.00	0.79	0.79	NA[1]	NA[1]
Sand and Macroalgae	0.00	0.00	0.00	0.00	0	0
Sand and Rock (Rubble)	0.10	0.00	0.00	0.00	0	0
Sand and Silt	0.00	0.00	0.00	0.00	NA[1]	NA[1]
Seagrass	<0.01	0.00	0.00	0.00	0	0
Silt	0.00	0.00	0.00	0.00	NA[1]	NA[1]
Strickland Bay LAU						
Mangrove	0.09	0.00	0.00	0.00	0	0
Filter Feeders	0.00	0.00	0.00	0.00	0	0
Coral	0.75	0.00	<0.01	<0.01	1.3	1.3
Rock (Rubble)	0.44	0.00	0.03	0.03	6.8	6.8
Rock (Rubble) and Macroalgae	0.03	0.00	0.00	0.00	0	0
Sand	5.19	0.00	2.03	2.03	NA[1]	NA[1]
Sand and Macroalgae	0.13	0.00	0.00	0.00	0	0
Sand and Rock (Rubble)	6.22	0.00	0.59	0.59	9.5	9.5
Sand and silt	0.00	0.00	0.00	0.00	NA[1]	NA[1]
Seagrass	0.00	0.00	0.00	0.00	0	0
Silt	0.00	0.00	0.00	0.00	NA[1]	NA[1]
Bayliss Islands LAU						
Mangrove	0.04	0.00	0.00	0.00	0	0
Filter Feeders	0.00	0.00	0.00	0.00	0	0
Coral	0.50	0.00	0.08	0.08	16	16
Rock (Rubble)	0.21	0.00	<0.01	<0.01	<1	<1
Rock (Rubble) and Macroalgae	0.02	0.00	0.00	0.00	0	0
Sand	1.02	0.00	0.00	0.00	NA[1]	NA[1]

Benthic habitat type	Area mapped (km²)	Historical loss (km²)	Area of permanent loss (ZoHI) (km²)	Total area impacted (km²)	Proportion of total mapped, cumulative loss (%)	Proportion of permanent and recoverable Project loss (%)
Sand and Macroalgae	0.11	0.00	0.00	0.00	0	0
Sand and Rock (Rubble)	0.69	0.00	<0.01	<0.01	<1	<1
Sand and silt	2.79	0.00	2.27	2.27	NA[1]	NA[1]
Seagrass	0.57	0.00	0.00	0.00	0	0
Silt	0.00	0.00	0.00	0.00	NA[1]	NA[1]
Dorothy LAU						
Mangrove	0.15	0.00	0.00	0.00	0	0
Filter Feeders	0.00	0.00	0.00	0.00	0	0
Coral	0.51	0.00	0.03	0.03	5.8	5.8
Rock (Rubble)	0.32	0.00	0.03	0.03	9.4	9.4
Rock (Rubble) and Macroalgae	1.51	0.00	0.00	0.00	0	0
Sand	0.38	0.00	0.00	0.00	NA[1]	NA[1]
Sand and Macroalgae	0.00	0.00	0.00	0.00	0	0
Sand and Rock (Rubble)	0.22	0.00	0.00	0.00	0	0
Sand and silt	6.45	0.00	3.11	3.11	NA[1]	NA[1]
Seagrass	0.00	0.00	0.00	0.00	0	0
Silt	0.41	0.00	0.21	0.21	NA[1]	NA[1]

Notes:
1. Sand or silt are unvegetated habitats, so no BCH are lost

Results of the cumulative loss assessment indicate that there are limited permanent or irrecoverable impacts to vegetated habitats, with most of the zone of impact occurring over unvegetated habitats (sand, silt). The habitat that will potentially be affected the most was coral, where conservative modelling predicted cumulative loss totals of up to 16%, 5.8%, 1.3% and 1.3% in both modelled scenarios within the Bayliss Islands, Dorothy, Strickland Bay and Cone Bay LAUs respectively. However, it is important to note that both the Bayliss Island and Dorothy Island LAUs are relatively small, and the amount of coral habitat within the broader LAU is restricted due to constraints regarding the mapping of the region, as such the overall cumulative % loss potentially exaggerates the effects on this habitat on a regional scale. Furthermore, the mapping of the coral habitats was conservative, including any area of fringing reef regardless of whether that reef contained live or dead coral. The only other vegetated habitat to be impacted were filter feeders, which were only mapped within a very small area within the Cone Bay LAU, with 2.2% predicted to be lost in both modelled scenarios. The comparison between the two scenarios primarily shows that impacts to vegetated habitats are unlikely to differ significantly, with the greatest change between the scenarios shown in the sand / silt habitats.

6.5 Mitigation

Tassal has applied the mitigation hierarchy to the Proposal to protect BCH, and to meet the EPA's environmental quality objective for ecosystem integrity. Management procedures proposed to minimise impacts to BCH from the Proposal are summarised in Table 6.9 and Table 6.10 in accordance with EPA's mitigation hierarchy.

6.5.1 Construction

Appropriate avoidance measures have been taken where possible to limit the impact of the construction of the sites on BCH.

Table 6.9 Mitigation strategies for reducing construction related impacts on BCH from the Proposal following EPA's mitigation hierarchy

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets
Removal	• The placement of the sites have been such that BCH is avoided as much as possible if not completely. The placement of the sea-pens within the sites follows the same avoidance approach	• Tassal will only use low-profile anchors for anchoring their sea-pens/barges, meaning no pile driving or drilling is required to secure them. These anchors are relatively small and reduce the total benthic footprint of the operations.	NA	NA	NA	NA
Shading / smothering	NA	• Anchoring of the sea-pens/barges will be conducted in as short a time span as possible so as to reduce potential for multi-day shading / smothering impacts.	NA	NA	NA	NA

6.5.2 Operation

Appropriate avoidance measures have been taken where possible to limit the impact of the operation of the sites BCH.

Environmental monitoring and management for the operational phase is outlined in the EMMP in Annex A. The plan provides guidance on operational activities and the details in relation to the following:

- Detailed monitoring and management requirements
- Timing/frequency of monitoring and management commitments
- Responsibilities for monitoring and management commitments
- Contingency planning/measures in the event of an environmental or safety issue
- Reporting requirements to government and environmental regulators.

The major impacts on BCH from the Proposal are associated with smothering, particularly on coral habitats. Similar to the maintenance of marine environmental quality, the main mitigation strategy that Tassal can implement is the complete cessation of feeding at any particular site, where nutrients or the condition of the sediments were shown to be exceeding the relevant monitoring criteria (as defined in the EMMP). This immediately reduces the nutrient inputs into the system. Similarly, Tassal has the ability to fallow sites after harvesting, or for longer periods if the production model allows for it with stock spread across six sites, while the seventh can be left to be fallowed for a whole production cycle if necessary. What occurs during this fallowing period is that all stock within the site/sea-pen are harvested, and the sea-pens are left empty for the defined period of time. During this time there are no feed inputs, and no waste material being deposited on the benthos, allowing for sediment and water quality recovery to background condition.

Table 6.10 Mitigation strategies for reducing operation related impacts on BCH from the Proposal following EPA's mitigation hierarchy

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets
Shading (sea-pen infrastructure)	• The placement of the sites have been such that BCH is avoided as much as possible. The placement of the sea-pens within the sites follows the same avoidance approach. As such, the potential for shading effects on BCH is avoided as much as feasible.	NA	NA	NA	NA	NA
Shading (elevated TSS)	• Placement of pen infrastructure in a naturally highly energetic, well mixed environment to assist with dilution • Maintenance of stocking densities, feed inputs and target FCRs to minimise nutrient inputs to the local environment • Use of floating/sinking feed in combination with video	• At the conclusion of each grow-out cycle, the sites will be fallowed for a period of a minimum of 1 month, allowing time for the sediment conditions to recover. • Reduced stocking density (in comparison to current operations in Cone Bay) leading to a reduction in the	Implementation of a EMMP (Annex A), with specific measures including: • If suspended solids levels exceed the respective criteria, then Tassal will instigate an appropriate management action to reduce the effect and restore environmental quality. These	• Suspended solid measurements at fixed distances up and downcurrent of the sea-pen installation and at appropriate reference sites, with at least some of the fixed site positioned at the MEPA/HEPA boundary.		

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets
	surveillance to cease feeding as soon as stock cease eating	concentration of wastes	measures could include the cessation of feeding			
Shading (increased phytoplankton biomass)	• Placement of pen infrastructure in a naturally highly energetic, well mixed environment. • Maintenance of stocking densities, feed inputs and target FCRs to minimise nutrient inputs to the local environment • Use of floating/sinking feed in combination with video surveillance to cease feeding as soon as stock cease eating • Deeper pens will allow Tassal to encourage stock to move to the bottom of the pens if harmful algal are present. Fresh, highly oxygenated water can also be pumped into the	• In the event of a bloom, or if there is a high risk of a bloom occurring due to natural / anthropogenic conditions, Tassal will stop feeding stock, reducing nutrient inputs and minimising the potential for a bloom to occur • Reduced stocking density (in comparison to current operations in Cone Bay) leading to a reduction in the concentration of wastes	Implementation of a EMMP (Annex A), with the following specific strategies: • If chlorophyll-a levels exceed the respective criteria, then Tassal will instigate an appropriate management action to reduce the effect and restore environmental quality. These measures could include the review of feeding and stock biomass loading.	• Nutrient and chlorophyll-a measurements at fixed distances up and down-current of the sea-pen installation and at appropriate reference sites, with at least some of the fixed site positioned at the MEPA/HEPA boundary. • Additional chlorophyll-a sites will be included in nearshore areas where modelling indicated phytoplankton biomasses might increase.	NA	NA

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets
	pens to reduce the opportunities for algae to proliferate					
Smothering	• Placement of pen infrastructure in a naturally highly energetic, well mixed environment to assist with dilution • Maintenance of stocking densities, feed inputs and target FCRs to minimise nutrient inputs to the local environment • Use of floating/sinking feed in combination with video surveillance to cease feeding as soon as stock cease eating	• At the conclusion of each grow-out cycle, the sites will be fallowed for a period of a minimum of 1 month, allowing time for the sediment conditions to recover. • Reduced stocking density (in comparison to current operations in Cone Bay) leading to a reduction in the concentration of wastes	Implementation of a EMMP (Annex A).	• Suspended solids measurements at fixed distances up and downcurrent of the sea-pen installation and at appropriate reference sites, with at least some of the fixed site positioned at the MEPA/HEPA boundary.	NA	NA
Sediment toxicity (deoxygenation and hydrogen sulphide concentrations)	• Maintenance of stocking densities, feed inputs and target FCRs to minimise nutrient inputs to the local environment	• At the conclusion of each grow-out cycle, the sites will be fallowed for a period of a minimum of 1 month, allowing time for the sediment	Implementation of a EMMP (Annex A).	• Videos of sediment condition will be taken to confirm absence of spontaneous outgassing of hydrogen sulphide and/or	NA	NA

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets
	• Use of floating/sinking feed in combination with video surveillance to cease feeding as soon as stock cease eating • Deeper pens will allow Tassal to encourage stock to move to the bottom of the pens if harmful algal are present. Fresh, highly oxygenated water can also be pumped into the pens to ensure any deoxygenation which occurs does not result in direct mortalities of stocked fish	conditions to recover. • Reduced stocking density (in comparison to current operations in Cone Bay) leading to a reduction in the concentration of wastes		observations of bacterial mats (*Beggiatoa* spp.)		
Nutrient enrichment (aquaculture wastes – algal growth potential)	• Placement of pen infrastructure in a naturally highly energetic, well mixed environment to assist with dilution • Maintenance of stocking densities, feed inputs and	• At the conclusion of each 18-month grow-out cycle, the sites will be fallowed for a period of a minimum of 1 month, allowing time for the sediment	Implementation of a EMMP (Annex A) with the following specific strategies: • If nutrient levels exceed the respective criteria, then Tassal will instigate an	• Nutrient measurements at fixed distances up and downcurrent of the sea-pen installation and at appropriate reference sites, with at least	NA	NA

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets
	target FCRs to minimise nutrient inputs to the local environment • Use of floating/sinking feed in combination with video surveillance to cease feeding as soon as stock cease eating	conditions to recover. • Reduced stocking density (in comparison to current operations in Cone Bay) leading to a reduction in the concentration of wastes	appropriate management action to reduce the effect and restore environmental quality. These measures could include the review of feeding and stock biomass loading	some of the fixed site positioned at the MEPA/HEPA boundary.		

6.6 Assessment and significance of residual impacts

The residual impacts of the Proposal are summarised in Table 6.11 where present. The main residual impacts are associated with nutrient enrichment which subsequently enhances algal growth potential as well as potentially changing the condition of soft sediments as a result of the input of organic material. Both of these cause-effect pathways will be monitored under the EMMP, with management actions included to ensure these effects do not become significant, such as the management of feeding activity or the fallowing of particular sites.

Table 6.11 Residual impacts on BCH

Impact	Phase	Assessment	Residual impact
Removal	Construction	As the sea-pens / barge moorings will be sited in a way to avoid BCH, no removal impacts on BCH are predicted.	1-Insignificant
Shading / smothering	Construction	The anchoring of the sea-pens / barges may re-suspend sediments in the immediate vicinity of the anchoring / securing, however any re-suspended materials will be minimal and are expected to settle within a day. The potential for increase in total suspended solids is expected to be kept within the vicinity of the sites, with only minor reduction of light levels in comparison to baseline conditions.	1-Insignificant
Shading (sea-pen infrastructure)	Operations	The placement of the sea-pens within the sites will help reduce potential shading effects on any BCH present. No significant shading effects are expected on BCH in this manner	2-Minor
Shading (elevated TSS)	Operations	The potential for increase in total suspended solids is expected to be kept within the vicinity of the sites, with only minor reduction of light levels in comparison to baseline conditions. No significant shading effects are expected on BCH in this manner.	2-Minor
Shading (increased algal biomass)	Operations	Increased phytoplankton biomasses are expected in nearshore areas of Strickland Bay and Cone Bay in particular, however modelling predicted that this would not result in significant shading effects on any BCH. The extent of these increases is significantly reduced if Tassal achieve an FCR of 1.5. The potential for long-term increases in phytoplankton biomasses (as well as discrete algal bloom events) will be monitored and managed under the EMMP. This includes additional monitoring sites in	2-Minor

Impact	Phase	Assessment	Residual impact
		nearshore areas where modelling results showed that elevated chlorophyll-a values were expected. Tassal's management actions, in the event that elevated phytoplankton biomasses are recorded, will help reduce nutrient loading into the system and reduce the potential for phytoplankton increases. Monitoring of phytoplankton will be particularly important during the wet season when riverine inflows increase nutrient loading in nearshore areas, further exacerbating the risk of algal blooms. Particular management of the timing of feeding etc during these seasons will help further reduce the risk of elevated phytoplankton biomasses and the risk of algal blooms.	
Smothering	Operations	The level of deposition was predicted to impact some coral in the near vicinity to the sites. However, the monitoring prescribed within the EMMP will detect potential changes in indicators of coral health/cover at each site, with actions required to be implemented prior to any actual impacts to coral occurring. Furthermore, the impact assessment is very conservative, and likely overestimates impacts to coral. Tassal also have the opportunity to adjust the location of the sea-pens, such that they are further from the fringing reefs while remaining within the sites, which would significantly reduce the potential for impacts. As such, any potential effects on BCH are only expected directly underneath the pens, and then only if BCH are present in these locations.	2-Minor
Nutrient enrichment (aquaculture wastes) resulting in a phase shift from coral to macroalgae	Operations	The risk of nutrient enrichment from aquaculture wastes will be significantly reduced through the mitigation strategies implemented by Tassal, as well as the direction to achieve an target FCR of 1.5. Any potential for nutrient enrichment long-term will be monitored and managed under the EMMP to verify that Tassal's operations do not pose a continual risk of nutrient enrichment beyond the site boundaries, and potential subsequent effects on BCH (such as a phase shift from coral habitats to macroalgal habitats). This	3-Moderate

Impact	Phase	Assessment	Residual impact
		monitoring includes the monitoring of coral habitats in areas near to the sites which might be impacted by increased nutrient concentrations. Any increases in growth of macroalgae (in comparison to suitable reference sites) will subsequently be recorded and can be responded to, mitigating significant effects from occurring.	
Sediment toxicity (oxygen content and hydrogen sulphide concentrations)	Operations	Modelling results indicated that dissolved oxygen levels, even in close proximity to the sediments, remained relatively consistent between scenarios and between baseline conditions. The results of the sediment diagenesis model indicate that the ZoHI will be for the most part directly underneath the sea-pens, with moderate impacts expected beyond the boundaries of the sites. However, both these zones fall for the most part on soft sediments, including the area of south-east of the Edeline Island North site where an intersection with the Garrooggoorrod Special Purpose Zone (cultural protection) occurs. Long-term impacts associated with this cause-effect pathway will be mitigated through the implementation of regular fallowing post-harvest at each respective site.	3-Moderate

6.7 Predicted outcome

Considering the mitigation strategies implemented by this proposal, and the minimal cumulative impacts from other proposals, only moderate to minor impacts to BCH are expected within the respective LAUs. These moderate to minor changes are for the most part on soft sediments, with less than 0.13 km^2 of coral habitats predicted to fall within the zone of high impact. Many of the contributing factors to the potential impacts on BCH will be monitored under the EMMP, including on coral habitats (Annex A). With this monitoring, and the potential actions to be followed (e.g. management of feeding), it is expected that no material impacts with the potential to compromise the EPA's objective for BCH will occur.

7 Marine fauna

7.1 EPA objective

The EPA objective for the environmental factor marine fauna is to protect marine fauna so that biological diversity and ecological integrity are maintained.

7.2 Policy and guidance

The relevant EPA policies and guidelines for marine fauna and the scope of each of these as relevant to the Proposal are outlined in Table 7.1.

Table 7.1 Policies and guidelines

Policy or guidance	Consideration
Factor Guideline – Marine Fauna (EPA 2016d)	EPA (2016d) provides guidance on marine fauna, including factors which can impact marine fauna. Assessment is based on potential impacts on marine fauna present within the Proposal area, either permanently or as part of their migration (e.g. cetaceans). Specifically, the guideline details the importance of protecting marine fauna for their ecological roles.
Bardi Jawi, Mayala and Lalang-gaddam Marine Park Management Plans	The Bardi Jawi, Mayala and Lalang-gaddam Marine Park Management Plans dictate how marine fauna of conservation significance should be managed within the borders of the marine park. This includes but is not limited to cetaceans, dugongs and other taxa, some of which are also relevant as being listed as Matters of National Environmental Significance under the EPBC Act 1996.
Mayala Country Plan (MIAC 2019)	The Mayala Country Plan sets out the biocultural heritage and relationship Mayala people have with Country. It further dictates Mayala's strategic approach and priorities for Country, including relations with external projects on Mayala Country, such as this Proposal.
Environmental Protection of Biodiversity Act (1996)	The EPBC Act 1996 is the legal act dictating how MNES are managed and protected by the Commonwealth. It has been considered in relation to the species of conservation significance which may interact with this proposal.
Biodiversity Conservation Act (2016)	The Biodiversity Conservation Act (2016) replaces the Wildlife Conservation Act (1950) and provides a statutory basis for the listing of threatened species, specially protected species, threatened ecological communities, critical habitat and key threatening processes, while also providing the legal framework

Policy or guidance	Consideration
	for managing species of conservation significance, which in this case would include marine fauna.
Species specific recovery plans (e.g. marine turtles, seabirds, whale sharks)	Recovery plans are in place for specific species which may interact with this proposal. These management plans outline how these species are to be managed including a description of their biology, ecology as well as a summary of potential threats and how they should be addressed.
Australian National Guidelines for Whale and Dolphin Watching 2017	The Guidelines set out the minimum approach distances for vessels which may interact with cetaceans in Australian waters.

7.3 Receiving environment

7.3.1 Desktop Assessment

Database searches

To assess the potential presence of marine fauna within the vicinity of the proposed sites, a desktop assessment was conducted using government database searches and a review of the scientific literature. Database searches were completed to generate lists of species which were potentially within or in the vicinity of each of the sites, either permanently or as part of their migration, with a focus on species of significance as defined under the EPBC Act and BC Act, as well as the Department of Biodiversity, Conservation and Attractions (DBCA) Priority list. Three databases were searched (Table 7.2). The search parameters used in the DCCEEW Protected Matters Search Tool included the whole of the Buccaneer Archipelago where the sites are present. For the Atlas of Living Australia Search tool, the Archipelago was searched with a 10 km radius.

Table 7.2 Summary of databases for the sites for marine fauna

Database	Authority	Date of Receipt
Atlas of Living Australia	NA	11 June 2024
Dandjoo	Department of Biodiversity, Conservation and Attractions (DBCA 2024a)	11 June 2024
Threatened & Priority Fauna List	Department of Biodiversity, Conservation and Attractions (DBCA 2024b)	11 June 2024
Protected Matters Search Tool (PMST)	Department of Climate Change, Energy, the Environment and Water (DCCEEW 2024)	11 June 2024

The results of the database searches that list the conservation significant marine fauna species, which include marine mammals, marine reptiles, sharks and rays, finfish and marine birds, is provided in Table 7.3. It was also determined if the marine fauna species had a potential critical window of environmental sensitivity, based on the existing state of knowledge, and if there was a likelihood of this occurring within the Proposal area (Table 7.3). Critical windows of environmental sensitivity may include times of the year or particular locations where key species or ecological communities or critical processes (e.g. feeding, breeding, nursing or resting) may be particularly vulnerable to pressures from anthropogenic activities (EPA 2016e).

EPBC Act 1999

The marine waters surrounding the Proposal support a variety of fauna, several of which are significant and protected under the EPBC Act. A search of the online EPBC Act Protected Matters Reporting Tool (Annex G) identified 20 listed threatened marine species and 26 listed migratory marine species that may occur near the Proposal. The listed marine species include: four marine mammals (whales), eight marine reptiles (turtles and seasnakes), one fish and seven shark species. There were also 19 listed marine migratory species (seabirds, sharks, rays, cetaceans, dugong, and crocodiles). Additional marine species listed as possibly occurring within the project area (other matters protected by the EPBC Act) included 25 fish (pipefish and seahorses), 16 reptiles (seasnakes) and five other whales and cetaceans (dolphins).

BC Act 2016

Four marine species potentially occurring in the Proposal area are listed under Schedule 1 – Fauna that are rare or are likely to become extinct as critically endangered fauna (Table 7.3). Five marine species are listed under Schedule 2 (fauna that are rare or are likely to become extinct as endangered fauna) and seven marine species under Schedule 3 (fauna that are rare or are likely to become extinct as vulnerable fauna; Table 7.3). Thirteen marine birds potentially occurring in the Proposal area are listed under Schedule 5 in which migratory birds are protected under an internal agreement (Table 7.3).

DBCA Priority Fauna

A search of the DBCA Dandjoo search tool did not identify any additional species not already identified in the EPBC Act Protected Matters Reporting Tool (Annex H).

Atlas of Living Australia

A search for marine fish species reported a total of 37 species of fish within a 1 km radius of each of the sites.

Likelihood of Occurrence Assessment

The likelihood of occurrence of each species of significance that were identified from the database searches was assessed in relation to the Proposal. The likelihood of conservation significant marine species identified in the database searches occurring at or adjacent to the Proposal area was determined through the assessment of the 1) habitat present in the Proposal area compared to the habitat typically associated with the species; and 2) typical species behaviour (e.g. foraging behaviour, migration, calving, nursing, spawning, roosting and nesting). The results of the assessment are presented in Table 7.3.

Only marine bird species are presented here. No other matters as defined by State and Commonwealth legislation beyond those already covered as conservation significant fauna were assessed as likely to interact with the Proposal area, and as such are not presented in Table 7.3. For the full listing under the EPBC Act and BC Act see Annex G and Annex H.

Table 7.3 Summary of significant or migratory marine fauna listed as possible or likely to occur within the Proposal Area

Scientific Name	Conservation Code (Acts)		Habitat description	Period of habitat use within proposal area	Presence / known use	Likelihood Assessment
	BC	EPBC				Leases
Humpback whale (*Megaptera novaeangliae*)	Conservation Dependent (Schedule 6)	Vulnerable, migratory	Known calving, migration and resting areas in between in Camden Sound, which is approx. 20 kms at its closest to the Proposal. The migratory habitat is primarily coastal water <200 m in depth and within 20 km of the coast (DAWE 2021).	Female-calf pairs and unaccompanied individuals present near to the Proposal area between June-November.	Breeding known to occur near to Proposal area	**Likely**
Blue whale / Pygmy blue whale (*Balaenoptera musculus / musculus brevicauda*)	Endangered (Schedule 2)	Endangered, migratory	Blue whales, principally pygmy blue whales use coastal and offshore waters in the Kimberley. Potentially seasonally present in the Proposal area and adjacent waters	No critical habitat or feedings grounds found within the Proposal area	Species or species habitat known to occur near to Proposal area.	**Possible**
Sei whale (*Balaenoptera boreali*)	Endangered (Schedule 2)	Vulnerable, migratory	Australian Antarctic and temperate cool waters are important feeding grounds (Horwood 1997), while breeding occurs in tropical and subtropical waters (DAWE 2021). Movements and distributions of sei whales are unpredictable and not well documented	No critical habitat or feeding grounds found within the Proposal area	Species or species habitat may occur within area	**Unlikely**

Scientific Name	Conservation Code (Acts)		Habitat description	Period of habitat use within proposal area	Presence / known use	Likelihood Assessment
	BC	EPBC				Leases
Fin whale (*Balaenoptera physalus*)	Endangered (Schedule 2)	Vulnerable, migratory	Fin whales migrate through WA waters, with earliest arrival of the animals recorded on the WA coast, at Cape Leeuwin in April, with some migrating as far north as Dampier (Aulich et al. 2019). Acoustics have been heard off the Rottnest Trench between January and April 2000 (DAWE 2021).	No critical habitat or feeding grounds found within the Proposal area	Species or species habitat likely to occur within area	**Unlikely**
Brydes whale (*Balaenoptera edeni*)	-	Migratory	Found year-round in waters between 40° S and 40° N, primarily in temperatures exceeding 16.3 °C (DAWE 2021).	No critical habitat or feeding grounds found within the Proposal area	Species or species habitat may occur within area	**Unlikely**
Killer Whale, Orca (*Orcinus orca*)	Migratory	Migratory	Considered a regular visitor to State waters in WA and known to follow whale migrations along the West Australian coast.	No critical habitat or feeding grounds found within the Proposal area	Species or species habitat may occur within area	**Unlikely**
Snubfin dolphin (*Orcaella heinsohni*)	Priority 4	Migratory	Rare species which limited data suggests more likely to be found in shallow and protected coastal habitats (water less than 15-20 m deep) and are mainly found	Known population within Cone Bay, Roebuck Bay and Cygnet Bay present all year round.	Species known to occur near to Proposal area	**Likely**

Scientific Name	Conservation Code (Acts)		Habitat description	Period of habitat use within proposal area	Presence / known use	Likelihood Assessment
	BC	EPBC				Leases
			in water less than 20 km from shore (Parra et al., 2006, Parra & Cagnazzi 2016).			
Dugong (*Dugong dugon*)	Other protected fauna	Migratory	Dugongs exhibit seasonal movements as a behavioural thermoregulatory response to winter water temperatures, though scales of movement are individualistic and heterogeneous (Marsh et al. 2011). Most individuals maintain a close association with inshore seagrass beds (Sheppard et al. 2006; Gredzens et al. 2014	Known populations off the Dampier peninsula present all year round.	Species known to occur near to Proposal area	**Likely**
Australian humpback dolphin (*Sousa sahulensis* as *Sousa chinensis*)	Priority 4	Migratory	Rare species which limited data suggests more likely to be found in shallow and protected coastal habitats (water less than 15-20 m deep) and are mainly found in water less than 20 km from shore (Parra et al., 2006, Parra & Cagnazzi 2016).		Species or species habitat likely to occur near to Proposal area.	**Likely**

Scientific Name	Conservation Code (Acts)		Habitat description	Period of habitat use within proposal area	Presence / known use	Likelihood Assessment
	BC	EPBC				Leases
Spotted bottlenose dolphin (*Tursiops aduncus*)	-	Migratory	Restricted to inshore areas such as bays and estuaries, nearshore waters, open coast environments, and shallow offshore waters including coastal areas around oceanic islands (Hale et al. 2000). They have been confirmed to occur in estuarine and coastal waters of eastern, western and northern Australia. Reside in WA waters year-round.	All year round	Species or species habitat likely to occur near to Proposal area.	**Likely**
Short-nosed Seasnake (*Aipysurus apraefrontalis*)	Critically Endangered	Critically Endangered	Typically inhabit reef flats adjacent to living coral and on coral substrates, or shallow waters along the outer reef edge (DAWE 2021, McCosker 1975). The observed range of the Short-nosed seasnake is ~50 m away from the reef flat (Cogger 2000).	All year round	Species or species habitat likely to occur near to Proposal area	**Likely**
Leaf-scaled seasnake (*Aipysurus foliosquama*)	Critically Endangered	Critically Endangered, Migratory	Typically inhabit reef flats adjacent to living coral and on coral substrates, or shallow waters along the	All year round	Species or species habitat may occur near to Proposal area	**Unlikely**

Scientific Name	Conservation Code (Acts)		Habitat description	Period of habitat use within proposal area	Presence / known use	Likelihood Assessment
	BC	EPBC				Leases
			outer reef edge (DAWE 2021, McCosker 1975).			
Horned seasnake (*Acalyptophis pernoii*)	-	Migratory	Typically occur in shallow water up to 20 m (DAWE 2021) on sandy/muddy substrates and are known to inhabit shallow bays, estuaries and tidal pools (DAWE 2021)	All year round	Species or species habitat may occur near to Proposal area	**Unlikely**
Dubois seasnake (*Aipysurus duboisii*)	-	Migratory	Typically occur in shallow water up to 20m, with records of Dubois' seasnakes having been caught in trawling nets at depths of approximately 45 m (Dunson 1975). Typically inhabit reef flats adjacent to living coral and on coral substrates, or shallow waters along the outer reef edge (DAWE 2021, McCosker 1975)	All year round	Species or species habitat may occur near to Proposal area	**Possible**
Spine-tailed seasnake (*Aipysurus eydouxii*)	-	Migratory	Typically occur in shallow water up to 20 m (DAWE 2021) on sandy/muddy substrates and are known to inhabit shallow bays,	All year round	Species or species habitat may occur near to Proposal area	**Unlikely**

Scientific Name	Conservation Code (Acts)		Habitat description	Period of habitat use within proposal area	Presence / known use	Likelihood Assessment
	BC	EPBC				Leases
			estuaries and tidal pools (DAWE 2021)			
Olive seasnake (*Aipysurus foliosquama*)	-	Migratory	Typically occur in shallow water up to 20m, inhabiting reef flats adjacent to living coral and on coral substrates, or shallow waters along the outer reef edge (DAWE 2021, McCosker 1975)	All year round	Species or species habitat may occur near to Proposal area	**Unlikely**
Stokes' seasnake (*Astrotia stokesii*)	-	Migratory	Typically occur in shallow water up to 20m, inhabiting reef flats adjacent to living coral and on coral substrates, or shallow waters along the outer reef edge (DAWE 2021, McCosker 1975)	All year round	Species or species habitat may occur near to Proposal area	**Unlikely**
Loggerhead turtle (*Caretta caretta*)	Endangered	Endangered	Commonly found in coral and rocky reefs, sandy beaches and seagrass habitats, feeding on seagrass, sponges and/or algae (DAWE 2021).	Possible use of habitat for feeding but periods unknown.	Species or species habitat known to occur near to Proposal area	**Likely**
Green turtle (*Chelonia mydas*)	Vulnerable	Vulnerable, Migratory	Commonly found in coral and rocky reefs, sandy beaches and seagrass habitats, feeding on	Documented sightings in the Buccaneer Archipelago. Possible use of habitat for feeding but	Breeding known to occur near to Proposal area	**Likely**

Scientific Name	Conservation Code (Acts)		Habitat description	Period of habitat use within proposal area	Presence / known use	Likelihood Assessment
	BC	EPBC				Leases
			seagrass, sponges and/or algae (DAWE 2021).	periods unknown. Nesting occurs year-round but predominantly November to March in the Kimberley		
Leatherback turtle (*Dermochelys coriacea*)	Vulnerable	Endangered, Migratory	Pelagic feeder found in tropical, subtropical and temperate waters throughout the world. No major nesting has been recorded in Australia although scattered isolated nesting occurs in Queensland (Qld) and the Northern Territory (NT) (DoEE 2017)	Possible use of habitat but periods unknown	Breeding likely to occur near to Proposal area	**Likely**
Hawksbill turtle (*Eretmochelys imbricata*)	Vulnerable	Vulnerable	Commonly found in coral and rocky reefs, sandy beaches and seagrass habitats, feeding on seagrass, sponges and/or algae (DAWE 2021).	Possible use of habitat. Nesting occurs year-round but predominantly October to January in the Kimberley	Breeding likely to occur near to Proposal area	**Likely**
Olive ridley turtle (*Lepidochelys olivacea*)	Endangered	Endangered	Foraging habitat of Olive Ridley turtles tends to occur across a wider range of depths (50-100 m) than for other more coastal nearshore species.	Possible use of habitat but periods unknown.	Congregation or aggregation known to occur near to Proposal area. Records of hatchlings at Camden Sound.	**Likely**

Scientific Name	Conservation Code (Acts)		Habitat description	Period of habitat use within proposal area	Presence / known use	Likelihood Assessment
	BC	EPBC				Leases
Flatback turtle (*Natator depressus*)	Vulnerable	Vulnerable, Migratory	Foraging habitat of Flatback turtles tends to occur across a wider range of depths (100-200 m) than for other more coastal nearshore species.	Possible use of habitat. Nesting occurs year-round but predominantly September to March in the southern Kimberley	Breeding known to occur near to Proposal area	**Likely**
Estuarine or Salt-water crocodile (*Crocodylus porosus*)	Other protected fauna	Migratory	Large crocodilian which may move through project area, though is unlikely to be resident as sites are located away from waterways.	Possible use of habitat but periods unknown	Species or species habitat likely to occur to Proposal area. Previous records of sightings in proximity to the sea-pens at Cone Bay.	**Likely**
Northern river shark (*Glyphis garrickii*)	Priority 1	Endangered	Medium sized requiem shark generally found in tidal rivers or coastal areas including the Buccaneer Archipelago.	Possible use of habitat but periods unknown	Breeding likely to occur near to Proposal area	**Likely**
Dwarf sawfish (*Pristis clavate*)	Priority 1	Vulnerable, Migratory	Small primarily estuarine sawfish, typically inhabit inshore waters, estuaries, tidal mudflats and sometimes the lowest reaches of rivers.	Possible use of habitat but periods unknown	Breeding known to occur near to Proposal area	**Likely**
Freshwater sawfish (*Pristis pristis*)	Priority 3	Vulnerable, Migratory	Large sawfish typically inhabits inshore waters, estuaries, tidal mudflats and sometimes the lowest reaches of rivers, up to a	Possible use of habitat but periods unknown	Species or species habitat known to occur near to Proposal area.	**Likely**

Scientific Name	Conservation Code (Acts)		Habitat description	Period of habitat use within proposal area	Presence / known use	Likelihood Assessment
	BC	EPBC				Leases
			depth of 25 m but mostly <10 m (Fernandez-Carvalho et al. 2014, Stevens et al. 2008)			
Green sawfish (*Pristis zijsron*)	Vulnerable	Vulnerable, Migratory	Large sawfish typically inhabits inshore waters, estuaries, tidal mudflats and sometimes the lowest reaches of rivers.	Possible use of habitat but periods unknown.	Species or species habitat known to occur near to Proposal area.	**Likely**
Whale shark (*Rhincodon typus*)	Other Protected Fauna	Vulnerable, Migratory	Large generally pelagic shark species with known foraging areas in proximity to the Proposal area	Possible use of habitat but periods unknown	Foraging, feeding or related behaviour known to occur near to Proposal area	**Likely**
Scalloped hammerhead shark (*Sphyrna lewini*)		Conservation Dependent	Widely distributed shark with suitable habitat known to occur in proximity to the Proposal area	Possible use of habitat but periods unknown	Species or species habitat likely to occur near to Proposal area.	**Likely**
Reef Manta Ray, Coastal Manta Ray (*Mobula alfredi*)	-	Migratory	Typically persist in tropical and subtropical coastal waters and often form seasonal aggregations close to shore when food is abundant (DAWE 2021)	Possible use of habitat but periods unknown	Species or species habitat known to near to Proposal area.	**Likely**
Giant Manta Ray (*Mobula birostris*)	-	Migratory	Circumglobal species spend the majority of their time offshore at areas where upwellings of	Possible use of habitat but periods unknown	Species or species habitat likely to occur near to Proposal area.	**Unlikely**

Scientific Name	Conservation Code (Acts)		Habitat description	Period of habitat use within proposal area	Presence / known use	Likelihood Assessment
	BC	EPBC				Leases
			nutrient-rich water increase the availability of zooplankton (Luiz et al, 2009).			
Common Noddy (*Anous stolidus*)	-	Migratory	Migratory species known to feed primarily on fish and breed on islands and similar habitats as that found in the Buccaneer Archipelago	Possible use of habitat but periods unknown	Species or species habitat likely to occur near to Proposal area.	**Likely**
Fork-tailed swift (*Apus pacificus*)	-	Migratory	An aerial species which forages high above the tree canopy and rarely lower (Johnstone and Storr 1998). Occurs over a range of habitats including islands, open country, coasts, semi-deserts, urban, forests (Pizzey and Knight 2007).	Possible use of habitat but periods unknown	Species or species habitat likely to occur near to Proposal area.	**Likely**
Streaked shearwater (*Calonectris leucomelas*)	-	Migratory	Widely distributed migratory species present across coastal areas of northern and eastern Australia	Possible use of habitat but periods unknown	Species or species habitat known to occur near to Proposal area.	**Likely**
Lesser frigatebird (*Fregata ariel*)	-	Migratory	The Lesser Frigatebird has a very large range, breeding on small, remote tropical and sub-tropical	Possible use of habitat but periods unknown	Breeding known to occur near to Proposal area	**Likely**

Scientific Name	Conservation Code (Acts)		Habitat description	Period of habitat use within proposal area	Presence / known use	Likelihood Assessment
	BC	EPBC				Leases
			islands, in mangroves or bushes, and even on bare ground.			
Greater frigatebird (*Fregata minor*)	-	Migratory	Narrowly distributed migratory species present in Buccaneer Archipelago	Possible use of habitat but periods unknown	Species or species habitat likely to occur near to Proposal area.	**Likely**
Bridled tern (*Onychoprion anaethetus*)	-	Migratory	Widely distributed medium-sized tern primarily found on offshore islands and coastline like the Buccaneer Archipelago	Possible use of habitat but periods unknown	Breeding known to occur near to Proposal area	**Likely**
Roseate tern (*Sterna douglii*)	-	Migratory	Extremely large global range, mostly occurring on offshore islands and foraging by plunge diving into marine environments.	Possible use of habitat but periods unknown	Breeding known to occur near to Proposal area	**Likely**
Little tern (*Sternula albifrons*)	-	Migratory	Predominantly a coastal species, inhabiting beaches, sheltered inlets, estuaries, lakes, sewage farms, lagoons, river mouths and deltas.	Possible use of habitat but periods unknown	Breeding known to occur near to Proposal area	**Likely**
Red-footed booby (*Sula sula*)	-	Migratory	Widely distributed large marine bird with breeding known to occur in the Buccaneer Archipelago	Possible use of habitat but periods unknown	Breeding known to occur near to Proposal area	**Likely**

Scientific Name	Conservation Code (Acts)		Habitat description	Period of habitat use within proposal area	Presence / known use	Likelihood Assessment
	BC	EPBC				Leases
Osprey (*Pandion cristatus*)	Migratory	Migratory	Associated with waterbodies, particularly coastal areas, mangroves, inshore seas, rivers and estuaries (Simpson and Day 2010).	Possible use of habitat but periods unknown	Foraging behaviour known to occur near to Proposal area	**Likely**

State of knowledge for Conservation Significant Marine Fauna

The likelihood of occurrence assessment determined that the following conservation significant marine species are known to occur or have a high potential to occur in the Proposal area.

- Four cetaceans (Humpback whales, Snubfin dolphins, Humpback dolphins, Spotted Bottlenose dolphins)
- Dugongs
- Eight reptiles (all sea turtle species known to occur in Australia, saltwater crocodiles and short-nosed sea snakes)
- Six sharks (northern river sharks, dwarf sawfish, freshwater sawfish, green sawfish, whale sharks and scalloped hammerhead sharks) and one ray (coastal manta rays)
- Ten seabirds

Cetaceans

A number of marine mammal species are known to occur in the West Kimberley region including humpback whales, pygmy blue and blue whales, false killer and pygmy killer whales, snubfin dolphins and dugong (DBCA 2020a, b, c). Of the four whale species identified in the Proposal area, only the humpback whale is known to commonly occur in the West Kimberley, which is the northern migration destination and calving ground for the largest population of humpback whales in the world (DBCA 2020a, b, c). There is evidence suggesting that pygmy blue whales may be present in the Kimberley, though data is limited, and further studies are required to investigate further (Double et al. 2014). Migrating killer and Bryde's whales are most often seen in relatively deeper waters and in Australia are most commonly seen along the continental slope and shelf areas (Bannister et al 1996).

The three proposed sites north of the Bayliss Islands fall within a biologically important area for Humpback whales (Figure 12.1). This area is listed as a biologically important area as it is used for several reasons by Humpbacks on their annual migration north along the Kimberley Coast, including nursing, calving and resting (DAWE 2022). Humpbacks (in mother and calf pairings) are generally present during the mid-year months (June-August). The reasons as to why humpbacks use this region is because of its warm water and sheltered environment, which makes it an ideal resting place before they return on their southerly migration in the latter parts of the year.

A biologically important area which includes the entirety of the region for the proposed sites is listed for the three inshore dolphin species (Australian snubfin dolphin, Australian humpback dolphin and the spotted bottlenose dolphin) (Figure 12.1). All three species reside in the region year-round, with Yampi Sound being particularly important breeding, calving and foraging grounds for each species due to the high density of prey species within the area (DAWE 2022). The Australian snubfin dolphin is a poorly understood tropical species with a distribution across shallow coastal and estuarine waters of northern Australia. Limited available data on this species suggests that they are discontinuously distributed along the northern coastline in small sub-populations, with limited gene flow between sub-populations and evidence of site fidelity to the near-shore habitats of which they are reliant upon (Brown et al. 2016). A recent study aimed to quantify abundance data for the Australian snubfin dolphin in the Kimberley region for the first time, along with two other inshore dolphin species. The study recorded sightings of Snubfin dolphins at all surveyed sites, including repeated sightings of the same individuals between years at Cone Bay suggesting strong site fidelity to the area (Brown et al. 2016). Previously, estimates of snubfin dolphin population size and structure were limited to accessible areas including Roebuck and Cygnet Bay, although baseline information on the relative importance to snubfin dolphins of several Kimberley region sites (Cygnet Bay, Cone Bay, Prince Regent River) has now been gathered (Brown et al. 2016). The humpback and spotted bottlenose dolphins are also known to use similar areas as the snubfin dolphin within the Buccaneer Archipelago region, with the deep fjord-like passages throughout the northern section of the Buccaneer Archipelago providing ideal habitat for these species. This is because of a high density of prey items which exist within these areas. Key habitats for these species, particularly the spotted bottlenose dolphin, include tidal mangrove systems and fringing coral and sponge reefs inside Talbot Bay (more than 45 km from the nearest site) (DAWE 2022). Of the habitats mapped as part of this assessment, none are known to be key habitats for cetaceans.

Dugongs

Dugongs are widely known to occur within the West Kimberley region and have strong cultural significance for coastal indigenous people of the Kimberley as a traditional food source (DBCA 2020a, b c). Dugongs are known to feed on both above and below-ground seagrass biomass, so their distribution broadly coincides with seagrass (Masini et al 2001, De Longh et al 2003). Dugongs are mainly associated with shallow protected bays and may also be found in offshore waters, though are generally confined to areas up to 20 m depth within the photic zone where seagrass occurs (Grech et al 2011, Marsh et al 2011). A recent study confirmed the presence of a dugong hotspot in south-eastern parts of the Kimberley Marine Park near the Proposal area (Bayliss and Hutton 2017). However, little is known of seasonal movement patterns and important feeding or breeding areas for dugong (Sheppard et al. 2006). Although there is an indigenous cultural understanding of dugong distribution at certain times of the year, there are gaps in knowledge for other times and uncertainty regarding dugong density due to fluctuations in numbers of animals seen and hunted from year to year (Bayliss and Hutton 2017). No significant seagrass meadows were predicted to be impacted by the Proposal (see Section 6).

Reptiles

The coastal and inshore waters of the Kimberley region supports foraging habitats and nesting beaches for four of the five species of marine turtles present in Australia including green, loggerhead, olive ridley, hawksbill and flatback turtles, with indications that breeding of leatherbacks may also occur in the region (DBCA 2020a, b, c). The Kimberley coast presents a large quantitative gap in marine turtle knowledge for Indian Ocean waters. Limited data indicates that Loggerhead, Green and Hawksbill turtles are commonly found in coral and rocky reefs, sandy beaches and seagrass habitats, and feed on seagrass, sponges and/or algae (DAWE 2017). Therefore, foraging sites occur in shallow predictable habitats over a depth range of 10-60 m (Pendoley 2005). The foraging habitat of Flatback and Olive Ridley turtles are assumed to occur across a wider range of depths (50-100 m and 10-200 m, respectively), whereas leatherback turtles are pelagic feeders occurring intermittently throughout the Kimberley region, but more commonly offshore in deeper waters (Whiting et al, 2018). Sea turtles will typically make long reproductive migrations to specific nesting habitats, the Hawksbill turtle migrates up to 2400 km between foraging areas and nesting beaches (Miller et al. 1998). There are no known biologically important areas or areas of critical habitat for marine turtles listed in proximity to the proposed sites, though turtles are observed in the region.

Saltwater crocodiles (*Crocodylus porosus*) are found in Australian coastal waters, estuaries, lakes, inland swamps and marshes (Webb et al. 1987). In WA the species is found in most major river systems of the Kimberley. Distribution and individual behaviour are largely determined by the surrounding temperature. The movement patterns of mature salt-water crocodiles are not well known, but the movements of relocated animals demonstrate their ability to make long distance movements (up to 280 km; Walsh & Whitehead 1993). Saltwater crocodiles have been recorded in proximity to the current operations at Cone Bay (MPA pers, comm).

The Horned, Short-nosed, Dubois', Spine-tailed, Leaf-scaled, Olive and Stokes' seasnakes typically occur in shallow water (up to 20 m; DAWE 2021), with records of the Dubois' seasnake having been caught in trawling nets at depths of approximately 45 m (Dunson 1975). The Horned, Spine-tailed and Stokes' seasnakes are typically found on sandy/muddy substrates and are known to inhabit shallow bays, estuaries, and tidal pools (DAWE 2021). The Short-nosed, Dubois', Leaf-scaled, and Olive seasnake typically inhabit reef flats adjacent to living coral and on coral substrates, or shallow waters along the outer reef edge (DAWE 2021, McCosker 1975). The observed range of the Short-nosed seasnake is ~50 m away from the reef flat (Cogger 2000).

Finfish and sharks

Limited data is available on the life history of Narrow, Dwarf and Green Sawfish, though individuals have historically been recorded in the coastal waters off Broome. Sawfish typically inhabit inshore waters, estuaries, tidal mudflats and sometimes the lowest reaches of rivers. Green Sawfish have been recorded in very shallow water (<1 m) to offshore trawl grounds at depths >70 m, and the Narrow sawfish is found at depths of ~100 m (Stevens et al. 2008). Sawfish can tolerate a wide range of salinity and move between estuarine and marine environments. The Largetooth sawfish have a greater affinity for freshwater habitats than the Narrow, Dwarf and Green Sawfish. Adult Largetooth sawfish are primarily found in estuaries and marine waters to a depth of 25 m but mostly <10 m (Fernandez-Carvalho et al. 2014, Stevens et al. 2008). There are no known biologically important areas for sawfish in relation to the proposed sites, though sawfish are observed in the region.

The Northern River shark inhabits large rivers, estuaries, and coastal bays, all of which are characterized by high turbidity, silty or muddy bottoms, and large tides (Thorburn et al, 2004). Young and juvenile sharks are found in fresh, brackish, and salt water (salinity ranging from 2-36 ppt), whereas adults have only been found in marine environments. The Northern River shark has been reported from King Sound, the Ord River, and Doctors Creek near Derby, WA (Thorburn et al, 2004).

Reef manta rays, giant manta rays and whale sharks inhabit wide ranges. Reef manta rays and whale sharks typically persist in tropical and subtropical coastal waters and often form seasonal aggregations close to shore when food is abundant (DAWE 2021). These aggregations may coincide with fish spawning events and zooplankton blooms. Comparatively, giant manta rays are a Circumglobal species which spend the majority of time offshore. Giant Manta Rays typically migrate with ocean-currents to areas where upwellings of nutrient-rich water increase the availability of zooplankton (Luiz et al, 2009). Giant manta rays are known to aggregate around Ningaloo Reef during autumn and winter.

Seabirds

The little tern nests on coastal ridges, islets, banks or sand-spits, as well as wide or flat beaches; and is known to breed offshore from the Dampier Peninsula. The bridled tern also breeds in the region off the Dampier Peninsula, including as far offshore as the Bonaparte Gulf and Ashmore Reef (Barrett et al. 2003; Blakers et al. 1984; Higgins & Davies 1996; Johnstone & Storr 1998). Though present within the region, there are no known breeding locations for the roseate tern in the region. All three species feed at sea on primarily on fish and crustaceans.

The red-footed booby is the smallest species in the Booby family (Marchant & Higgins 1990), and though widespread globally is not well recorded in the region. The streaked shearwater, lesser and greater frigatebirds and red-footed booby are all known to occur in the region of the Archipelago, generally feeding on fish and cephalopods at sea.

A biologically important area is identified for both the lesser and greater frigatebird for almost the entire Buccaneer Archipelago, which includes all of the proposed sites (Figure 12.3). For the greater frigatebird, this area is identified as it is known that breeding occurs on the offshore islands beyond the extent of the Archipelago at Ashmore Reef (small numbers) and Adele Island (2-300 pairs), so there is potential for moderate usage of the nearshore areas where the sites are proposed. Breeding occurs in May-June and August. For the lesser frigatebird, breeding is known to occur on Ashmore Reef, Long

Reef, Adele Island and Bedout Island in relation to the sites, and Lacepede Islands. Breeding occurs from March to September. Birds are generally resident in the area all year round, particularly within 30 km of the breeding sites, though they do move around the region to different islands for foraging (DAWE 2022).

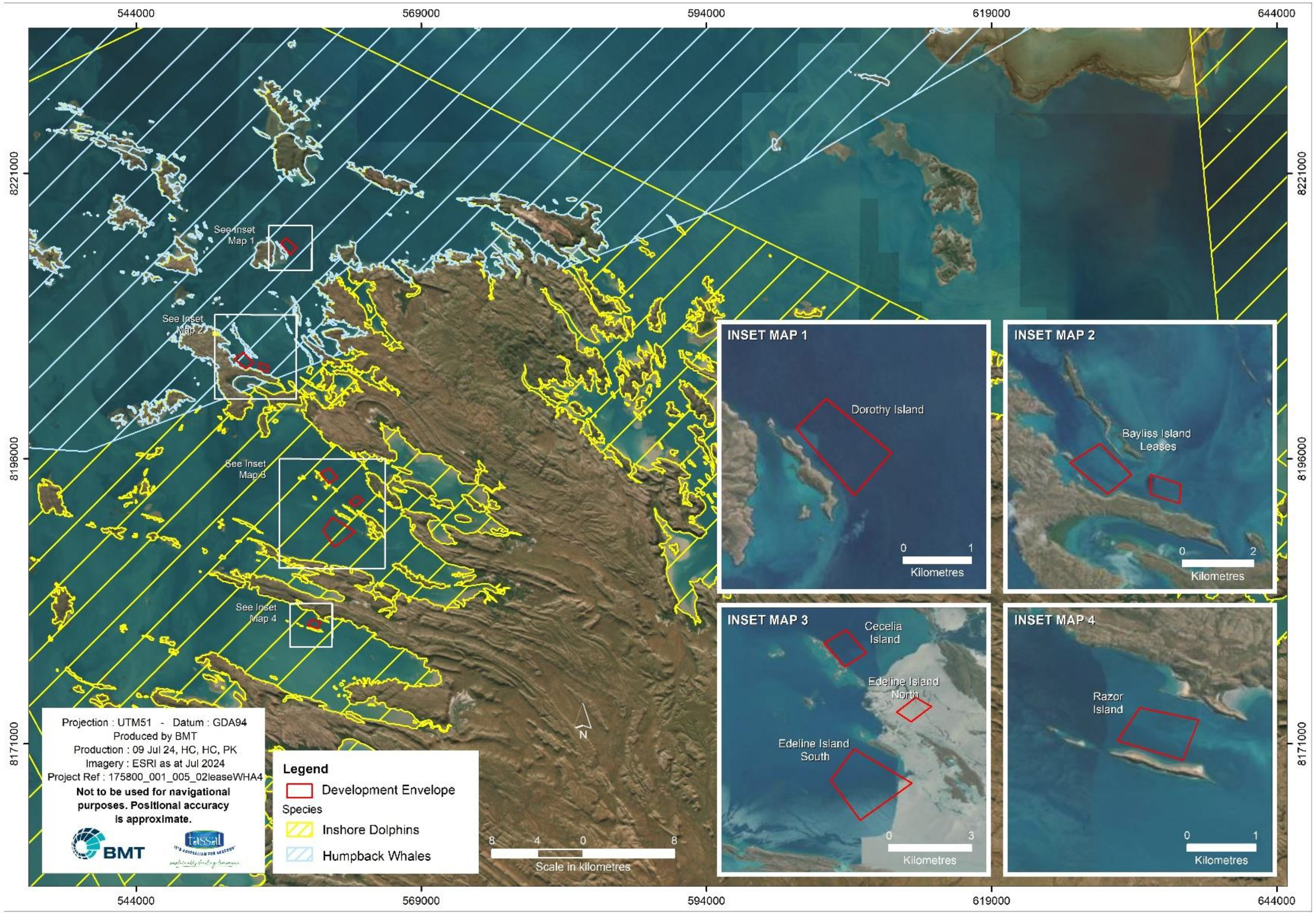


Figure 7.1 Biologically Important Areas for cetaceans in proximity to the proposed sites

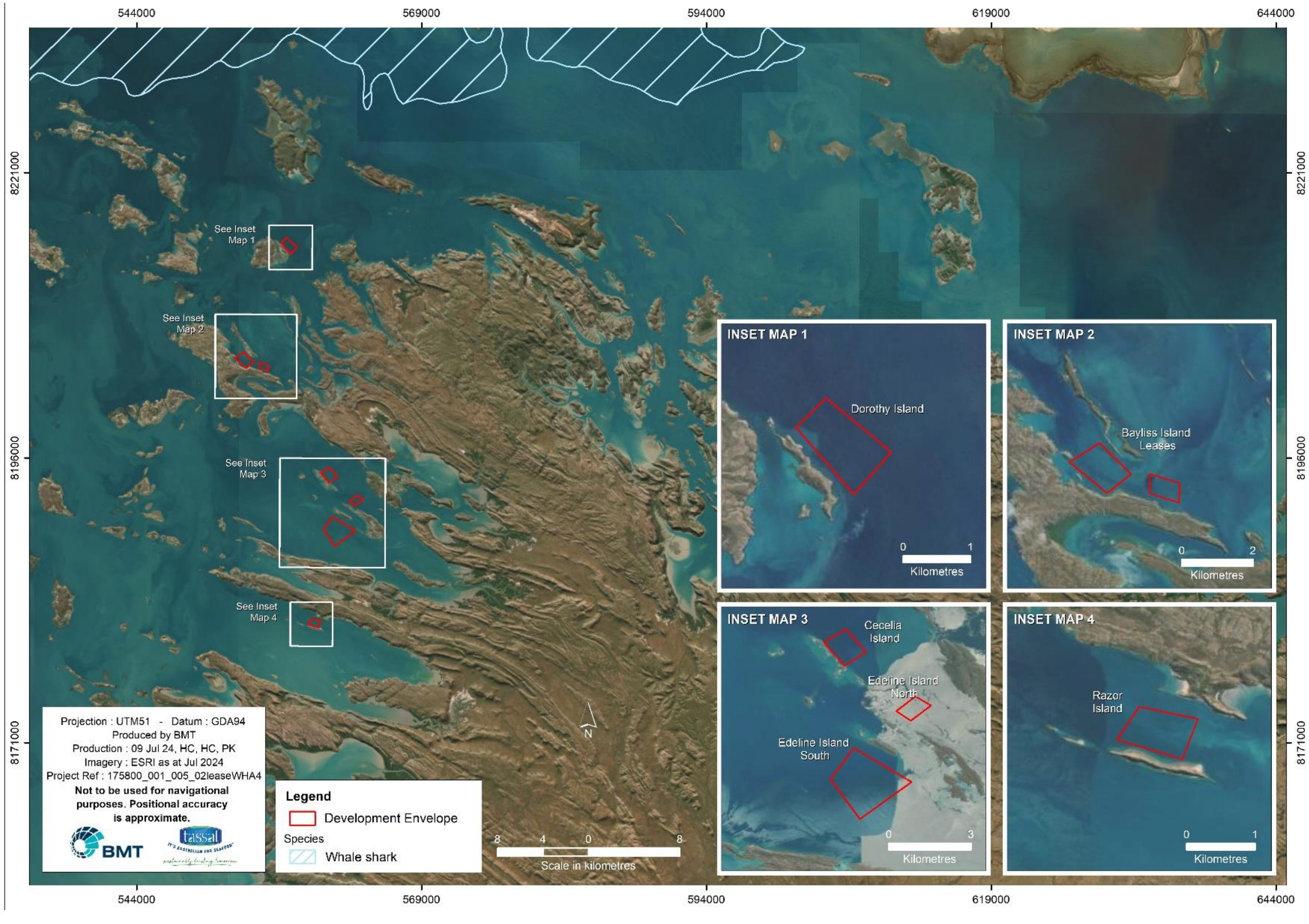


Figure 7.2 Biologically Important Areas for sharks in proximity to the proposed sites

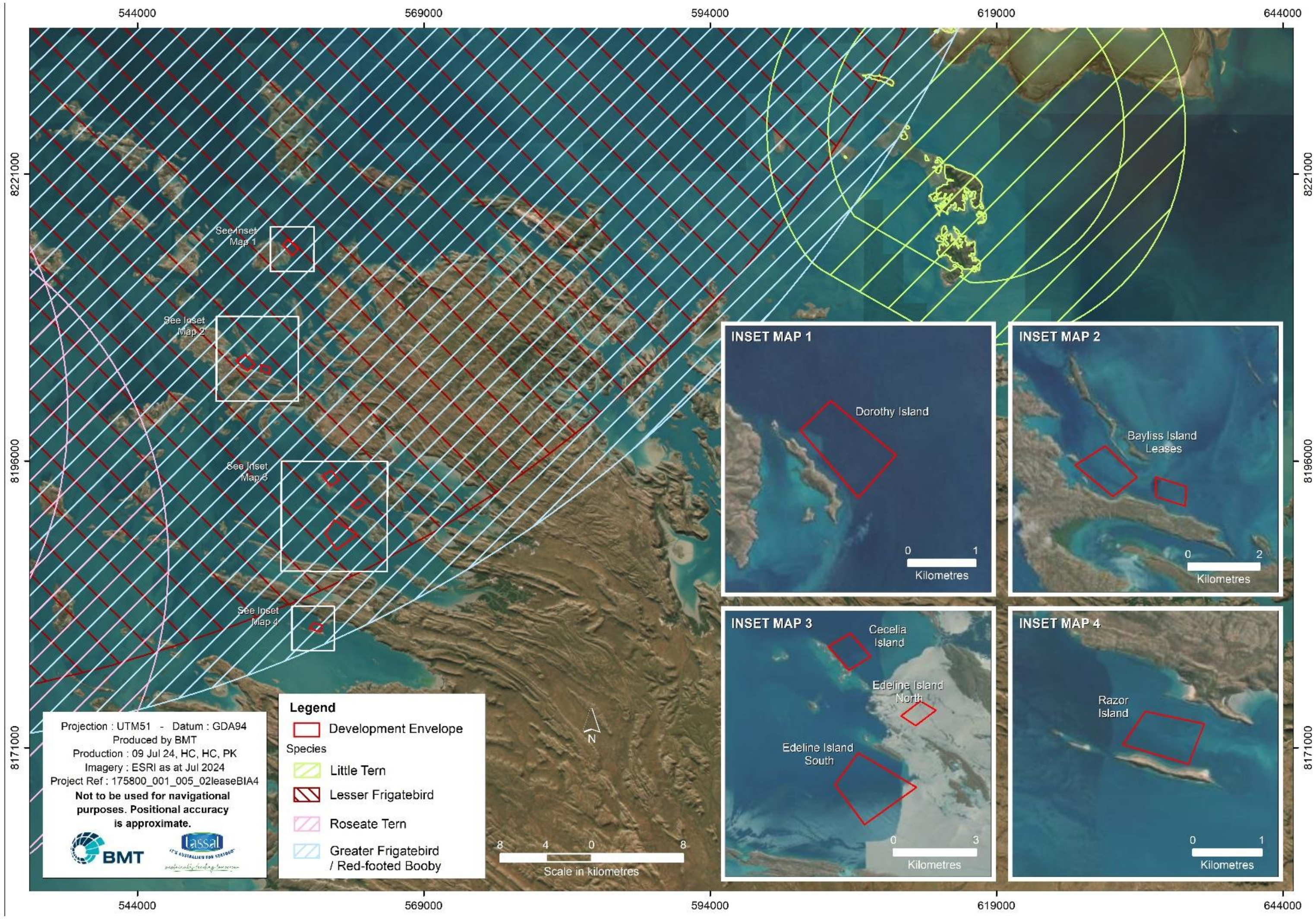


Figure 7.3 Biologically Important Areas for seabirds in proximity to the proposed sites

7.4 Potential impacts

7.4.1 Approach

Potential impacts to marine fauna have been considered for both the construction and operation of the sites. The impact of other operations in the area nearby the proposed sites, including commercial and industrial operations, on marine fauna are also considered to ensure the total cumulative impacts are well understood. Details on potential impacts which are more complex or more likely to have a significant impact are also provided, however where impacts are on MNES, these have been summarised in Section 12 instead.

Impacts have been defined as summarised below:

- Lead to a long-term decrease in the size of a population
- Reduce the area of occupancy of a species
- Fragment an existing population into two or more populations
- Adversely affect habitat critical to the survival of a species
- Disrupt the breeding cycle of a population
- Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
- Result in invasive species that are harmful to a critically endangered / endangered species habitat
- Increase disease that may cause the species to decline
- Interfere with the recovery of a species

The significance of impacts have been classified as follows:

- Major – E.g. leads to a long-term decrease in the size of a population, adversely affect habitat critical to the survival of a species
- Moderate – E.g. Results in loss of habitat for marine fauna at a local scale, though this habitat is not critical to the survival of a species
- Minor – E.g. Introduction of invasive marine species already present in the region, but not considered harmful to a critically endangered / endangered species habitat
- Insignificant – no impacts to marine fauna are expected

Potential construction impacts

The potential construction associated impacts from the construction of the sites are summarised in Table 7.4.

Table 7.4 Potential construction impacts to marine fauna from construction of sites

Development type	Potential impacts	Impact	Context and assessment	Extent	Duration	Significance of Impacts (prior to the application of mitigation measures)
Leases	Vessel strike	Direct	Vessels used during anchoring or towing the sea-pens may potentially strike marine fauna	Limited (impact likely only possible in areas close to site)	NA	3-Moderate
Leases	Noise/vibration generation	Direct	Noise/vibrations generated during anchoring or towing of sea-pens may disturb or repel marine fauna	Limited (close to or within sites)	<1 day at a time during construction	2-Minor
Leases	Plume generation	Indirect	Small plumes may be created when anchorages are driven into seabed	Limited (within sites)	<1 day for anchoring to occur	1-Insignificant
Leases	Increased risk of introduced marine pests	Indirect	Construction vessels may introduce marine pests not present in the area	Limited (within sites)	Throughout construction phase	2-Minor

Potential operation impacts

The potential operation associated impacts from the operation of the sites are summarised in Table 7.5.

Table 7.5 Potential operation impacts to marine fauna from operation of sites

Development type	Potential impacts	Impact	Context and assessment	Extent	Duration	Significance of Impacts (prior to the application of mitigation measures)
Leases	Vessel strike	Direct	Vessels used during operations may potentially strike marine fauna	Limited (within sites)	Lifetime of project	3-Moderate
Leases	Entanglement	Direct	Marine fauna may become entangled in anchorage lines or sea-pens particularly if they are attracted to sea-pens by potential opportunity to feed on farmed fish	Limited (in close proximity to the pens)	Lifetime of project	3-Moderate
Leases	Change to natural predatory behaviour	Direct	Marine fauna, particularly avifauna, may change their natural behaviour if they can access the sea-pens and prey on farmed fish	Limited (in close proximity to pens)	Lifetime of project	2-Minor
Leases	Noise/vibration generation	Indirect	Noise/vibrations generated during operations of vessels, diesel powered generators and other equipment	Limited (within sites)	Lifetime of project	2-Minor

Development type	Potential impacts	Impact	Context and assessment	Extent	Duration	Significance of Impacts (prior to the application of mitigation measures)
			may disturb or repel marine fauna			
Leases	Waste generation	Indirect	Wastes generated (e.g. farmed fish mortalities) may attract marine fauna if not disposed of appropriately	Limited (within sites)	Lifetime of project	2-Minor
Leases	Light pollution	Indirect	Lighting around the sea-pens and vessels may attract/repel marine fauna, or disorientate marine turtle hatchlings	Limited (in close proximity to pens)	<10 hours a day Lifetime of project	2-Minor
Leases	Spread of disease/change to genetic structure of local populations of barramundi if farmed fish escape from pens	Indirect	If fish are able to escape from pens, they may spread diseases not present in the native population or change the genetic structure of the native population if they are given the opportunity to interbreed	Moderate (potential for impact beyond sites)	Beyond lifetime of project	3-Moderate

Development type	Potential impacts	Impact	Context and assessment	Extent	Duration	Significance of Impacts (prior to the application of mitigation measures)
Leases	Increase in nutrients in water column resulting in increased likelihood of algal blooms	Indirect	Increased nutrient loading from fish wastes or feed increases the likelihood of algal blooms, which if they become harmful/toxic may poison marine fauna	Broad (well beyond sites)	During 18-month grow-out cycle, aside from 1-month fallowing period with no impacts. Lifetime of project	3-Moderate
Leases	Deoxygenation of the water column as a result of algal blooms	Indirect	The breakdown of algal material may lead to deoxygenation events in the water column which can result in localised deaths of marine fauna	Broad (well beyond sites)	Lifetime of project	3-Moderate
Leases	Increased risk of introduced marine species	Indirect	Vessels operating at the sites may introduce species as they mobilise from different ports	Limited (within sites)	Lifetime of project	2-Minor
Leases	Minor blocking of channels through which marine fauna migrate through	Indirect	The physical structure of the sea-pens may discourage marine fauna from transiting through	Limited (close proximity to pens)	Lifetime of project	2-Minor

Development type	Potential impacts	Impact	Context and assessment	Extent	Duration	Significance of Impacts (prior to the application of mitigation measures)
			certain channels, particularly at the Bayliss Islands sites			

Vessel strike

The Proposal will result in an increased risk of vessel strike particularly in the vicinity of the sites where the sea-pen infrastructure will be installed. This risk is generally only from the operational vessels that Tassal are proposing to use, each of which is approximately 15-20 m long, as well as other smaller dinghies used in operations at each site. Marine fauna which are likely most at risk of being stricken include cetaceans (particularly inshore dolphin species), dugongs and sea-turtles, considering each spends significant time at the surface to breathe as well as for foraging and other key behaviours. Considering the vessels will however only operate at very slow speeds within the sites (<8 knots), and will only be transiting between nearby sites, the risk of vessel strike occurring is relatively low. Furthermore, all vessels will comply with the Australian National Guidelines for Dolphin and Whale Watching (DoEE 2017) which dictate what the minimum approach distances are for vessel operators.

Entanglement

There is only a minor risk of entanglement of marine fauna with the sea-pen infrastructure (i.e. anchorage lines, sea-pen netting), as to maintain the sea-pens in position the anchorage lines must be very rigid or taut. Few other ropes or lines which might pose a risk of entanglement are present. This as such makes it difficult for any fauna to become entangled in the line. The number of ropes and surface buoys are minimised as much as possible to reduce the risk of entanglement. Furthermore, particular rope gauges, colours and tensions that are more frequently associated with entanglements will be avoided where possible.

In terms of the netting, the mesh size is small enough to ensure that no barramundi are able to escape, and as such this reduces the risk of any marine fauna on the outside from becoming entangled themselves. Netting and lines are inspected regularly by divers, and hence any broken or damaged material will be reported before it has a chance to become severely degraded to the point that it poses a greater risk of entanglement with marine fauna.

The overall risk of entrapment of marine fauna within the sea-pens themselves is very low. As stated, the mesh size is too small to allow for small marine fauna, other than very small (<13 mm girth) fish from moving past the inner nets. The breaking strain of the netting (240 kg inner, 600 kg outer), and the material it is made from further reduces the risk of predators damaging the netting in the process of trying to gain access to the farmed barramundi. Furthermore, with regular net cleaning and maintenance, any damage to the netting will be reported and subsequently dealt with rapidly before it results in significant affects.

Attraction of marine fauna

Natural predators of barramundi and other marine fauna may be attracted to the sea-pens due to effects from farm wastes (such as uneaten feed and faeces) or from fish aggregating device or artificial reef effects, where the sea-pens and associated infrastructure provide shelter to marine fauna. Secondary attraction may then occur whereby predators of those species attracted to the sea-pens in the first place may subsequently be attracted, and so on and so forth. Those fauna attracted to the sea-pens may subsequently suffer from a greater level of predation than that which is naturally present (Papastamatiou et al 2010, Callier et al 2018, Barrett et al 2019). Any incidences of damage to the sea-pens, either from predators or from natural events such as cyclones, may result in fish escapes. Predators may subsequently be more attracted to the sea-pens if these events occur regularly, considering they benefit from the feeding opportunity.

The quantification of these effects is limited within the published scientific literature; however, it is known to have some effect on the way marine fauna interact in these areas and may result in subtle changes to behavioural patterns in areas in close proximity to the sea-pens. For example, mobile predators may show greater site fidelity to areas where sea-pens are present (Arechavala-Lopez et al 2014, 2015a, b; Price et al 2017). As such, the introduction of the sea-pens has the potential to adjust localised behaviour of predatory marine fauna and increase the risk of entanglement or other interactions with sea-pen infrastructure.

Noise/vibration generation

Noise generated by vessels and diesel generators used at the sites for both construction and operations has the potential to result in localised noise pollution, which may impact marine fauna in the region, particularly inshore dolphins which are known to use the area around the proposed sites year-round for breeding, calving and foraging. The operational vessels used for the Proposal will always operate at less than 8 knots within the sites and will only operate at higher speeds when transiting between sites. As such, the intensity of the noise generated by the vessels engines is predicted to be in the order of 130 dB at most (Olesiuk et al 2012). The diesel generators in use at the sites will also create some low-level noise pollution above the surface of the water, likely in the order of ~86 dB (ASHRAE 2002). These noise levels are not predicted to be harmful to marine fauna, however they are likely to be audible. As such, the potential impacts on marine fauna are likely to be centred on short-term behavioural responses (e.g. separation of mother-calf pairings, fleeing from site of disturbance), long-term avoidance (e.g. reduced abundance within or utilisation of noisy areas) and masking of animal sounds (e.g. masking of prey resulting in increase to foraging effort, masking of communication between individuals resulting in decrease in reproductive rates) (Olesiuk et al 2012).

Studies of the effects of whale watching vessels, which are likely comparable to the small vessels used at aquaculture sites, showed the source levels ranged from 145 to 169 dB re: 1uPa @ 1m, slightly higher than that likely to be generated by the vessels used in the Proposal. According to the criteria in Southall et al (2007), noise at these levels could potentially result in moderate behavioural responses in the low-frequency cetaceans at distances of up to 10 km, and up to several kilometres for other functional marine mammal groups (humpback dolphins for example detect sounds in the range of 5-120 kHz which is in the mid to low frequency range, while humpback whales operate at a low frequency between 5-24 kHz; Li and Wang 2017, Whitlow et al 2006). However, the noise levels discussed here are for vessels operating at mid to high speeds, while the vessels in use at the sites will as stated only operate at very low speeds. Though vessels will operate at higher speeds when transiting, these transit times will be relatively short (generally 1 hour max) and will not be required every day of operations.

Previous studies have indicated that noise generated by routine aquaculture operations, which includes the use of diesel generators as well as pumps, pen cleaning with pressure hoses amongst others, is unlikely to be sufficient to cause injury to marine fauna, though it may result in behavioural responses at close range. For example, harbour porpoises at an aquaculture site in the Bay of Fundy were observed to be temporarily displaced by noisy activities such as pen cleaning yet returned quickly (within 10 minutes) to the area when the disturbance ended (Haar et al 2009). Furthermore, a study conducted at the site of the current Cone Bay operations to identify the presence and behaviour of snubfin and humpback dolphins indicated that the behaviour of the individuals present at the site were similar to behaviour of individuals at other sites in the region, and as such there was no suggestion that they were directly impacted by the noise generated by vessels nearby (Brown et al. 2017).

As the construction of the sites for the purposes of securing the sea-pens does not require any pile driving or other significant noise-generating activities, other than that of general vessel operations, it is not expected that the potential for noise pollution is any greater than that already described above.

Light pollution

A minor level of light pollution will be generated at each of the sites, with navigational lighting required on the sea-pens and vessels (flashing LEDs) for safety and navigation; while some lighting will also be present on the centralised barge considering it is the accommodation centre for Tassal staff at the sites. As the lighting required at each of the sites is centred around the barge systems, it is not expected that significant light pollution would be observed beyond the border of the sites.

Light pollution has the potential to change the behaviour of marine fauna, particularly marine turtle hatchlings which may be disorientated or misorientated by artificial light (Kamrowski et al 2012, Thums et al 2016, Wilson et al 2018). No biologically important areas (i.e. nesting sites) for marine turtles have been identified in proximity to any of the sites. It is possible that some turtles do nest on the sandy beaches in proximity to the sites, with these areas potentially not yet identified as survey effort has not been able to encompass the entire Buccaneer Archipelago considering its remoteness. However, due to the nature of the rugged coastline of the Archipelago and its islands, sandy beaches are very rare in proximity to the sites and, if they are present, they are generally less than 100 m in length. As such, considering the low level of light generated by the Proposal, and the lack of significant habitats in proximity to the Proposal, the potential impacts on marine turtles from light pollution are predicted to be non-significant.

Spread of disease / change to genetic structure of local populations

If farmed barramundi are able to escape from the sea-pens, either due to damage to the net from predators or from natural events such as cyclones, there is a risk that they may introduce pathogens in local native populations which are not currently present. This could have a significant impact on native barramundi populations particularly as they will likely have no immunity to the introduced disease or pathogen. There is also a risk that the disease becomes endemic in native barramundi populations beyond the local area if diseased individuals mix with individuals from other regions. The National Biosecurity Plan for Barramundi Farms lists 13 exotic and 33 endemic diseases which barramundi have either been confirmed to be susceptible or are possibly susceptible. These diseases include bacteria, viruses, fungi as well as endo and ectoparasites (Landos et al 2019). Each of these diseases impacts barramundi differently, however they all generally result in mortality of diseased individuals in a matter of days or months from infection. Furthermore, each disease can spread quickly within a particular sea-pen or site once an infected individual is introduced. There is also the risk of transfer between infected sites, which generally occurs if they are within 5 km of each other. For the Proposal, the greatest risks are generally from bacteria, as outbreaks in Australian barramundi farms are usually associated with elevated temperatures during summer or rapid changes in salinity, which is a common occurrence in the Buccaneer Archipelago during the wet season. Other diseases known to be present in Western Australia and are a risk to barramundi include redspot, or epizootic ulcerative syndrome (EUS), which was most likely introduced to the state through the importation of ornamental fish (Makaira 1999).

Escapees from sea-pens may also pose a risk of changing the genetic structure of local populations. Barramundi that are translocated for the purposes of aquaculture are generally genetically different to natural populations as a result of artificial selection. If they escape, these individuals may inter-breed with native populations. Any change to the genetic structure of native populations due to inter-breeding with farmed fish will likely reduce the overall health of native populations in the sense that farmed fish will not know how to respond to predators while adverse genetic mutations which are removed through natural selection are able to prevail in farmed individuals (Makaira 1999).

Chemical therapeutant usage

The usage of chemical therapeutants to medicate farmed fish has the potential for subsequent impacts to other marine fauna. Any marine fauna near to the sea-pens at the time of medication may incidentally consume therapeutant material if it is provided in-feed to the farmed fish or be exposed if the therapeutants are otherwise used. However, the risk of exposure is extremely low, as therapeutants will only be used as a last resort to manage fish health, while any such usage will be limited to the individual cage/s where the fish health has been affected. If exposed / ingested, the risk of harm to marine fauna is low, considering all therapeutants that may be used will have been approved by the Australian Pesticides and Veterinary Medicines Authority, with the requirements that any treatments are non-toxic and therefore not harmful to fauna.

Nutrient enrichment and deoxygenation

The risk of nutrient enrichment to marine fauna is two-fold; firstly, nutrient enrichment can increase the likelihood of algal blooms, which if they become toxic may result in the reduction in health or mortalities of marine fauna. Secondly, the breakdown of algal blooms may lead to deoxygenation in the water column and sediments, which may result in eutrophication and subsequent mortalities to marine fauna. These events can be both localised or broadscale, depending on the extent of nutrient enrichment and the background water quality at the time (i.e. during wet season there is already higher nutrient concentrations in the region due to fluvial inputs, meaning the potential risk/extent of nutrient enrichment is also naturally higher at these times). Fish kills as a result of eutrophication do occur naturally, however the input of extra nutrients from the Proposal does increase the risk of this occurring more often. Though these risks are real, the modelling results predicted that even in areas of enrichment and/or high phytoplankton biomass (and therefore high risks of algal blooms) that no significant anoxia or hypoxia events were predicted to occur. The reason for this is that though the model projects high levels of biological oxygen demand at the sediment water interface, the extent of water movement through the system is such that the level of drawdown is unlikely to be ecological consequence, as oxygen levels are quickly resupplied by new seawater inputs.

Introduced marine species

There is a low-level risk of the introduction of invasive marine species (IMS) as a result of the Proposal, mainly due to vessel movements to the sites from Derby. Most of the known IMS present in Western Australia are temperate species, however some are known to occur in the tropics including the Acorn barnacle (*Megabalanus rosa*) which is found at Cockatoo Island in the north of the Buccaneer Archipelago. Anytime Tassal's vessels are in the port there is a risk IMS may interact with the vessel. However, as Tassal's vessels are generally only in the port for a short space of time (less than 5 days at a time generally) the risk of IMS interacting with the vessels is relatively low. Furthermore, as the vessels are not returning to any other ports as part of normal operations, nor will they transit beyond the Kimberley region, there is little to no risk of IMS from other areas being introduced into the Archipelago by the Proposal.

7.4.2 Cumulative impacts

The cumulative direct and indirect impacts of other operations ongoing or proposed in the vicinity of the development envelopes for the sites are summarised in Table 7.6. A search of the Environment Online database for other referred significant proposals, as well as current or ongoing projects, was undertaken to confirm the potential cumulative impacts in the vicinity of the Proposal. The other relevant projects were limited to the Cockatoo Island Multi-user Supply Base (Koolan Island Iron Ore Mine was assessed as having minimal to nil impacts on marine fauna). Impacts to marine fauna from this project are limited to the near vicinity of the project footprint and are unlikely to have a regional impact across the Archipelago. As such, there is no likely interaction of impacts on marine fauna from the Proposal and from this project. Regionally, marine fauna is relatively unimpacted from anthropogenic sources across the Archipelago. Vessel usage is relatively minimal, being sourced mainly from recreational fishing vessels or tourist vessels, which generally do not intersect with the Proposal’s development envelope. As such, the Proposal presents the likely first potential impact to marine fauna from anthropogenic sources in the region and does not present a significant cumulative impact to marine fauna.

Though not listed as actual proposed projects, the establishment of the Mayala, Lalang-gaddam and Bardi Jawi Gaarra Marine Parks have the potential to result in a number of positive impacts for marine fauna in the region, with key benefits listed below:

- Increase targeted research on the health and condition of marine fauna in the marine parks
- Establish protected areas (sanctuary zones) in which marine fauna cannot be taken

- Establish guidelines by which benthic habitats and marine environmental quality, which marine fauna rely on, are protected

Table 7.6 Impacts from other ongoing and proposed operations in vicinity of the development envelope for the sites

Development type	Phase	Approved / Operational / Referred	Potential impacts	Impact	Context and assessment
Cockatoo Island Multi-user Supply Base	Construction / operations	Referred	Vessel strike	Direct	Vessels used during construction or operations may strike marine fauna
Cockatoo Island Multi-user Supply Base	Construction	Referred	Loss of benthic habitats and communities	Indirect	The clearing of 5.64 ha of bare rock, sand or pebbles and 0.54 ha of hard coral or algae may result in loss of habitat for some marine fauna
Cockatoo Island Multi-user Supply Base	Construction / operations	Referred	Reduction in marine environmental quality	Indirect	A reduction in marine environmental quality with pile driving and waste generation may impact marine fauna
Cockatoo Island Multi-user Supply Base	Construction / operations	Referred	Light pollution	Indirect	Light emitted from the project may attract some marine fauna (fish, zooplankton, birds) while disorientating marine turtle hatchlings
Cockatoo Island Multi-user Supply Base	Construction / operations	Referred	Noise pollution	Direct / Indirect	Noise generated from the project may change fauna behaviour, interfere with communication between fauna or cause physical injury to hearing and other internal organs.
Pearl leases (managed by DPIRD)	Operations	Operational	Vessel strike	Direct	Vessels used during operations in the area may strike marine fauna
Pearl leases (managed by DPIRD)	Operations	Operational	Entanglement	Direct	Marine fauna may become entangled in the pearl lease surface longlines
Pearl leases (managed by DPIRD)	Operations	Operational	Noise pollution	Direct	Vessels operating at the pearl leases will generate low level noise which may change fauna behaviour or interfere with communication between fauna

7.5 Mitigation

Management procedures proposed to minimise impacts to marine fauna from the Proposal are summarised below in accordance with EPA's mitigation hierarchy.

7.5.1 Construction

Appropriate avoidance measures have been taken where possible to limit the impact of the construction of the sites on marine fauna (Table 7.7).

Table 7.7 Mitigation strategies for reducing construction related impacts at the sites following EPA's mitigation hierarchy

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets
Vessel strike	• Vessels will only operate at ~1 knot when towing pens and as such pose no risk to striking marine fauna. At other times, vessels will keep to local speed limits.	NA	NA	• A dedicated marine fauna observer will be appointed while transiting to monitor for marine fauna	NA	NA
Noise/vibration generation	• The mooring system used for these pens will not require any drilling/pile driving reducing potential noise/vibration generation.	• Vessels will operate at low speeds when towing and anchoring pens or less reducing the amount of noise/vibration generation.	NA	NA	NA	NA
Plume generation	NA	• Low-profile anchors used in anchoring sea-pens will likely produce only a very small plume which will not last for more than half a day	NA	NA	NA	NA
Increased risk of introduced marine pests	NA	• Vessels used in construction work will likely be owned by Tassal and only operate in the			NA	NA

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets
		Kimberley region, reducing the likelihood of IMS from other regions being introduced.				

7.5.2 Operation

Appropriate avoidance measures have been taken where possible to limit the impact of the operation of the sites on marine fauna (Table 7.8).

On transit between sites or on other jobs they pose no greater risk than any fishing or tourist vessels which operate in the area.

Table 7.8 Mitigation strategies for reducing operation related impacts at the sites following EPA's mitigation hierarchy

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets (if required)
Vessel strike	• Preferred vessel routes are established and adhered to by skippers to avoid areas of known usage by marine fauna	• Operations vessel speeds limited to less than 8 knots within sites. • Vessels will comply with the minimum approach distances as set out in the Australian National Guidelines for Whale and Dolphin Watching (DoEE 2017) • Vessel activities limited as much as practicable, particularly at night when visibility is reduced • Vessels must avoid making sudden or repeated changes in direction	Implementation of a EMMP (Annex A), with specific measures including: • If vessel strike occurs, then it will be immediately reported to the DBCA Wildcare Helpline, the DBCA Derby Ranger and the Broome DBCA District Office for assistance • An investigation into the cause of the strike will follow, including recommendations for management actions to reduce the risk of these events occurring in future	• A dedicated marine fauna observer will be appointed while transiting to monitor for marine fauna	NA	NA
Entanglement	• Anchorage lines are taut enough such that they would not allow for any marine fauna to become entangled, rather the lines act as a barrier. • Mesh size / netting material is such that marine fauna will not become entangled	• Staff will present permanently meaning if any fauna do become entangled action can be taken immediately to follow the appropriate process in disentangling the fauna	Implementation of a EMMP (Annex A), with specific measures including: • If entanglement occurs, then it will be immediately reported to the DBCA Wildcare Helpline, the DBCA Derby Ranger and the	• An MFO log will be updated after entanglement interactions to provide statistics / recording of animal behaviour to assist in adapting infrastructure to further reduce risks • Daily inspections / audits of netting condition	NA	NA

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets (if required)
	within the netting itself		Broome DBCA District Office for assistance • An investigation into the cause of the entanglement will follow, including recommendations for management actions to reduce the risk of these events occurring in future			
Change to natural predatory behaviour	• Anti-bird nets above the pens prevent access to fish and fish feed from both groups of predators • External nets are designed to have a minimum breaking strain of 600 kg	• Removal of dead fish daily (where possible) and stored in enclosed containers to discourage scavenging • Minimise feed wastage with the following protocols - Minimise feed wastage to less than 2% through the use of high quality and sinking pelletised feeds - All pelletised feeds used must be produced by a manufacturer that complies with AS/NZS ISO 9001:2008 standards (or equivalent);	Implementation of a EMMP (Annex A), with specific measures including: • If an interaction occurs, then it will be immediately reported to the DBCA Wildcare Helpline, the DBCA Derby Ranger and the Broome DBCA District Office for assistance • An investigation into the cause of the entanglement will follow, including recommendations for management actions to reduce the risk of these events occurring in future	• Daily inspections / audits of netting condition	NA	NA

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets (if required)
		contemporary feeding technologies and practices will be used in order to minimise feed wastage to the surrounding environment - Pellet food will primarily be stored on site in bulk feed hoppers and any loose bags of feed will be stored in either the below-deck compartments or on-deck covered by heavy duty PVC tarpaulin or similar - Aquaculture staff and visitors prevented from feeding, touching or swimming with marine fauna within the sites				
Noise/vibration generation	NA	• Unnecessary vessel movements will be kept to a minimum.	NA	NA	NA	NA
Waste generation	• A mortality disposal system will be implemented which ensures dead fish are removed from pens	• Any wastes generated from staff living on site will be taken back to the Derby shore-base and	NA	NA	NA	NA

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets (if required)
	as soon as possible. No mortalities will be disposed of at sea, rather they will be taken back to the Derby shore-base and disposed of appropriately there.	disposed of appropriately there.				
Light pollution	• All work activities (e.g. feeding, harvesting) requiring illumination on site will occur during daylight hours, avoiding the need for significant lighting at night	• Lighting will follow the below protocols - Lighting present will be limited to that required for navigational safety purposes on the buoys that surround the sea-pens. - Avoid the use of bright white lights (e.g. mercury vapour, metal halide, halogen and fluorescent light) on aquaculture gear (orange lights, red lights and low-pressure sodium lights are to be used where practicable. - Light spill to be reduced by shielding lights, pointing lights directly at the work area (directional	NA	NA	NA	NA

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets (if required)
		alignment), reducing the amount of light shining directly onto water and covering windows with tinting or drapes to reduce light emissions from service vessels - Reduce horizon glow through the use of downward-facing luminaries, attention to reflecting surfaces and reducing the intensity of indoor lighting used in vessels without compromising worker safety - Lighting to follow Environmental Assessment Guideline No. 5 (EPA 2010) and National Light Pollution Guidelines for Wildlife including Marine Turtles, Seabirds and Migratory Shorebirds (DoEE 2020)				
Spread of disease/change to genetic structure of local populations of	NA	• Broodstock with the same Australian genetic lineage will be used to reduce the potential for changes in	• The management of barramundi stock on site including the risk of introduction of diseases	• DPIRD's biosecurity group will require testing of all fish stock before they are transferred to the	NA	NA

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets (if required)
barramundi if farmed fish escape from pens		the genetic structure in native barramundi populations. • All juvenile populations will be checked for potential diseases before they are accepted at the BTAP nursery (external to this Proposal) and again before they are transported to the sites as part of DPIRD's regulatory requirements.	is managed under the aquaculture licence that Tassal will receive from DPIRD for each of the proposed sites.	sea-pens to certify they are disease free as detailed in DPIRD's translocation policy for barramundi, including the provision of a Translocation Approval (DOF 2002). Further monitoring as detailed under the National Biosecurity Plan Guidelines for Australian Barramundi Farms will be followed, including; • Visual examination of fish daily • Routine surveillance for parasites • Diver inspection of nets twice weekly • Removal of any mortalities regularly to prevent spread of disease from dead fish		
Increase in nutrients in water column resulting in increased likelihood of algal blooms	See Table 5.25					

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets (if required)
Deoxygenation of the water column because of algal blooms	See Table 5.25					
Increased risk of introduced marine species		• Vessels used in operations will be from within the region reducing the potential for IMS being introduced from other regions.	NA	• DPIRD's biosecurity group will require testing of the vessels used in construction and operations to reduce the risk of IMS introduction	NA	NA

7.6 Assessment and significance of residual impacts

The residual impacts of the Proposal are summarised in Table 7.9 where present. Overall, the Proposal, along with the potential cumulative impacts from other proposals or projects in the vicinity of this proposal, do not pose a significant impact to marine fauna on a regional or local scale.

Table 7.9 Residual impacts on marine fauna

Impact	Phase	Assessment	Residual impact
Vessel strike	Construction / operations	All vessels will be operating at ~1 knot during construction and will keep to local speed limits, meaning there is no greater risk of vessel strike from vessels from the project then there already is from tourist or fishing operations. All vessels will comply with the minimum approach distances as stated in the Australian National Guidelines for Whale and Dolphin Watching, while further measures set out in Annex A will also be complied with.	1-Insignificant
Noise/vibration generation	Construction / operations	All noise and vibration will be kept to a minimum both during construction and operations. However, some noise generation which will be consistent at each site throughout the lifetime of the project will be present, potentially repelling fauna at a minor level	2-Minor
Plume generation	Construction	The level of plume expected from anchoring the sea-pens using the low-profile anchoring system is minimal and will not pose a threat to marine fauna	1-Insignificant
Increased risk of introduced marine pests	Construction / operations	All vessels will be operating only on a local scale reducing the threat of introduction of IMS from other regions. DPIRD biosecurity protocol requirements will help ensure any IMS are detected before they pose a significant risk	2-Minor
Entanglement	Operations	Because of the tautness of the anchoring lines of the sea-pens it is very difficult if not impossible for marine fauna to become entangled, meaning there is little to no risk of entanglement occurring. If any marine fauna do become entangled, then Tassal staff are on site at all times and can report any entanglements to appropriate authorities (i.e. DBCA), therefore allowing for a rapid response and resolution to free the entangled animal.	1-Insignificant
Change to natural predatory behaviour	Operations	With the inclusion of anti-predator nets above and below the surface of the sea	1-Insignificant

Impact	Phase	Assessment	Residual impact
		predators will be unable to enter the pens to feed on fish or fish feed, reducing the potential for changes in predator behaviour. Some secondary impacts on aggregating fish near to the sea-pens due to natural predation may occur.	
Waste generation	Operations	With the inclusion of the mortality waste program and the removal of all wastes from vessels to the Derby shore base there is no waste which will be disposed of at sea, therefore there will be no impact on marine fauna	1-Insignificant
Light pollution	Construction / operations	Anchoring of the sea-pens will only occur during the day reducing the amount of light pollution generated during construction to little or nothing. The amount of light generated once sites are operational will be kept to a minimal level with the mitigation strategies included, therefore there is only a minor level of impact on marine fauna expected.	2-Minor
Spread of disease/change to genetic structure of native populations of barramundi if farmed fish escape from pens	Operations	With the use of an Australian barramundi genetic strain and appropriate fish health checks required under DPIRD regulations there is only a minor risk of fish escapees from the sea-pens causing any spread of disease or change to the genetic structure of the natural population of barramundi. See DOF (2002) for further details on the specific testing requirements that the Proposal will be subject to under DPIRD (previously DOF) regulations.	2-Minor
Increase in nutrients in water column resulting in increased likelihood of algal blooms	Operations	The level of nutrient enrichment from aquaculture wastes is substantial, though it will be significantly reduced through the mitigation strategies implemented by Tassal, particularly the direction to achieve a target FCR of 1.5. Any potential for nutrient enrichment long-term will be monitored and managed under the EMMP to verify that Tassal's operations do not pose a continual risk of nutrient enrichment beyond the site boundaries. Subsequent impacts on marine fauna will as such be reduced.	2-Minor
Deoxygenation of the water column as a result of algal blooms	Operations	Modelling results indicated that dissolved oxygen levels, even in close proximity to the sediments, remained relatively	2-Minor

Impact	Phase	Assessment	Residual impact
		consistent between scenarios and between baseline conditions. Because dissolved oxygen is key to the survival of the stocked fish, it will be monitored on site at all sites every single day, in addition to the monitoring required under the EMMP. As such, any time low oxygen levels are recorded management actions will be immediately implemented to help increase oxygen levels. Subsequent impacts on marine fauna will as such be reduced.	
Minor blocking of channels through which marine fauna migrate through	Operations	The worst potential blockage of channels will occur at Bayliss and Hidden Islands, at which there will still be at least 0.5 km of space between the pens and the shoreline for marine fauna to pass through. This is also not noted as being a major channel for the passage of marine fauna, while there are multiple alternate areas marine fauna could pass through without any more physical effort.	2-Minor

7.7 Predicted outcome

Considering the mitigation strategies implemented by this proposal, and the little to no cumulative impacts from other proposals or projects, no significant harm to marine fauna is expected in the vicinity of the Proposal. As such, it is expected that the EPA's objective for Marine Fauna can be met.

8 Greenhouse Gas Emissions

8.1 EPA objectives

The EPA objective for this environmental factor is to reduce net greenhouse gas (GHG) emissions in order to minimise the risk of environmental harm associated with climate change.

8.2 Policy and guidance

The relevant EPA policies and guidelines for greenhouse gas emissions and the scope of each of these as relevant to the Proposal are outlined in Table 8.1.

Table 8.1 Policies and guidelines

Policy or guidance	Consideration
Factor Guideline – Greenhouse Gas Emissions (EPA 2019)	EPA (2019) provides guidance on greenhouse gas emissions, including factors which can impact the environment associated with climate change. Greenhouse gas emissions are assessed based on certain development activities within the Proposal area, either during construction or ongoing operations. Specifically, the guideline details the threshold criteria for assessing scope 1 emissions of a proposal.
State Greenhouse Gas Emissions Policy for Major Projects (State Emissions Policy)	The State Emissions Policy commits the State Government to working with all sectors of the WA economy to achieve net zero GHG emissions by 2050, through the development of GHG management plans and credible offsets schemes.
Carbon Credits (Carbon Farming Initiative) Act 2011	Australian standard for recognising Australian Carbon Credit Units. The EPA advises that where carbon offsets are to be implemented under a GHG management plan, they should meet offset integrity principles and be based on clear, enforceable and accountable methods based on this standard.

8.3 Receiving environment

8.3.1 Environmental values

The environmental values related to greenhouse gases as applied in EIA are assessed on its potential impact to the environment through climate change.

With little to no major industrial activity, or commercial activity of another kind, there has been as of, yet few emissions created at a local scale.

8.3.2 Overview of studies

BMT conducted a study to determine the level of GHG emissions that are expected to occur through the development of this Proposal and the ongoing operations. An assessment of GHG emissions (annual and total) over the estimated life of the Proposal was provided according to the internationally recognised and accepted standard for companies to use in quantifying and reporting their GHG emissions. The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (World Resources Institute, 2004) Guideline was used to estimate the level of GHG emissions likely to be generated by the Proposal.

8.4 Potential impacts

Using the GHG calculation methodology and emission factor from the National Greenhouse Accounts Factors Workbook (2020), the total GHG emissions has been calculated using the following formulas:

1. For transportation fuel:

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1\,000}$$

Where:

i. Eij is the emissions of gas type (j), carbon dioxide, methane or nitrous oxide, from fuel type (i) (CO2-e tonnes).

ii. Qi is the quantity of fuel type (i) (kilolitres or gigajoules) combusted for transport energy purposes

iii. ECi is the energy content factor of fuel type (i) (gigajoules per kilolitre or per cubic metre) used for transport energy purposes

iv. EFijoxec is the emission factor for each gas type (j) (which includes the effect of an oxidation factor) for fuel type (i) (kilograms CO2-e per gigajoule) used for transport energy purposes

2. For Stationary Energy (non-transport, liquid fuel):

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1\,000}$$

where:

i. Eij is the emissions of gas type (j), (carbon dioxide, methane or nitrous oxide, from fuel type (i) (CO2-e tonnes)

ii. Qi is the quantity of fuel type (i) (kilolitres) combusted for stationary energy purposes

iii. ECi is the energy content factor of fuel type (i) (gigajoules per kilolitre) for stationary energy purposes, according to Table 3.

If Qi is specified in gigajoules, then ECi is 1.

iv. EFijoxec is the emission factor for each gas type (j) (which includes the effect of an oxidation factor) for fuel type (i) (kilograms CO2-e per gigajoule) according to Table 3.

3. For electricity use:

$$Y = Q \times \frac{EF}{1\,000}$$

i. Y is the scope 2 emissions measured in CO2e tonnes

ii. Q is the quantity of electricity purchased (kWH)

iii. EF is the scope 2 emissions factor for Western Australia (kg CO2e per KWH) (i.e. 0.58)

The potential impacts to greenhouse gas emissions generated by the Proposal are associated with construction of the sites, as well as the use of diesel generators at sites during operations. As such, Tassal has estimated the following Scope 1 and Scope 2 emission sources for the Proposal which are largely extrapolated from existing operations in Cone Bay.

Table 8.2 Total estimated fuel and electricity use from the Proposal

Activity	Equipment	Duration (total)	Est Fuel use (KL)	Est. Electricity Use (kWH)
Scope 1				
Construction vessel fuel	1 x 20-30m length vessel		351	-
Operational vessel fuel	7 x 20-30m length vessels 2 x 15-20m length vessels	10 hours per day, 365 days per year	12,410	-
Fuel used for pen operations	7 x 7kVa Generators	24 hours per day, 365 days per year	1022	-
Scope 2 - Nil				
TOTAL			13,783	-

8.5 Mitigation

Management procedures proposed to minimise greenhouse gas emissions from the Proposal are summarised below in accordance with EPA's mitigation hierarchy.

8.5.1 Construction

The likely construction GHG emissions are minor, being associated with vessel fuel use. No suitable emissions reducing mitigation strategies are available for use during construction of the sites.

8.5.2 Operations

Appropriate emissions reduction measures have been taken where possible to limit the impact of the operation of the sites on greenhouse gas emissions. These are summarised in Table 8.3. Tassal will also explore the potential use of alternative energy supply options (i.e. use of alternative fuels or renewable energy) as the project progresses, which will reduce overall greenhouse gas emissions.

Table 8.3 Mitigation strategies for reducing greenhouse gas emissions generated during operations at the sites following EPA's mitigation hierarchy

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets
Emissions generated from diesel generator usage at leases	NA	• Tassal will also explore the use of solar or other alternate power systems to enable off grid operations which will significantly reduce fuel emissions.	NA	NA	NA	NA

8.6 Predicted outcome

The project will not produce Scope 1 emissions that exceed the 100,000t annual limit set by the WA Government. Therefore, the predicted outcome is that the Proposal will not adversely impact the State's ability to achieve net zero GHG emissions by 2050.

9 Social surroundings

9.1 EPA objectives

The EPA's objective for the factor Social Surroundings is to protect social surroundings from significant harm.

9.2 Policy and guidance

The relevant EPA policies and guidelines for social surroundings and the scope of each of these as relevant to the Proposal are outlined in Table 9.1.

Table 9.1 Policies and guidelines

Policy or guidance	Consideration
Factor Guideline – Social surroundings (EPA 2023a)	EPA (2023a) provides guidance on social surroundings, including how it is considered by the EPA. Specifically, the Factor Guideline states "there must be a clear link between a proposal or scheme's impact on the physical or biological surroundings and the subsequent impact on a person's aesthetic, cultural, economic or social surroundings". Examples of social surroundings which may be affected include Aboriginal heritage and culture, natural and historical heritage, amenity and economic values.
Technical Guidance – Environmental impact assessment of Social Surroundings – Aboriginal cultural heritage (EPA 2023b)	EPA (2023b) provides technical guidance on how to conduct environmental impact assessment for Aboriginal cultural heritage as part of the EPA's factor for Social Surroundings, in the context of the amended *Aboriginal Heritage Act 1972*.
Bardi Jawi, Mayala and Lalang-gaddam Marine Park Management Plans	The Bardi Jawi, Mayala and Lalang-gaddam Marine Park Management Plans dictate how areas of significance should be managed, including in terms of social surroundings.
Mayala Country Plan (MIAC 2019)	The Mayala Country Plan sets out the biocultural heritage and relationship Mayala people have with Country. It further dictates Mayala's strategic approach and priorities for Country, including relations with external projects on Mayala Country, such as this Proposal.

9.3 Receiving environment

9.3.1 Population

The proposed sites are located within the West Kimberley, with the major population centres of Broome (population ~14,660) and Derby (~3,009) (ABS 2022). The entire Derby-West Kimberley shire, which includes the Buccaneer Archipelago, has a total population of ~8,443 (ABS 2022). The majority of these are based in Derby or other small communities or stations, not located on the Buccaneer Archipelago. Other towns and communities in the nearby region include Ardyaloon and Beagle Bay on the Dampier Peninsula. Within the Buccaneer Archipelago, there are few populated centres, with access to the area limited primarily to vessel. Road access is virtually non-existent.

Other population centres include the existing mining settlements on Koolan Island and Cockatoo Island, as well as the pearl aquaculture facilities located across the Archipelago.

9.3.2 Native title

The Proposal is located within the traditional Sea and Land Country for the Mayala People and is in proximity to the traditional Sea and Land Country for the Dambimangari People. The Mayala People hold non-exclusive possession of native title rights and interests for the entire area in which the Proposal is located. The Mayala Inninalang Aboriginal Corporation RNTBC (MIAC) is the registered native title body corporate that administers and manages native title land on behalf of the Mayala People (Figure 9.1). As noted, an Indigenous Protected Area has been established with Mayala over the entirety of their Native Title determination area (MIAC 2019).

The Proposal has the potential to impact on existing Native Title Rights and Interests where they have been found to exist for both Mayala and Dambimangari People's. Consultation with Registered Native Title Representative Bodies has been undertaken since the commencement of the Proposal (see Section 3 for details) and continues regarding the management of impacts to Native Title Rights and Interests.

Tassal is committed to minimising the impacts of its operations and maximising opportunity and benefits to Traditional Owners throughout the Proposals lifetime. Tassal is therefore seeking to execute an ILUA where Native Title may be impacted; and working with all Native Title Determination Bodies to develop training, employment and business procurement strategies that will ensure opportunities extends beyond the direct impacts of Native Title.

Tassal has currently executed (or is in the process of) the following documents/agreements with MIAC with respect to the Proposal occurring within Mayala People's traditional Sea and Land Country:

- Deed of Novation of Negotiation Protocol
- Heritage Agreement
- Execution of Heritage Survey
- Indigenous Land Use Agreement (authorised by Native Title holders and submitted for registration with the Native Title Tribunal as of February 2025)

Tassal is engaging further with Dambimangari Aboriginal Corporation (DAC) as well as MIAC and other groups in order to resolve any concerns in the early stages of the Proposal's lifetime.

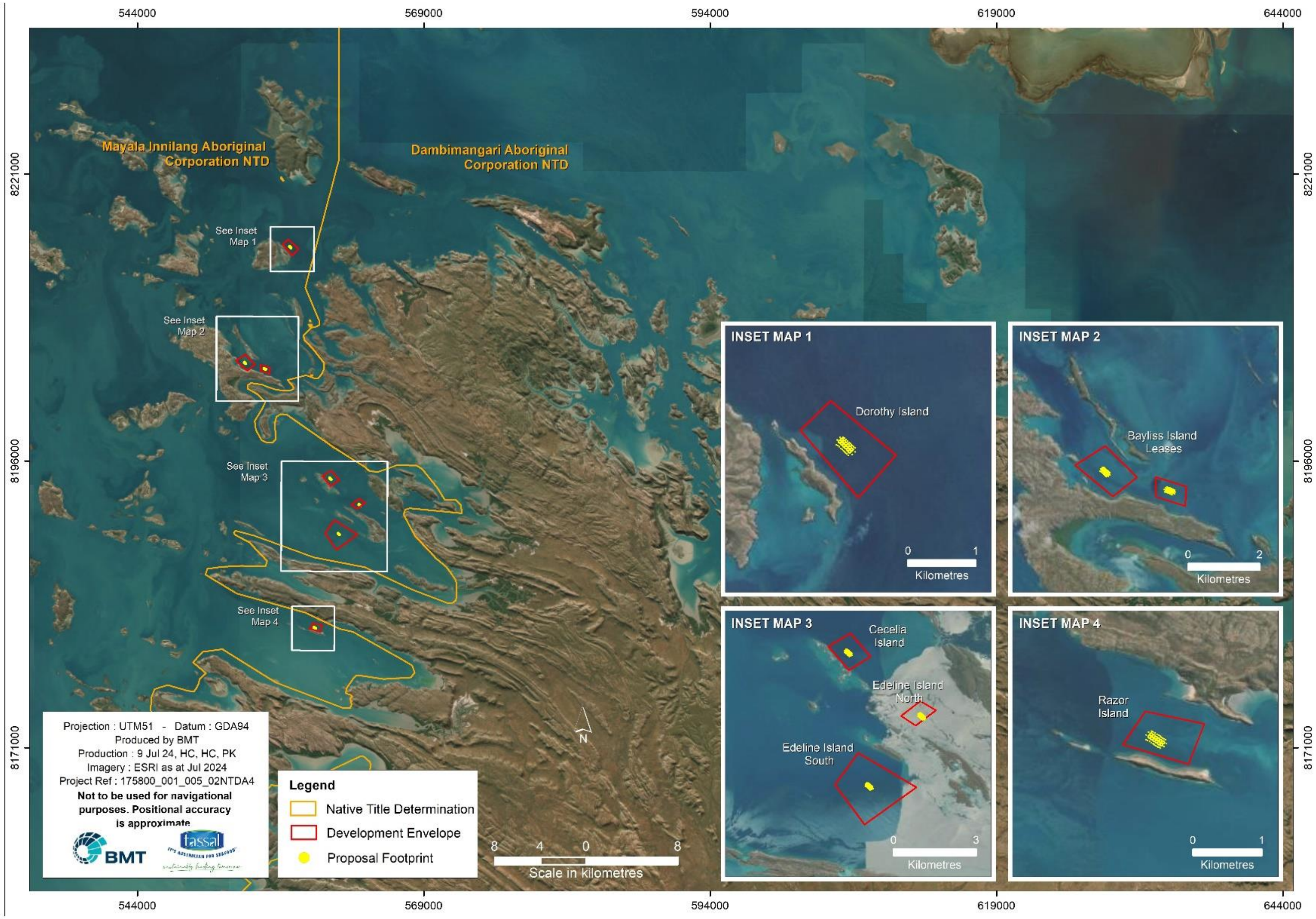


Figure 9.1 Native Title Determinations in the vicinity of the sites

9.3.3 Aboriginal cultural heritage

Aboriginal cultural heritage sites

A desktop search of the Department of Planning, Lands and Heritage (DPLH) Aboriginal Cultural Heritage Inquiry System (ACHIS; 27 May 2024) identified that the sites intersect one known Aboriginal Heritage Value (Table 9.2).

Table 9.2 Aboriginal / Other Heritage Sites within the Development Envelope

Site ID	Name	Type	Status	Relevant part of DE
14676	Strickland Bay	Painting	Registered Site	Razor Island Lease Area Edeline Island South Lease Area

Figure 9.2 shows the known extent of definitively mapped culturally significant sites in proximity to the proposed sites, as well as areas identified as culturally significant in heritage surveys. This Aboriginal site is a painting. As a painting it is located on land on the nearby isthmus. The two proposed sites are not likely to be anywhere near the actual Strickland Bay painting.

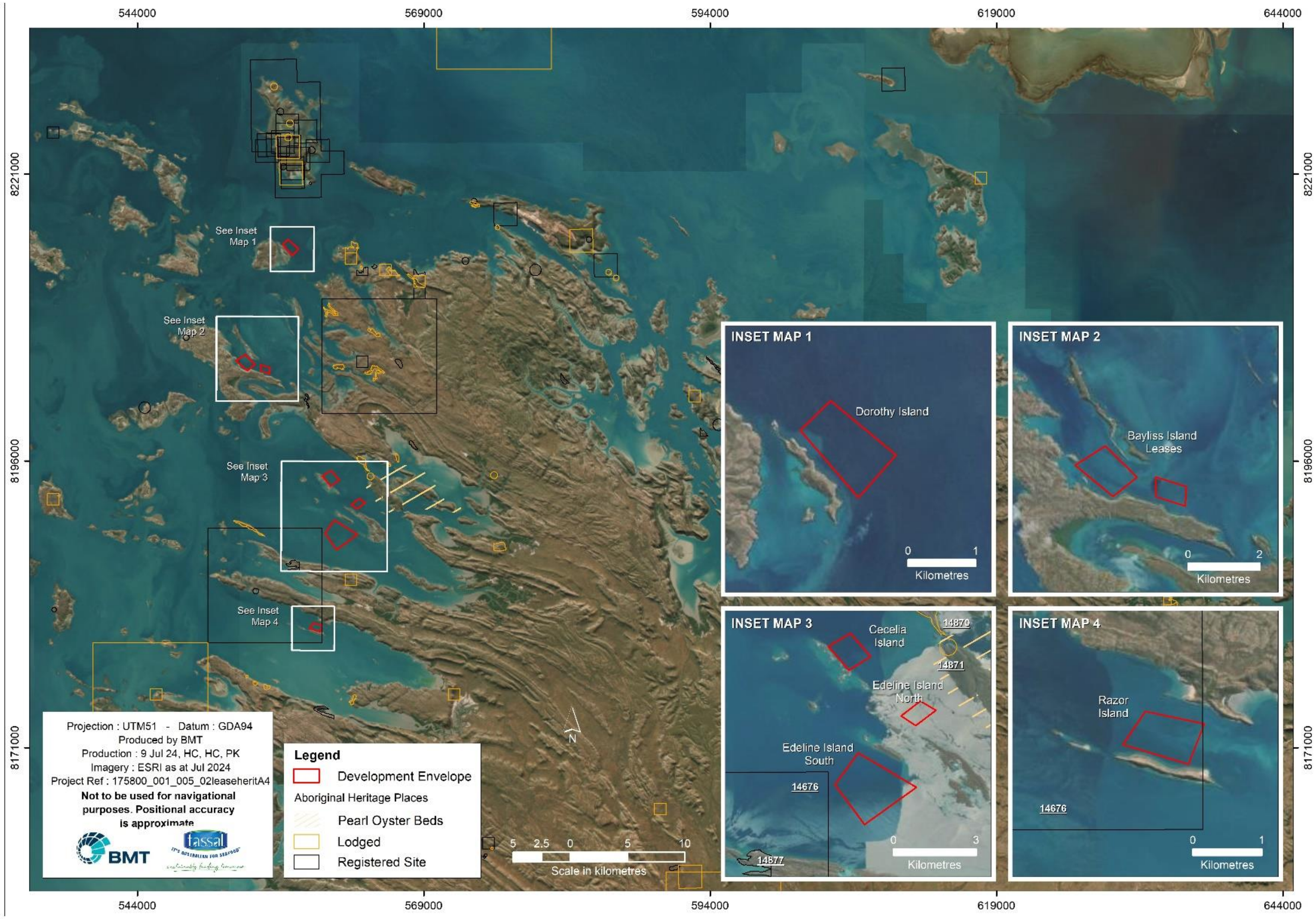


Figure 9.2 Lodged and registered Aboriginal heritage listings in the vicinity of the sites

Aboriginal cultural heritage values

The Traditional Owners of the sea country in which the proposed sites are based are the primary sensitive receptors who may be impacted by the Proposal. In addition, community respite and living sites on Country, such as Silvergull Creek and Coppermine Creek, established by Traditional Owners may also interact with the Proposal. The project spans across numerous different language groups country including Dambimangari and Mayala.

The respective Mayala and Dambimangari Traditional Owners in the region have strong cultural associations with the area surrounding the proposed sites. The peoples of these groups hold deep and spiritual connections to Country where they have practiced their culture for thousands of years. They carry a responsibility to manage and speak for Country on behalf of their ancestors. As such, it is of vital importance that these connections to Country are maintained and enhanced. These connections are listed specifically within the management plans for the marine parks in the region to manage emerging and potential pressures which may impact or harm Country. A summary of these key values for the Mayala People is provided in Table 9.3.

Table 9.3 Summary of key ecological values identified in the Mayala Marine Park Management Plan and/or the Mayala Country Plan

Value	Importance (as derived from DBCA 2022a)
Coral reefs	Most islands in the marine park are surrounded by extensive intertidal *marnany* (reef) platforms, including a diverse array of *marrgoorr* (coral) species. *Marnany* provide food sources such as *niwarda* (small rock oyster), *jarlnggoon* (large rock oyster), *alngir* (trochus), *goowarn* (pearl oyster) pearl shell, *aarli* (fishes) and *goorlil* (sea turtles). Also allow for the collection of useful materials such as *amboorl* (baler shell) and *ngoolnga* (trumpet shell)
Mangrove communities	18 species of mangrove found through Australia, all are found in the Kimberley region, ten of which are only found in the Kimberley. Mayala have sustainably used the wood from particular mangroves to make *biyal-biyals* (mangrove double log rafts, also called *gaalwas*).
Seagrass and macroalgae communities	*Noomool* (seagrass) and *laanyji* (macroalgae) provide energy, nutrients and food for a number of culturally significant fauna, particularly the *odorr* (dugong) and green turtle (*Chelonia mydas*).
Water and sediment quality	High water and sediment quality are essential to the protection of species living within Mayala sea country.
Geomorphology	The coastline is comprised of a large-scale ria (submerged ria valley) coast. Mayala people acknowledge powerful and creative ancestral beings roamed the Country, creating the beaches, islands and reefs. Many beaches in the marine park are important cultural camping areas, holding particular significance to Mayala people.
Subtidal filter-feeders	These communities typically comprise of species from phyla and classes such as Porifera (sponges), Tunicata (sea squirts) and Anthozoa (soft and hard corals and anemones). Generally found in areas with strong water currents and hard underwater surfaces.
Intertidal sand and mudflat communities	Abundance of invertebrate life found on intertidal sand and mudflats provide a food source for *aarli* (fish) and other fauna. Large tidal range creates extensive expanses of intertidal sand and mudflats, some of which are sacred and significant to Mayala people.

Value	Importance (as derived from DBCA 2022a)
Sea-turtles	Six species of *goorlil* (sea-turtles) are likely to occur within the marine park. They are an important food source for Mayala people, who hunt green *goorlil* and harvest green and flatback *goorlil* eggs on nesting beaches throughout Mayala Country.
Fish, including sharks and rays	*Aarli* (fish), *joorroo* (sharks) and *barnamb* (rays) are all of significant importance throughout the marine park, particularly the *loolooloo* (whale sharks) which are referred to as the protector or guardian of the sea.
Dugongs	*Odorr* (dugongs) are of high cultural significance as an important *arli goolil* (meat of the sea). Traditional knowledge informs that *odorr* are fat when the easterly winds blow and arrive during Irralboo season around March/April.
Whales and dolphins	*Miinimbi* (whales) and *bayalbarr* (dolphins) are important seasonal indicators to Mayala people, with the presence of the *miniimbi* during *lalin* (hot weather time) telling Mayala to get ready for *married* (mating) *goorlil* (turtle) time.
Estuarine crocodiles	*Linygurra* (estuarine crocodiles) are found throughout Mayala sea country.
Sea and shore birds	*Garrabal* (birds) are found throughout the islands and mainland of Mayala sea country, with the islands of particular importance for maintain populations which are threatened on the mainland due to human pressures and feral predators.
Invertebrates	Invertebrates that are particularly valued by Mayala people include g*arrangg* (mud crabs), rock oysters and *alngir* (*Trochus niloticus*). Mayala collect *alngir* from inter-tidal reef platforms by hand at low tide. Currently, Mayala together with Bardi Jawi Traditional Owners still collect trochus and commercially harvest it for sale both locally and overseas.

Heritage surveys

A heritage survey on Mayala country was conducted by Tassal and MIAC in April 2024 to determine the heritage values associated with the areas near to the proposed sites, as well as report on whether the Proposal was likely to have a significant impact on these values. A brief summary of the heritage survey report is provided here. This heritage survey identified the following key values that are directly relevant to the Proposal:

- Pearl oyster beds along the coast of Aveling Island in Strickland Bay (Figure 9.2)
- Shorelines of islands and mainland in vicinity of the sites throughout Mayala sea country
- Culturally important species as follows, noting that ultimately all marine species have cultural significance:
  - Dugong
  - Sea turtles (multiple sp.)
  - Whales (multiple sp.)
  - Pearl shells
  - Baler shells (multiple sp.)
  - Oysters (multiple sp.)

- Crabs (multiple sp.)
- Cypress pine (*Callitris columellaris*)
- *Jalgir* (*Canarium australianum*)
- *Madoor* / gubinge trees (*Terminalia ferdinandiana*)

- Aesthetic values of Mayala sea country

Key findings of the heritage survey can be summarised as follows:

- No impacts to existing ACH places (including registered, lodged and historical places) listed on the Department of Planning, Land and Heritage (DPLH) Aboriginal Cultural Heritage Inquiry System (ACHIS; as of 27/05/2024) are expected from the Proposal
- Concern around the potential for impacts to pearl oyster shell beds (and other culturally associated marine species) along the southern coast of Aveling Island from particulate feed waste from the proposed sites at Cecelia Island and Edeline Island North
- Concern for potential impacts to shorelines of the mainland and islands that are in close proximity to the sites from particulate feed waste or changes in marine environmental quality
- Potential for impacts to the aesthetic value of Mayala sea country, particularly the service barges which are to be in place adjacent to the sea-pens within each site
- Potential for impacts to access to Mayala land and sea, with an acknowledgement that most of the proposed sites are either in areas rarely visited or the proposed sites would be a negligible restriction on sea country
- Request to re-route proposed vessel corridor between Edeline Island South and Edeline Island North sites to avoid the Mayala Marine Park Gaarroogoorrood Special Purpose Zone (cultural protection), with the revised route shown in Figure 9.3.
- Potential overarching concerns of the proposal to Mayala land and sea country were as follows:
  - Contamination from feed and fish waste materials
  - Sea-pens may disturb the ecological balance near the pens by luring in other species of fish
  - Cyclonic weather events may damage aquaculture infrastructure and subsequently the environment (i.e fish escapes)
  - More activities on Mayala country will have a cumulative impact and that any potential damage to Mayala land and sea country is long lasting
- Potential concerns associated with the management of any environmental impacts on land and sea country as follows
  - How Tassal manages any environmental impacts on Mayala land and sea country such as those from service barges and feed waste from sea-pens

- Further, whether the requisite monitoring of potential impacts to ecological surrounds as requested by the ACH survey team will be undertaken

- Whether Tassal will be respectful of Mayala people and culture with the following to be a requirement of operations

    - Ensuring Tassal staff and contractors undergo cultural awareness training to facilitate cultural competency of its workers

- Findings:

    - That Tassal workers or contractors going ashore on land or islands within the Mayala Native Title Determination Area is cleared with conditions, being that the purpose is for aquaculture activities-related purposes

    - That monitoring to determine the health of reefs, shorelines proximate to the seven proposed aquaculture sites and the identified pearl shell beds near Aveling Island will need to be undertaken annually (see Annex A for details on the monitoring plan)

    - That the proposed sites and vessel routes are all cleared with conditions, being the two findings listed above

As such, the extent to which the AH Act 1972 would apply to the Proposal is limited, noting the Act only applies to direct impacts to existing places of significance. Therefore, the impact assessment conducted here focuses on impacts to ACH not considered by the AH Act 1972.

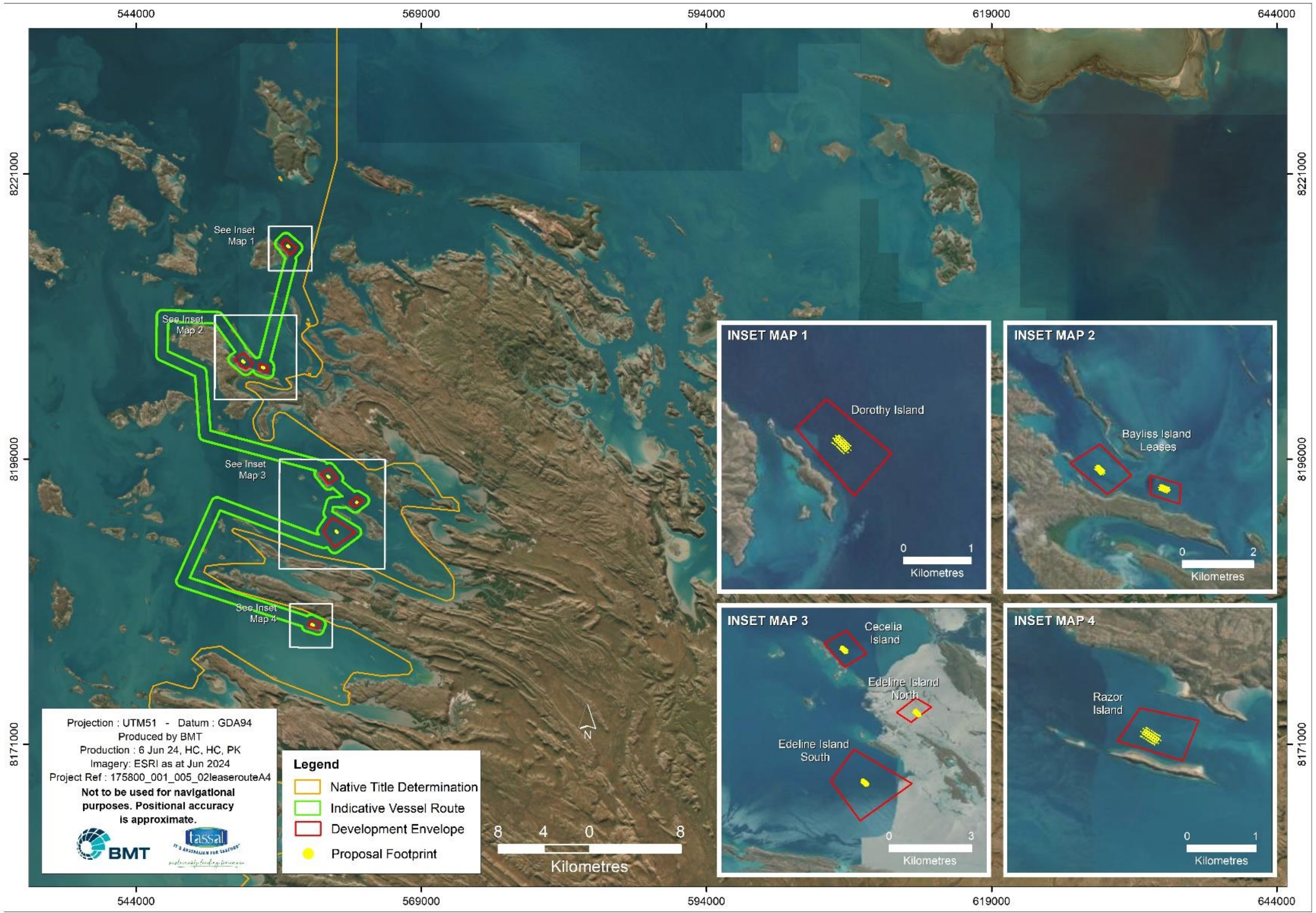


Figure 9.3 Indicative vessel route between proposed sites for Tassal vessel operations within Mayala sea country

9.3.4 Historic / Natural Heritage

A search of the Australian National Shipwreck Database indicated there were no shipwrecks in the vicinity of the Development Envelope of the Proposal.

A search of the inHerity database for historic/European heritage places listed under the State Register identified no known historic or European heritage places within the Development Envelope of the Proposal.

The West Kimberley, which includes the entire Development Envelope of the Proposal is listed as a National Heritage Place for natural heritage. National Heritage Places are Australia's natural, historic and Indigenous places of outstanding significance to the nation and are a MNES under the EPBC Act 1999. The region was listed as it contains unique examples of natural heritage found nowhere else in Australia as well as significant sites or areas of cultural heritage for Aboriginal peoples. Some of the key reasons for its listing are summarised below:

- King Leopold Orogen – records of key geological events in the evolution of the Australian continent
- Devonian Reef – continuous record of 20 million years of reef deposition and shows response of a Late Devonian reef to a mass extinction event
- Gogo fossil sites
- Current biological/ecological significance – Devonian Reef systems, vine thickets, freshwater river systems
- Movement of material (marine shell beads) by Aboriginal people
- Symbolic use of Ochre
- Aboriginal trade in pearl shell (*Pinctada maxima*)

As the National Heritage Place is a MNES, this has been assessed directly by DCCEEW within the PER (Stantec 2024a). See Section 12 for further details.

9.3.5 Economic

Iron ore mining has occurred intermittently on Cockatoo and Koolan Islands, with Mt Gibson Iron currently operating the mine at Koolan Island and Cockatoo Island Mining acquiring the mining leases for Cockatoo Island in 2021 (Figure 2.2). With the establishment of state managed marine parks in the Archipelago it is expected tourist use of the region will grow (DBCA 2022a; b, c) through nature-based and cultural tourism activities.

The primary economic sectors in the region are mining, construction, transport and tourism, with aquaculture (as included under fishing) an area of significant potential expansion. Mining operations on Koolan Island by Mt Gibson is the largest industrial scale operation in the Buccaneer Archipelago. A historical mine of BHP, Mt Gibson acquired the mining rights with production and sales of high-grade hematite recommenced in April 2019 following a two-year seawall reconstruction and mine refurbishment program. As of 31 December 2020, Mount Gibson had exported in excess of 28Mt of ore from Koolan Island. Cockatoo Island Iron Ore operations most recently operated in 2015 until the operator, Pluton resources was placed into administration. Recently, drilling programs by tenement holders on the island have commenced with an intention to firm up potential viability of recommencing operations. In Dogleg creek, east of the most north-eastern sites, safe harbour is provided for barge operations of CMC marine which supports the provision of supplies to Mt Gibson Iron's operations and activity on Cockatoo Island. The safe harbour is also a refuelling supply base for passing recreational and commercial fishers.

Commercial fishing in the region of the Archipelago contributes significantly to the local economy, equating to more than $65 million annually. Six state-based commercial fisheries operate within or adjacent to the Buccaneer Archipelago, with the most likely potential interactions to occur with the Kimberley Gillnet and Barramundi Managed Fishery, the Trochus fishery which is jointly operated by native title holders, and the aquaculture Pearl Oyster Fishery (DPIRD 2017). However, the Kimberley Gillnet and Barramundi Fishery is limited to four licences who can only operate within three nautical miles of the high-water mark in the nearshore and estuarine zones (DPIRD 2021). As such, little to no commercial barramundi fishing occurs in the vicinity of the sites. Together, the KGBF and Trochus fishery contribute <$1 million annually to the region, while the aquaculture Pearl Oyster Fishery contributes approximately $63.5 million annually. Charter fishing and recreational fishing in the region also contribute significantly to the state and local economy (part of the $2.4 billion attributed at a state level to recreational fishing annually), with a report on the total expenditure of West Australians on recreational fishing in the Kimberley estimated at $184 million (McLeod and Lindner 2018).

Tourism in the Kimberley region was estimated to employ 12% of the areas workforce as well as attract ~400,000 visitors annually, 89% of which were domestic and 11% international. The industry accounts for nearly 10% of gross regional revenue with 500 businesses directly involved, though the flow on effect from visitation likely means there is a much greater economic contribution. The Kimberley has on the highest visitor spends per capita in Australia, with the average annual visitor spend of $14,455 per person. Several barriers to tourism in the region however include high costs for access (air-travel) as well as workforce participation and productivity being maintained particularly in the wet season, where many tourist businesses cease operations over this period due to a lack of visitation (RDA 2020).

The proposed expansion of operations is expected to derive substantial economic and employment benefits to the region. The overall project is expected to create 140 jobs in the region.

According to the 2021 Census, unemployment in the West Kimberley was 6.1% compared to the national rate at the same time of 5.1%. Such growth in employment opportunities supporting the sites will create new meaningful training and employment pathways for the existing communities in the West Kimberley. These remote workforce positions may further support Traditional Owner aspirations to have greater residency in the Buccaneer Archipelago where sustainable employment can be secured, and integration of logistics associated with the operations make access for goods and services would be greatly enhanced.

9.3.6 Amenity

The West Kimberley Region where the project is located is recognised nationally as one of Australia's most special places. The area is described in its National Heritage Register listing as follows:

> *It is a vast area of dramatic and relatively undisturbed landscapes that has great biological richness and provides important geological and fossil evidence of Australia's evolutionary history.*
>
> *With sheer escarpments and pristine rivers that cut through sandstone plateaux and ancient coral reefs to create spectacular waterfalls and deep gorges, the region's remoteness has created a haven that supports plant and animal species found nowhere else on the Australian continent.*
>
> *Against the backdrop of this extraordinary landscape is woven a remarkable account of Aboriginal occupation over the course of more than 40,000 years and the story of European exploration and settlement, from William Dampier's landing at Karrakatta Bay to the development of rich and vibrant pastoral and pearling industries that continue today.*

The Archipelago is known for its remoteness and healthy environment. The visual amenity of the location is highly valued by Traditional Owners, residents of the region and visitors, who frequent the region annually via the remote cruise industry.

Though the installation of the sea-pens may alter visual amenity, the extensive historical use over 70-years of the areas for pearling activity however is expected to result in an impact to the landscape that is still synonymous with the historical use of the region Traditional Owners, residents and visitors already experience and are cognisant of, particularly compared to the significant impacts alternative uses, such as mining, have had.

Recreational fishers frequent the Buccaneer Archipelago, with locally based fishing clubs focusing their fishing on nearshore reefs of the Archipelago. Though areas of exclusion will be implemented around the sea-pens (not the entire sites), this will not significantly limit recreational fishing opportunities, considering most of the sites are located in deep waters distanced from habitats where recreational targeted species are more likely to reside. Furthermore, the proposed footprint of the sea-pens at the sites is <15 ha, which would only exclude <0.1% more area than that already defined under the marine park zoning (for the Mayala and Lalang-gaddam Marine Parks) with its sanctuary zones and special purpose zones.

Recreational boaters also frequent the Buccaneer Archipelago. Similar to recreational fishers, while exclusion areas may be implemented around the sea-pens this will not significantly impede free navigation or quiet enjoyment by mariners.

Multiple tour groups and small cruise businesses operate in the region of the sites. These include Ocean Dream Charters, Horizontal Falls Seaplane Adventures, Bluesun Travel Kimberley and One Tide Charters. The majority of these tour groups offer flights to Cape Leveque or Cockatoo Island from which boat tours are run. The regular travel routes for these operates are not expected to intersect with any of the sites.

The Buccaneer Archipelago, though environmentally and culturally significant, is limited in access to the public. Most public use of the area are from recreational or charter fishers, or other boat-based tours or cruises which operate from Derby or Broome. The importance of the Archipelago to these groups is its remoteness and environment which remains relatively undisturbed and developed, with no significant human settlements (the population is sparse, with some small Aboriginal and mining settlements and visiting fishers and tourists).

9.4 Potential impacts

9.4.1 Approach

Potential impacts to social surroundings have been considered for both the construction and operation of the sites. The primary focus is how the Proposal may have direct or indirect impacts on Aboriginal cultural heritage, particularly that of importance to MIAC and DAC. Many direct and indirect impacts to ACH are covered in previous sections, noting they relate to key environmental values such as marine fauna, benthic communities and habitats and/or marine environmental quality. This impact assessment section details how these particular impacts directly affect the cultural heritage value that is associated with them.

Impacts to other aspects of Social Surroundings, i.e. natural and historical heritage, amenity and economic values are also considered where appropriate.

The impact of other operations in the area nearby the proposed sites, including commercial and industrial operations, on social surroundings are also considered to ensure the total cumulative impacts on social surroundings are well understood.

Impacts have been defined as summarised below.

- Major – E.g. Results in direct impact to cultural values, significantly reduces capability for other commercial projects in the region to operate, reduces amenity or access to areas permanently
- Moderate – E.g. Results in indirect impacts to cultural values, loss of access to areas of cultural significance for a moderate period of time, visual amenity of an area of natural heritage is reduced or has a moderate and ongoing impact on other commercial projects in the region to operate
- Minor – E.g. results in some disturbance of cultural heritage values which can be readily ameliorated, results in temporary loss of amenity or access or has a minor and short-term impact on other commercial projects in the region
- Insignificant – no impacts to social surroundings are expected

Aboriginal cultural heritage

This assessment follows the technical guidance provided in EPA 2023b.

In response to Section 3.1 of EPA 2023b, it is unlikely that the Proposal would impact any ACH values directly protected under the AH Act 1972. Therefore, the EPA's objective for Social Surroundings environmental factor would not be met through protections under the AH Act 1972. This is for the following reasons:

- Though the Razor Island site falls within the identified area for Aboriginal Cultural Heritage Registered Place 14676, the heritage survey conducted on sea country identified that this ACH Place is almost certainly located on land, and therefore the passage of marine vessels through the proposed vessel corridor would not impact the site.

- Though there are other registered places in the vicinity of Proposal elements, none of these are encroached upon by the Proposal. Furthermore, they are all limited to land-based areas, while the Proposal is entirely marine based.

- Therefore, there are no other potential impacts from the Proposal on ACH that the AH Act 1972 processes would mitigate.

In response to Section 3.2 of EPA 2023b, information has subsequently been provided in the respective sections to follow regarding how construction or operational elements of the Proposal will impact on ACH, and therefore what mitigative actions are required to protect ACH values such that the EPA's objective for Social Surroundings is met.

In response to Section 3.3 of EPA 2023b, Tassal has conducted the following targeted consultation (in addition to that already detailed in Section 3) to ensure that relevant stakeholders have had appropriate opportunity to review the information provided in this referral and comment on the environmental outcomes in relation to ACH:

- Provision of environmental documentation, including draft management targets and objectives for the EMMP which detail proposed avoidance and mitigation actions, prior to the conduction of the heritage survey, for comment and review

- Discussion of potential environmental impacts of the Proposal on ACH throughout Mayala sea country during the heritage survey, based on documentation previously provided
- Provision of revised environmental documentation, including the EMMP, after the completion of the heritage survey, for comment and review, to MIAC
- Organisation of workshops with representatives from MIAC, to discuss the environmental impacts and outcomes of the Proposal as detailed in the revised environmental documentation. Workshops with DAC have also been organised and are due to take place in Q1 2025.

9.4.2 Potential construction impacts

The potential for associated impacts from the construction of the sites are summarised in Table 9.4.

Table 9.4 Potential construction impacts to social surroundings from construction of sites

Development type	Potential impacts	Impact	Context and assessment	Extent	Duration	Significance of Impacts (prior to the application of mitigation measures)
Leases	Disturbance to visual amenity	Direct	During the construction phase there may be a loss of visual amenity as sea-pens are towed to site within the proposed sites. This may temporarily impact visual amenity.	Limited (development envelope of sites)	Construction phase of the project	1 - Insignificant
Leases	Loss of access	Direct	During the construction phase (only a matter of days or weeks for each site) loss of access, both for members of the public and traditional owners will occur at the proposed sites in the vicinity of the sea-pens	Limited (development envelope of sites)	Construction phase of the project	2 - Minor
Leases	Navigational hazards	Direct	The sea-pens, barges and associated vessels have the potential to be navigational hazards for vessel operators.	Limited (development envelope of sites)	Construction phase of the project	1 - Insignificant

9.4.3 Potential operational impacts

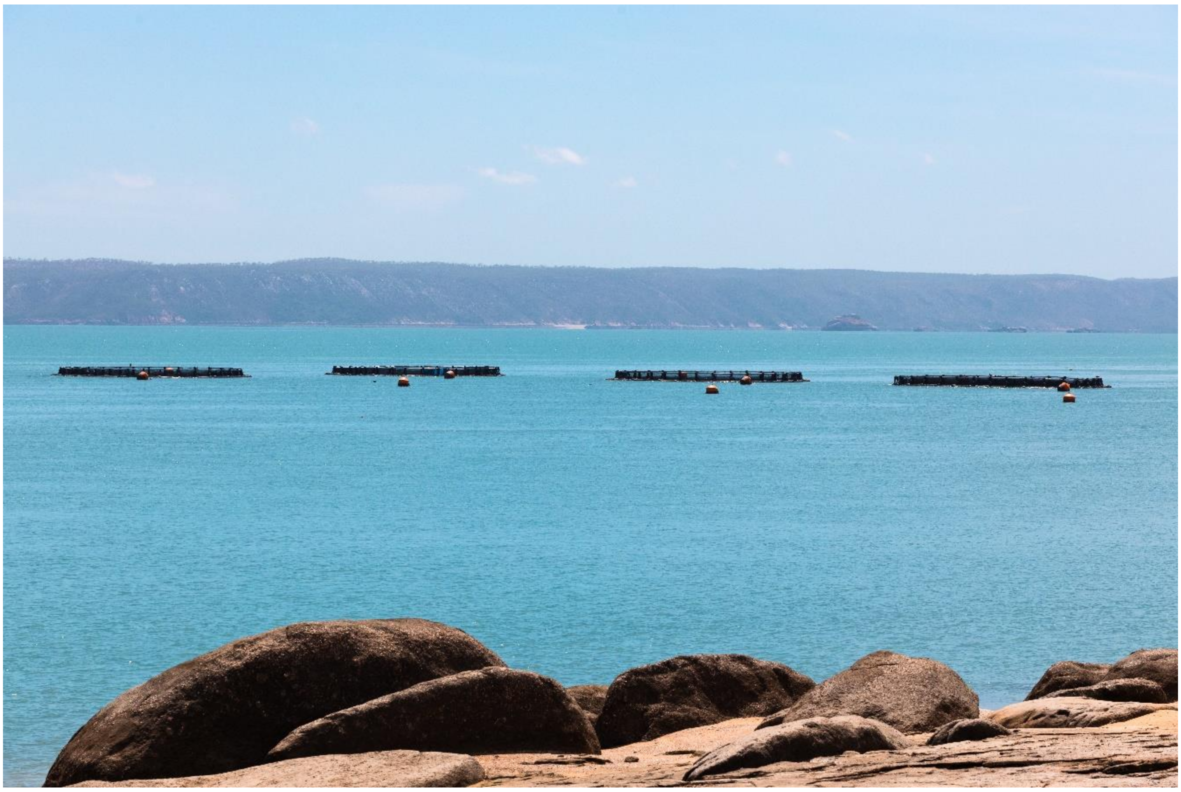
The potential for impacts from the operation of the sites are summarised in Table 9.5. Further details are provided in the following sections where there is the potential for significant impacts, particularly if these impacts are on ACH.

Visual amenity

Visual amenity is not covered directly by AH Act 1972, and as such any impacts to visual amenity in relation to ACH must be assessed under EPA processes.

The sea-pens and feed barges, which will be on site within the sites 24/7 365 days a year, have the potential to impact visual amenity. This is relevant both for ACH, noting that as identified in the heritage survey the visual amenity of Mayala sea country is of high value, and anything which disturbs this visual amenity will impact this value. Furthermore, it is of relevance to other users within the Buccaneer Archipelago, such as recreational or commercial fishers as well as tour operators who transit through the region.

Though the sea-pens and feed barges will be present continuously, the extent to which they can be observed is limited (Figure 9.4). All sites are in areas that are not regularly visited by Mayala People (as identified in the heritage survey), and as such the level of impact on the visual amenity value associated with ACH is reduced. Furthermore, the sites are also distant from areas that are regularly visited by tour operators (such as Horizontal Falls in Lalang-gaddam Marine Park), and as such the likelihood of tour vessels transiting in the vicinity of the sites once operational is low. From land, there are limited public access points which allow for observation of the areas in which the proposed sites are located.



Source: Tarryn Yeates Photography (2024)

Figure 9.4 Example sea-pen visual from land of current operations within Cone Bay

Access

Access is not covered directly by AH Act 1972, and as such any impacts to access in relation to ACH must be assessed under EPA processes.

Access within the development envelope (i.e. the sites) will not be restricted, with Traditional Owners and members of the public able to transit through the sites. Restrictions to access will only occur around Proposal infrastructure (I.e. vessels, sea-pens, buoys) with a 100 m buffer zone applied to these areas. Before activities are to be conducted within the sites, notification to Tassal would be required, and all members of the public or Traditional Owners would be required to take part in a safety briefing. Subsequently, some loss of access to the areas in the direct vicinity of Proposal infrastructure will occur. However, as previously noted the areas adjacent to the sites are not visited regularly either by Traditional Owners or members of the public, and as such this loss of access is unlikely to result in significant impacts.

Unauthorised access by Tassal staff or contractors to culturally significant places is also a risk, with visitation to protected areas considered a key risk within the Mayala Marine Park Management Plan (DBCA 2022a). Though there is no need for staff or contractors to make landfall throughout Mayala sea country as part of normal operations, occasional landings may occur during emergencies (e.g. to provide first aid to crew or to shelter from storms). These landings however are likely to be rare. Furthermore, as identified in the heritage survey, access to lands within Mayala sea country has been conditionally approved by MIAC as long as the activities requiring the landing are for the purpose of conducting aquaculture activities (i.e. no recreational activities).

Alterations to predator behaviour / nutrient enrichment / smothering

For a full assessment of impacts to ACH values that are ecological in nature (i.e. marine fauna, marine environmental quality, benthic communities and habitats) in relation to fish escapes, nutrient enrichment and smothering, see Sections 5, 6 and 7 respectively. However, the relevant impacts to particular ACH values associated with these factors are assessed here.

Any damage to sea-pen infrastructure (e.g. due to storm events) may result in fish escapes. Escaped barramundi may be eaten by predators (i.e. sharks, crocodiles, other fish), with the regular occurrence of fish escapes having the potential to alter natural predator behaviour (as discussed in Section 7). In the context of ACH, any changes to natural predator behaviour may impact the ability of Traditional Owners to catch and hunt fish as part of traditional hunting practices, considering these predators may aggregate around the sea-pens rather than being dispersed across their natural ranges.

All impacts to MEQ, BCH and marine fauna associated with nutrient enrichment will impact on Mayala People, considering all aspects of the marine environment on sea country is of significance. Nutrient enrichment impacts are however predicted to be limited to the immediate vicinity of the proposed sites for the most part, and areas of impact beyond the sites are generally limited to deepwater soft sediment areas. As such, the overarching impact to key values identified either in the Mayala Marine Park Management Plan or during the heritage survey is limited.

Smothering impacts, as discussed in Section 6, have the potential to impact nearshore fringing reefs of the islands and mainland through Mayala sea country. Any change to these habitats will impact the ability for Mayala People to conduct traditional hunting practices within these areas, noting the quality of the coral habitat may be degraded and subsequently marine fauna diversity and/or abundance (including fish, invertebrates, turtles etc) would also be reduced. No impacts due to smothering or nutrient enrichment are predicted however for the pearl oyster beds that are on the southern side of Aveling Island, which Mayala People identified as having significant cultural value.

Table 9.5 Potential operations impacts to social surroundings from operation of sites

Development type	Potential impacts	Impact	Context and assessment	Extent	Duration	Significance of Impacts (prior to the application of mitigation measures)
Leases	Odour generation	Indirect	There is potential for fuel emissions from diesel engines/generators to be generated during operations at the sites.	Limited (development envelope of the sites)	Lifetime of project	1 - Insignificant
Leases	Noise generation	Indirect	Noise emissions from generators will be present during operations at the sites.	Limited (development envelope of the sites)	Lifetime of project	1 - Insignificant
Leases	Disturbance to visual amenity	Direct	During operations phase there will be a loss of visual amenity, due to the presence of the sea-pens and operational vessels on site at all times	Limited (development envelope of the sites)	Lifetime of project	2 - Minor
Leases	Access	Direct	Traditional owners and members of the public will have some limitation on access in the vicinity of the sea-pens. Unauthorised access by Tassal staff and	Moderate (beyond the development envelope of the sites)	Lifetime of project	2 - Minor

Development type	Potential impacts	Impact	Context and assessment	Extent	Duration	Significance of Impacts (prior to the application of mitigation measures)
			contractors to restricted areas may impact the cultural value these significant areas hold			
Leases	Navigational hazards	Direct	The sea-pens, barges and associated vessels have the potential to be navigational hazards for vessel operators.	Limited (development envelope of the sites)	Lifetime of project	1 - Insignificant
Leases	Alterations to predator behaviour	Indirect	Potential fish escapes may endanger key ACH values associated with *aarli* (fish), particularly barramundi, as well as the natural balance of predators in the vicinity of the sea-pens	Moderate (beyond the development envelope of the sites)	Lifetime of project	3 - Moderate
Leases	Nutrient enrichment	Indirect	Nutrient enrichment as a result of particulate and dissolved wastes from sea-pens has the potential to impact water and sediment quality (i.e. MEQ), visual aesthetics as well as marine fauna and benthic habitats and communities, all of	Moderate (beyond the development envelope of the sites)	Lifetime of project	3 - Moderate

Development type	Potential impacts	Impact	Context and assessment	Extent	Duration	Significance of Impacts (prior to the application of mitigation measures)
			which hold key ACH value			
Leases	Smothering	Indirect	Smothering impacts associated with particulate wastes from sea-pens has the potential to impact pearl oyster beds in proximity to Aveling Island in Strickland Bay, as well as nearshore reefs and shorelines, all of which hold key ACH value	Moderate (beyond the development envelope of the sites)	Lifetime of project	3 - Moderate

9.4.4 Cumulative impacts

The cumulative direct and indirect impacts of other operations ongoing or proposed in the vicinity of the development envelopes for the sites are summarised in Table 9.6. A search of the Environment Online database for other referred significant proposals, as well as current or ongoing projects, was undertaken to confirm the potential cumulative impacts in the vicinity of the Proposal. As for other EPA Factors, these projects are limited to the Cockatoo Island Multi-user Supply Base and the Koolan Island Iron Ore Mine. Both of these projects impacts to Social Surroundings are focused primarily on visual aesthetics. The Proposal presents the first anthropogenic impacts to visual aesthetics from a marine perspective, noting both mines are land-based. Furthermore, as the development envelope of the Proposal is at least ~9.5 km's from the nearest mine (Cockatoo Island), the impact to regional visual aesthetics is limited. Similarly to the Proposal, the public access to these areas is limited, with access primarily only by vessel. As such, the Proposal does not pose a significant cumulative impact to Social Surroundings.

Though not listed as actual proposed projects, the establishment of the Mayala, Lalang-gaddam and Bardi Jawi Gaarra marine parks have the potential to result in a number of positive impacts for social surroundings in the region, with key benefits listed below:

- Enhance eco-tourism operations as demand for tourism in an established marine park will likely increase
- Establish clear management guidelines regarding cultural associations within the marine parks and how these should be interacted with by members of the public, tour groups, fisheries operators etc
- Enhance educational programs regarding land and sea country within the marine parks to help improve both local and tourists understanding of the cultural and environmental values of the region

Table 9.6 Impacts from other ongoing and proposed operations in vicinity of the development envelope for the sites

Development type	Phase	Approved / Operational / Referred	Potential impacts	Impact	Context and assessment
Cockatoo Island Multi-User Supply Base	Construction / Operations	Referred	Impacts to visual amenity	Direct	The development of a large supply base on the southern end of Cockatoo Island will result in further changes to visual amenity of the region already impacted by the original mine and other facilities established on the Island.
Koolan Island Iron Ore Mine and Port Facility	Operations	Operational	Impacts to visual amenity	Direct	The continuing mining of ore from Koolan Island significantly impacts the visual amenity of the surrounding area for any groups or individuals passing through the area by vessel.
Pearl leases (managed by DPIRD)	Operations	Operational	Impacts to visual amenity	Direct	The pearl leases currently in operation throughout the Buccaneer Archipelago impact the visual amenity of the region in the sense that buoys, lines and navigational lighting for these operations are present in areas where groups or individuals pass through by vessel.

9.5 Mitigation

Management procedures proposed to minimise impacts to social surroundings from the Proposal are summarised below in accordance with EPA's mitigation hierarchy.

9.5.1 Construction

Appropriate avoidance measures have been taken where possible to limit the impact of the construction of the sites on social surroundings (Table 9.7).

Table 9.7 Mitigation strategies for reducing construction related impacts at the sites following EPA's mitigation hierarchy

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets
Odour generation from fuel emissions from diesel generators used during construction of sites	NA	• Diesel generators will only be run when needed to minimise emissions of fuel and potential for odour generation.	NA	NA	NA	NA
Noise generation from diesel generators, construction equipment	NA	• Construction equipment and diesel generators only to be used in daylight eliminating noise pollution after or before work hours.	NA	NA	NA	NA
Visual amenity	• Significant stakeholder engagement has been conducted with the Mayala People to ensure that the proposed sites are not in proximity to areas of cultural significance. This has included the removal of several sites from the Proposal (e.g.	NA	NA	NA	NA	NA

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets
	Edeline Island East) • Stakeholder engagement with the DBCA has also been carried out to ensure sites are not interacting with sanctuary or special purpose zones of the Mayala Marine Park					
Access	• Vessel routes have been designed to avoid transiting through special purpose zones and other culturally significant areas	• All sites are located away from areas of cultural or environmental significance ensuring no loss of access to these areas from the Proposal. • Construction at the sites will only begin when at the appropriate point of the staged expansion plan, i.e. loss of access will only occur after this point.	NA	NA	NA	NA
Navigational hazards	NA	• During construction of	• Notices to mariners as	NA	NA	NA

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets
		the sea-pens exclusion zones will be established around the construction area, with appropriate signage and lighting denoting the exclusion zones.	required under Department of Transport procedures will be acquired and advertised in the appropriate manner.			

9.5.2 Operation

Appropriate avoidance measures have been taken where possible to limit the impact of the operation of the sites on social surroundings (Table 9.8). For mitigation methods associated with impacts to ACH values that are encompassed within the factors MEQ, BCH or marine fauna, see Sections 5.5, 6.5 and 7.5.

Table 9.8 Mitigation strategies for reducing operation related impacts at the sites following EPA's mitigation hierarchy

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets
Odour generation from fuel emissions from diesel generators used either as main or backup power sources and sites	NA	• Tassal will also explore the use of solar or other alternate power systems to enable off grid operations which will significantly reduce fuel emissions.	NA	NA	NA	NA
Noise generation from diesel generators	NA	• Tassal will also explore the use of solar or other alternate power systems to enable off grid operations which will significantly reduce fuel emissions.	NA	NA	NA	NA
Visual amenity	• Significant stakeholder engagement has been conducted with the Mayala People to ensure that the proposed sites are not in proximity to areas of cultural significance. This has included the	• NA	Implementation of the Heritage Management Plan (HMP; Stantec 2024b)	NA	NA	NA

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets
	removal of several sites from the Proposal (e.g. Edeline Island East) • Stakeholder engagement with the DBCA has also been carried out to ensure sites are not interacting with sanctuary or special purpose zones of the Mayala Marine Park					
Access	• Vessel routes have been designed to avoid transiting through special purpose zones and other culturally significant areas • All Tassal staff will be required to undergo requisite training to ensure they understand culturally appropriate behaviours to be conducted while	• All sites are located away from areas of cultural or environmental significance ensuring no loss of access to these areas from the Proposal. • Construction at the sites will only begin when at the appropriate point of the staged expansion plan, i.e. loss of access	• Tassal will follow the management strategies outlined in the Mayala Marine Park Management Plan as well as the EMMP and HMP designed for this Proposal	• Tassal will provide annual information to verify vessel activity has not interacted with designated exclusion zones • Training and induction records to be kept up to date for all Tassal staff and contractors with regards to culturally	NA	NA

Potential impact	Avoidance	Minimisation	Manage	Monitor	Restoration	Offsets
	on Mayala sea country	will only occur after this point.		appropriate behaviours • Visitation of workers or contractors from the Proposal to land or islands within Mayala NTD is only for the purposes of aquaculture-related activities		
Navigational hazards	NA	• Once operational, exclusion zones will be established around the sites with appropriate signage and lighting denoting the exclusion zones.	• Notices to mariners as required under Department of Transport procedures will be acquired and advertised in the appropriate manner.	NA	NA	NA

9.6 Assessment and significance of residual impact

The residual impacts of the Proposal are summarised in Table 9.9 where present. Overall, the Proposal, along with the potential cumulative impacts from other proposals or projects in the vicinity of this proposal, do not pose a significant impact to the social surroundings on a regional or local scale, as long as the appropriate mitigative actions are undertaken.

Table 9.9 Residual impacts on social surroundings

Impact	Phase	Assessment	Residual impact
Odour generation	Construction / operations	Odour generation from construction and operation of the Proposal will be kept to an absolute minimum.	1-Insignificant
Noise generation	Construction / operations	Noise generation from construction and operation of the Proposal will be kept to an absolute minimum.	1-Insignificant
Visual amenity	Construction / operations	The constrained arrangement of sea-pens within the sites reduces the overall visual footprint to an insignificant level. No cumulative impacts from other proposals or projects exist.	1-Insignificant
Access	Construction / operations	Leases are arranged to avoid culturally or environmentally significant areas. However, some loss of access to the public, including commercial and recreational fishers, is unavoidable. Regardless, most fishing in the region does not occur in proximity to the sites considering the depth in which they are located. Tassal will ensure Traditional Owners have access to sea country per the management strategies outlined in Annex A and the HMP (Stantec 2024b). Unauthorised access to culturally significant areas will be minimised as much as practicable and will only occur in the event of emergencies. Training will ensure all Tassal staff and contractors are aware of their responsibilities and the importance of behaving in a culturally appropriate manner. No cumulative impacts from other proposals or projects exist.	2-Minor
Alteration in predator behaviour	Operations	Alterations in predator behaviour are expected only in the immediate vicinity of the sea-pens. Damage to sea-pens, including by storms or predators, will be minimised through constant monitoring of the netting, as well as personnel being present on-site	2-Minor

Impact	Phase	Assessment	Residual impact
		24/7 265 days a year. This will reduce the likelihood of fish escapes, which further reduces the likelihood of predators altering their behaviour to stay in close proximity to the sea-pens	
Nutrient enrichment	Operations	The potential for nutrient enrichment is generally limited to the immediate vicinity of the sites. Some areas of soft sediment beyond the sites are predicted to be impacted, however this is not expected to impact any ACH values associated with these areas. Nutrient enrichment of the water column is not predicted to be extensive. Extensive monitoring, as detailed in Annex A, and associated management actions are expected to mitigate any potential impacts to ACH values as a result of nutrient enrichment. No cumulative impacts from other proposals or projects exist.	2-Minor
Smothering	Operations	The potential for smothering of coral habitats is predicted to be minimal, though still present for some areas. The pearl beds near to Aveling Island are not predicted to be impacted by particulate waste deposition from the sea-pens. Extensive monitoring, as detailed in Annex A, and associated management actions are expected to mitigate any potential impacts to ACH values as a result of nutrient enrichment. No cumulative impacts from other proposals or projects exist.	2-Minor
Navigational hazards	Construction / operations	Appropriate signage and lighting will be implemented around the sea-pens and sites to minimise risk of the accidental access by the public. No cumulative impacts from other proposals or projects exist.	1-Insignificant

9.7 Predicted outcome

Considering the mitigation strategies implemented by this proposal, including appropriate site selection of sites to avoid areas of cultural or environmental significance, no significant harm to Aboriginal heritage and culture or natural and historic heritage sites is expected in the vicinity of the Proposal. The establishment of the marine parks in the Buccaneer Archipelago will further help ensure the cultural associations and values on land and sea country are upheld through clear management strategies which Tassal will follow. The Proposal specific management and monitoring actions, detailed in Annex

A and the HMP (Stantec 2024b), will hold Tassal accountable for the activities undertaken as part of the Proposal, and will require continual engagement with Traditional Owners including Mayala People in the region. Furthermore, the economic benefits the project provides will help diversity the local economy significantly and provide employment to many local communities. As such, it is expected that the EPA's objective for Social Surroundings can be met.

10 Other environmental factors

The following environmental factors are not considered to be Key Environmental Factors for the Proposal:

- Coastal processes
- Terrestrial flora and vegetation
- Terrestrial fauna
- Landforms
- Subterranean fauna
- Terrestrial environmental quality
- Inland waters
- Air quality
- Human health

These are summarised in Table 10.1.

Table 10.1 Summary of impact assessment on other environmental factors

Environmental Factor & Objective	Relevant Proposal Activities	Potential Impact	Mitigation	Impact Assessment
Coastal Processes To maintain the geophysical processes that shape coastal morphology so that the environmental values of the coast are protected.	Sea-pens. General operations (e.g. vessel movements)	The sea-pens may change local hydrodynamic conditions in the immediate vicinity of the pens, which could potentially alter beach formations or profiles. Greater vessel usage in these areas may also contribute to the same changes.	<u>Avoid:</u> The proposed sites are distant from any shoreline and as such no change in hydrodynamic conditions is expected at the shoreline	Meets EPA objective. Though the sea- may change hydrodynamics or coastal process on a local scale, any affects are not expected to be significant and the EPA objective for coastal processes is considered to be met.
Terrestrial flora and vegetation To protect flora and vegetation so that biological diversity and ecological integrity are maintained.	None of the proposal elements are expected to affect terrestrial flora and vegetation	NA	NA	NA
Terrestrial fauna To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.	None of the proposal elements are expected to affect terrestrial fauna	NA	NA	NA
Landforms To maintain the variety and integrity of significant physical landforms so that environmental values are protected.	None of the Proposal elements are expected to affect landforms	NA	NA	NA

Environmental Factor & Objective	Relevant Proposal Activities	Potential Impact	Mitigation	Impact Assessment
Subterranean Fauna To protect subterranean fauna so that biological diversity and ecological integrity are maintained.	None of the Proposal elements are expected to affect subterranean fauna	NA	NA	NA
Terrestrial Environmental Quality To maintain the quality of land and soils so that environmental values are protected.	None of the Proposal elements are expected to affect terrestrial environmental quality	NA	NA	NA
Inland Waters To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected	None of the Proposal elements are expected to affect inland waters	NA	NA	NA
Air Quality To maintain air quality and minimise emissions so that environmental values are protected.	Fuel emissions from diesel generators Fuel emissions from vessels	Fuel emissions from diesel generators and vessels may change the air quality at a local scale	NA	Meets EPA objective. Fuel emissions from both diesel generators and vessels are not expected to be significant, and any changes to air quality will be on a very limited scale and will not continue for a long period of time.
Human Health	Fuel emissions from diesel generators/vessels	Fuel emissions from diesel generators and vessels may	NA	Meets EPA objective.

Environmental Factor & Objective	Relevant Proposal Activities	Potential Impact	Mitigation	Impact Assessment
To protect human health from significant harm.		impact Tassal staff operating the vessels / sites.		Fuel emissions from both diesel generators and vessels are not expected to be significant, and any changes to air quality will be on a very limited scale and will not continue for a long period of time.
	Evacuation in the event of emergencies (i.e. cyclones)	Considering the remoteness of the region, evacuations in the event of emergencies such as cyclones may be difficult without suitable warning and planning	Tassal to develop an protocols which outline the planned operational decisions to be made in the event of an emergency such as a cyclone. This will include provisions for monitoring of fish health and sea-pen infrastructure as soon as possible after the event to determine potential damage, if any, and report to the appropriate party in the event of any fish escapes or other damage.	Meets EPA objective. By following pre-planned evacuation procedures, as well as appropriate training for all staff, human health associated with emergencies should not be compromised.

11 Offsets

No offsets are predicted to be required as part of this Proposal.

12 Matters of National Environmental Significance

The Proposal has been referred under the Commonwealth EPBC Act. DCCEEW have subsequently requested a Public Environmental Report level of assessment for the Proposal. This PER has been developed to address all matters related to Matters of National Environmental Significance (MNES), and as such can be referred too when it comes to MNES and the approval of the Proposal under the EPBC Act. See Stantec (2024a) for the PER. The Proposal is not being assessed under a Bilateral Agreement.

A summary of requisite information on MNES in relation to the Proposal, as required under the EP Act, is presented here that is consistent with the information provided in the PER.

12.1 Relevance of MNES to the Proposal

The Proposal has been deemed a controlled action under the Commonwealth EPBC Act, with a PER level of assessment set. No controlled action provisions are currently applicable.

Table 12.1 presents a summary of the relevant Matters of National Environmental Significance (MNES). As presented, the Proposal intersects with or is in the vicinity of the following MNES:

- Listed threatened species (marine fauna)
- Listed migratory species
- National heritage areas
- Commonwealth land

Table 12.1 Summary of MNES relevant to the Proposal

Matter of MNES	Relevance to the Proposal
Listed threatened species and ecological communities	**Relevant** Leases lie adjacent to habitat for several threatened marine fauna species. See Section 7
Listed migratory species	**Relevant** Leases lie adjacent to habitat for several migratory marine fauna species. See Section 7
Wetlands of national importance	**Not relevant** Proposed sites are >20 km from nearest RAMSAR wetland.
Commonwealth marine areas	**Not relevant** Proposed sites are >10 km from commonwealth waters, and no impacts from the Proposal are predicted to reach these waters.
World Heritage properties	**Not relevant** No World Heritage properties in vicinity of the Proposal.
National Heritage places	**Relevant**

Matter of MNES	Relevance to the Proposal
	The West Kimberley National Heritage Place covers both the proposed sites. See Sections 5 to 7 for relations to environmental values of the national heritage place, and Section 9 for social surroundings aspect of the national heritage place.
Nuclear actions	**Not relevant** Proposal is not a nuclear action
Great Barrier Reef marine park	**Not relevant** Proposal is not near to the Great Barrier Reef Marine Park
Protection of water resources from coal seam gas development and large coal mining development	**Not relevant** Proposal is not a coal-related development

12.2 Relevant policy and guidance

The relevant policy and guidance regarding MNES are summarised in Table 12.2.

Table 12.2 Policies and guidelines

Policy or guidance
Environmental Protection and Biodiversity Conservation Act 1999 Matters of National Environmental Significance Significant impact guidelines (Commonwealth of Australia 2013)
Environmental Management Plan Guidelines (Commonwealth of Australia 2014)
Working Together- Managing National Heritage Places (DEWHA 2008)
Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (DAWE 2015)
Offshore aquaculture – EPBC Policy Act Statement 2.2

12.3 Existing environmental values

Table 12.3 provides a summary of the listed threatened species and migratory species which have been identified to have some extent of suitable habitat within the Proposal area. Further details of the environmental values presented in Table 12.3 are presented in Section 7. A summary of the environmental values listed under the West Kimberley National Heritage Place (WKNHP) which are relevant to this proposal in terms of potential impacts is provided in Table 12.3.

Table 12.3 Environmental values of MNES adjacent to or intersecting the proposed sites

Listed species / community	EPBC Act Status	Likelihood of occurrence	Description of values adjacent to or intersecting proposed sites	Biologically important area: yes / no
Ecological communities – none listed under the EPBC act are likely to occur in proximity to the sites (Stantec 2024a)				
Terrestrial flora – none listed under the EPBC act are likely to occur in proximity to the sites (Stantec 2024a)				
Terrestrial fauna – none listed under the EPBC act are likely to occur in proximity to the sites (Stantec 2024a)				
Marine fauna / migratory species				
Humpback whale (*Megaptera novaeangliae*)	Vulnerable, migratory	Likely	Breeding known to occur near to proposed sites.	Yes
Snubfin dolphin (*Orcaella heinsohni*)	Migratory	Likely	Species known to occur near to Proposal area	Yes
Dugong (*Dugong dugon*)	Migratory	Likely	Species known to occur near to Proposal area	Yes
Australian humpback dolphin (*Sousa sahulensis* as *Sousa chinensis*)	Migratory	Likely	Species or species habitat likely to occur near to Proposal area.	Yes
Spotted bottlenose dolphin (*Tursiops aduncus*)	Migratory	Likely	Species or species habitat likely to occur near to Proposal area.	Yes
Short-nosed Seasnake (*Aipysurus apraefrontalis*)	Critically Endangered	Likely	Species or species habitat likely to occur near to Proposal area	NA
Loggerhead turtle (*Caretta caretta*)	Endangered	Likely	Species or species habitat known to occur near to Proposal area	No

Listed species / community	EPBC Act Status	Likelihood of occurrence	Description of values adjacent to or intersecting proposed sites	Biologically important area: yes / no
Green turtle (*Chelonia mydas*)	Vulnerable, Migratory	Likely	Breeding known to occur near to Proposal area	No
Leatherback turtle (*Dermochelys coriacea*)	Endangered, Migratory	Likely	Breeding likely to occur near to Proposal area	No
Hawksbill turtle (*Eretmochelys imbricata*)	Vulnerable	Likely	Breeding likely to occur near to Proposal area	No
Olive ridley turtle (*Lepidochelys olivacea*)	Endangered	Likely	Congregation or aggregation known to occur near to Proposal area. Records of hatchlings at Camden Sound.	No
Flatback turtle (*Natator depressus*)	Vulnerable, Migratory	Likely	Breeding known to occur near to Proposal area	Yes
Estuarine or Salt-water crocodile (*Crocodylus porosus*)	Migratory	Likely	Species or species habitat likely to occur to Proposal area. Previous records of sightings in proximity to the sea-pens at Cone Bay.	NA
Northern river shark (*Glyphis garrickii*)	Endangered	Likely	Breeding likely to occur near to Proposal area	No
Dwarf sawfish (*Pristis clavate*)	Vulnerable, Migratory	Likely	Breeding known to occur near to Proposal area	No
Freshwater sawfish (*Pristis pristis*)	Vulnerable, Migratory	Likely	Species or species habitat known to occur near to Proposal area.	No

Listed species / community	EPBC Act Status	Likelihood of occurrence	Description of values adjacent to or intersecting proposed sites	Biologically important area: yes / no
Green sawfish (*Pristis zijsron*)	Vulnerable, Migratory	Likely	Species or species habitat known to occur near to Proposal area.	No
Whale shark (*Rhincodon typus*)	Vulnerable, Migratory	Likely	Foraging, feeding or related behaviour known to occur near to Proposal area	No
Scalloped hammerhead shark (*Sphyrna lewini*)	Conservation Dependent	Likely	Species or species habitat likely to occur near to Proposal area.	No
Reef Manta Ray, Coastal Manta Ray (*Mobula alfredi*)	Migratory	Likely	Species or species habitat known to near to Proposal area.	No
Common Noddy (*Anous stolidus*)	Migratory	Likely	Species or species habitat likely to occur near to Proposal area.	No
Fork-tailed swift (*Apus pacificus*)	Migratory	Likely	Species or species habitat likely to occur near to Proposal area.	No
Streaked shearwater (*Calonectris leucomelas*)	Migratory	Likely	Species or species habitat known to occur near to Proposal area.	No
Lesser frigatebird (*Fregata ariel*)	Migratory	Likely	Breeding known to occur near to Proposal area	Yes

Listed species / community	EPBC Act Status	Likelihood of occurrence	Description of values adjacent to or intersecting proposed sites	Biologically important area: yes / no
Greater frigatebird (*Fregata minor*)	Migratory	Likely	Species or species habitat likely to occur near to Proposal area.	Yes
Lesser crested tern (*Thalasseus bengalensis*)	Migratory	Likely	Species or species habitat likely to occur near to Proposal area.	Yes
Bridled tern (*Onychoprion anaethetus*)	Migratory	Likely	Breeding known to occur near to Proposal area	Yes
Roseate tern (*Sterna douglii*)	Migratory	Likely	Breeding known to occur near to Proposal area	Yes
Little tern (*Sternula albifrons*)	Migratory	Likely	Breeding known to occur near to Proposal area	Yes
Red-footed booby (*Sula sula*)	Migratory	Likely	Breeding known to occur near to Proposal area	Yes
Osprey (*Pandion cristatus*)	Migratory	Likely	Foraging behaviour known to occur near to Proposal area	NA
West Kimberley National Heritage Place	NA	Present	The West Kimberley national heritage place includes the entire region of the Proposal. Further detail on the values of the West Kimberley are provided in Table 12.4.	NA

Table 12.4 Summary of the environmental values for the West Kimberley National Heritage Place that are relevant to the Proposal

Relevant criteria	Values	Reason for Listing	Relevance to the Project
A – Events and processes	Ecology, biogeography, and evolution Wealth of land and sea	High species richness and endemism; and as a refugia protecting against human-induced threatening changes. Pearl shell beds at a number of identified sites from Bidyadanga to Cape Londonderry where, in aboriginal law and culture, the shell is believed to have been created by Dreamtime Beings and is collected by Traditional Owners. These are the items most widely distributed by Aboriginal people in the course of Australia's cultural history.	Lease sites may impact certain species. Lease sites may impact certain habitats. Lease operations may indirectly impact on the biological and ecological values due to nutrient enrichment and subsequent algal blooms, and toxicity from hydrocarbon spills/ waste generation/ ammonia waste/ antibiotics.
C - Research	Ecology, biogeography, climate, and evolution	Coast from Cape Londonderry to Cape Leveque for the potential to yield significant new archaeological information contributing to an understanding of Australia's natural and cultural history.	Lease operations may indirectly impact on the biological and ecological values due to nutrient enrichment and subsequent algal blooms, toxicity from hydrocarbon spills/ waste generation/ ammonia waste/ antibiotics, which may impact future ecological and archaeological surveys.
D - Principal characteristics of places	Ancient landscapes, geological processes Ecology, biogeography, climate, and evolution	The coastline from Helpman Islands to the western shore of the Cambridge Gulf (including islands, peninsulas, inlets, and inundated features) demonstrates a major coastal landform type without significant modification by coastal infrastructure. Roebuck Bay is an important migratory hub or staging post for the regular presence of migratory, protected, or endangered avifauna.	The number of sites and number of sea-pens at each site could be considered significant coastal infrastructure. The sea-pens at the sites may indirectly alter hydrodynamic conditions resulting in changes to the natural landscape. Lease operations may indirectly impact biological values and natural landscapes due to nutrient enrichment and subsequent algae blooms; toxicity from hydrocarbon spills/ waste generation/ ammonia waste/ antibiotics.

Relevant criteria	Values	Reason for Listing	Relevance to the Project
E – Aesthetic characteristics	Wealth of land and sea.	Kimberley coast from Buccaneer Archipelago to George River (including tidal movement), and its offshore reefs and islands, has out spectacular scenery and substantially unmodified landscapes which hold aesthetic value by the Australian community. Including its rugged sandstone coast with rocky headlands and prominent peaks and striking landforms, sandy beaches, pristine rivers, waterfalls and drowned river valleys with rich flora and fauna, offshore reefs, and numerous islands in extensive seascapes in a sea supporting diverse marine life. The unusual effect of tidal movement is also part of the aesthetic appreciation of some areas like the Horizontal Waterfall. Aboriginal rock art paintings in the West Kimberley, are of deep religious significance to Kimberley Aboriginal people and have outstanding heritage value as they represent a stunning visual record of an ongoing Aboriginal painting tradition in a substantially unmodified landscape.	The sea-pens at the sites may indirectly alter hydrodynamic conditions resulting in changes to the unmodified natural landscape. Lease operations may indirectly reduce public access to culturally and environmentally significant sites. The sea-pens and barges in each of the sites may change the aesthetics on a local scale. Lease operations may impact aesthetics through increased vessel traffic and increased lighting at sea-pens and vessels.

12.3.2 Biologically important areas – Humpback whales and Pygmy blue whales

The three proposed sites north of the Bayliss Islands fall within a biologically important area for Humpback whales (Figure 12.1). This area is listed as a biologically important area as it is used for several reasons by Humpbacks on their annual migration north along the Kimberley Coast, including nursing, calving and resting (DAWE 2022). Humpbacks (in mother and calf pairings) are generally present during the mid-year months (June-August). The reasons as to why humpbacks use this region is because of its warm water and sheltered environment, which makes it an ideal resting place before they return on their southerly migration in the latter parts of the year.

12.3.3 Biologically important areas – inshore dolphins

A biologically important area which includes the entirety of the region for the proposed sites is listed for the three inshore dolphin species (Australian snubfin dolphin, Australian humpback dolphin and the spotted bottlenose dolphin) (Figure 12.1). All three species reside in the region year-round, with Yampi Sound being particularly important breeding, calving and foraging grounds for each species due to the high density of prey species within the area (DAWE 2022). For the snubfin and humpback dolphins, the deep fjord-like passages throughout the northern section of the Buccaneer Archipelago provides ideal habitat for these species; while the tidal mangroves and shallow coral reefs are preferred by the spotted bottlenose dolphins. It should be noted that the whole region is listed as a biologically important area for these species, and as such the sites do not take up a significant proportion of that region.

12.3.4 Biologically important areas – dugongs

There are no known biologically important areas for dugongs listed in proximity to the proposed sites, though dugongs are commonly observed in the region.

12.3.5 Biologically important areas – marine turtles

There are no known biologically important areas or areas of critical habitat for marine turtles listed in proximity to the proposed sites, though turtles are observed in the region.

12.3.6 Biologically important areas – sawfish

There are no known biologically important areas for sawfish in relation to the proposed sites, though sawfish are observed in the region.

12.3.7 Biologically important areas – seabirds

A biologically important area is identified for both the lesser and greater frigatebird for almost the entire Buccaneer Archipelago, which includes all of the proposed sites (Figure 12.3). For the greater frigatebird, this area is identified as it is known that breeding occurs on the offshore islands beyond the extent of the Archipelago at Ashmore Reef (small numbers) and Adele Island (2-300 pairs), so there is potential for moderate usage of the nearshore areas where the sites are proposed to be sited. Breeding occurs in May-June and August. For the lesser frigatebird, breeding is known to occur on Ashmore Reef, Long Reef, Adele Island and Bedout Island in relation to the sites, and Lacepede Islands. Breeding occurs from March to September. Birds are generally resident in the area all year round, particularly within 30 km of the breeding sites, though they do move around the region to different islands for foraging (DAWE 2022).

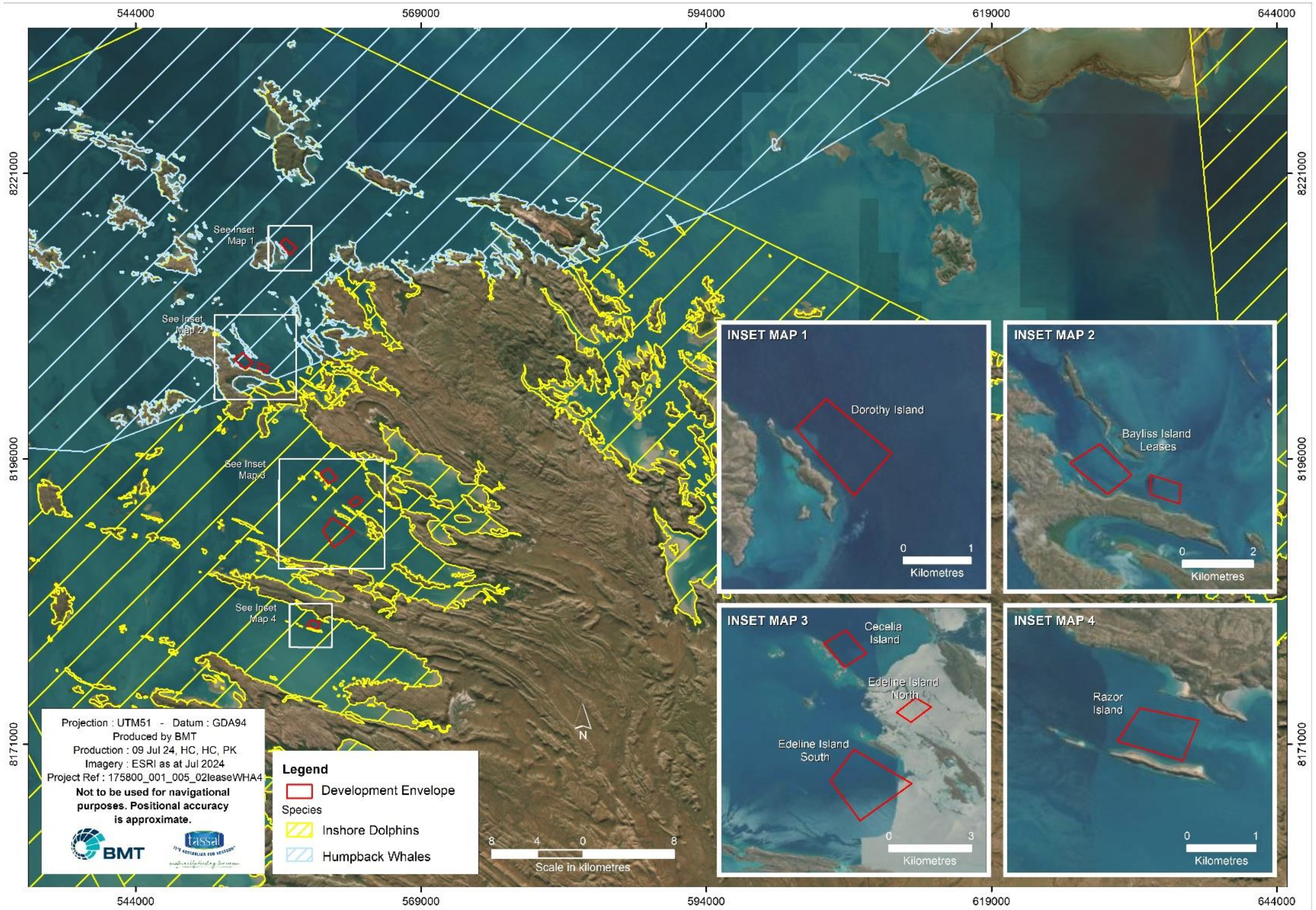


Figure 12.1 Biologically Important Areas for cetaceans in proximity to the proposed sites

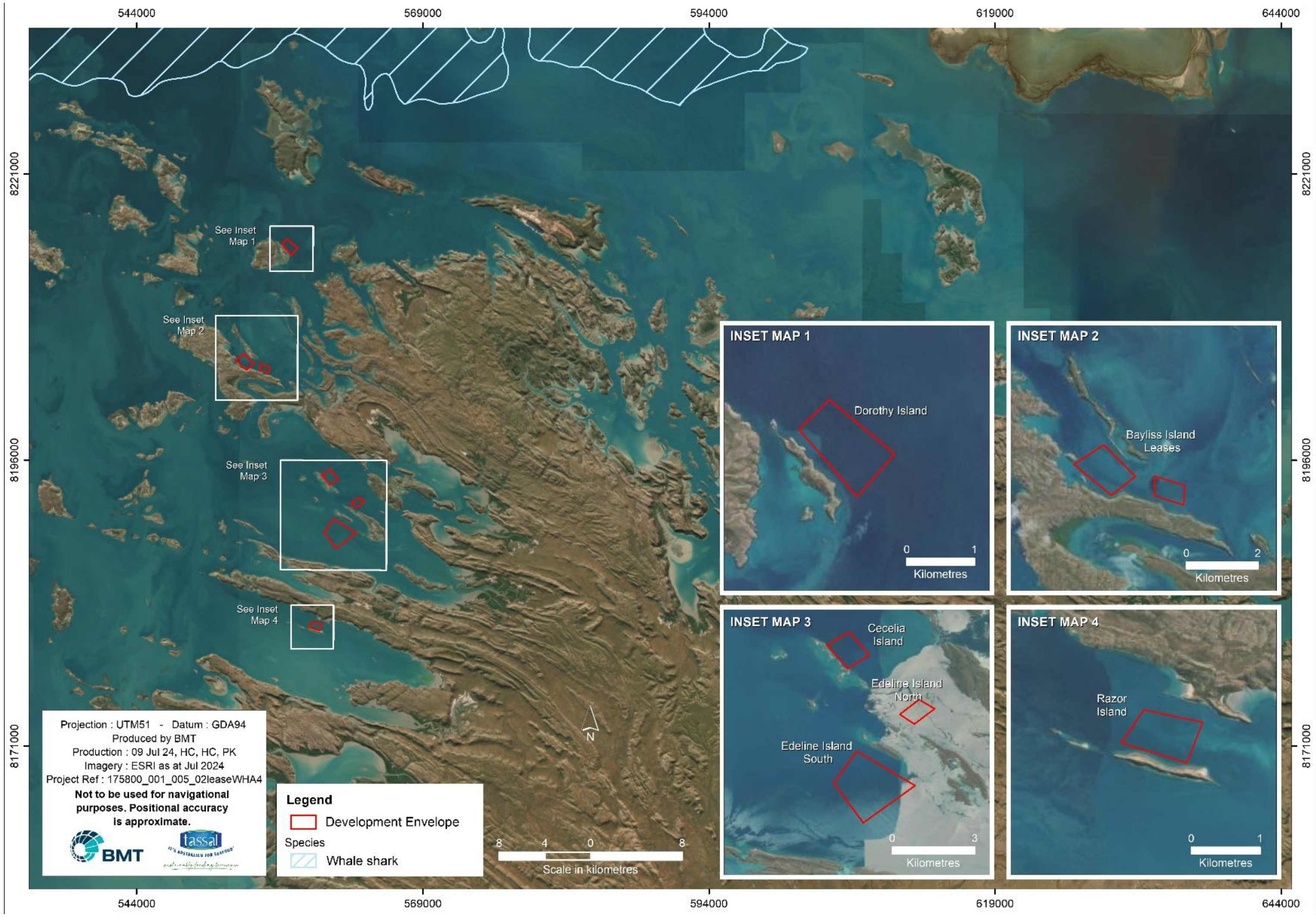


Figure 12.2 Biologically Important Areas for sharks in proximity to the proposed sites

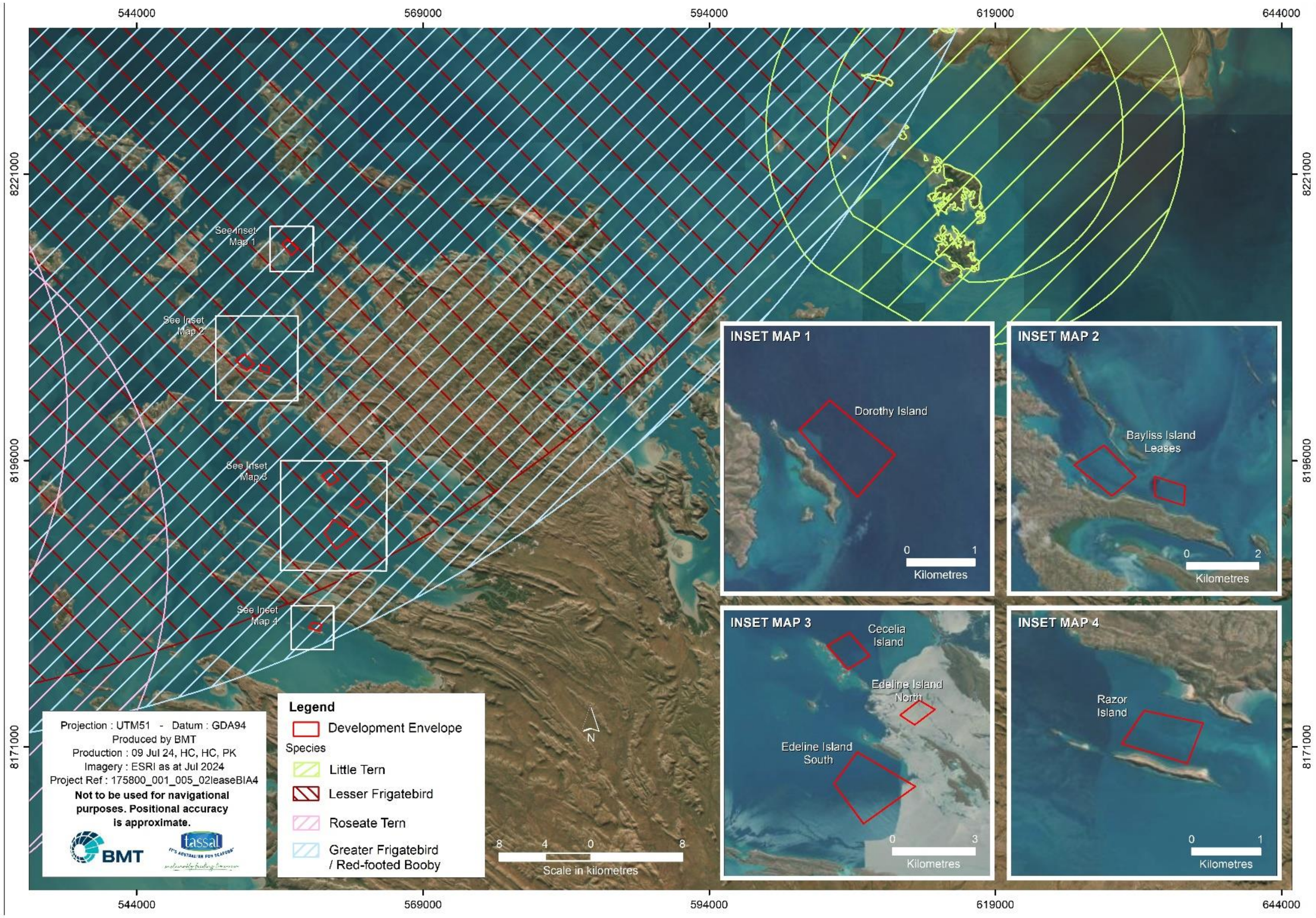


Figure 12.3 Biologically Important Areas for seabirds in proximity to the proposed sites

12.4 Summary of potential impacts

Potential impacts to MNES have been considered for both the construction and operation of the sites. All impacts are discussed in the relevant WA EPA environmental factors in Sections 7 and 9, as they primarily centre on flora and fauna which are covered also by state legislation, as well as the West Kimberley National Heritage Place. However brief summaries are provided below. With the lack of development in the region, there are also no significant cumulative impacts from other developments, past, present or near future, expected on MNES. Cumulative impacts which are present are summarised in Table 7.6 and Table 9.6.

The significance criteria of the potential impacts are aligned with those listed in DAWE (2013) and the marine bioregional plan for the North-west marine region (DAWE 2012), and definitions for significance are summarised below for the MNES relevant to this Proposal (Table 12.5).

Table 12.5 Significant impact criteria for MNES relevant to the Proposal

MNES	Significant impact criteria
Listed threatened species and ecological communities – critically endangered and endangered species, vulnerable species	• Lead to a long-term decrease in the size of a population • Reduce the area of occupancy of a species • Fragment an existing population into two or more populations • Adversely affect habitat critical to the survival of a species • Disrupt the breeding cycle of a population • Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline • Result in invasive species that are harmful to a critically endangered / endangered species habitat • Increase disease that may cause the species to decline • Interfere with the recovery of a species
Listed threatened species and ecological communities – critically endangered and endangered ecological communities, vulnerable ecological communities	• Reduce the extent of an ecological community • Fragment or increase fragmentation of an ecological community • Adversely affect habitat critical to the survival of an ecological community • Modify or destroy abiotic factors necessary for an ecological community's survival • Cause a substantial change in the species composition of an occurrence of an ecological community • Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community e.g. assisting invasive species or causing mobilisation of fertilisers, herbicides or other chemicals • Interfere with the recovery of an ecological community
Listed migratory species	• Substantially modify, destroy or isolate an area of important habitat for a migratory species • Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species • Seriously disrupt the lifecycle of an ecologically significant proportion of the population of a migratory species
National heritage places	• One or more of the National Heritage values to be lost • One or more of the National Heritage values to be degraded or damaged • One or more of the National Heritage values to be notably altered, modified, obscured or diminished

12.4.2 West Kimberley National Heritage Place

Potential impacts to the West Kimberley National Heritage Place from the Proposal, as well as the significance assessment of these impacts, is provided in Table 12.6 and Table 12.7.

Table 12.6 Potential impacts to the relevant values of the West Kimberley National Heritage Place from the Proposal

Relevant National Heritage Place Values	National Heritage Criteria	Relevant Significant Impact Guidelines Criteria Examples (DoE 2013) An action is likely to have a significant impact on heritage values of a National Heritage place if there is a real chance or possibility that the action will:	Potential Impacts to the WKNHP Values from the Proposed Action	Impact Type
Natural Heritage Values:				
Biological and ecological values	Criteria A: Events and processes - Ecology, biogeography, and evolution Criteria C: Research - Ecology, biogeography, climate, and evolution Criteria D: Principal characteristics of places - Ecology, biogeography, and evolution	• modify or inhibit ecological processes in a National Heritage place. • reduce the diversity or modify the composition of plant and animal species in a National Heritage place. • fragment or damage habitat important for the conservation of biological diversity in a National Heritage place. • cause a long-term reduction in rare, endemic, or unique plant or animal populations or species in a National Heritage place. • fragment, isolate, or substantially damage habitat for rare, endemic or unique animal populations or species in a National Heritage place.	• Changes to the biological and ecological values of the WKNHP due to: • Habitat modification (physical) • Vessel disturbance • Anthropogenic noise • Anthropogenic light • Entanglement • Habitat modification (chemical, nutrient and hydrocarbon discharge)	Direct
			• Changes to natural predatory behaviour • Invasive species • Disease and pathogens	Indirect
Values associated with geology or landscapes	Criteria D: Principal characteristics of places - ancient landscapes, geological processes.	• damage, modify, alter or obscure important geological formations in a National Heritage place. • divert, impound or channelise a river, wetland or other water body in a National Heritage place, and • substantially increase concentrations of suspended sediment, nutrients, heavy metals, hydrocarbons, or other pollutants or substances in a river, wetland, or water body in a National Heritage place.	Changes to the natural landscapes within the WKNHP from changes to hydrodynamic conditions Changes to the substantially unmodified nature of the natural landscapes due to: • Nutrient enrichment and subsequent algal blooms. • Increased toxicity from hydrocarbon spills/ waste generation/ ammonia waste/ antibiotics.	Direct
Wilderness, aesthetic or other rare or unique environmental values.	Criteria E: Aesthetic characteristics - Wealth of land and sea.	• introduce noise, odours, pollutants, or other intrusive elements with substantial and/or long-term impacts on relevant values. • involve the construction of buildings or other structures within, adjacent to, or within important sight lines of, a National Heritage place which are inconsistent with relevant values	Changes to the aesthetic characteristics of WKNHP through: • The construction and operation of sea-pens and associated infrastructure • Disturbance to visual amenity • Increased lighting • Increased vessel traffic	Direct
			• Increase in odours from fuel emissions.	Indirect
Indigenous Heritage Values:				
Indigenous heritage values	Criteria A: Events and processes - Wealth of land and sea Criteria E: Aesthetic characteristics - Wealth of land and sea.	• restrict or inhibit the continuing use of a National Heritage place as a cultural or ceremonial site causing its values to notably diminish over time. • permanently diminish the cultural value of a National Heritage place for an Indigenous group to which its National Heritage values relate. • alter the setting of a National Heritage place in a manner which is inconsistent with relevant values. • destroy, damage or permanently obscure rock art or other cultural or ceremonial, artefacts, features, or objects in a National Heritage place.	Changes to the Indigenous heritage values of the WKNHP through: • Disturbance to features of cultural and/or environmental importance. • Disturbance to cultural associations and traditions on sea country through loss of public access to sites.	Indirect

Relevant National Heritage Place Values	National Heritage Criteria	Relevant Significant Impact Guidelines Criteria Examples (DoE 2013) An action is likely to have a significant impact on heritage values of a National Heritage place if there is a real chance or possibility that the action will:	Potential Impacts to the WKNHP Values from the Proposed Action	Impact Type
		• involve activities in a National Heritage place with substantial and/or long-term impacts on the values of the place.		

Table 12.7 Significance of impact assessment of the relevant values of the West Kimberley National Heritage Place from the Proposal

Relevant National Heritage Place Values	National Heritage Place Criteria	Activity	Potential impacts	Impact Type	Extent	Duration	Significance of Impact (prior to the application of mitigation measures)
Biological and ecological values	Criteria A: Events and processes - Ecology, biogeography, and evolution Criteria C: Research - Ecology, biogeography, climate, and evolution Criteria D: Principal characteristics of places - Ecology, biogeography, and evolution	Construction / Operation	Habitat modification (physical) through: • Removal of Benthic Community and Habitats (BCH) • Plume generation • Minor blocking of channels through which marine fauna migrate. • Shading	Direct	Limited (within sites)	Lifetime of project	Direct removal of BCH may occur through the construction activities (placement of cages, anchoring, etc.) of the Proposal. Construction on the seafloor is limited to the sea-pen anchorages, therefore direct losses of BCH, where present, will be limited to the size of the anchorages, each of which has a footprint of 4 m^2. With ~36 anchorages per site (between the sea-pens and the barges), this equates to a total footprint of approximately 0.12 ha. The installation of such anchors will not result in significant sediment plumage (i.e., total suspended solids), and any material that is re-suspended is expected to settle in less than a day. Construction activities and the physical structure of the cages may discourage marine fauna from transiting through certain channels, particularly at the Bayliss Islands sites. However, this is not regarded as a major channel for the passage of marine fauna, with multiple alternate areas available which marine fauna could pass through without any additional physical effort. Given the small extent of the sites compared to the surrounding marine region and limited duration of construction, any risk of impediment from construction activities and the cages is not considered significant. Roebuck Bay is a site of international importance for waterbird species which is listed as a national heritage value for its recognition as an important migratory hub for waterbird species. Given that Roebuck Bay is located > 150km from the Proposal, it is unlikely that the value of Roebuck Bay as an important migratory hub for waterbird species will be impacted. The sea-pen infrastructure will reduce light conditions underneath the cages, which may result in shading effects and alteration of the composition of any BCH, if present.
			Vessel disturbance	Direct	Limited (within sites)	Lifetime of project	Vessels used during construction and operation phases at the sites have the potential to disturb and strike marine fauna. This is particularly relevant for inshore dolphins and marine turtles. However, the number of vessels operating in the vicinity of the sites is not expected to increase significantly (two vessels total transiting between sites). As such, the level of vessel disturbance and risk of vessel strike is no greater than that which currently exists from commercial and recreational fishers.
			Anthropogenic noise/vibration	Direct	Limited (close to or within sites)	<1 day at a time during construction	The scale of noise generated by vessel movements and construction activities will be small given the very short duration of the construction phase and limited extent of vessel movements. These noise levels are not predicted to be harmful to marine fauna but will likely be audible, which may disturb or repel marine fauna.

Relevant National Heritage Place Values	National Heritage Place Criteria	Activity	Potential impacts	Impact Type	Extent	Duration	Significance of Impact (prior to the application of mitigation measures)
						Throughout operations	As such, the potential impacts on marine fauna are more likely to be centered on short-term behavioural responses. Noise/vibrations generated by operational activities at the sites may result in localised noise pollution, however it is not expected to be at an intensity or extent to significantly impact marine fauna.
			Anthropogenic light	Direct	Limited (near sea-pens)	<10 hours a day over the lifetime of project	All operations will be primarily conducted during daylight hours, with no operational lighting taking place at night. Low levels of light pollution will be generated at each of the sites by the safety and navigational lighting (flashing LEDs) on the corners of the sea-pens and on the centralised barges. Some additional lighting will also be present on the barges since they are the accommodation centres for Tassal staff at the sites. Lighting around the sea-pens and vessels may attract/repel marine fauna and birds, or disorientate marine turtle hatchlings, however since the lighting at the sites is centered around the barge systems, it is not expected that significant light pollution would be observed beyond the border of the sites.
			Entanglement	Direct	Limited (near sea-pens)	Lifetime of project	There is potential that marine fauna and waterbirds could become entrapped or entangled in the anchorage lines, mooring system, or netting of the sea-pens whilst in operation. To ensure that the barramundi stock is contained within, the mesh size of the netting will be relatively small, which reduces the risk of any fauna becoming entangled with the netting from the outside. In order to maintain the position of the sea-pens, anchorage lines will remain taut and highly rigid, which would be difficult for any fauna to become entangled within.
			Habitat modification through: Chemical, nutrient, and hydrocarbon discharge Subsequent shading and smothering	Direct / Indirect	Broad (well beyond sites)	Lifetime of project	There may be increased chemical, nutrient, and hydrocarbon discharge from the Proposal due to fish feed, faecal wastes or general waste during the construction and operation activities. These discharges may result in the deterioration of the local water quality and benthic habitats within the WKNHP. Increased nutrient discharge may lead to phytoplankton biomass proliferation and increased likelihood of algal blooms, which have potential negative downstream effects on marine habitat and associated fauna. Nutrient inputs will be highest at the end of the grow-out period of the barramundi, after which the sea-pens have a one-month fallow period during which no impacts occur. An increase in phytoplankton biomass due to elevated nutrient inputs from aquaculture wastes may result in increased TSS in the water column, which can further increase light attenuation at the sea floor and in turn affect the benthic composition of the sea floor. This may lead to shading and smothering effects on BCH. Current modelling predicts velocities of 20-50 cm/s at the surface and 10-30 cm/s at the benthos (Annex B) around the Proposal area, which is conducive to conditions described as either 'moderately' or 'not sensitive' to impact. The breakdown of algal material may lead to deoxygenation events in the water column which can result in localised deaths of marine fauna. Modelling of the average current velocities in the Proposal area revealed speeds of 20-50 cm/s at the surface and 10-30 cm/s at the benthos (Annex B), whereas currents speeds >10 cm/s are widely considered 'ideal' for sea-pen aquaculture. The extent of water movement through the system is such that the level of oxygen drawdown is unlikely to have ecological consequence, as oxygen levels are quickly resupplied by new seawater inputs.

Relevant National Heritage Place Values	National Heritage Place Criteria	Activity	Potential impacts	Impact Type	Extent	Duration	Significance of Impact (prior to the application of mitigation measures)
			Change to natural predatory behaviour	Indirect	Limited (near sea-pens)	Lifetime of project	Marine fauna, including waterbirds, may change their natural behaviour if they can access the sea-pens and prey on farmed fish. Surface anti-bird mesh netting will be attached to the sea-pens to prevent seabirds accessing the stock and feed, whilst preventing waterbirds from getting caught or stuck within the mesh netting due to the small mesh size. Due to the taut, rigid material used in the sea-pen infrastructure, it is unlikely that marine fauna, including waterbirds, will be at risk of becoming entangled or entrapped in the sea-pen infrastructure.
			Invasive species	Indirect	Limited (within sites)	Lifetime of project	The potential risk of introducing invasive marine species to the marine environment at the Proposal area arises from biofouling on vessel hulls moving between the shore-base and the aquaculture sites. However, since these vessels will not transit beyond the Kimberley region, there will be no risk of introducing novel invasive marine species into the Buccaneer Archipelago. Furthermore, Tassal's vessels will only be docked at port for a short space of time (less than 5 days at a time generally), therefore the expected risk of invasive species interacting with the vessel is relatively low.
			Disease and pathogens	Indirect	Moderate (potential for impact beyond sites)	Beyond lifetime of project	Any escape of barramundi from the sea-pens may pose a risk of introducing diseases into local native populations of barramundi. This could have a significant impact and potentially change the genetic structure of native populations, particularly if there is no immunity to the introduced disease and the barramundi are given the opportunity to interbreed.
Values associated with geology or landscapes	Criteria D: Principal characteristics of places - ancient landscapes, geological processes.	Construction / Operation	Change to hydrodynamic conditions	Direct	Limited (immediate vicinity of the sea-pens)	Lifetime of project	The installation of the sea-pens may change the local hydrodynamics around the sites through restriction of water flow and velocity enhancement of the water beneath the sea-pens, which, although dependent on depth, may result in scouring of the seabed. This relationship may lead to the alteration and degradation of the seabed geology and benthic communities. The placement of the sites and so too the sea-pens has avoided benthic communities and habitats as much as possible to limit disruption to ecological processes.
			Nutrient enrichment and subsequent algal blooms	Direct	Broad (nutrient enrichment may extend to a regional scale)	Lifetime of project	There may be increased nutrient enrichment due to fish feed and/or faecal wastes in the water column, which may lead to phytoplankton biomass proliferation and increased likelihood of algal blooms, which have potential negative downstream effects on marine habitat and associated fauna. Nutrient inputs will be highest during the 18-month grow-out period of the barramundi, after which the sea-pens have a one-month fallow period during which no impacts occur.
			Toxicity (hydrocarbon spills and waste generation)	Direct	Limited (vessels are only small and as such do not contain a significant amount of fuel)	<1 week for a spill to occur and be cleaned up	Construction and operational activities for the Proposed Action present potential risk of hydrocarbon spills and waste generation. Sources of hydrocarbon discharge from the Proposed Action area include fuel spills from transport and support vessels, barges, or diesel generators. The extent of the impact will be limited as construction vessels are only small and as such do not contain a significant amount of fuel. The operation will also generate a small quantity of used oil from engine servicing at each site. The duration of potential impacts will be short, with the clean-up of any hydrocarbon discharge to be completed within <1 week of the spill occurring. The deposition of aquaculture waste products (i.e., finfish feed, faecal wastes) may result in deoxygenation and a change to sediment chemistry, including the creation of anoxic zones, potentially impacting BCH where present. Current modelling predicts velocities of 20-50 cm/s at the surface and 10-30 cm/s at the benthos around the Proposal area, whereas currents speeds >10 cm/s are widely considered 'ideal' for sea-pen aquaculture. The extent of water movement through

Relevant National Heritage Place Values	National Heritage Place Criteria	Activity	Potential impacts	Impact Type	Extent	Duration	Significance of Impact (prior to the application of mitigation measures)
							the system is such that the level of oxygen drawdown is unlikely to have ecological consequence, as oxygen levels are quickly resupplied by new seawater inputs.
		Operation	Toxicity (ammonia)	Indirect	Broad (nutrient enrichment may extend to a regional scale)	Lifetime of project	Ammonia wastes produced by the farmed finfish may cause deterioration and concentration to a toxic level if waters are not well mixed. The impacts from deoxygenation and ammonia toxicity are largely dependent on the depth of the water and the rate of water movement through the site. Current modelling predicts velocities of 20-50 cm/s at the surface and 10-30 cm/s at the benthos around the Proposal area, which is conducive to conditions described as either 'moderately' or 'not sensitive' to impact.
			Toxicity (anti-biotics)	Indirect	Moderate (potential for impact beyond leases)	Lifetime of project	The input of anti-biotics into the aquaculture farms may impart pressure on the marine environment by directly harming fauna or changing the composition of sediment bacteria communities, which in turn may affect broader ecological processes and habitat quality. Though commonly used in other finfish farming operations in Australia and elsewhere, the use of anti-biotics by Tassal at the current Cone Bay site is generally minimal due to ongoing vaccination programs.
Wilderness, aesthetic or other rare or unique environmental values.	Criteria E: Aesthetic characteristics - Wealth of land and sea.	Construction / Operation	Change to aesthetic characteristics	Direct	Limited (close to or within sites)	Lifetime of project	The sea-pens at the sites have the potential to change the aesthetic characteristics of WKNHP in the local area through disruption to local tourist, fishing or public activities and loss of access/usage of areas in the footprint of the Proposal area. Due to the small footprint which the sites will occupy in comparison to the surrounding region, and the removal of the initially proposed sites closest to the tourist attraction ‘Horizontal Falls,’ the extent of impacts to the aesthetics of the WKNHP is considered minimal.
			Change to aesthetics – visual amenity	Direct	Limited (close to or within sites)	Lifetime of project	Installation and operation of the sea-pens at the sites, including the associated infrastructure of the surface netting, above-water support poles and covered walkways, has the potential to change the visual amenity of the local area and aesthetic value of nearby cultural heritage sites. The proportion of sea-pen infrastructure which will extend above the water is unlikely to modify the visual landscape such that it would have a significant impact on the visual amenity of the local area. Furthermore, to comply with national marine safety standards, vessels and associated infrastructure will exhibit muted tones and restrict bright colours, which reduces the visual footprint and detectability of the sites in the wider area.
			Change to aesthetics – light pollution	Direct	Limited (close to or within sites)	Lifetime of project	Construction and operation of the aquaculture sites have the potential to change the aesthetic characteristics of WKNHP through increased lighting at the sea-pens, barges, and operating vessels. All operations will be primarily conducted during daylight hours, with no operational lighting taking place at night. Low levels of light pollution will be generated at each of the sites by the safety and navigational lighting (flashing LEDs) on the corners of the sea-pens and on the centralised barges. Some additional lighting will also be present on the barges since they are the accommodation centres for Tassal staff at the sites. As lighting at the sites is centred around the barge systems, it is not expected that significant light pollution would be observed beyond the border of the sites.
			Change to aesthetics – vessel traffic	Direct	Limited (within and near vicinity of sites)	Lifetime of project	The Proposal has the potential to change the aesthetic characteristics of WKNHP through increased vessel traffic for construction activities and operations. The number of vessels operating in the vicinity of the sites is not expected to increase significantly (two vessels total transiting between sites). As such, the level of vessel disturbance and risk of vessel strike is no greater than that which currently exists from commercial and recreational fishers.

Relevant National Heritage Place Values	National Heritage Place Criteria	Activity	Potential impacts	Impact Type	Extent	Duration	Significance of Impact (prior to the application of mitigation measures)
		Operation	Change to aesthetics - odour generation	Indirect	Limited (within sites)	Lifetime of project	There is potential risk of fuel emissions from diesel engines/generators to be generated during operations at the sites, which may impact the aesthetic or environmental values of the WKNHP. The extent of the impact will be limited as construction and operation vessels are small and as such do not contain a significant amount of fuel. The risk of odour generation is no greater than that which currently exists from commercial and recreational fishers.
Indigenous heritage values	Criteria A: Events and processes - Wealth of land and sea Criteria E: Aesthetic characteristics - Wealth of land and sea.	Construction / Operation	Disturbance to features of cultural and/or environmental importance	Indirect	Moderate (beyond the sites)	Lifetime of project	Construction and operations at the sites have the potential to disturb cultural associations of local Traditional Owner groups through a change in the environmental conditions, the significance of which has been discussed in this table prior. Within the WKNHP, there are features of significant heritage value to Indigenous communities, including pearl shell beds and painted 'rock art' sites. Rock art sites serve as geographical focal points for Indigenous tradition throughout the Kimberley, with sites located along the Kimberley coastline and islands. The Proposal will be sited only within the bounds of the Mayala Native Title Determination Area (NTDA), and consequently, features of Indigenous traditions of other NTDAs, such as the rock art sites under the Wanjina-Wunggurr tradition of the Dambimangari people, are not considered or included within this assessment. As the Proposal will be constructed and operated within the marine environment, any rock art sites, or land-based sites of significance to the Mayala people will not be directly disturbed, however indirect disturbance may potentially arise through alteration of access to such sites for tour groups and the local community. The findings of the heritage survey identified pearl shell beds sites which are of cultural importance to the Mayala people. Of note are the pearl shell beds in proximity to the sites situated near the Aveling Island. The placement of the aquaculture sites has been arranged as to avoid any proposed sanctuary zones and special purpose zones (cultural protection) within the Mayala Marine Park (Figure 1.4), as well as any cultural sites identified by the Mayala people during the Heritage Survey. Pearl shell bed sites will not be directly impacted, however indirect impacts may arise through changes to marine environmental conditions as a result of nearby construction and operational activities.
			Disturbance to cultural associations and traditions - loss of public access to sites.	Direct	Limited (within sites)	Lifetime of project	Once the Proposal is operational, there will be a loss of public access to the marine areas within the sites. The footprint of the 7 sites will cover a total area of 817 ha, however the area for access to be excluded within each site relates only to the areas of space between the twelve sea-pens due to piping and net infrastructure. This area will occupy only a small portion of the wider marine environment such that the sites are unlikely to significantly disrupt any access to, or public activities within, environmentally and culturally significant areas.

12.4.3 Migratory / Threatened Species

Table 12.8 Potential impacts to MNES as a result of the construction / operation of the Proposal

MNES	Development type	Potential impacts	Impact	Context and assessment	Extent	Duration	Significance of Impacts (according to MNES guidance)
Threatened / migratory species	Leases	Vessel strike	Direct	Vessels operating at the sites have the potential to strike marine fauna. This is particularly relevant for inshore dolphins and marine turtles. However, the number of vessels operating in the vicinity of the sites is not expected to increase significantly (3 vessels total transiting between sites). As such, the risks of vessel strike are no greater than that which currently exists from commercial and recreational fishers.	Limited (within development envelope)	Lifetime of project	Non-significant
	Leases	Noise/vibration generation	Indirect	Noise/vibrations generated during anchoring or towing of sea-pens may disturb or repel marine fauna. Noise/vibrations generated by vessels operating at the sites may result in localised noise pollution, however it is not expected to be at an intensity or extent to significantly impact marine fauna	Limited (close to or within sites areas)	<1 day at a time during construction Throughout operations	Non-significant
	Leases	Plume generation	Indirect	Small plumes may be created when anchorages are driven into seabed	Limited (within sites)	<1 day for anchoring to occur	Non-significant
	Leases	Increased risk of introduced marine pests	Indirect	Construction vessels may introduce marine pests not present in the area	Limited (within sites)	Throughout construction phase	Non-significant
	Leases	Entanglement	Direct	Marine fauna may become entangled in anchorage lines or sea-pens particularly if they are attracted to sea-pens by potential opportunity to feed on farmed fish	Limited (in close proximity to the pens)	Lifetime of project	Non-significant
	Leases	Change to natural predatory behaviour	Direct	Marine fauna, particularly avifauna, may change their natural behaviour if they can	Limited (in close proximity to pens)	Lifetime of project	Non-significant

MNES	Development type	Potential impacts	Impact	Context and assessment	Extent	Duration	Significance of Impacts (according to MNES guidance)
				access the sea-pens and prey on farmed fish			
	Leases	Waste generation	Indirect	Wastes generated (e.g. farmed fish mortalities) may attract marine fauna if not disposed of appropriately	Limited (within leases)	Lifetime of project	Non-significant
	Leases	Light pollution	Indirect	Lighting around the sea-pens and vessels may attract/repel marine fauna, or disorientate marine turtle hatchlings	Limited (in close proximity to pens)	<10 hours a day Lifetime of project	Non-significant
	Leases	Increase in nutrients in water column resulting in increased likelihood of algal blooms	Indirect	Increased nutrient loading from fish wastes or feed increases the likelihood of algal blooms, which if they become harmful/toxic may poison marine fauna	Broad (well beyond sites)	During 18-month grow-out cycle. 1-month fallowing period with no impacts. Lifetime of project	Significant
	Leases	Deoxygenation of the water column as a result of algal blooms	Indirect	The breakdown of algal material may lead to deoxygenation events in the water column which can result in localised deaths of marine fauna	Broad (well beyond sites)	Lifetime of project	Significant
	Leases	Increased risk of introduced marine species	Indirect	Vessels operating at the sites may introduce species as they mobilise from different ports	Limited (within sites)	Lifetime of project	Non-significant
	Leases	Minor blocking of channels through which marine fauna migrate through	Indirect	The physical structure of the pens may discourage marine fauna from transiting through certain channels, particularly at the Bayliss Islands sites	Limited (close proximity to pens)	Lifetime of project	Non-significant

Vessel strike

The Proposal will result in an increased risk of vessel strike particularly in the vicinity of the sites where the sea-pen infrastructure will be installed. This risk is generally only from the three operational vessels that Tassal are proposing to use, each of which is approximately 15-20 m long, as well as other smaller dinghies used in operations at each site. MNES which are likely most at risk of being stricken include inshore dolphin species (humpback, snubfin and spotted bottlenose dolphins), humpback whales, dugongs, resting sea/water birds and sea-turtles, considering each spends significant time at the surface to breathe as well as for foraging and other key behaviours. The risk to humpback whales will be seasonal, considering they are only present in the Kimberley region between June-August. The risk to migratory seabirds will also be seasonal. The risk to all other listed MNES will be year-round, as the majority of these species are resident in the region and do not undertake any significant migrations. Considering the vessels will however only operate at very slow speeds within the sites (<8 knots) and will only be transiting between sites which are within close proximity to each other, the risk of vessel strike occurring is relatively low.

Entanglement

There is only a minor risk of entanglement of listed MNES with the sea-pen infrastructure (i.e. anchorage lines, sea-pen netting), as to maintain the sea-pens in position the anchorage lines must be very rigid or taut. Few other ropes or lines which might pose a risk of entanglement are present. This as such makes it difficult for any fauna to become entangled in the line. In terms of the netting, the mesh size is relatively small to ensure that no farmed fish are able to escape, and as such this reduces the risk of any marine fauna on the outside from becoming entangled themselves.

Noise generation

Noise generated by vessels and diesel generators used at the sites for both construction and operations has the potential to result in localised noise pollution, which may impact marine fauna in the region, particularly inshore dolphins which are known to use the area around the proposed sites year-round for breeding, calving and foraging. The operational vessels used for the Proposal will always operate at less than 8 knots within the sites and will only operate at higher speeds when transiting between sites. As such, the intensity of the noise generated by the vessels engines is predicted to be in the order of 130 dB at most (Olesiuk et al 2012). The diesel generators in use at the sites will also create some low-level noise pollution above the surface of the water, likely in the order of ~86 dB (ASHRAE 2002). These noise levels are not predicted to be harmful to marine fauna, however they are likely to be audible. As such, the potential impacts on marine fauna are likely to be centred on short-term behavioural responses (e.g. separation of mother-calf pairings, fleeing from site of disturbance), long-term avoidance (e.g. reduced abundance within or utilisation of noisy areas) and masking of animal sounds (e.g. masking of prey resulting in increase to foraging effort, masking of communication between individuals resulting in decrease in reproductive rates) (Olesiuk et al 2012).

Studies of the effects of whale watching vessels, which are likely comparable to the small vessels used at aquaculture sites, showed the source levels ranged from 145 to 169 dB re: 1uPa @ 1m, slightly higher than that likely to be generated by the vessels used in the Proposal. According to the criteria in Southall et al (2007), noise at these levels could potentially result in moderate behavioural responses in the low-frequency cetaceans at distances of up to 10 km, and up to several kilometres for other functional marine mammal groups (humpback dolphins for example detect sounds in the range of 5-120 kHz which is in the mid to low frequency range, while humpback whales operate at a low frequency between 5-24 kHz; Li and Wang 2017, Whitlow et al 2006). However, the noise levels discussed here are for vessels operating at mid to high speeds, while the vessels in use at the sites will as stated only operate at very low speeds. Though vessels will operate at higher speeds when transiting, these transit times will be relatively short (generally 1 hour max) and will not be required every day of operations.

Previous studies have indicated that noise generated by routine aquaculture operations, which includes the use of diesel generators as well as pumps, pen cleaning with pressure hoses amongst others, is unlikely to be sufficient to cause injury to marine fauna, though it may result in behavioural responses at close range. For example, harbour porpoise at an aquaculture site in the Bay of Fundy were observed to be temporarily displaced by noisy activities such as pen cleaning yet returned quickly (within 10 minutes) to the area when the disturbance ended (Haar et al 2009). Furthermore, a study conducted at the site of the current Cone Bay operations to identify the presence and behaviour of snubfin and humpback dolphins indicated that the behaviour of the individuals present at the site were similar to behaviour of individuals at other sites in the region, and as such there was no suggestion that they were directly impacted by the noise generated by vessels nearby (Brown et al. 2017).

As the construction of the sites for the purposes of securing the sea-pens does not require any pile driving or other significant noise-generating activities, other than that of general vessel operations, it is not expected that the potential for noise pollution is any greater than that already described above.

Light pollution

A minor level of light pollution will be generated at each of the sites, with navigational lighting required on the sea-pens and vessels (flashing LEDs) for safety and navigation; while some lighting will also be present on the centralised barge considering it is the accommodation centre for Tassal staff at the sites. As the lighting required at each of the sites is centred around the barge systems, it is not expected that significant light pollution would be observed beyond the border of the sites.

Light pollution has the potential to change the behaviour of marine fauna, particularly marine turtle hatchlings which may be disorientated or misorientated by artificial light (Kamrowski et al 2012, Thums et al 2016, Wilson et al 2018). No biologically important areas (i.e. nesting sites) for marine turtles have been identified in proximity to any of the sites. It is possible that some turtles do nest on the sandy beaches in proximity to the sites, with these areas potentially not yet identified as survey effort has not been able to encompass the entire Buccaneer Archipelago considering its remoteness. However, due to the nature of the rugged coastline of the Archipelago and its islands, sandy beaches are very rare in proximity to the sites and, if they are present, they are generally less than 100 m in length. As such, considering the low level of light generated by the Proposal, and the lack of significant habitats in proximity to the Proposal, the potential impacts on marine turtles from light pollution are predicted to be non-significant.

Nutrient enrichment/algal blooms

Fish and feed wastes at the sites have the potential to result in nutrient enrichment, and subsequently algal blooms, in areas across the Archipelago (see Section 5.4 for details on modelling results of this particular impact). In relation to MNES, this does have the potential to impact the biological diversity of the region, which is a key value of the West Kimberley National Heritage Place. Though these risks are real, the modelling results predicted that even in areas of enrichment and/or high phytoplankton biomass (and therefore high risks of algal blooms) that no significant anoxia or hypoxia events were predicted to occur. The reason for this is that though the model projects high levels of biological oxygen demand at the sediment water interface, the extent of water movement through the system is such that the level of drawdown is unlikely to be ecological consequence, as oxygen levels are quickly resupplied by new seawater inputs.

12.4.4 Commonwealth land

The Proposal does not require any access to Commonwealth Land, with the only part of the Proposal in proximity to Commonwealth Land being the site near Razor Island in Cone Bay, which is approximately 5 km away at its closest point to the Yampi Sound Defence Area.

Though there will be vessel traffic to and from the sea-pends during daylight hours, there will be no vessel movements during night hours and the sea-pens should not provide any hazard to defence vessels as they will be suitably lit at night. As such, the Proposal will not cause any of the following impacts to Commonwealth Land:

- Changes to water quality on site or downcurrent of site
- Changes to siltation
- Hydrological impacts, including, but not limited to
  - Changes to surface or groundwater, and
  - Saltwater intrusion
- Removal and/ or degradation of heritage items/places
- Native flora and fauna habitat removal and degradation
- Noise and vibration impact on everyday activities and on sensitive environmental receptors
- Noise and vibration from construction
- Changes to air quality during construction and operation
- Vehicle strike (fauna)
- Lighting impacts on everyday activities and on sensitive environmental receptors
- Changes in recreational use and amenity of natural areas
- Creation of any risks or hazards to people and property that may be associated with any component of the action

12.5 Mitigation

Appropriate mitigation strategies in reference to threatened and migratory species and the WKNHP following the mitigation hierarchy have been applied and are summarised in Sections 5, 6, 7 and 9. In addition, a specific Heritage Management Plan (HMP; Stantec 2024b) will be implemented which details how indigenous heritage values, which are a key part of the WKNHP, will be managed.

Given that:

- the Proposal is not in proximity to or on Commonwealth Land;
- there are existing operations and sites between Razor Island and Commonwealth Land;
- operations near Razor Island will not inhibit access to and from Commonwealth Land; and
- operations near Razor Island will be well marked and lit at night;
- there is therefore no need for a Commonwealth Land Management Plan, or consideration of further mitigation methods for management of impacts to Commonwealth Land.

12.6 Assessment and residual impacts

The residual impacts of the Proposal on MNES are summarised in Table 12.9 where present. Overall, the Proposal, along with the potential cumulative impacts from other proposals or projects in the vicinity of this proposal, do not pose a significant impact to MNES on a regional or local scale. No offsets are expected to be required in relation to MNES.

Table 12.9 Residual impacts on MNES

Impact	Phase	Assessment	Residual impact
Vessel strike	Construction / operations	All vessels will be operating at ~1 knot during construction and will keep to local speed limits, meaning there is no greater risk of vessel strike from vessels from the project then there already is from tourist or fishing operations	Non-significant
Noise/vibration generation	Construction / operations	All noise and vibration will be kept to a minimum both during construction and operations. However, some noise generation which will be consistent at each site throughout the lifetime of the project will be present, potentially repelling fauna at a minor level. This is not expected to isolate populations of marine fauna or impact migratory routes.	Non-significant
Plume generation	Construction	The level of plume expected from anchoring the sea-pens using the low-profile anchoring system is minimal and will not pose a threat to marine fauna	Non-significant
Increased risk of introduced marine pests	Construction / operations	All vessels will be operating only on a local scale reducing the threat of introduction of IMS from other regions. DPIRD biosecurity protocol requirements will help ensure any IMS are detected before they pose a significant risk	Non-significant
Entanglement	Operations	Because of the tautness of the anchoring lines of the sea-pens it is very difficult for marine fauna to become entangled, meaning there is little to no risk of this impact occurring	Non-significant
Change to natural predatory behaviour	Operations	With the inclusion of anti-predator nets above and below the surface of the sea predators will be unable to enter the pens to feed on fish or fish feed, meaning no change to natural predatory behaviour is expected	Non-significant
Waste generation	Operations	With the inclusion of the mortality waste program and the removal of all wastes from vessels to the Derby shore base there is no waste which will be disposed of at sea,	Non-significant

Impact	Phase	Assessment	Residual impact
		therefore there will be no impact on marine fauna	
Light pollution	Construction / operations	Anchoring of the sea-pens / barges will only occur during the day reducing the amount of light pollution generated during construction to little or nothing. The amount of light generated once sites are operational lighting will be kept to a minimal level with the mitigation strategies included, therefore there is only a minor level of impact on marine fauna expected.	Non-significant
Spread of disease/change to genetic structure of native populations of barramundi if farmed fish escape from pens	Operations	With the use of an Australian barramundi genetic strain and appropriate fish health checks required under DPIRD regulations there is only a minor risk of fish escapees from the sea-pens causing any spread of disease or change to the genetic structure of the natural population of barramundi.	Non-significant
Increase in nutrients in water column resulting in increased likelihood of algal blooms	Operations	The level of nutrient enrichment from aquaculture wastes is substantial, though it will be significantly reduced through the mitigation strategies implemented by Tassal. Any potential for nutrient enrichment long-term will be monitored and managed under the EMMP to verify that Tassal's operations do not pose a continual risk of nutrient enrichment beyond the site boundaries	Non-significant
Deoxygenation of the water column as a result of algal blooms	Operations	Modelling results indicated that dissolved oxygen levels, even in close proximity to the sediments, remained relatively consistent between scenarios and between baseline conditions. Because dissolved oxygen is key to the survival of the stocked fish, it will be monitored on site at all sites every single day, in addition to the monitoring required under the EMMP. As such, any time low oxygen levels are recorded management actions will be immediately implemented to help increase oxygen levels.	Non-significant
Minor blocking of channels through which marine fauna migrate through	Operations	The worst potential blockage of channels will occur at Bayliss and Hidden Islands, at which there will still be at least 0.5 km of space between the pens and the shoreline for marine fauna to pass through. This is also not noted as being a major channel for the passage of marine fauna, while there are multiple alternate areas marine fauna could	Non-significant

Impact	Phase	Assessment	Residual impact
		pass through without any more physical effort	
Change to aesthetics	Operations	Though sea-pens will change the aesthetics in the sites, the use of the areas by tourists, commercial/recreational fishers and other users is expected to be minimal, even if tourism increases when the region where the sites are proposed will be designated as marine parks in the future.	Non-significant
Disturbance of culturally significant sites	Construction	The arrangement of the sites are such that disturbance to culturally or environmentally significant areas will be avoided. Tassal's adherence to the management strategies outlined in the management plans for the marine parks (DBCA 2020a, b, c) will further minimise any potential impacts to cultural associations or other values within the Archipelago. Cumulative impacts from other proposals or projects are therefore unchanged.	Non-significant

13 Holistic impact assessment

The EP Act principles and EPA guidance documents have been considered in this document to assess the potential impacts of the Proposal on the EPA’s environmental factors. The preliminary environmental factors considered most relevant to the Proposal are:

- Marine environmental quality
- Benthic communities and habitats
- Marine fauna
- Social surroundings

Each of these factors have been addressed separately in Sections 5-9 with other environmental factors considered in Section 10. Though it is predicted that the EPA's Objectives for each environmental factor can be met following implementation of this Proposal, some consideration for the holistic impacts of the Proposal on the environment must be undertaken as per EPA's guidance. The connection of these environmental factors, as well as the potential combined effects, residual impacts and final outcomes are summarised below, in line with EPA (2021c).

13.1 Interactions between environmental factors

13.1.1 Marine environmental factors

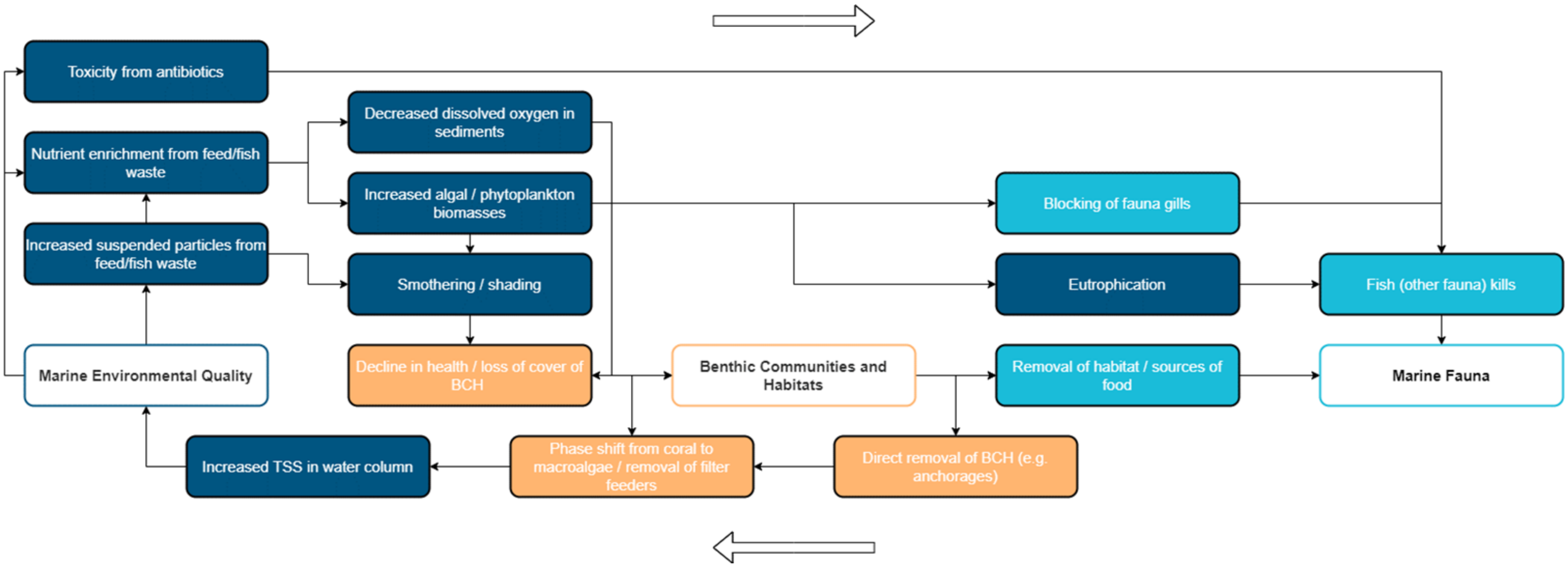
The EPA factors for marine environmental quality, benthic communities and habitats, and marine fauna are intrinsically linked. Potential impacts of the Proposal on one factor inherently impact other factors. The key interactions or connections present in this case are highlighted in Figure 13.1 and summarised below.

The project may result in several changes to marine environmental quality. These changes have the potential to either then directly or indirectly effect both benthic communities and habitats as well as marine fauna. The most significant potential changes will be because of nutrient enrichment from feed and fish wastes, both in the water column and in the sediments. Nutrient enrichment in the water column may result in increases to phytoplankton biomass as well as allowing for greater algal growth potential. Both changes may impact benthic communities and habitats, with elevated phytoplankton biomasses potentially increasing light attenuation at the benthos while algal growth on corals and other BCH is more likely with increased nutrients. In a worst-case scenario, this could eventually result in phase shifts from coral to macroalgal habitats. Nutrient enrichment in the sediments in a worst-case scenario can also result in deoxygenation of sediments, which may further result in the decline in health and/or loss of cover of benthic communities and habitats. An increase in particulate deposition from feed and fish wastes may further increase light attenuation at the benthos while potentially resulting in smothering effects on benthic communities and habitats.

Any potential changes to benthic communities and habitats could result in the loss of habitat or sources of food for any marine fauna present. Effects to marine environmental quality can also directly impact marine fauna. Fish kill events are also possible as a result of elevated phytoplankton biomasses, either directly if they block fish gills or indirectly in the event of eutrophication.

All of the above changes could further alter social surroundings, as they may result in the reduction in health of key environmental values, such as coral reefs or marine fauna, all of which are of great importance as Aboriginal cultural heritage, to fishers (both recreational and commercial), and tour groups who operate in the region. Any change to these values may impact these groups in different ways.

The results of the technical studies completed here however suggest that, once mitigation strategies are applied (e.g. targeting of an FCR of 1.5), the majority of the potential changes become minor in significance. Where residual impacts remain, these will all be directly monitored and managed under the EMMP. The monitoring will confirm if any of these potential changes are occurring before they result in a significant impact, with associated management actions at this point ensuring the reduction of the stressors relevant to the potential changes. As such, it is predicted that the EPA's objectives for each of the relevant key factors will be achieved.



Notes:

1. Dark blue = marine environmental quality impacts/effects, orange = benthic communities and habitats impacts/effect; light blue = marine fauna impacts/effects
2. Not all interactions between factors are shown, just those which are expected to be significant as a result of this proposal

Figure 13.1 Key interactions of impacts between marine environmental factors

13.2 Additional mitigation measures

No additional mitigation measures are required to mitigate combined effects between environmental factors. Each of the mitigation measures detailed above or in the EMMP (Annex A) will reduce the potential impact at its source, meaning combined effects are not likely to subsequently occur.

13.3 Assessment and residual impacts

No significant residual combined effects are expected from the Proposal once mitigation measures (specific for each environmental factor) are implemented.

13.4 Outcomes based conditions

Though each of the environmental factors are intrinsically linked with each other, and combined effects are possible as a result of the Proposal, each of the combined effects will be sufficiently mitigated through the strategies detailed in the sections for the respective key environmental factors noted above and in the EMMP (Annex A). As such, no outcomes-based conditions for the environment as a whole are expected to be necessary.

13.5 Summary

In summary, the Proposal has the potential to alter various aspects of the environment, particularly marine environment quality and benthic communities and habitats. The mitigation strategies implemented however are expected to reduce the overarching environmental impact. As such, the Proposal does not pose a significant risk to the environment as a whole, with the potential for impacts on one factor causing follow-on effects on another negligible with the management actions detailed under the mitigation hierarchy including the monitoring specified in the EMMP.

14 Cumulative environmental impact assessment

Cumulative impacts from this proposal have been considered within the respective impact assessment sections for each key environmental factor. Overall, no significant cumulative impacts are expected, either from past, current or near-future projects. The only project which has the potential for cumulative impacts is the Koolan Island Iron Ore mine on benthic communities and habitats. The impacts of this Proposal, in conjunction with those from the mine are not expected to result in significant losses of habitats. Furthermore, any future impacts on the marine environment in the region of the Proposal will be mitigated with the inclusion of the whole region under the Lalang-gaddam, Mayala and Bardi Jawi Gaarra Marine Parks. As such, it is expected that the EPA's objectives for each of the respective environmental factors discussed here will be met after the implementation of this Proposal.

15 References

AFMA (2012) Northern Prawn Fishery Operational Information 2012, Australian Fisheries Management Authority. Canberra, Australia

AFMA (2015) Ecological risk management: report for the Western Tuna and Billfish Fishery, Australian Fisheries Management Authority, Canberra

AFMA (2021a) Bigeye tuna. Australian Fisheries Management Authority. Available at <https://www.afma.gov.au/fisheries-management/species/bigeye-tuna> [Accessed 22 October 2021]

AFMA (2021b) Skipjack tuna. Australian Fisheries Management Authority. Available at <https://www.afma.gov.au/fisheries-management/species/skipjack-tuna> [Accessed 22 October 2021]

AFMA (2021c) Scampi. Australian Fisheries Management Authority. Available at <https://www.afma.gov.au/fisheries-management/species/scampi> [Accessed 22 October 2021]

AFMA (2021d) Striped Marlin. Australian Fisheries Management Authority. Available at <https://www.afma.gov.au/fisheries-management/species/striped-marlin> [Accessed 22 October 2021]

AFMA (2021e) Yellowfin Tuna. Australian Fisheries Management Authority. Available at <https://www.afma.gov.au/fisheries-management/species/yellowfin-tuna> [Accessed 22 October 2021]

Anderson MJ, Gorley RN, Clarke KR (2008) PERMANOVA+ for PRIMER: Guide for Software and Statistical Methods. Prepared by University of Auckland and Plymouth Marine Laboratory, Plymouth, UK

ANZECC & ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Volume 1: The Guidelines, Prepared by Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand, Canberra, ACT, October 2000

ANZG (2018) Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Available from <http://www.waterquality.gov.au/anz-guidelines> [Accessed 08 September 2021]

Austen MC, Warwick RM, Rosando MC (1989) Meiobenthic and macrobenthic community structure along a putative pollution gradient in southern Portugal. Marine Pollution Bulletin 20: 398–405

Baden SP, Loo L-O, Pihl L, Rosenberg R (1990) Effect of eutrophication on benthic communities including fish: Swedish West Coast. Ambio 19: 113–122

Bannister JL, Kemper CM, Warneke RM (1996) The Action Plan for Australian Cetaceans. Canberra: Australian Nature Conservation Agency. Available at <http://www.environment.gov.au/resource/action-plan-australian-cetaceans> [Accessed 20 October 2021]

Barrett G, Silcocks A, Barry S, Cunningham R, Poulter R (2003) The New Atlas of Australian Birds. Melbourne, Victoria: Birds Australia.

Bayliss P, Hutton M (2017) Integrating Indigenous knowledge and survey techniques to develop a baseline for dugong (*Dugong dugon*) management in the Kimberley: Final Report of project 1.2.5 of the

Kimberley Marine Research Program Node of the Western Australian Marine Science Institution, WAMSI, Perth, Western Australia, 98 pp

Bellwood DR, Hughes TP, Folke C, Nystrom M (2004) Confronting the coral reef crisis. Nature 429: 827–833

Benshemesh J (2007) National Recovery Plan for Malleefowl *Leipoa ocellata*. Department for Environment and Heritage, South Australia.

Benson SR, Eguchi T, Foley DG, Forney KA, Bailey H, Hitipeuw C, Samber BP, Tapilatu RF, Rei V, Ramohia P, Pita J, Dutton PH (2011) Large-scale movements and high-use areas of western Pacific leatherback turtles, *Dermochelys coriacea*. Ecosphere. 2(7):art84.

Birdlife Australia (2021) Birdata: Custom Atlas Bird Lists (custom search). Available at <https://birdlife.org.au/projects/atlas-and-birdata> [Accessed November 2021]

Blakers M, Davies SJJF, Reilly PN (1984) The Atlas of Australian Birds. Melbourne, Victoria: Melbourne University Press.

BMT (2019) Delma Island Aquaculture Development Zone, Modelling Report, R.B22025.002.00

BMT (2020) TUFLOW FV User Manual, Build 2020.01, Sediment Transport and Particle tracking modules

BMT Oceanica (2016) Modelling and Technical Studies in Support of the Mid-West Aquaculture Development Zone, Technical Report,1051_009/1_Rev3

BOM (2021) Weather station 003073 - 1991-2020 Weather and Climate Data. Bureau of Meteorology.

Borja A, Rodriguez GJ, Black K, Bodoy A, Emblow C, Fernades TF, Forte J, Karakassis I, Muxika I, Nickell TD, Papageorgiou N, Pranovi F, Sevastou K, Tomassetti P, Angel D (2009) Assessing the suitability of a range of benthic indices in the evaluation of environmental impact of fin and shellfish aquaculture located in sites across Europe. Aquaculture 293: 231-240

Boudreau BP (1996) A method-of-lines code for carbon and nutrient diagenesis in aquatic sediments. Computers & Geosciences, 22(5): 479-496

Brigolin DR, Pastres TD, Nickell CJ, Cromey DR, Aguilera and P Regnier (2009) Modelling the impact of aquaculture on early diagenetic processes in sea loch sediments. Marine Ecology-Progress Series 388: 63-80

Brocx M, Semeniuk V (2011) The Global Geoheritage Significance of the Kimberley Coast, Western Australia. Journal of the Royal Society of Western Australia. 94: 57-88.

Brooks KM, Stierns AR, Backman C (2004) Seven-year remediation study at the Carrie Bay Atlantic salmon (Salmo salar) farm in the Broughton Archipelago, British Columbia, Canada. Aquaculture 239: 81-123

Brooks KM, Stierns AR, Mahnken CVW, Blackburn DB (2003) Chemical and biological remediation of the benthos near Atlantic salmon farms. Aquaculture 219: 355—377

Brown AM, Bejder L, Pollock KH, Allen SJ (2016) Site-Specific Assessments of the Abundance of Three Inshore Dolphin Species to Inform Conservation and Management. Frontiers in Marine Science Volume 3 DOI=10.3389/fmars.2016.00004. ISSN=2296-7745

Brocx M, Semeniuk V (2011) The global geoheritage significance of the Kimberley Coast, Western Australia. Journal of the Royal Society of Western Australia 94: 57-88.

Burbidge A (2018) Recent news regarding Night Parrots (October 2018). The Night Parrot Recovery Team. Available at <https://nightparrot.com.au/index.php/2018/10/12/recent-news-regarding-night-parrots-october-2018/> [Accessed September 2021].

Callier MD et al (2018) Attraction and repulsion of mobile wild organisms to finfish and shellfish aquaculture: a review. Rev Aquacult 10, 924–949.

Carroll ML, Cochrane S, Fieler R, Velvin R, White P (2003) Organic enrichment of sediments from salmon farming in Norway: Environmental factors, management practices, and monitoring techniques. Aquaculture 226: 165–180

Chambers M, Larcombe J (2015) ‘North West Slope Trawl Fishery scampi assessment’, in J Larcombe, R Noriega & I Stobutzki (eds), Reducing uncertainty in fisheries stock status, ABARES research report, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra

Cheng H, Lin L, Ong M, Aarsæther K, Sim J (2021) Effects of mooring line breakage on dynamic responses of grid moored fish farms under pure current conditions. Ocean Engineering. 237. 109638. 10.1016/j.oceaneng.2021.109638.

Clarke KR, Green RH (1988) Statistical design and analysis for a "biological effects" study. Marine Ecology Progress Series 46: 213–226

Clarke KR (1993) Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology, 18: 117-143. https://doi.org/10.1111/j.1442-9993.1993.tb00438.x

Cogger HC (2000) Reptiles and Amphibians of Australia - 6th edition. Sydney, NSW: Reed New Holland.

Colquhoun JR (2001) Habitat preferences of juvenile trochus in Western Australia: implications for stock enhancement and assessment. SPC Trochus Information Bulletin, 7, 14-20.

Condie SA, Andrewartha JR (2008) Circulation and connectivity on the Australian North West shelf. Continental Shelf Research, 28(14):1724-39.

Crawford C (2003) Environmental management of marine aquaculture in Tasmania, Australia. Aquaculture 226: 129-138

Cresswell I, Semeniuk V (2011) Mangroves of the Kimberley coast: Ecological patterns in a tropical Ria coast setting. Journal of the Royal Society of Western Australia. 94. 213-237.

Cresswell GR, Badcock KA (2000) Tidal mixing near the Kimberley coast of NW Australia. Marine and Freshwater Research, 51(7):641-6.

Cromey CJ, Black KD, Edwards A, Jack IA (1998) Modelling the deposition and biological effects of organic carbon from marine sewage discharges. Estuarine, Coastal and Shelf Science 47: 295–308

Dauer DM, Rodi AJJ, Ranasinghe JA (1992) Effects of low dissolved oxygen events on the macrobenthos of the lower Chesapeake Bay. Estuaries 15: 384–391

DAWE (2012) Marine bioregional plan for the North-west Marine Region. Commonwealth of Australia. Prepared by the Department of Agriculture, Water and Environment, Canberra

DAWE (2013) Matters of National Environmental Significance: Significant Impact Guidelines 1.1. Commonwealth of Australia. Prepared by the Department of Agriculture, Water and Environment, Canberra

DAWE (2017) Recovery Plan for Marine Turtles in Australia. Commonwealth of Australia. Prepared by the Department of Agriculture, Water and Environment, Canberra

DAWE (2021) Species Profile and Threats Database. Managed by the Department of Agriculture, Water and Environment, Canberra

DAWE (2022) National Conservation Values Atlas. Managed by the Department of Agriculture, Water and Environment, Canberra. Accessed February 2022

DBCA (2021a) Threatened and Priority Flora Database (custom search). Available at <http://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-plants> [Accessed September 2021]

DBCA (2021c) Priority Ecological Communities for Western Australia 28, Kensington, Western Australia

DBCA (2022a) Mayala Marine Park Joint Management Plan 2022. Department of Biodiversity, Conservation and Attractions, Perth.

DBCA (2022b) Lalang-gaddam Marine Park Joint Management Plan 2022. Department of Biodiversity, Conservation and Attractions, Perth.

DBCA (2022c) Bardi Jawi Gaarra Marine Park Joint Management Plan 2022. Department of Biodiversity, Conservation and Attractions, Perth.

DBCA (2024a) Dandjoo: Biodiversity Data Repository (custom search). Available at <https://dandjoo.bio.wa.gov.au/ [Accessed June 2024]

DBCA (2024b) Threatened and Priority Fauna List. Available at <https://www.dbca.wa.gov.au/wildlife-and-ecosystems/animals/list-threatened-and-priority-fauna> [Accessed June 2024]

De Iongh H, Kiswara H, Kustiawan W, Loth P (2003) A review of research on the interactions between dugongs (*Dugong dugon* Muller 1776) and intertidal seagrasss beds in Indonesia. Hydrobiologia. 591:73-83

de Tores P, Williams R, Podesta M, Pryde J (2013) Quokka (*Setonix brachyurus*) Recovery Plan Department of Environment and Conservation, Western Australian Management Program No. 56, Perth, Western Australia

Dennis AJ (2012) Bare-rumped Sheathtail Bat. In: Curtis, L.K., A.J. Dennis, K.R. McDonald, P.M. Kyne & S.J.S. Debus, eds. Queensland's Threatened Animals. CSIRO Publishing.

DER (2014) A Guide to the Assessment of Applications to Clear Native Vegetation. DER, WA.

DHI (2013) Kimberley Aquaculture Zone - Environmental Field Studies and Numerical Modelling in Support of an EIS. Final report prepared for the Western Australian Govt. Dept. of Fisheries, May 2013

DHI (2019) Cone bay Algal Bloom Study. Report prepared by DHI for Marine Produce Australia, April 2019

Dimitriadis C, Koutsoubas D (2011) Functional diversity and species turnover of benthic invertebrates along a local environmental gradient induced by an aquaculture unit: the contribution of species dispersal ability and rarity. Hydrobiologia 670: 307-315

DoF (2012) Policy for Managing Translocations of Live Fish Into and Within Western Australia. Department of Fisheries, Perth, Western Australia

DoF (2015) Kimberley Aquaculture Development Zone Management Policy, Internal Department of Fisheries Report, August 2015.

DotEE (2017) Revised draft referral guideline for three threatened black cockatoo species: Carnaby's Cockatoo (Endangered) *Calyptorhynchus latirostris*, Baudin's Cockatoo (Vulnerable) *Calyptorhynchus baudinii*, Forest Red-tailed Black Cockatoo (Vulnerable) *Calyptorhynchus banksii naso* Department of the Environment and Energy.

DotEE (2020) Protected Matters Search Tool (custom search). Commonwealth of Australia. Available at <http://www.environment.gov.au/epbc/protected-matters-search-tool> [Accessed September 2021]

Double MC, Andrews-Goff V, Jenner KCS, Jenner MN, Laverick SM (2014) Migratory Movements of Pygmy Blue Whales (*Balaenoptera musculus brevicauda*) between Australia and Indonesia as Revealed by Satellite Telemetry. PLOS ONE 9(4): e93578. https://doi.org/10.1371/journal.pone.0093578

DPIPWE (2011) Section 40 report in relation to the draft amendment no.3 to the D'Entrecasteaux Channel Marine Farming Development Plan February 2002. Department of Primary Industries, Parks, Water and Environment, Tasmania

DPIRD (2013) Barramundi. Department of Primary Industries and Regional Development. Available at < http://www.fish.wa.gov.au/Species/Barramundi/Pages/default.aspx> [Accessed 22 October 2021]

DPIRD, (2017). Status reports of the fisheries and aquatic resources of Western Australia 2016/17, Department of Primary Industries and Regional Development, Western Australia.

Dunson WA (1975) The Biology of Sea Snakes. Page(s) 151-162. Baltimore, University Park Press

EPA (2005) Koolan Island Iron Ore Mine and Port Facility: Report and recommendations of the Environmental Protection Authority. Bulletin 1203. Environmental Protection Authority, Perth, Western Australia, November 2005

EPA (2016a) Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2016. Western Australian Government Gazette 223 (special):5601–5616

EPA (2016b) Environmental Factor Guideline – Benthic Communities and Habitats. Environmental Protection Authority, Perth, Western Australia, December 2016

EPA (2016c) Environmental Factor Guideline – Coastal Processes. Environmental Protection Authority, Perth, Western Australia, December 2016

EPA (2016d) Environmental Factor Guideline – Marine Environmental Quality. Environmental Protection Authority, Perth, Western Australia, December 2016

EPA (2016e) Environmental Factor Guideline – Marine Fauna. Environmental Protection Authority, Perth, Western Australia, December 2016

EPA (2016f) Technical Guidance – Protection of Benthic Communities and Habitats, Environmental Protection Authority. Perth, Western Australia, December 2016

EPA (2016g) Technical Guidance – Protecting the Quality of Western Australia's Marine Environment. Environmental Protection Authority, Perth, Western Australia, December 2016

EPA (2016h) Environmental Factor Guideline - Air Quality. Environmental Protection Authority, Perth, Western Australia, December 2016

EPA (2016i) Environmental Factor Guideline - Human Health. Environmental Protection Authority, Perth, Western Australia, December 2016

EPA (2017) Environmental Quality Criteria Reference Document for Cockburn Sound – A Supporting Document to the State Environmental (Cockburn Sound) Policy 2015. Environmental Protection Authority, Perth, Western Australia, April 2017

EPA (2019) Environmental Factor Guideline – Greenhouse Gas Emissions. Environmental Protection Authority, Perth, Western Australia, March 2019

EPA (2021a) Statement of environmental principles, factors, objectives and aims. Environmental Protection Authority, Perth, Western Australia, October 2021

EPA (2021b) Technical Guidance – Environmental impact assessment of marine dredging proposals, EPA, Western Australia, September 2021

EPA (2021c) Environmental Impact Assessment (Part IV Divisions 1 and 2) Procedures Manual: Requirements under the Environmental Protection Act 1986. Environmental Protection Authority, Perth, Western Australia, October 2021

EPA (2022) Notice requiring information for assessment: Ocean Barramundi Expansion Project, Assessment No. 2343, EPA, Western Australia, October 2022.

EPA (2023a) Environmental Factor Guideline – Social Surroundings. Environmental Protection Authority, Perth, Western Australia, November 2023.

EPA (2023b) Technical Guidance: Environmental impact assessment of Social Surroundings – Aboriginal Cultural Heritage. Environmental Protection Authority, Perth, Western Australia, November 2023

EPA (2024a) Notice of Decision to Consent to Amend a Referred Proposal During Assessment. Environmental Protection Authority, Perth, Western Australia, June 2024

EPA (2024b) How to prepare an Environmental Review Document: Instructions. Environmental Protection Authority, Perth, Western Australia, October 2021

Fernandez-Carvalho J, Imhoff JL., Faria VV, Carlson JK, Burgess GH (2014) Status and the potential for extinction of the largetooth sawfish *Pristis pristis* in the Atlantic Ocean. Aquatic Conserv: Mar. Freshw. Ecosyst., 24: 478-497. https://doi.org/10.1002/aqc.2394

Findlay RH, Watling L, Mayer LM (1995) Environmental impact of salmon net-pen culture on marine benthic communities in Maine: a case study. Estuaries 18: 145– 179

Fletcher W, Friedman K, Weir V, McCrea J, and Clark R (2006) Pearl Oyster Fishery – Report Series 5. Department of Fisheries, Western Australia.

Forbes TL, Forbes VE, Depledge MH (1994) Individual physiological responses to environmental hypoxia and organic enrichment: Implications for early soft-bottom community succession. Journal of Marine Research 52: 1081–1100

Forbes TL, Lopez G R (1990) The effect of food concentration, body size and environmental oxygen tension on the growth of the deposit-feeding polychaete, Capitella species 1. Limnology and Oceanography 35: 1535–1544

Gaston GR, Edds KA (1994) Long-term study of benthic communities on the continental shelf off Cameron, Lousiana: a review of brine effects and hypoxia. Gulf Res Reports. 9: 57–64

Gaughan DJ, Santoro K (eds) (2021) Status Reports of the Fisheries and Aquatic Resources of Western Australia 2019/20: The State of the Fisheries. Department of Primary Industries and Regional Development, Western Australia.

Gov. of WA (1978) Geological Survey of Western Australia: Annual Report 1978. Government of Western Australia, Perth.

Gov. of WA (2004) State Water Quality Management Strategy Report 6: Implementation Framework for Western Australia for the Australian and New Zealand Guidelines for Fresh and Marine Water Quality and Water Quality Monitoring and Reporting (Guidelines No.s 4 & 7: National Water Quality Management Strategy). Report No. 6. Government of Western Australia.

Gray JS (1992) Eutrophication in the sea. In: Marine Eutrophication and Population Dynamics. Colombo G, Ferrari I, Ceccherelli VU, Rossi R. Olsen and Olsen, Fredensbor (eds), Denmark. pp. 3–16

Grech A, Sheppard J, Marsh H (2011). Informing species conservation at multiple scales using data collected for marine mammal stock assessments. PLoS ONE. 6(3):e17993.

Gredzens C, Marsh H, Fuentes MMPB, Limpus CJ, Shimada T & Hamann M (2014) Satellite Tracking of Sympatric Marine Megafauna Can Inform the Biological Basis for Species Co-Management. PLoS ONE. 9(6):e98944.

Gross JE (2003) Developing conceptual models for monitoring programs. National Parks Service Inventory and Monitoring Program, Ft Collins

Gunaratne GL, Carmody H, Crisp J, McCall E, Bruce L (2021) A decision support tool for environmental impact assessment in mariculture; An integrated modelling approach, MODSIM2021, 24th International Congress on Modelling and Simulation. Modelling and Simulation Society of Australia and New Zealand, December 2021, ISBN: 978-0-9872143-8-6

Halpern BS, Walbridge S, Selkoe KA, Kappel CV, Micheli F, D'Agrosa C, Bruno JF, Casey KS, Ebert C, Fox HE, Fujita R (2008) A global map of human impact on marine ecosystems. Science, 319(5865):948-52.

Hargrave BT (2010) Empirical relationships describing benthic impacts of salmon aquaculture. Aquaculture Environment Interactions 1:33–46

Hargrave BT, Holmer M, Newcombe CP (2008) Towards a classification of organic enrichment in marine sediments based on biogeochemical indicators. Marine Pollution Bulletin 56:810–824

Heyward A, Stowar M, Wakeford M, Colquhoun J, Spagnol S, Radford B, Azmi Abdul Wahab M, Richards Z (2018) Shallow coral habitat distributions across the offshore Kimberley region. WAMSI Kimberley Marine Research Program, Final Report, September 2018.

Higgins PJ, Davies SJJF (eds) (1996) Handbook of Australian, New Zealand and Antarctic Birds. Volume Three - Snipe to Pigeons. Melbourne, Victoria: Oxford University Press.

Higgins PJ (1999) Handbook of Australian, New Zealand and Antarctic Birds Volume 4: Parrots to Dollarbird. Melbourne: Oxford University Press.

Hipsey MR, Bruce LC, Hamilton DP (2013) Aquatic Ecodynamics (AED) Model Library, Science Manual, https://aed.see.uwa.edu.au/research/models/aed/downloads/AED_ScienceManual_v4_draft.pdf

Hovey RK, Statton J, Fraser MW, Ruiz-Montoya L, Zavala-Perez A, Rees M, Stoddart J, Kendrick GA. (2015) Strategy for assessing impacts in ephemeral tropical seagrasses. Marine pollution bulletin, 101(2):594-9.

Hughes TP, Graham NAJ, Jackson JBC, Mumby PJ, Steneck RS (2010) Rising to the challenge of sustaining coral reef resilience. Trends Ecol Evol 25: 633–642

Huisman JM, Sampey A (2014) Kimberley marine biota. Historical data: marine plants. Records of the Western Australian Museum, Supplement, 84(1):45-67.

Jackson JBC, Kirby MX, Berger WH, Bjorndal KA, Botsford LW, Bourque BJ, Bradbury RH, Cooke R, Erlandson J, Estes JA, Hughes TP, Kidwell S, Lange CB, Lenihan HS, Pandolfi JM, Peterson CH, Steneck RS, Tegner MJ, Warner RR (2001) Historical overfishing and the recent collapse of coastal ecosystems. Science 293: 629–637

Johnstone RE, Storr GM (1998) Handbook of Western Australian Birds. Volume 1: Non-passerines (Emu to Dollarbird). Western Australian Museum, Perth, Western Australia.

Josefson AB, Jensen JN (1992) Effects of hypoxia on soft-sediment macrobenthos in southern Kattegat, Denmark. In: Marine Eutrophication and Population Dynamics. Colombo G, Ferrari I, Ceccherelli VU, Rossi R (eds). Olsen and Olsen, Fredensborg, Denmark. pp. 21–28

Karakassis I, Hatziyanni E, Tsapakis M, Plaiti W (1999) Benthic recovery following cessation of fish farming: A series of successes and catastrophes. Marine Ecology Progress Series 184:205–218

Kendrick GA, Vanderklift M, Bearham D, Mclaughlin J, Greenwood J, Säwström C, Laverock B, Chovrelat L, Zavala-Perez A, De Wever L, Trapon M, Grol M, Guilbault E, Oades D, McCarthy P, George K, Sampi T, George D, Sampi C, Edgar Z, Dougal K, Howard A (2016) Benthic primary productivity: production and herbivory of seagrasses, macroalgae and microalgae. Report of 2.2.4

prepared for the Kimberley Marine Research Program, Western Australian Marine Science Institution, Perth, Western Australia, 61 pp.

Klunzinger MW, Beatty SJ, Morgan DL, Pinder AM, Lymbery AJ (2015) Range decline and conservation status of *Westralunio carteri* Iredale, 1934 (Bivalvia :Hyriidae) from south-western Australia. Australian Journal of Zoology. 63:127-135. Available from: http://www.publish.csiro.au/zo/ZO15002.

Limpus CJ, MacLachlin N (1979) Observations on the leatherback turtle, *Dermochelys coriacea* (L.), in Australia. Australian Wildlife Research. 6:105-116.

Limpus CJ (1995) Conservation of marine turtles in the Indo-Pacific region. Brisbane: Queensland Department of Environment and Heritage.

Limpus CJ, Miller JD, Parmenter CJ, Reimer D, McLachlan N, Webb R (1992) Migration of green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) turtles to and from eastern Australian rookeries. Wildlife Research. 19(3):347-358.

Littler MM, Littler DS (1984) Models of tropical reef biogenesis: the contribution of algae. Round FE, Chapman DJ (Eds) Progress in phycological research. Biopress, Bristol, pp 323–364

Lowe RJ, Leon AS, Symonds G, Falter JL, Gruber R (2015) The intertidal hydraulics of tide-dominated reef platforms. Journal of Geophysical Research: Oceans, 120(7):4845-68.

Lucid Economics (2019) MPA Economic Impact Assessment. Report prepared by Lucid Economics for Marine Produce Australia.

Luiz Jr OJ, Balboni AP, Kodja G, Andrade M, Marum H (2009) Seasonal occurrences of *Manta birostris* (Chondrichthyes: Mobulidae) in southeastern Brazil. Ichthyological Research. 56 (1): 96–99. doi:10.1007/s10228-008-0060-3. ISSN 1616-3915. S2CID 38384569

Macleod C, Moltschaniwskyj NA, Crawford CM (2006) Evaluation of short-term fallowing as a strategy for the management of recurring organic enrichment under salmon pens. Marine Pollution Bulletin 52: 1458-1466

Macleod CKA, Mitchell IM, Crawford CM, Connell RD (2002) Evaluation of sediment recovery after removal of finfish pens from marine farm lease no. 76 (Gunpowder Jetty), North West Bay. TAFI Technical Report No. 13. January 2002. Tasmanian Aquaculture and Fisheries Institute, University of Tasmania, Hobart, Australia

Mahnken CVW (1993) Benthic faunal recovery and succession after removal of a marine fish farm. PhD thesis, University of Washington, Seattle 290 pp

Mathews D, Semeniuk V, Semeniuk CA (2011) Freshwater seepage along the coast of the western Dampier Peninsula, Kimberley Region, Western Australia. Journal of the Royal Society of Western Australia, 94: 207–212

Marchant S, Higgins PJ (1990) Handbook of Australian, New Zealand and Antarctic Birds. Volume One - Ratites to Ducks. Melbourne, Victoria: Oxford University Press.

Marsh H, O'Shea TJ, Reynolds JR (2011) The ecology and conservation of sirenia; dugongs and manatees. Cambridge University Press, London.

Masini RJ, Anderson PK, McComb AJ (2001). A Halodule-dominated community in a subtropical embayment: physical environment, productivity, biomass, and impact of dugong grazing. Aquatic Botany. 71:179-197.

Masini RJ, Sim CB, Simpson CJ (2009) Part A: marine environments. Protecting the Kimberley: a synthesis of scientific knowledge to support conservation management in the Kimberley region of Western Australia. 2009:5-18.

Mayala Inninalang Aboriginal Corporation RNTBC ICN 9067 (2019) Mayala Country Plan 2019-2029

Mazzola A, Mirto S, La Rosa T, Fabiano M, Danovaro R (2000) Fish-farming effects on benthic community structure in coastal sediments: Analysis of meiofaunal recovery. ICES Journal of Marine Science 57: 1454–1461

McCosker JE (1975) Feeding behaviour of Indo-Australian Hydrophiidae. In: Dunson, W. A., ed. The Biology of Sea Snakes. Page(s) 217-232. Baltimore: University Park Press.

McKenzie NL, Johnson RP, Kendrick PG (1991) Kimberley rainforests of Australia. Published by S. Beatty in association with the Department of Conservation and Land Management, Western Australia and the Department of Arts, Heritage and Environment, Canberra.

McKenzie NL, Fontanin L, Lindus NV, Williams NR (1995) Biological inventory of Koolan Island, Western Australia. 2. Zoological notes. Records of the Western Australian Museum 17: 249–266.

McLeod P, Lindner R (2018) Economic Dimension of Recreational Fishing in Western Australia. October 2018.

McMahon K, U Hernawan, Dawkins K, van Dijk KJ, Waycott M (2017) Population genetic diversity, structure and connectivity of two seagrass species, *Thalassia hemprichii* and *Halophila ovalis* in the Kimberley

Miller JD, Dobbs KA, Limpus CJ, Mattocks N, Landry Jr AM (1998) Long-distance migrations by the hawksbill turtle, *Eretmochelys imbricata*, from north-eastern Australia. Wildlife Research. 25:89-95.

Moccia R, Bevan D, Reid G (2007) Composition of Fecal Waste from Commercial Trout Farms in Ontario: Macro and Micro Nutrient Analyses and Recommendations for Recycling. Final Report Submitted to the Ontario Sustainable Aquaculture Working Group Environment Canada, 22pp

Morris KD (2000) The status and conservation of native rodents in Western Australia. Wildlife Research. 27:405-419.

Morrisey DJ, Gibbs MM, Pickmere SE, Cole RG (2000) Predicting impacts and recovery of marine-farm sites in Stewart Island, New Zealand, from the Findlay–Watling model. Aquaculture 185 (3– 4): 257–271

Oceanica (2013a) Kimberley Aquaculture Zone Strategic Assessment, Baseline Water and Sediment Quality Analysis. Report prepared for DHI by Oceanica Consulting Pty Ltd, May 2013.

Oceanica (2013b) Kimberley Aquaculture Zone Strategic Assessment, Cause-Effect Pathways and Impact Thresholds. Report prepared for DHI by Oceanica Consulting Pty Ltd, May 2013.

Papastamatiou, YP, Itano, DG, Dale JJ, Meyer CG, Holland KN (2010) Site fidelity and movements of sharks associated with ocean-farming pens in Hawaii. Mar. Freshwater Res. 61, 1366.

Paraska DW, MR Hipsey, Salmon SU (2014) Sediment diagenesis models: Review of approaches, challenges, and opportunities. Environmental Modelling & Software 61(0): 297-325

Parra GJ, Cagnazzi D (2016) Conservation Status of the Australian Humpback Dolphin (*Sousa sahulensis*) Using the IUCN Red List Criteria. Advances in Marine Biology. 73:157-192.

Parra GJ, Schick P, Corkeron PJ (2006) Spatial distribution and environmental correlates of Australian snubfin and Indo-Pacific humpback dolphins. Ecography. 29:496-406.

Parsons K (2012) State of the D'Entrecasteaux Channel and the lower Huon Estuary 2012. Report prepared by Ecomarine Consulting for the D'Entrecasteaux Channel Project, 222pp

Patterson H, Mobsby D (2020) Skipjack Tuna Fishery, Department of Agriculture, Water and the Environment, Canberra.

Pearson TH, Rosenberg R (1978) Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanography and Marine Biology An Annual Review 16: 229–311

Pearson D, Cowan M, Caton W (2013) The avifauna of larger islands along the Kimberley coast, Western Australia. Records of the Western Australian Museum, Supplement. 81. 125. 10.18195/issn.0313-122x.81.2013.125-144.

Pedersen O, Colmer TD, Borum J, Zavala-Perez A, Kendrick GA (2016) Heat stress of two tropical seagrass species during low tides–impact on underwater net photosynthesis, dark respiration and diel in situ internal aeration. New Phytologist, 210(4):1207-18.

Pendoley Kellie (2005) Sea Turtles and the Environmental Management of Industrial Activities in North West Western Australia. PhD thesis, Murdoch University.

PIANC (2010) Dredging and Port Construction around Coral Reefs. PIANC and United Nations Environment Program, Report No 108

Pizzey G, Knight F (2012) Field Guide to the Birds of Australia. Harper Collins Publishers, Sydney, New South Wales.

Prince RI (1994) Status of the Western Australian marine turtle populations: the Western Australian Marine Turtle Project 1986-1990. In: Russell, J., ed. Proceedings of the Australian Marine Turtle Conservation Workshop, Gold Coast 14-17 November 1990. Page(s) 1-14. Queensland Department of Environment and Heritage. Canberra, ANCA.

Rasher DB, Engel S, Bonito V, Fraser GJ, Montoya JP, Hay ME (2012) Effects of herbivory, nutrients, and reef protection on algal proliferation and coral growth on a tropical reef. Ecologia 169: 187–198

Reardon TB, Robson SKA, Parsons JG, Inkster T (2010) Review of the threatened status of microchiropteran bat species on Cape York Peninsula.

Regassa, T, Koelsch R, Wortmann C, Randle R (2009) Antibiotic Use in Animal Production: Environmental Concerns. University of Nebraska-Lincoln Extension RP196. Published January 9, 2009.

Regional Development Australia (2020) Tourism Kimberley. Prepared by RDA, Broome, Western Australia.

Richards ZT, Garcia RA, Wallace CC, Rosser NL, Muir PR (2015). A diverse assemblage of reef corals thriving in a dynamic intertidal reef setting (Bonaparte Archipelago, Kimberley, Australia). PLoS One, 10(2):e0117791

Schaffner LC, Jonsson P, Diaz RJ, Rosenberg R, Gapcynski P (1992) Benthic communities and bioturbation history of estuarine and coastal systems: effects of hypoxia and anoxia. In: Marine Coastal Eutrophication (eds) Vollenweider RA, Marchetti R. Viviani R, Elsevier, Amsterdam, London, New York, Tokyo pp. 1001–1016

Schultz G & Lee H (2015) Status of key Northern Territory fish stocks report – King Threadfin *Polydactylus macrochir*. Northern Territory Government. Department of Primary Industry and Resources. Fishery Report No. 118. Available at <https://dpir.nt.gov.au/__data/assets/pdf_file/0007/434878/FR118.pdf#page=63> [Accessed 22 October 2021]

Schulz M, Thomson B (2007). National recovery plan for the bare-rumped sheathtail bat *Saccolaimus saccolaimus nudicluniatus*. Report to Department of the Environment and Heritage, Canberra. Brisbane: Queensland Parks and Wildlife Service. Available at <http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-bare-rumped-sheathtail-bat-saccolaimus-saccolaimus-nudicluniatus>. In effect under the EPBC Act from 08-Jan-2008.

Sheppard J, Preen AR, Marsh H, Lawler IR, Whiting S & Jones RE (2006) Movement heterogeneity of dugongs, *Dugong dugon* (Muller) over large spatial scales. Journal of Experimental Marine Biology and Ecology. 334:64-83

Short AD (2011) Kimberley beach and barrier systems: An overview. Journal of the Royal Society of Western Australia, 94: 121–132, 2011.

Simpson K, Day N (2010) Field Guide to the Birds of Australia. Penguin Books Australia, Hawthorn, Australia.

Sri Endah Purnamaningtyas and Mujiyanto (2021) IOP Conference Series: Earth Environ. Sci. 860 012082

Stantec (2022a) Kimberley Aquaculture Development Zone: Environmental Monitoring and Management Plan. Report prepared for Marine Produce Australia by Stantec, January 2022.

Stantec (2022b) Kimberley Aquaculture Development Zone: Review of Operational Monitoring Data 2014- 2021. Report prepared for Marine Produce Australia by Stantec, January 2022

Stantec (2024a) Public Environmental Report – Ocean Barramundi Expansion Project. Report prepared for Tassal by Stantec, July 2024.

Stantec (2024b) Heritage Management Plan – Ocean Barramundi Expansion Project. Report prepared for Tassal by Stantec, July 2024.

Stevens JD, McAuley RB, Simpfendorfer CA, Pillans RA (2008) Spatial distribution and habitat utilisation of sawfish (*Pristis* spp) in relation to fishing in northern Australia. A report to the Department of the Environment, Water, Heritage and the Arts. CSIRO and Western Australia Department of Fisheries. Available from: http://www.environment.gov.au/coasts/publications/pubs/sawfish-report.pdf.

Tassal (2024) Fish Containment Plan Barramundi Operations. Developed by Tassal Operations Pty Ltd, February 2024.

Thorburn DC, Morgan DL, Rowland AJ, Gill HS (2004) The northern river shark (*Glyphis* sp. C) in Western Australia. Report, Centre for Fish and Fisheries Research, Murdoch University, Australia

Underwood AJ (1997) Experiments in ecology: Their logical design and interpretation using analysis of variance. Cambridge University Press, Cambridge.

Van Cappellen P, Wang FY (1995) Metal cycling in surface sediments. Metal contaminated aquatic sediments. H. Allen. Chelsea, Ann Arbor Press: 21 - 61

van Dyck S, Gynther I, Baker A (2013) Field Companion to Mammals of Australia. New Holland Publishers, Sydney, New South Wales.

Walsh B, Whitehead PJ (1993) Problem crocodiles, *Crocodylus porosus*, at Nhulunbuy, Northern Territory: an assessment of relocation as a management strategy. Wildlife Research. 20:127-135.

Wardell-Johnson G, Roberts JD (1991). The survival status of the *Geocrinia rosea* (Anura: Myobatrachidae) complex in riparian corridors: biogeographical implications. In: Saunders & R.J. Hobbs, eds. Nature Conservation 2: the Role of Corridors. Page(s) 167-175. Surrey Beatty & Sons, Chipping Norton, Aust.

Warham J (1957) Cockatoo Island Birds. Emu – Austral Ornithology, 57(4): 225-31. https://doi.org/10.1071/MU957225

Webb GJW, Manolis SC, & Whitehead PJ (1987) Wildlife Management: Crocodiles and Alligators. Page(s) 107-124. Sydney, Surrey Beatty & Sons

Whiting S, Tucker T, Pendoley K, Mitchell N, Bentley B, Berry O, FitzSimmons N (2018) Final Report of Project 1.2.2 prepared for the Kimberley Marine Research Program, Western Australian Marine Science Institution, Perth, Western Australia, 146 pp.

Williams A, Patterson H, & Mobsby D, (2020) Western Tuna and Billfish Fishery, Department of Agriculture, Water and the Environment, Canberra.

Wilson B (2013) The biogeography of the Australian North West Shelf: Environmental change and life's response. Elsevier Inc, San Diego, USA

World Resources Institute (2004) The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard. World Resources Institute, Washington, USA

Wu Y, Chaffey J, Law B, Greenberg DA, Drozdowski A, Page F, Haigh S (2014) A three-hydrodynamic model for aquaculture: a case study in the Bay of Fundy. Aquaculture Environmental Interactions 5: 235-248

Annex A Environmental Monitoring and Management Plan (DWER)

Annex B Monitoring and Environmental Management Plan (DPIRD)

Annex C Calibration Modelling Report

Annex D Integrated Modelling Report

Annex E Baseline Marine Environmental Quality Report

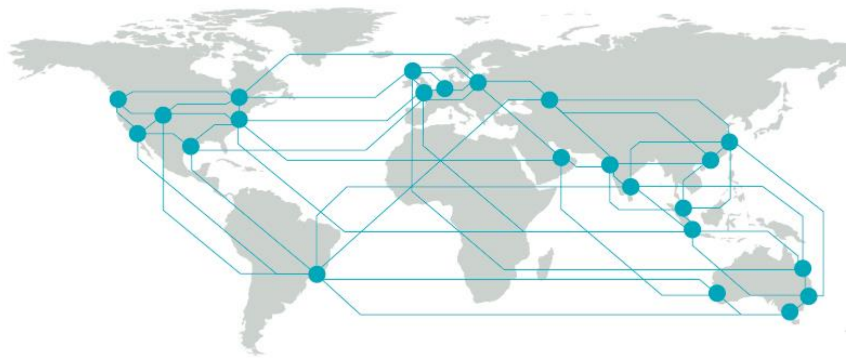
Annex F Benthic Communities and Habitats Report

Annex G EPBC Protected Matters Tool Report

Annex H Dandjoo Report

Annex I Aboriginal Heritage Inquiry System Report

Annex J IMSA Metadata Package Statement



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