MID WEST AQUACULTURE DEVELOPMENT ZONE

PUBLIC ENVIRONMENTAL REVIEW

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Mid West Aquaculture Development Zone – Public Environmental Review

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Invitation to make a submission

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal. The environmental impact assessment process is designed to be transparent and accountable, and includes specific points for public involvement, including opportunities for public review of environmental review documents. In releasing this document for public comment, the EPA advises that no decisions have been made to allow this proposal to be implemented.

The Western Australian Department of Fisheries, on behalf of the Minister for Fisheries, proposes to establish an aquaculture development zone in the Mid West region of Western Australia for the purpose of marine finfish aquaculture. The Mid West Aquaculture Development Zone is being assessed by the EPA as a strategic proposal. In accordance with the Environmental Protection Act 1986, a Public Environmental Review (PER) document has been prepared which describes this strategic proposal and its likely effects on the environment. The PER document is available for a public review period of 4 weeks from 18 July 2016, closing on 15 August 2016.

Comments from government agencies and the public will assist the EPA to prepare an assessment report in which it will make recommendations to government.

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Submissions will be treated as public documents unless provided and received in confidence, subject to the requirements of the *Freedom of Information Act 1992* (FOI Act), and may be quoted in full or in part in the EPA's report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining a group interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the PER or the specific proposal. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal more environmentally acceptable.

When making comments on specific elements of the PER:

- clearly state your point of view;

- indicate the source of your information or argument if this is applicable; and
- suggest recommendations, safeguards or alternatives.

Points to keep in mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- attempt to list points so that issues raised are clear. A summary of your submission is helpful;
- refer each point to the appropriate section, chapter or recommendation in the PER;
- if you discuss different sections of the PER, keep them distinct and separate, so there is no confusion as to which section you are considering; and
- attach any factual information you may wish to provide and give details of the source.

Make sure your information is accurate.

Remember to include:

- your name;
- address;
- date; and
- whether and the reason why you want your submission to be confidential.

Information in submissions will be deemed public information unless a request for confidentiality of the submission is made in writing and accepted by the EPA. As a result, a copy of each submission will be provided to the proponent but the identity of private individuals will remain confidential to the EPA.

The closing date for submissions is: **15 August 2016**

The EPA prefers submissions on PER documents to be made electronically on its consultation hub at https://consultation.epa.wa.gov.au**.**

Alternatively, submissions can be:

- posted to;
  - Chairman, Environmental Protection Authority, Locked Bag 10, EAST PERTH WA 6892; or
- delivered to;
  - Environmental Protection Authority, Level 8, The Atrium, 168 St Georges Terrace, Perth.

If you have any questions on how to make a submission, please contact the EPA via telephone at (08) 6145 0800; or via e-mail at info@epa.wa.gov.au.

EXECUTIVE SUMMARY

Overview

The Minister for Fisheries (Minister) proposes to establish an aquaculture development zone (zone) in the Mid West region of Western Australia for the purpose of marine finfish aquaculture.[1]

Rationale

A strategic planning approach to aquaculture development is regarded as best regulatory practice and a key method of providing for industry growth while achieving ecologically sustainable development outcomes.[2] Some Australian states have established significant marine aquaculture industries using a regional zone methodology in their strategic planning.

The Western Australian Government is committed to the development of a sustainable marine aquaculture industry and, to further this commitment, the Minister announced a funding package to enable the establishment of two such zones: one in the Kimberley and one in the Mid West region of the State.[3]

The Department of Fisheries Western Australia (Department) is managing the creation of these two zones on behalf of the Minister.

The proposed Mid West Aquaculture Development Zone (MWADZ Proposal) is located within the southern part of the Abrolhos Islands Fish Habitat Protection Area (FHPA), between the Pelsaert and Easter groups of the Abrolhos archipelago, approximately 65 kilometres west of Geraldton.[4] This will be the second aquaculture development zone to be established in Western Australia, the Kimberley Aquaculture Development Zone being declared by the Minister on 22 August 2014. The MWADZ Proposal is located in a part of the Western Australian coast where there is a confluence of both temperate and tropical sea life, forming one of the State's unique marine areas. This presents a rare opportunity for the development of a range of marine finfish aquaculture species that occur naturally within the West Coast Region of the State.[5]

The establishment of commercial marine finfish aquaculture projects within the zone is not expected to cause a significant environmental impact. This assessment of the likely environmental impacts is due to two factors.

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[1] Section 101A(2A) of the *Fish Resources Management Act 1994* provides for the Minister to declare an area of WA waters (other than inland waters) to be an aquaculture development zone.
[2] *Best practice framework of regulatory arrangements for aquaculture in Australia* [Primary Industries Ministerial Council – 2005].
[3] Refer to the Statement of Commitment – August 2015 at:
http://www.fish.wa.gov.au/Documents/Aquaculture/aquaculture_statement_of_commitment.pdf
[4] Fish Habitat Protection Areas are created by the Minister under the provisions of Part 11, Division 1 of the *Fish Resources Management Act 1994*.
[5] *West Coast Region* is defined in Regulation 3 *Terms used* of the Fish Resources Management Regulations 1995 as:

(a) all land in the State; and
(b) all WA waters,

that are south of 27⁰ 00' south latitude, excluding the South Coast Region;

First, the zone's physical characteristics, in particular the high rates of flushing or water exchange in the Zeewijk Channel that is sufficient to dilute nutrients before they are assimilated by the ecosystem. Second, the adaptive management controls and environmental monitoring framework the Department has developed for the zone, and the individual proposals within it, through the strategic assessment process (see below) consistent with the guidance set out in the relevant Environmental Protection Authority (EPA) policies and guidelines.

Approvals Pathway

The Department referred the MWADZ Proposal to the EPA in April 2013 and the EPA subsequently determined the level of assessment be Public Environmental Review.

The MWADZ Proposal will be assessed through a process that principally involves environmental assessment of the zone as a **strategic proposal** under Part IV of the *Environmental Protection Act 1986* (EP Act).

Once the strategic proposal has been approved by the Minister for Environment, the Minister for Fisheries (with the concurrence of the Minister for Lands) may declare the MWADZ Proposal area to be an aquaculture development zone under section 101A of the *Fish Resources Management Act 1994* (FRMA).

Approval of the strategic proposal will create opportunities for existing and future aquaculture operators to refer project proposals to the EPA as **derived proposals**. The desired outcome is a more efficient and effective zone assessment and regulation process. This will be achieved through the early consideration of the identified potential environmental impacts and additional cumulative impacts associated with the project proposals, and of the relevant management measures designed to control these.

Subject to the Minister for Environment approving these derived proposals, aquaculture licences (granted by the Chief Executive Officer of the Department of Fisheries) and aquaculture leases (granted by the Minister for Fisheries) may be issued to the aquaculture operators.

The Proposal

Subject to the relevant environmental approvals under the EP Act, the MWADZ Proposal aims to:

- declare an area of Western Australian (WA) waters, based on its biological, environmental, economic and social attributes, as suitable for large-scale commercial marine finfish aquaculture; and
- establish an effective management framework, including an efficient approval process, for operators within that area.

The strategic proposal area has been selected by the proponent to maximise suitability for marine finfish aquaculture and minimise potential impacts on existing marine communities and disruption to existing human use.

The MWADZ Proposal, encompasses 3,000 hectares (ha) of marine waters within two separate areas (800 ha and 2,200 ha).

1. The **Southern area** comprises an 800-hectare existing licensed aquaculture site to the north of Sandy Island in the Pelsaert Group. This existing site will likely be the only aquaculture site within the Southern area.

2. The **Northern area** comprises a 2,200-hectare site east of Wooded Island in the Easter Group and north of Gee Bank reef. The final size, location and design of aquaculture sites within the Northern area will be subject to, *inter alia*, the outcomes of the tenure allocation process conducted after the zone has been declared.

The main infrastructure of future derived proposals will consist of floating sea cages, typically arranged in clusters, and secured to the seabed by an anchoring and bridle system. The sea cages are circular in shape and may range in size (18-38 metres diameter) depending on the number and size of the cultured fish. In general, the sides of the proposed cages would have a drop of 18 metres; with the bottom of the cage reaching a depth of around 21 metres. The sea cages must conform to the navigation and marking requirements as specified by the Department of Transport.

Only marine finfish of a species that occurs naturally within the West Coast region of Western Australia are permitted to be cultured within the zone. The use of local species and the outcomes of the technical studies, environmental impact modelling undertaken and the proposed environmental and farm modelling and management regime provide confidence that a standing biomass limit of 24,000 tonnes of marine finfish at any one time for the zone would be appropriate.

Potential Impacts, Risk Assessment and Mitigation

The identification of potential impacts of the MWADZ Proposal, the assessment of the risks they posed and the likely effects of the management and mitigation controls designed to address them has been an iterative process throughout the development of the proposal.

The assessment of these potential impacts was undertaken based on available evidence, current knowledge, and through the application of professional judgement. However, some scientific uncertainty still exists with respect to the actual impacts that may occur; this uncertainty is a result of a number of factors including variation within natural systems, limited understanding of complex systems and interactions between components, and unanticipated or uncontrollable factors that may affect an impact pathway.

Any scientific uncertainty regarding the potential impact of the proposal resulted in the application of a conservative approach to the assessment and to the definition of mitigation and management measures. Where any identified potential impacts are likely to be unknown, unpredictable, or irreversible, this conservative approach was adopted by considering the ‘worst-case’ situation. This approach, however, did lead to some overly pessimistic initial assessments (refer to the *Approach to Environmental Management* section of this Executive Summary).

A cumulative impact assessment considered potential incremental impacts, in terms of the environmental and social factors outlined in this Public Environmental Review (PER), of the MWADZ Proposal. The cumulative impact assessment evaluated the potential incremental impacts of the MWADZ Proposal when combined with other present and reasonably foreseeable future actions in the vicinity of the proposed MWADZ area.

This cumulative impact assessment was based on a mostly qualitative, high-level analysis of potential impacts using professional judgement of subject matter experts, supported by baseline information (current and historic) and a range of quantitative assessments.

The views of stakeholders were also an important part of the impact assessment process and numerous opportunities were provided throughout the proposal development for their input.

The following Table lists the most significant potential impacts associated with the MWADZ Proposal, along with mitigation and management measures to be implemented to address these.

Table ES: Summary of environmental factors, management and predicted outcomes relevant to the MWADZ Proposal

Environmental Factor	EPA Objective	Existing Environment	Potential Impact	Environmental Management	Predicted Outcome
Benthic Communities and Habitat	To maintain the structure, function, diversity, distribution and viability of benthic communities and habitats at local and regional scales.	The benthic environment consists generally of a shallow (~ 15 centimetre thick) layer of sand overlying rocky substrate. Surveys undertaken in 2014 indicate that the seafloor is a mosaic of habitats consisting of bare sand and mixed biological assemblages where the sand veneer is thin or rocky substrate is exposed. These assemblages comprise of filter feeders (sponges, and bryozoans), macroalgae, rhodoliths and some hard corals (though the latter was observed infrequently). Despite the observed diversity of the biological assemblages, their presence is	1. Direct and indirect disturbance or loss of benthic communities and habitat; 2. Direct and indirect impacts to key sensitive receptors; and 3. Impacts to marine environment and biota quality through release of nutrients, organic material, pharmaceuticals, metals or metalloids and/or petroleum hydrocarbons.	• Avoid direct and indirect impacts on benthic communities and habitat and protect marine environmental quality (EAG 8). This can be achieved by implementing measures that include the following: o Where practical, avoid locating sea cages over areas of benthic communities and habitat. o Adopt best-management practices in relation to infrastructure design, installation, maintenance and animal husbandry. o Locate the sea cages in well-flushed locations with good water circulation, dispersion, with water depth below the sea cages exceeding 10 metres. o Set stocking densities for aquaculture at conservative levels to help minimise enrichment of the surrounding environment. o Use only AQIS-approved, high-quality, species and system-specific feeds in order to minimise feed waste. o Use dry pelletised feed and disease free certified stock to prevent contamination and introduction of pests and pathogens. o Fallow sites to allow seabed recovery. o No prophylactic use of antibiotics; and if required to treat any acute situation, only administer for short periods of time. o Monitor the input of stock feed and fish feeding behaviour to inform and adapt the feeding strategy to maximise feeding efficiency.	• Benthic communities and habitat of the Abrolhos marine environment are well-protected at both local and regional scales from any potential impacts from the proposed aquaculture. • Benthic communities and habitat (EAG 3) are reliant on the maintenance of sediment and water quality to support the environmental value of ecosystem health (EAG 15). • The most significant impacts are restricted to small areas (i.e. less than 300 hectares) when aquaculture production is at full capacity. • The proposal is unlikely to yield significant cumulative losses of benthic communities and habitat. • The cumulative loss would be restricted to less than two per cent of the local assessment units (LAU) that were defined for the MWADZ Proposal (Appendix 1).

Environmental Factor	EPA Objective	Existing Environment	Potential Impact	Environmental Management	Predicted Outcome
		considered itinerant given their propensity to change significantly between surveys, and over time. Habitats in the northern MWADZ area are more diverse and comprise 83% bare sand and 17% mixed assemblages. No seagrasses were observed in the 2014/2015 assessment.		o Monitor concentrations of nutrients and metals in the seabed sediment, and suspended material, light attenuation, chlorophyll a, nutrients and dissolved oxygen in the water column at sites near beneath and surrounding the sea cages.	• Compliance with the EPA's Cumulative Loss Guidelines (EAG 3) that signify a low risk to the ecological integrity of benthic communities and habitat.
Marine Environmental Quality	To maintain the quality of water, sediment and biota so that the environmental values, both ecological and social, are protected.	Waters inside the MWADZ are clean and well mixed. Maximum and minimum water temperatures are achieved in autumn (23.5°C) and winter (20.8°C), respectively. Salinity and dissolved oxygen levels are consistent through the water column with little evidence of stratification. The water is highly	1. Degradation of marine water and sediment quality through the deposition of organic wastes and inorganic nutrients; 2. Direct and indirect impacts to key sensitive receptors; and 3. Impacts to marine environment and biota quality through release of pharmaceuticals, trace metals or	• Avoid direct and indirect impacts on marine environmental quality (EAG 8) by implementing measures that include those outlined above for Benthic Communities and Habitats.	• Environmental values, both ecological and social (EAG 15), are well-protected from any potential impacts from the proposed aquaculture through the maintenance of water, sediment and biota quality. • The Environmental Monitoring and Management Plan (EMMP) (Appendix 2) provides appropriate monitoring and management of these environmental values in the vicinity of the proposed aquaculture.

Environmental Factor	EPA Objective	Existing Environment	Potential Impact	Environmental Management	Predicted Outcome
		oxygenated, achieving surface oxygen saturation levels between 96% and 99% and bottom oxygen saturation levels between 95% and 98%. MWADZ water currents are variable, ranging between 5.8 and 14.4 cm/s. Concentrations of ammonium and chlorophyll-a indicate an overall oligotrophic (nutrient poor) environment. Concentrations of inorganic nutrients and chlorophyll-a are seasonally variable. The benthic environment consists generally of a shallow (~15 cm thick) layer of sand overlying rocky substrate. Higher current speeds in the northern area (northern 13-14.5 cm/s compared	metalloids and/or petroleum hydrocarbons.		• Results of the modelling indicate that the impacts of the proposal can be constrained within small areas of the seafloor within the proposed MWADZ, with no adverse effects to regional environmental quality. • Any fish faecal plumes or phytoplankton blooms within the proposed MWADZ will dissipate rapidly, and water quality will be maintained at levels consistent with a high level of ecological protection. • Phytoplankton concentrations, as indicated by chlorophyll-a concentrations, are not expected to change significantly across the proposed MWADZ. Consequently, any light reduction (or shading) is expected to be insignificant. • Similarly, light and dissolved oxygen levels in the water column of the proposed MWADZ are not expected to be affected.

Environmental Factor	EPA Objective	Existing Environment	Potential Impact	Environmental Management	Predicted Outcome
		to the south 8.7-11 cm/s) are reflected in the tendency toward larger sediment grain sizes in the northern reaches of the MWADZ. Sediment conditions are also variable, with seasonal fluctuations in nitrogen, phosphorus and total organic carbon. Infauna assemblages are diverse and dominated by polychaetes (marine worms).			• No discernible impacts on sub-surface light conditions are expected to be caused by increased phytoplankton blooms or suspended waste in the water column (Appendix 1). • The seafloor sediments beneath the sea cages will be exposed to deposition of organic material. Organic waste inputs will lead to some localised sediment organic enrichment and changes to sediment chemistry. • Appropriate levels of standing biomass and three-year cage cluster site rotation will constrain the extent of the zone of high impact. After more than three years of finfish production at any one location, the zone of high impact is unlikely to breach the cage cluster perimeter (Appendix 1). • It is predicted that the low concentrations of zinc and copper in the fish waste will be insufficient to result in

Environmental Factor	EPA Objective	Existing Environment	Potential Impact	Environmental Management	Predicted Outcome
					sediment concentrations in excess of the Environmental Quality Criteria (EQC), even after five years production at the upper end of the proposed standing biomass limit of 24,000 tonnes of marine finfish for the proposed MWADZ (Appendix 1).
Marine Fauna (including seabirds)	To maintain the diversity, geographic distribution and viability of fauna at the species and population levels.	The MWADZ Proposal is located within the Abrolhos Islands Fish Habitat Protection Area (FHPA). This FHPA surrounds the Abrolhos Islands Reserve, which is the most significant seabird breeding location in the eastern Indian Ocean. The Abrolhos Islands Reserve and FHPA also provide habitat for an array of marine mammals, comprising mainly whales, dolphins and sea lions. Thirty one cetacean and two pinniped species are	Note: While there is no terrestrial component to the MWADZ Proposal, the Department nevertheless considered the possibility of any direct or indirect impacts of the proposal on the terrestrial environments of the Abrolhos Islands Reserve. In particular, any possible impacts on seabirds (avifauna) and seabird breeding colonies were investigated (see points 14 and 15 below). As the ESD included seabirds under the environmental factor	• Avoid direct and indirect impacts on marine fauna and protect marine environmental quality (EAG 8) as outlined above. • Implement infrastructure design, systems and practices that eliminate, substitute, isolate or otherwise minimise the potential impacts of hazards that may contribute to the attraction of marine fauna. This can be achieved by implementing measures that include the following: o Locate sea cages in areas away from sea lion haul-out sites. o Design railings, floats, net rings, etc. to reduce the opportunity for roosting sites that could be used by increaser seabird species. o Use surface and sub-surface exclusion or “anti-predator” netting. o Minimise opportunities for provisioning (i.e. artificial access to food) of marine fauna by promptly removing any dead or moribund stock and preventing access to pelletised feed. o Contain all post-harvest blood water and effluent.	• Diversity, geographic distribution and viability of Abrolhos fauna are well-protected at the species and population levels from any potential impacts from the proposed aquaculture. • The EMMP (Appendix 2), Marine Fauna Interaction Management Plan (Appendix 5) and Waste Management Plan (Appendix 6) provide appropriate monitoring and management of these environmental values in the vicinity of the proposed aquaculture. • The key pressures associated with aquaculture are inputs of nutrients and organic material derived from fin-fish metabolic processes and

Environmental Factor	EPA Objective	Existing Environment	Potential Impact	Environmental Management	Predicted Outcome
		known to occur within a 50 km radius of the MWADZ. Four species of marine turtle may also occur within this radius. The benthic habitats of the FHPA support rich finfish (including sharks and rays) and invertebrate communities; although the benthos of the MWADZ Proposal area is primarily composed of sand and has correspondingly lower levels of diversity and abundance relative to other locations within the FHPA.	of “marine fauna”, that is where it has been addressed in this PER. Direct and indirect impacts on significant marine fauna, include: 1. nutrient enrichment of the water column and increased turbidity; 2. organic deposition and nutrient enrichment of the sediments; 3. release of trace metals, therapeutants and other contaminants into the marine environment; 4. introduction of marine pests and pathogens; 5. additional food from aquaculture activities; 6. physical presence of aquaculture infrastructure; 7. artificial lighting; 8. noise and vibrations;	o Prevent the recreational fishing and feeding of marine avifauna by aquaculture farm staff on board commercial infrastructure. o Use mesh or netting of an appropriate mesh size (e.g. less than 60 millimetres in bar-length), tear-resistant and tangle-resistant. o Tension anti-predator netting as tight as is practicable. o Manage sea cage infrastructure to minimise entanglement hazards, roosting opportunities and potential collisions with seabirds. o Inspect nets, ropes and sea cages daily for any marine fauna that may have become entangled and release them in accordance with protocols outlined in Appendix 5, MWADZ Marine Fauna Interaction Plan. o Monitor interactions between seabirds and sea cage infrastructure daily. o Monitor seabird activity (by suitably-trained farm crew) and record and report interactions of seabirds with the aquaculture infrastructure. o Minimise to levels as low as practicable the intensity and quantity of light emissions from aquaculture infrastructure at night. o Use, maintain and inspect noise generating equipment (e.g. vessel engines, drilling equipment) to reduce unnecessary increase in noise levels from the equipment (i.e. all vessels shall operate in accordance with the appropriate industry noise codes).	feeding. • None of the pressures on marine environmental quality and benthic communities and habitat are expected to impact on significant marine fauna (i.e. marine mammal, turtle, seabird, wild fish populations). • The implementation of appropriate management and mitigation measures ensures the potential risks associated with provisioning of food and artificial habitats are low. • Ongoing monitoring of the activity and populations of these species will ensure any impacts to populations of vulnerable species are managed through measures which avoid, minimise, or mitigate any impacts. • Compliance with the EMMP and the adoption of best-practice aquaculture management will minimise any impacts to marine fauna. • In summary, the proponent

Environmental Factor	EPA Objective	Existing Environment	Potential Impact	Environmental Management	Predicted Outcome
			10. competition or genetic mixing implications for wild stocks from escaped farm fish; 11. potential changes in benthic/fish habitat; 12. changes in recruitment patterns and spawning stock of invertebrate and fish species; 13. changes in the abundance and distribution of fish and invertebrate species; 14. attraction to, altered feeding behaviour from, and possible entanglement in or entrapment within, sea cages and associated infrastructure; and 15. indirect impacts on other avifauna (particularly in relation to competition for breeding sites) as a result of any expansion to	○ Comply with the Marine Fauna Interaction Management Plan requirements (including reporting of interactions between ETP and other species). ○ Comply with the Waste Management Plan requirements. ○ Monitor fish feeding behaviour and the generation of waste feed to inform and adapt the feeding strategy to maximise feeding efficiency and minimise waste. ○ Conduct regular cleaning and maintenance of sea cage infrastructure to avoid accumulation of biofouling organisms and reduce the need for anti-foulants. ○ Promote high level of fish welfare and husbandry through regulatory measures and the ACWA Code of Conduct. ○ Use pathogen-free brood stock and exclude known significant pathogens through health testing of stock prior to translocation to sea cages. ○ Limit pressure from biological threats through regular cleaning and exchange of nets. ○ Prevent stock from escaping and report all stock escape events. ○ Train staff in escape-critical operations and techniques. ○ Develop a biosecurity monitoring regime based on a recognised and agreed national biosecurity surveillance system. ○ Report all instances of suspected marine pests to the Department of Fisheries.	considers that the potential risks to marine fauna will be adequately managed such that future derived proposals will achieve the EPA's environmental objective by providing a high level of protection for marine fauna.

Environmental Factor	EPA Objective	Existing Environment	Potential Impact	Environmental Management	Predicted Outcome
			‘increaser’ seabird species (i.e. silver gull, Pacific gull or pied cormorant) due to aquaculture activities in the proposed MWADZ.		
Amenity	To ensure that impacts to amenity are reduced as low as reasonably practicable.	While the FHPA is a multi-use marine area, it is relatively pristine in condition. Consequently, the environmental quality of its waters is valued by the community. The MWADZ Proposal area is located in a relatively remote part of the FHPA.	1. excessive presence of macroalgae, phytoplankton and encrusting invertebrates on and around the sea cages; 2. reductions in the natural visual clarity of the water; 3. visible film the water from petrochemical origins; 4. floating debris, dust or other objectionable matter; and 5. presence of objectionable odours.	• Protect both the ecological and social values of the marine environment through the establishment and implementation of an effective environmental quality management framework (EQMF) specific to the MWADZ Proposal in accordance with the guidance described in the EPA’s EAG 15. • Protect marine environmental quality by implementing measures that include those outlined above for both Marine Fauna and Benthic Communities and Habitats. • Incorporate the management measures to protect the environmental factor of amenity (EAG 8) and maintain aesthetic values (EAG 15) of the area within and surrounding the proposed MWADZ. • Monitor assessments of amenity (based on observations made adjacent to sea cage clusters) against the relevant Environmental Quality Criteria (EQC). • Assess against the Environmental Quality Standards (EQS) based upon credible community observations of the aesthetics within the proposed MWADZ. • Provide community users of the Abrolhos Islands FHPA and other relevant stakeholders with an open invitation to comment on any depreciation of the aesthetic values of the	• Amenity and aesthetic values of the Abrolhos marine environment are well-protected from any potential impacts from the proposed aquaculture. • Protection of both the ecological and social values of the marine environment specific to the MWADZ Proposal (refer to Appendix 2). • The EMMP (Appendix 2) and Waste Management Plan (Appendix 6) provide appropriate monitoring and management of the aesthetic values of the marine environment in the vicinity of the proposed aquaculture. • Any unlikely decrease in the aesthetic values of the marine environment in the vicinity of the proposed aquaculture, as determined

Environmental Factor	EPA Objective	Existing Environment	Potential Impact	Environmental Management	Predicted Outcome
				Zeewijk Channel that may be attributable to the aquaculture within the proposed MWADZ (using the Department's website as a mechanism by which the community and stakeholders can submit comments. • Measure any decreases in aesthetic water quality values of the Zeewijk Channel as an increase in the number of complaints or a distinct change in the perception of the community. • Record instances of complaints and document the correspondence in the Annual Compliance Report. • Include all records associated with the monitoring in the Annual Compliance Report.	using direct measures of the community's perception of aesthetic values (exceedance of EQC), will instigate a prompt and effective management response. • The EPA's environmental factor of amenity (EAG 8) and its associated values are supported through the maintenance of the key environmental value of ecosystem health (EAG 15).
Heritage	To ensure that historical and cultural associations, and natural heritage, are not adversely affected.	In the context of the MWADZ Proposal, heritage encompasses Aboriginal cultural heritage and European (maritime) heritage. A search of the Register of Aboriginal Sites maintained by the Western Australian Department of Indigenous Affairs returned no results. In addition, a search of the available literature on the Abrolhos Islands did	1. The physical presence of marine finfish sea cage aquaculture infrastructure within the MWADZ Proposal area is the only possible potential impact on environmental heritage values. However, there do not appear to be any such values applicable to that particular area.	• Protect marine environmental quality (as outlined above). • Given the absence of any evidence of indigenous heritage and cultural issues relating to the Abrolhos Islands; and considering the remoteness of the wrecks and associated dive trails from the MWADZ Proposal area, it is unlikely that the proposed zone will have any impact on their values. • The MWADZ Proposal does not present any known potential impacts to either of these heritage values. • Nevertheless, if any cultural heritage material is uncovered within the proposed MWADZ at any time in the future, the appropriate authorities (e.g. Department of Aboriginal Affairs and the Western Australian Museum) will be immediately contacted for advice.	• There is unlikely to be any adverse impacts to historical and cultural associations, and natural heritage, as a result of the MWADZ Proposal. • Therefore, there is a high degree of confidence that the EPA objective will be met.

Environmental Factor	EPA Objective	Existing Environment	Potential Impact	Environmental Management	Predicted Outcome
		not indicate there were any indigenous heritage and cultural issues that may be impacted by the MWADZ Proposal. There is currently no native title or native title claim over the Abrolhos Islands and the MWADZ Proposal area. A number of shipwrecks are scattered throughout the Abrolhos Islands; however, none are in the vicinity of the MWADZ Proposal area.			

Further detail of the impact assessment processes undertaken for the MWADZ Proposal is outlined in the Modelling and Technical Studies in Support of the Mid West Aquaculture Development Zone (Appendix 1) and Sections 6 to 13 of this PER.

Approach to Environmental Management

The Environmental Scoping Document (ESD) associated with the Mid West Aquaculture Development Zone (MWADZ) strategic proposal (Assessment No. 1972) was determined by the Environmental Protection Authority (EPA) in July 2013. This document defined the requirements of the PER document that were to be met by the Department of Fisheries (Department) on behalf of the Minister for Fisheries (the proponent for the MWADZ strategic proposal).

The preliminary key environmental factors, scope of works and policy documents relevant to the MWADZ Proposal and required to be addressed in the PER document included the EPA's Environmental Assessment Guidelines (EAG) No.3 Protection of Benthic Communities Habitats in Western Australia's Marine Environment (2009) and the EPA's EAG No.7 Marine Dredging Proposals (2011). Although the MWADZ Proposal didn't involve dredging, the principles and approaches for describing the potential impacts and addressing predictive uncertainty outlined in the latter EAG could be applied when assessing impacts to primary producing and non-primary producing communities and habitat.

These documents played a significant role in shaping the Department's approach towards developing the Environmental Monitoring and Management Plan (EMMP) for the MWADZ Proposal. The EMMP consists of a series of sub-management plans, monitoring programs and protocols that address the potential environmental impacts identified in the PER.

Given there is a level of uncertainty in predicting the long-term consequences of conducting sea cage aquaculture in the Mid West, the Department, with the assistance of its environmental consultant (BMT Oceanica), chose to adopt a conservative approach to developing the EMMP. This conservative approach was taken to ensure that the potential scale and intensity of the potential cumulative impact of the proposed aquaculture operations in the MWADZ on the local marine environment was not understated. In other words, it consistently focused on what could be termed the "most likely worst case" scenario when considering the inputs of aquaculture activity (e.g. fish faeces and uneaten fish feed) and their potential impacts on the receiving environment.

Such an approach was reinforced by the available published literature (albeit mostly relating to marine finfish aquaculture in the Northern Hemisphere) pertaining to the potential environmental impacts that may be associated with large-scale marine finfish sea cage aquaculture, supplemented by the outcomes of the environmental modelling undertaken for the MWADZ Proposal.

While this approach can be effective in reducing the likelihood of any unforeseen negative environmental impacts associated with the MWADZ Proposal, it can also result in an overly negative perception of the magnitude of the likely "actual" environmental impacts of the proposal, and (in this instance) the resultant levels of ecological protection considered appropriate when designing the proposal Environmental Quality Plan (EQP).

The combined effects of these factors led to the Department (through its environmental consultants) exploring the possibility of incorporating the principles described in Environmental Assessment Guidelines No.7 Marine Dredging Proposals (2011) in the design of the MWADZ EQP. This idea was supported in that both the published literature and the environmental modelling undertaken indicated the primary environmental impact of the proposed aquaculture was to the sediments immediately beneath the sea cages; but that such impacts did not extend significantly beyond this deposition area. At the same time, the impact of the aquaculture activity on water quality was likely to be negligible. In this respect, the anticipated behaviour of the organic inputs and the resulting environmental impacts of the MWADZ Proposal more closely reflected those expected of (say) a wastewater outfall rather than that previously thought to represent sea cage aquaculture (such as in some other locations within the State).

As a consequence, based on the available information and outputs of the 'conservative' environmental impact modelling undertaken, an EQP based on a small total area of Low Ecological Protection Area (LEPA), (occupying less than one per cent of the area encompassed within a ten kilometre radius of the zone), surrounded by larger areas of High Ecological Protection Area (HEPA) was contemplated. This was considered to reflect the 'likely worse case' scenario.

However, while the Department was confident that such a level of impact and effect is at the upper end of what might be expected and would not be exceeded by the aquaculture activity, it was of the view that, through good farm management, a better environmental outcome could be achieved. It was also conscious that the resultant 'low' level of ecological protection is not consistent with the recently-published EPA EAG No. 15 Protecting the Quality of Western Australia's Marine Environment (2015) (EAG 15). This document, among other things, sets out the EPA's views on the level of ecological protection it would normally expect to be applied, and the environmental values expected to be protected, in relation to certain types of marine areas, including those areas subject to sea cage aquaculture. For this sea cage aquaculture, EAG 15 suggests the most appropriate level of ecological protection is a Moderate Ecological Protection Area (MEPA).

As set out above, the level of uncertainty and the conservative approach to predicting the potential impacts of the proposed MWADZ in the PER resulted in a level of protection that would likely equate to 'Low'. However, the EAG 7 approach, which is designed for dealing with dredging proposals that typically have similar "levels of uncertainty" involved in predicting impacts to that of large-scale aquaculture, suggests that proponents of derived proposals should not only consider the 'most likely worst case' but should also consider the 'most likely best case'. The latter would indicate the level of impact that would occur if realistic, but less conservative (i.e. more optimistic), assumptions were considered and optimum levels of management were achieved.

Due to the lack of published literature relating to marine finfish sea cage aquaculture in sub-tropical waters where the sea bed predominately comprises calcareous sediments (i.e. like the proposed MWADZ), the design of the EQP for the MWADZ Proposal was based on studies conducted in temperate waters in the Northern Hemisphere and on locations that have sediments markedly different (and arguably more vulnerable to environmental impacts from aquaculture) to those present in the proposed MWADZ. In addition, the relatively 'shallow' depth of sediment in the proposed MWADZ and the likely periodic influence of storms, which could rework and mobilise sediments, provides a plausible mechanism to reduce organic matter accumulation rates and consequential sediment anoxia.

Combined, the overstating of potential sediment impacts due to the design basis for the EQP (i.e. Northern Hemisphere examples) and the understating of the potential ameliorating effects of shallow sediment depth and periodic storm activity have probably contributed to a far more pessimistic (i.e. worst case) assessment of the likely environmental impacts of the proposed aquaculture activity being incorporated in the modelling than should have been the case.

Considered from this viewpoint, a likely 'best case scenario' would be that organic enrichment and associated levels of oxygen depletion/hydrogen sulphide production would probably **not** occur to the same extent as that generated through the conservative modelling. Under this scenario, it is possible that the resultant environmental quality would more closely resemble that characterised as a 'moderate' level of ecological protection (i.e. MEPA).

The combined effect of the factors set out above creates some uncertainty as to whether the most appropriate EQP approach for the MWADZ Proposal should be based on a LEPA or MEPA. While not dismissing the potential applicability of the LEPA approach to the proposed MWADZ, the Department acknowledges this approach is built upon the worst case scenario and may not be the only viable approach. It recognises the uncertainty surrounding this matter and acknowledges the need to monitor and collect the relevant information necessary to remove this uncertainty.

Consequently, the Department now proposes a different approach in the EMMP for the MWADZ. This approach is iterative, informed by the results of the monitoring and other information gathered over time and aims to ascertain the most appropriate environmental management arrangements for the MWADZ Proposal. The approach includes the following key elements:

- Apply a MEPA approach to the EQP;
- Apply a 24,000 tonne standing biomass limit;
- Implement a specially-designed environmental monitoring program with the aim to acquire the scientific data necessary to clarify what EQP approach is the most appropriate for the MWADZ (noting this monitoring program is not intended to create an additional operational or financial burden to industry);
- Review all information collected over the first ten years[6] of commercial operations in the zone to clarify the continuing:
    - ✓ appropriateness of the current (MEPA) EQP approach;
    - ✓ environmental compatibility of the 24,000 tonne standing biomass limit for the MWADZ; and
- Subject to the outcomes of the review, thereafter, continue the iterative MWADZ management processes of monitoring, evaluation, review, planning and implementation conducted in consultation with industry and other relevant stakeholders.

[6] By the tenth year of commercial operations in the MWADZ operators should have achieved a complete rotation of their sea cage cluster locations throughout their lease and be back at the (year 1) commencement site. They are also likely to be operating close to their maximum allocated standing biomass limits.

It is important to note that, no matter what the outcome, the environmental monitoring program implemented for the MWADZ Proposal and the adaptive management tools available to the aquaculture operators (i.e. derived proponents) and the Department will ensure a rapid and effective response to the information gathered as aquaculture development in the zone progresses. Collectively, these arrangements will ensure both the environmental integrity of the Abrolhos Islands Fish Habitat Protection Area is preserved; and (within this imperative) the sustainable commercial aquaculture opportunities are maximised.

The EMMP (Appendix 2) for the MWADZ Proposal enables the MWADZ to be developed with greater certainty for the Government, the industry and the community.

The EMMP, coupled with the Management and Environmental Monitoring Plan (MEMP), will ensure the commitments in this PER, subsequent assessment reports and any approval or licence conditions are fully implemented.

The key objective of the EMMP is to ensure the MWADZ Proposal is sustainably managed and that its operation does not have a significant impact on the marine environment. The EMMP will provide an appropriate environmental quality management framework (EQMF) to manage the potential impacts of stocking up to 24,000 tonnes of marine finfish across the proposed MWADZ, using pelletised feeds. The aim is to make sure the MWADZ Proposal is managed to achieve the relevant Environmental Values (EVs) and Environmental Quality Objectives (EQOs), as outlined in EAG 15 and the State Water Quality Management Strategy (Government of Western Australia).

While all the EVs and associated EQOs for the marine waters of Western Australia have been addressed in this PER (Section 7.5), the key EQOs most relevant to this EMMP are:

- maintenance of ecosystem integrity; and
- maintenance of aesthetic values.

Maintenance of ecosystem integrity is concerned with maintaining the structure (e.g. the variety and quantity of life forms) and functions (e.g. the food chains and nutrient cycles) of marine ecosystems to an appropriate level. In this context, the EMMP includes strategies and contingency management responses to protect the key ecosystem elements (EPA 2015), taking into account their occurrence and sensitivity to aquaculture pressures. These key ecosystem elements include:

- water quality
- sediment quality
- seabirds
- marine mammals and turtles
- finfish (including sharks and rays)

Maintenance of aesthetic values is concerned with maintaining the visual qualities of the marine environment, including water clarity, odours and incidences of debris (EPA 2015). The monitoring and management frameworks for the ecosystem and aesthetic elements are outlined in the EMMP (Appendix 2).

Consultation

The Department is committed to open and accountable processes that encourage ongoing stakeholder engagement during all stages of the MWADZ Proposal. It began the consultation process for this project with relevant stakeholders in February 2013 and will continue to do so throughout the PER process.

The purpose of engaging stakeholders during the planning and assessment of the MWADZ Proposal is to:

- inform stakeholders about the MWADZ Proposal by providing accurate and accessible information;
- provide adequate opportunities and timeframes for stakeholders to consider the MWADZ Proposal;
- engage stakeholders in meaningful dialogue and provide adequate opportunities to be involved in the decision making processes during the development of the proposal;
- identify and attempt to resolve potential issues;
- consider and address issues raised by stakeholders and provide feedback; and
- consider stakeholder views in planning future engagement.

A range of stakeholders has been engaged as part of the MWADZ Proposal. These included the following broad groups:

- Commonwealth Government
- State Government
- Local Government
- community groups and environment Non-Government Organisations (eNGOs)
- industry groups and representatives
- internal stakeholders

Stakeholder engagement activities for the MWADZ Proposal to date have included:

- consulting with other decision-making authorities identified in the EPA-prepared Environmental Scoping Document (ESD) on the works required to address the requirements of the ESD;
- conducting stakeholder meetings, briefings and presentations;
- posting periodic newsletters on the Department's website outlining the progress of the project; and
- mailing letters to eNGOs and interest groups.

Further details of the consultation processes undertaken for the MWADZ Proposal, including key issues identified, refer to Section 5 of this PER.

Conclusion

The EPA identified three key environmental factors for this proposal. The key environmental objectives for these factors are:

- *To maintain the quality of water, sediment and biota so that the environmental values, both ecological and social, are protected;*
- *To maintain the structure, function, diversity, distribution and viability of benthic communities and habitats at local and regional scales; and*
- *To maintain the diversity, geographic distribution and viability of fauna at the species and population levels.*

Within this PER and associated documents, the Department has addressed these objectives through considering the potential direct, indirect and cumulative environmental impacts of the MWADZ Proposal and comprehensively conducting the scope of work specified within the ESD. It has also addressed (EAG 8) environmental values and objectives (identified through public consultation) that are additional to those specified in the ESD; and conducted a similar assessment of their potential impacts, mitigation and management measures, and predicted outcomes. Although published over two years after the ESD was approved by the EPA, the provisions of the *Environmental Assessment Guideline for Protecting the Quality of Western Australia's Marine Environment* (EAG 15) has also been addressed in this PER. A summary of the EPA's policy and guidance documents, along with an outline of how and where they have been applied in this process, is listed in Table 1-1 of the PER.

Having completed the work outlined above, the Department concludes that all the EPA objectives have been adequately met. Further, that establishment of commercial marine finfish aquaculture projects within the proposed MWADZ is not expected to cause a significant environmental impact and will not result in a net environmental loss to the conservation values of the Abrolhos Islands Fish Habitat Protection Area or the associated Abrolhos Islands Reserve.

This assessment of the likely environmental impacts is due to several key factors, including:

- the zone's physical characteristics, in particular the high rates of flushing or water exchange in the Zeewijk Channel that is sufficient to dilute nutrients before they are assimilated by the ecosystem;
- the adaptive management controls and environmental monitoring framework the Department has developed for the zone, and the individual (derived) proposals within it, through the strategic assessment process for the MWADZ Proposal; and
- confidence in the effectiveness of these management controls and the environmental monitoring framework built upon the experience gained thus far through implementing similar arrangements in the Kimberley Aquaculture Development Zone.

The objectives described in this PER that have been established to determine the predicted environmental outcomes reflect the EP Act principle of conserving biodiversity and ecological integrity. This principle, in addition to the "precautionary" principle that is embodied in both the EP Act and the current FRMA is further reinforced in the *Aquatic*

Resources Management Bill 2015.[7] The Department is the Western Australian Government agency responsible for the administration and implementation of the FRMA and is committed to adopting a conservative approach to managing uncertainties over environmental impacts. This will be achieved through the early consideration of the identified potential environmental impacts and additional cumulative impacts associated with the project proposals, and of the relevant management measures designed to control these.

Collectively, these factors underpin the Department's confidence that the MWADZ Proposal will be environmentally acceptable, subject to the effective implementation of the mitigation and management measures outlined in this PER and its associated documents.

The results from the environmental monitoring program and reviews of the effectiveness of the management plans, protocols and other mitigation measures will also provide valuable information to support evidence-based policy development for future sustainable marine finfish aquaculture production in Western Australia.

[7] The 'precautionary' principle, as specified in s.4A of the FRMA requires that: "*In the performance or exercise of a function or power under this Act, lack of full scientific certainty must not be used as a reason for postponing cost-effective measures to ensure the sustainability of fish stocks or the aquatic environment.*"

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LIST OF ABBREVIATIONS

The following acronyms and abbreviations are commonly used in the Mid West Aquaculture Development Zone Public Environmental Review/Draft Environmental Impact Statement:

ACWA	Aquaculture Council of Western Australia
AIMWTMF	Abrolhos Islands and Mid West Trawl Managed Fishery
ANOVA	Analysis of Variance
ANZECC	Australian and New Zealand Environment and Conservation Council
AQIS	Australian Quarantine and Inspection Service
ARMB	Aquatic Resources Management Bill 2015
ARMCANZ	Agricultural and Resource Management Council of Australia and New Zealand
BCH	Benthic Communities and Habitat
BRA	Biosecurity Risk Assessment
CEO	Chief Executive Officer
Chl-a	Chlorophyll-a
CI	Confidence Interval
CoP	Code of Practice
Cu	Copper
Department	Department of Fisheries Western Australia
DIN	Dissolved Inorganic Nitrogen
DO	Dissolved Oxygen
DoF	Department of Fisheries Western Australia
DPaW	Department of Parks and Wildlife
EAG	Environmental Assessment Guidelines
EF	Environmental Factor
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMMP	Environmental Monitoring and Management Plan
EO	Environmental Objective
EP Act	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EQC	Environmental Quality Criteria
EQG	Environmental Quality Guideline
EQMF	Environmental Quality Management Framework
EQMP	Environmental Quality Management Plan
EQO	Environmental Quality Objective
EQP	Environmental Quality Plan
EQS	Environmental Quality Standard
ESD	Ecologically Sustainable Development
ESD	Environmental Scoping Document
ETP	Endangered, Threatened and Protected
EV	Environmental Value
FHPA	Fish Habitat Protection Area
FRMA	*Fish Resources Management Act 1994*
FRMR	*Fish Resources Management Regulations 1995*

GFC	Geraldton Fisherman's Co-operative
GRP	Gross Regional Product
GS	Guidance Statement
GSP	Gross State Product
HEPA	High Ecological Protection Area
IMP	Introduced Marine Pest
LAC	Light Attenuation Coefficient
LAU	Local Assessment Unit
LEP	Level of Ecological Protection
LEPA	Low Ecological Protection Area
LOR	Limits of Reporting
MEMP	Management and Environmental Monitoring Plan
MEPA	Moderate Ecological Protection Area
MFIMP	Marine Fauna Interaction Management Plan
Minister	Minister for Fisheries
MWADZ	Mid West Aquaculture Development Zone
MWADZ Proposal	Mid West Aquaculture Development Zone strategic proposal
NWQMS	National Water Quality Management Strategy
OEPA	Office of the Environmental Protection Authority
PER	Public Environmental Review
ROV	Remotely Operated Vehicle
SCUBA	Self-Contained Underwater Breathing Apparatus
SWQMS	State Water Quality Management Strategy
TN	Total Nitrogen
TOC	Total Organic Carbon
TP	Total Phosphorus
TSS	Total Suspended Solids
WC Act	*Wildlife Conservation Act 1950*
WCDSMF	West Coast Demersal Scalefish Managed Fishery
WCRLMF	West Coast Rock Lobster Managed Fishery
ZMP	Mid West Aquaculture Development Zone Management Policy
Zn	Zinc
zone	Aquaculture Development Zone

GLOSSARY OF TERMS

Anchoring and Bridle System	The series of ropes, chains, weights and anchors used to keep the sea cages and nets in place in the ocean.
Anoxic	Absence of or low concentrations of oxygen.
Anti-predator Net	A net that is suspended around the culture net to prevent predators from entering cages.
Aquaculture	Cultivating fish or marine vegetation for the purposes of harvesting the organisms or their progeny with a view to sell or keep the organisms in a confined area for commercial purposes.
Background (conditions)	Natural environmental conditions that are largely un-impacted by anthropogenic influences.
Baseline (conditions)	Environmental conditions prior to being subject to pressures from a development or operation of concern.
Benthic	Living in or on the seabed.
Benthic Communities and Habitat (BCH)	Are functional ecological communities that inhabit the seabed within which algae (e.g. macroalgae, turf and benthic microalgae), seagrass, mangroves, corals or combinations of these groups are prominent components. BCH also include areas of seabed that can support these communities.
Biofouling	The settlement, attachment and growth of organisms (e.g. microorganisms, plants, algae and animals) on submerged surfaces in aquatic environments.
Brood stock	The group of mature or parent fish used in aquaculture for breeding purposes.
Contaminant	Biological (e.g. bacterial and viral pathogens) and chemical (see Toxicants) introductions capable of producing an adverse response in a biological system, seriously injuring structure or function or causing mortality.
Control site	A site located in an area that is unaffected by a pressure being monitored (generally up-current) and used for determining baseline conditions/quality prior to becoming influenced by the pressure of concern.
Decommissioning	A general term for a formal process to dismantle or remove something from service i.e. removal of sea cage infrastructure.
Detectable change	A measurable change in an indicator (generally beyond the natural variability of that indicator) that is statistically significant.
Environmental Factor	A part of the environment that may be impacted by an aspect of a proposal. There are 15 environmental factors identified as relevant and practical for the EIA process (see EAG 8).
Environmental quality criteria	Environmental quality guidelines and/or standards.

Environmental quality guideline	A threshold numerical value or narrative statement which if met indicates there is a high degree of certainty that the associated environmental quality objective has been achieved.
Environmental quality indicator	A specific parameter that can be measured and used to indicate the quality of that part of the environment by comparing the measurements against the associated EQC for that parameter.
Environmental quality management framework	The framework adopted by the EPA and described in this EAG for managing the quality for the marine environment to meet the EPA's objectives and the community and stakeholder's long-term desires.
Environmental quality objective	A specific management goal for a designated part of the environment that signals the level of environmental quality needed to protect the environmental value.
Environmental quality plan	A plan that identifies the environmental values that apply to an area and spatially maps the zones where the environmental quality objectives (including levels of ecological protection) should be achieved.
Environmental quality standard	A threshold numerical value or narrative statement that indicates a level which if not met indicates there is a significant risk that the associated environmental quality objective has not been achieved and triggers a management response.
Environmental value	Particular value or use of the environment that is important for a healthy ecosystem or for public benefit, welfare, safety or health and that requires protection from the effects of pollution, waste discharges and deposits.
Fallowing	A good husbandry practice that involves moving cages over different seabed areas in order to minimise the build-up of organic wastes in any one area, and to subsequently allow these areas enough time for natural marine processes and the environment to assimilate any wastes.
Feed Conversion Ratio	The amount of food required to produce one unit of growth (e.g. kilogram) in an organism (e.g. fish).
In situ	Situated in the original, natural or existing place or position.
Infauna	Aquatic animals living in the sediment.
Increaser seabirds	Increaser seabird species take advantage of activities associated with humans that result in a food (energy) subsidy particularly during periods when food availability is limiting (Harris and Wanless, 1997, Montevecchi 2002). Additional food resources can result in increased breeding effort and success leading to expanding populations, with potential detrimental impacts on other seabirds and island ecosystems in the area.
Irreversible	Lacking a capacity to return or recover to a state resembling that prior to being impacted within a timeframe of five years or less (also see reversible).
Level of ecological protection	A level of environmental quality desired by the community and stakeholders for the EQO maintenance of ecological integrity.
Matters of National	Matters of national environmental significance are protected under

Environmental Significance national environment law – the Environment Protection and Biodiversity Conservation Act 1999. These include listed threatened species and communities, listed migratory species, Ramsar wetlands of international importance, Commonwealth marine environment, world heritage properties, national heritage places, the Great Barrier Reef Marine Park and nuclear actions.

Oligotrophic Nutrient poor.

Pelagic Organisms that inhabit open water.

Physico-chemical stressor Refers to physical (e.g. temperature, electrical conductivity, total suspended solids) and chemical characteristics (e.g. dissolved oxygen concentration, nutrient concentrations) of water that can cause changes in biological systems.

Plankton Organisms (< 0.5 mm) that drift with the ocean currents.

Pollution Where an emission causes direct or indirect alteration of the environment to the detriment of an environmental value.

Precautionary Principle A principle of ESD which states that where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

Reference site A site located in a similar system, or in a location that experiences similar natural environmental conditions as an area being managed, but largely un-impacted by anthropogenic influences and used as a benchmark for determining the environmental quality to be achieved.

Reversible A capacity to return or recover to a state resembling that prior to being impacted within a timeframe of five years or less.

Risk The likelihood of an undesired event (or impact) occurring as a result of some behaviour or action.

Risk Management The culture, processes and structures that are directed towards the effective management of potential opportunities and adverse effects.

Sedimentation The settling of particles (e.g. uneaten food and fish faeces) to settle out of the fluid in which they are suspended (e.g. out of the water column of the ocean onto the seabed).

Significant Impact A significant impact is an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted and upon the intensity, duration, magnitude and geographic extent of the impacts.

Standing Biomass Is the maximum fish biomass that may be supported in a system on a continuing basis.

State coastal waters The State coastal waters extend three nautical miles seaward from the territorial sea baseline.

Total Organic Carbon	The amount of carbon bound in an organic compound which is often used as a non-specific indicator of water quality.
Toxicant	A chemical capable of producing serious injury in an organism(s) or death at concentrations that might be encountered in the environment.
Uncertainty	In relation to prediction is doubt or concern about the reliability of achieving predicted outcomes.
WA Marine Waters	State coastal waters and waters within the limits of the state, excluding estuaries and other inland waters.
Waters within the Limits of the State	Waters on the landward side of the territorial sea baseline.
Wave Height	The vertical distance between a wave crest and preceding or succeeding wave trough.
Xenobiotic	A foreign chemical not produced in nature and not normally considered a constituent of a specified biological system. This term is usually applied to manufactured chemicals.

1 INTRODUCTION

The Minister for Fisheries (Minister) proposes to establish an aquaculture development zone (zone) in the Mid West region of Western Australia for the purpose of marine finfish aquaculture.[8]

1.1 Purpose and scope of this document

The purpose of this Public Environmental Review (PER) is to describe the principal components of the Mid West Aquaculture Development Zone proposal (hereafter referred to as the MWADZ Proposal), including an assessment of the environmental impacts reasonably expected to occur, the mitigation and management measures that the Department proposes to implement and the environmental acceptability of the MWADZ Proposal in the context of the objectives and requirements of the Western Australian *Environmental Protection Act 1986* (EP Act).

As the MWADZ Proposal is a strategic proposal and the proponent (i.e. the Minister for Fisheries) will not be the proponent of a future derived proposal under the strategic proposal (i.e. will not be conducting an aquaculture operation within the MWADZ), the MWADZ Proposal does not require assessment under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). However, proponents of future derived proposals may require assessment under the EPBC Act if, for example, they trigger the provisions under that Act relating to endangered, threatened and protected species. This PER contains additional information intended to address such EPBC Act matters should such circumstances ever eventuate.

The PER is primarily intended to inform stakeholders [including the community, other interested parties, the Western Australian Environmental Protection Authority (EPA) and the Commonwealth Department of the Environment (DotE)] about the MWADZ Proposal. Ultimately, the purpose of this document is to provide sufficient information to enable the EPA to assess the MWADZ Proposal and for them to be able to report to the Minister for Environment on the outcome of its environmental assessment of the Strategic Proposal. This then enables the Minister to determine whether or not the MWADZ Proposal can be implemented and, if so, what conditions would apply to future derived proposals identified within the document.

This document presents a PER of the MWADZ Proposal to satisfy the requirements for assessment under the EP Act. Section 4 of this PER describes the approach undertaken to meet the requirements of State (and Commonwealth) legislation.

The scope of the PER covers the establishment, operation and (if ever necessary) decommissioning of the MWADZ. A detailed description of the MWADZ Proposal is provided in Section 2.

The scope of this document considers the likely direct and indirect impacts of the MWADZ Proposal. It also includes an assessment, where relevant, of potential cumulative impacts of the MWADZ Proposal when combined with other past, present, and reasonably foreseeable

[8] Section 101A(2A) of the *Fish Resources Management Act 1994* provides for the Minister to declare an area of WA waters (other than inland waters) to be an aquaculture development zone.

future actions. Section 6 provides further detail on the impact assessment approach adopted and the types of impacts assessed.

1.2 Approach to preparing this Public Environmental Review

1.2.1 Western Australian Environmental Impact Assessment Process

The EPA undertakes the environmental impact assessment (EIA) of some proposals and schemes referred to it under Part IV of the *Environmental Protection Act 1986* (the EP Act).

EIA is a systematic and orderly evaluation of a proposal and its impact on the environment. The assessment includes considering ways in which the proposal, if implemented, could avoid or reduces any impact on the environment.

The EIA of proposals is undertaken in accordance with Part IV Division 1 of the EP Act and the Environmental Impact Assessment Administrative Procedures 2012 (EIAAP).[9]

The Department referred the MWADZ Proposal to the EPA in April 2013, for determination of whether the strategic proposal was valid, whether or not to assess the proposal and (if so) the level of environmental assessment. The referral was accepted by the Environmental Protection Authority (EPA) and the level of assessment determined by the EPA as applying to the MWADZ Proposal set at the Public Environmental Review (PER) level of assessment.

An Environmental Scoping Document (ESD) was prepared by the EPA. This document outlines the works required to demonstrate that the proposal has considered and addressed potential impacts on the environment.

The ESD also identifies the EPA policies and guidance documents that the Office of the Environmental Protection Authority (OEPA) believes are relevant to the MWADZ Proposal and set out how the preliminary key environmental factors are to be considered. These policy and guidance documents, along with an outline of how and where they have been applied in this PER, is listed in Table 1-1.

Table 1-1: Consideration of Relevant EPA Policies and Guidance Documents

Relevant Policy Identified in the ESD	Aspects of the Policy Applied to the Assessment	Section of the PER Document to which the Policy Applies
Environmental Assessment Guidelines No. 1 (EAG 1) *Defining the Key Characteristics of a Proposal*	Project operations of future derived proposals have been considered in defining the Key Characteristics of the MWADZ Proposal. Section 2 of this PER document provides tabular information to define both Key Characteristics of the strategic proposal and future derived proposals. This section contains a written summary that clearly defines the key elements of the derived proposals, including specifications in terms of infrastructure, actions, activities and processes. The geospatial data, maps and illustrative figures within the MWADZ Proposal PER document ensure the proposed	• Figures 2-1 and 2-2: Proposed Area – MWADZ • Section 2.3: Key Characteristics of the Strategic Proposal • Section 2.4 Key Characteristics of Future Derived Proposals

[9] Refer to the following link to the document on the EPA website: http://epa.wa.gov.au/EPADocLib/Environmental%20Impact%20Assessment%20Administrative%20Procedures%202012.pdf

Relevant Policy Identified in the ESD	Aspects of the Policy Applied to the Assessment	Section of the PER Document to which the Policy Applies
	elements are specifically and accurately defined in terms of the extent and intensity of areas of impact and a wider constrained footprint.	
Environmental Assessment Guidelines No. 3 (EAG 3) *Protection of Benthic Primary Producer Habitat in Western Australia's Marine Environment*	The PER document has used and presented a risk-based spatial assessment of the potential cumulative "irreversible loss" and, or, serious damage to benthic community habitats (BCH), including any benthic habitat that may support primary produces, e.g. macro algae and symbiotic filter feeders, such as corals. The PER is consistent in its application of the EAG 3 approach to defining local assessment units (LAU) for the MWDAZ strategic proposal and predicting cumulative loss of BCH within these LAU. Appropriate application of EAG 3 has facilitated a clear and logical indication of the risk the proposal presents to the ecological integrity associated with cumulative loss of BCH.	• Section 6.6.1 Application of EAG 3 • 7.4 Assessment of Potential Impacts • Section 8.3 – 8.6 of the PER document relating to potential and predicted environmental impacts on BCH. • Figure 8-28 The Northern and Southern Local Assessment Units and the indicative benthic substrates in the vicinity of the MWADZ.
Environmental Assessment Guidelines No. 5 (EAG 5) *Protecting Marine Turtles from Light Impacts*	EAG 5 provides specific procedures, methods and minimum requirements expected by the EPA for environmental management to protect marine turtles from the adverse impacts of light. The PER document has been informed by EAG 5 and where applicable, various procedures, methods and minimum requirements have been adopted to avoid interaction between the proposed aquaculture and marine turtles.	• Section 9.4.1.3 Artificial Lighting • Appendix 2. Environmental Monitoring and Management Plan – Section 4.5
Environmental Assessment Guidelines No. 7 (EAG 7) *Marine Dredging Proposals*	The predicted extent, severity and duration of impacts of the proposed aquaculture to benthic habitats are described in the context of EAG7. Although EAG7 was designed for dealing with dredging proposals, it is relevant and directly applicable to managing the most significant environmental impacts of marine sea-cage aquaculture. Deposition of organic waste from aquaculture can be similar in nature to the effects of sedimentation from dredging and disposal of dredge spoil on benthic communities. However, it is important to note and define significant differences between the potential extent, severity and duration of the proposed aquaculture activities in comparison to any dredging proposal. The environmental impact assessment of the strategic proposal is heavily based on the concepts and principles of EAG7. The EAG 7 approach is designed for dealing with dredging proposals, which typically have similar 'levels of uncertainty' involved in predicting impacts to that of large scale aquaculture operations. EAG 7 suggests that proponents of proposals should not only consider the 'most likely worst case' but should also consider the 'most likely best case'. The Environmental Monitoring and Management Plan (EMMP) for the MWADZ Proposal, was also developed in the context of the EAG 7.	• Section 6.6.2 Application of EAG 7 • Section 6.7.6 Biogeochemical processes • 7.4 Assessment of Potential Impacts • Section 8.2.2 • Table 8-3 • 14.2 Proposed Management • Appendix 2. - Environmental Monitoring and Management Plan
Environmental Assessment	EAG 8 was used to develop the basis for the assessing whether the environmental impact was acceptable. This	• Section 6.3.4.1 - Environmental and

Relevant Policy Identified in the ESD	Aspects of the Policy Applied to the Assessment	Section of the PER Document to which the Policy Applies
Guidelines No. 8 (EAG 8) *Environmental Principles, Factors and Objectives*	PER took into account the principles of environmental protection and relevant policies, factors and the associated environmental objectives. EAG 8 was also used as guidance in relation to applying the principles of environmental protection, such as the precautionary principle, the principle of intergenerational equity, the principle of biological diversity and ecological integrity, and the principle of waste minimisation. Additionally the EMMP calls for proponents to exercise best practice and employ management mechanisms aimed at continuous improvement. This PER has identified and addressed five key factors: • Marine Environmental Quality; • Benthic Communities and Habitat; • Marine Fauna; • Heritage; and • Amenity, in addition to the environmental objective associated with each factor. EAG 8 has helped to establish aspirational goals and promoted a holistic approach to the environmental assessment.	Social Objectives • Section 2.3.1.2 - Marine Fauna • 13.3.1.1 - Environmental Monitoring and Management Plan • 14.3 Predicted Outcome • Appendix 2. - Environmental Monitoring and Management Plan
Environmental Assessment Guidelines No. 9 (EAG 9) *Application of a Significance Framework in the Environmental Impact Assessment Process*	EAG 9 was used in conjunction with EAG 8 to ensure the proposal was consistent with the principles of the EP Act. EAG 9 was also used in conjunction with EAG 1 and helped to identify which environmental factors were the most significant, key factors. This was important for gauging the type and quantity of information required to demonstrate that implementation of the proposal would be acceptable.	• Section 6 – Environmental Impact Assessment Framework • (Section 6.3.2 – Identification of Environmental Stressors and Factors • Table 6-3 Environmental Factors and Objectives • Section 6.4 • Table 6-4 • Section 6.5)
Environmental Assessment Guidelines No. 15 (EAG 15) *Protecting the Quality of Western Australia's Marine Environment*	As part of the PER document, an environmental quality management framework (EQMF) has been developed in accordance with EAG 15 (EPA 2015) to protect the environmental values of the marine environment from any organic waste and, or, contaminants associated with the proposed aquaculture. Consistent with EAG 15 the environmental impact assessment (EIA) for the MWADZ Proposal involved modelling the distribution and fate of aquaculture waste. This information informed the development of specific environmental quality criteria for the purpose of monitoring the effects of organic enrichment on the marine environment. For this sea cage aquaculture, EAG 15 suggests the most appropriate level of ecological protection is a Moderate Ecological Protection Area (MEPA). The EQMF developed for the MWADZ Proposal will manage sea	• Sections 6.5 – Technical and Environmental Studies • Section 6.6 – Thresholds for Interrogation of the Ecosystem Model • Section 6.7 Integrated Model components • Section 7.5 – Management Measures • Section 8.5 – Management Measures • Section 14.2 – Proposed Management • Appendix 2 - Environmental

Relevant Policy Identified in the ESD	Aspects of the Policy Applied to the Assessment	Section of the PER Document to which the Policy Applies
	cage aquaculture within 'floating' MEPAs which are proportionate to fifty per cent of any given lease area. The EQMF is devised to maintain the existing environmental quality of remaining fifty per cent of the MWADZ and the surrounding area at a high level of ecological protection (HEPA).	Monitoring and Management Plan
Environmental Assessment Guidelines No. 17 (EAG 17) *Preparation of Management Plans under Part IV of the Environmental Protection Act 1986*	The PER document includes an Environmental Monitoring and Management Plan (EMMP). EAG 17 assisted in the development of the EMMP by providing guidance on high level principles and objectives relating to the function of an EMMP. EAG 17 provided the fundamental context for determining whether the environmental management system described in the EMMP would achieve the EPA's objectives for the key environmental factors that were determined by the environmental impact assessment. It affirmed the key elements of the EMMP, being; best practicable control measures to avoid and minimise potential impacts, and adaptive environmental management, to facilitate continual improvement. The EMMP is an integral part of the PER and demonstrates how the implementation of the proposal will meet the environmental objectives associated with the key environmental factors. The EMMP achieves this by stipulating: • Condition environmental objectives; • Management actions; • Management targets; • Monitoring; and • Reporting.	• Section 1.2 – Western Australian Environmental Impact Assessment Process • Section 2.3 – Key Characteristics of the Strategic and Future Derived Proposals • Section 6.4.5 - Mitigation and Management of Impacts • Section 7.5 - Management Measures • Section 8.5 - Management Measures • Section 9.5 - Management Measures • Section 10.5 - Management Measures • Section 11.4 - Management Measures • Section 12.6 - Management Measures • Section 13.3.1.1 - Environmental Monitoring and Management Plan • Section 14.2 - Proposed Management • Appendix 2 - Environmental Monitoring and Management Plan
EPA Checklist - *for Documents Submitted for Environmental Impact Assessment on Marine and Terrestrial Biodiversity*	The EPA checklist was used during the initial project planning, the environmental scoping process and the final check of the PER document to ensure the proposal is comprehensive and of high quality. The checklist help to ensure that the environmental impact assessment had included all required considerations and issues are addressed in an appropriate context.	• PER Sections 2, 3, 6, 7, 8, 9 and 14 • Appendix 2 - EMMP Section 4. • Appendices 1 – Modelling and Technical Studies in Support of the Mid West Aquaculture Development Zone and the • Appendix 5 – Marine Fauna Interaction Management Plan.
EPA Guidelines for	The EPA's Guidelines for preparing a Public	Entire PER document and

Relevant Policy Identified in the ESD	Aspects of the Policy Applied to the Assessment	Section of the PER Document to which the Policy Applies
Preparing a Public Environmental Review	Environmental Review were utilised in the preparation of the MWADZ PER document. The requirements to describe the proposal and the receiving environment, including potential impacts, management strategies have been fulfilled. The PER demonstrates that the principles of environmental protection had been implemented and it provides justification for the EPA to deem the proposal acceptable. The proponent has liaised with the OEPA and to ensure sound measures were developed to manage relevant environmental factors. The PER has been written to be read by the average, educated community member and contains no significant errors in its science or format.	all appendices
Environmental Protection Bulletin No. 17	The MWADZ Proposal is strategic in its approach, as opposed to a single case proposal. It identifies more than one future development that is likely within that MWADZ, and in combination, multiple derive proposals could have a significant effect on the environment. In accordance with the *Environmental Impact Assessment Administrative Procedures 2012*, the MWADZ Proposal is being assessed at the highest level of assessment, i.e. PER. The environmental impact assessment of the strategic proposal has facilitated early consideration of potential cumulative impacts of multiple derived proposals. The development of the MWADZ Proposal has rigidly followed the Strategic Proposal Assessment process set out in the Environmental Protection Bulletin No. 17. The PER document clearly describes prerequisites required before a future proposal can be deemed a derived proposal under the strategic proposal. Key to its development, the MWADZ PER involve community consultation commencing at the scoping phase and continuing throughout the development of the proposal. The location and final design of the MWADZ has been influenced by public input and stakeholder advice. The PER provides the EPA with a definite and comprehensive account of the MWADZ in terms of: • key characteristics and environmental factors; • the extent of scope of the proposed aquaculture; • the maximum footprint of impact; • cumulative impacts; and • an array of best management practices and strategies that will be implemented to avoid and minimise impacts.	Entire PER document and all appendices

1.2.2 Commonwealth Environmental Impact Assessment Process

The *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act) provides a legal framework to protect and manage nationally and internationally-important flora, fauna, ecological communities and heritage places.

Officers of the Department contacted the Commonwealth DotE (formerly SEWPaC) to discuss the referral of the MWADZ Proposal to that agency for assessment under the EPBC Act. The DotE Environmental Assessment and Compliance Division advised the Department that the proposed actions associated with the MWADZ Proposal were not of a magnitude that necessitates a "Strategic Assessment" at the Commonwealth level. DotE further advised that, in view of the fact that the Department (on behalf of the Minister for Fisheries) is not itself proposing to undertake aquaculture operations within the MWADZ (in other words, will not be a derived proponent under the strategic proposal), the Department is not required to refer a proposed action under the EPBC Act.

However, as outlined in sub-section 1.1, proponents of future **derived** proposals (i.e. aquaculture operators within the MWADZ) may require assessment under the EPBC Act if, for example, they trigger the provisions under that Act relating to endangered, threatened and protected species.

1.2.3 Other Environmental Approvals

The Commonwealth, State and local environmental policies, plans and guidelines relating to individual areas of assessment (e.g. biosecurity) are outlined within the relevant sections of this PER. For a detailed description of the environmental management framework and legislation which the Department intends to operate the MWADZ refer to Section 4 and Section 15.3.1.2 of this document.

Typically, the only other (State) environmental approval required of proponents of future derived proposals is the aquaculture licence granted under the *Fish Resources Management Act 1994* (FRMA). As a prescribed requirement the Chief Executive Officer (CEO) of the Department must be satisfied before granting the licence [s. 92(1)(c)], the potential environmental impacts of the proposed aquaculture activities must be considered. The statutory requirement for the applicant to provide an accompanying Management and Environmental Monitoring Plan (MEMP) identifying how the applicant will manage any risks to the environment in relation to the proposed aquaculture activity provides one of several mechanisms available to the CEO to consider and address any potential environmental issues.

1.2.4 Structure of this Document

This PER comprises:

- **Executive Summary** – summarises the content of the PER including the background and need for the MWADZ Proposal, environmental and social factors, key potential impacts, illustrative mitigation and management measures, and the predicted environmental and social outcome of implementing the MWADZ Proposal.

- **Section 1, Introduction and Overview of the Project** (this Section) – introduces the MWADZ Proposal, explains the objective and scope of the PER; and introduces the approach adopted to complete the assessment to meet both State and Commonwealth PER requirements respectively.

- **Section 2, Description of the Proposal** – describes the key characteristics of the MWADZ Proposal, including the associated construction, operation and decommissioning aquaculture activities. It also considers the alternatives to the MWADZ Proposal.

- **Section 3, Overview of Existing Environment** – describes the receiving environment (bio-physical and socio-economic) that the MWADZ Proposal has the potential to impact.

- **Section 4, Legislative Framework** – outlines the principal Commonwealth and State regulations, policies, plans, and guidelines relevant to the MWADZ Proposal.

- **Section 5, Stakeholder Consultation** – describes consultation with stakeholders to date, as well as planned stakeholder engagement.

- **Section 6, Environmental Impact Assessment Framework** – describes the environmental impact assessment framework and the assessment methodology used for the MWADZ Proposal.

- **Section 7, Assessment of Potential Impact on Marine Environmental Quality** – assesses the potential impacts of the MWADZ Proposal on benthic sediments and water quality and describes the mitigation and management measures to be implemented.

- **Section 8, Assessment of Potential Impact on Benthic Communities and Habitat -** assesses the potential impacts of the MWADZ Proposal on benthic communities and their habitat (i.e. seagrass, coral, and algae) and describes the mitigation and management measures to be implemented.

- **Section 9, Assessment of Potential Impact on Marine Fauna -** assesses the potential impacts of the MWADZ Proposal on marine fauna (i.e. fish, marine invertebrates, marine mammals, marine reptiles and marine avifauna) and describes the mitigation and management measures to be implemented.

- **Section 10, Assessment of Potential Impact on Biosecurity** – describes how impacts associated with the potential introduction of non-native species and diseases into the surrounding waters will be mitigated and managed.

- **Section 11, Assessment of Potential Impact on Fisheries** – assesses the potential impacts of the MWADZ Proposal on marine fisheries (both finfish and invertebrates) and describes the mitigation and management measures to be implemented.

- **Section 12, Assessment of Potential Impact on Heritage** – assesses the potential impacts of the MWADZ Proposal on the environmental factor of heritage and describes the mitigation and management measures to be implemented.

- **Section 13, Assessment of Potential Impact on Amenity** – assesses the potential impacts of the MWADZ Proposal on the environmental factor of amenity and describes the mitigation and management measures to be implemented.

- **Section 14, Assessment of Potential Impact on Non-Environmental Matters** – assesses the potential impacts of the MWADZ Proposal on those social and economic matters that are not related to an environmental factor (as listed in EAG 8) but have been raised in the course of the consultation conducted thus far. Where relevant, this section comments on any mitigation and management measures associated with such matters.

- **Section 15, Environmental Management Framework** – describes the environmental management framework to be implemented for the MWADZ Proposal. Additional information, including the technical studies completed to support this PER, is provided in accompanying Appendices, as listed in Section 18.

- **Section 16, Conclusion** – summarises the potential impacts resulting from the MWADZ Proposal, the proposed management of such impacts and the predicted outcomes arising from that management.

2 DESCRIPTION OF PROPOSAL

2.1 Proposal overview

The Department, on behalf of the Minister, proposes to create an Aquaculture Development Zone to provide a management precinct for prospective future aquaculture proposals within State Waters, approximately 65 kilometres west of Geraldton within the Fish Habitat Protection Area of the Abrolhos Islands. The strategic proposal area has been selected by the proponent to maximise suitability for marine finfish aquaculture and minimise potential impacts on existing marine communities and disruption to existing human use.

The strategic proposal, also known as the MWADZ Proposal, encompasses 3,000 hectares of marine waters within two separate areas (800 hectares and 2,200 hectares).

2.1.1 Proposal Title

The formal title of the proposal is the Mid West Aquaculture Development Zone Proposal (MWADZ Proposal).[10]

2.1.2 Proposal Objectives

The MWADZ Proposal aims to:

- declare an area of Western Australian (WA) waters, based on its biological, environmental, economic and social attributes, as suitable for large-scale commercial finfish aquaculture; and
- establish an effective management framework, including an efficient approval process, for operators within that area.

2.1.3 Proposal Background

A strategic planning approach to aquaculture development is regarded as best regulatory practice and a key method of providing for industry growth while achieving ecologically sustainable development outcomes.[11] Some Australian states have established significant marine aquaculture industries using a regional zone methodology in their strategic planning.

The Western Australian Government is committed to the development of a sustainable marine aquaculture industry and, to further this commitment, the Minister announced a funding package to enable the establishment of two such zones: one in the Kimberley and one in the Mid West region of the State.[12] The Kimberley Aquaculture Development Zone (KADZ) is the first aquaculture development zone to be established in Western Australia and was declared by the Minister on 22 August 2014.

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[10] All offshore installation activities, as well as commissioning, operating and decommissioning activities of the infrastructure described in this section and undertaken by the holders of aquaculture licences and leases authorised to conduct aquaculture within the zone, are considered part of the MWADZ Proposal.

[11] *Best practice framework of regulatory arrangements for aquaculture in Australia* [Primary Industries Ministerial Council – 2005].

[12] The Premier's Statement of Commitment to Aquaculture in Western Australia can be accessed at http://www.fish.wa.gov.au/About-Us/News/Pages/Bright-future-for-WA-aquaculture.aspx.

The Department is managing the creation of these two zones on behalf of the Minister.

2.1.4 Project Proponent

The Minister for Fisheries is the proponent of the MWADZ Proposal.[13]

2.1.5 Roles and Responsibilities

On behalf of the Minister for Fisheries, the Department is the zone manager for the MWADZ Proposal. Among other responsibilities within the zone, the Department is responsible for:

- the grant of aquaculture licences and administration of leases within the zone (leases are granted by the Minister for Fisheries);[14]
- adaptive management through aquaculture licence conditions or the Management and Environmental Monitoring Plan (MEMP), as appropriate;
- ensuring lease/licence holders comply with the Environmental Management and Monitoring Plan (EMMP) for the zone;
- ensuring compliance with the zone management policy; and
- ensuring the reporting requirements under the *Environmental Protection Act 1986* (EP Act) specified in the Ministerial Statement and any subsequent Section 45A notices are met.

The Department will work in conjunction with the Office of the Environmental Protection Authority (OEPA) to ensure compliance with authorisations, such as the strategic and derived proposal approvals, provided under the EP Act.

2.1.6 Precedence and Commitments

The MWADZ Proposal will be the second aquaculture development zone to be established in Western Australia. The Kimberley Aquaculture Development Zone was the first, being declared by the Minister on 22 August 2014.

The Department has approached the creation and ongoing management of these zones with the commitments embodied in the zone Mission Statement. This has been adopted as follows:

Mission

"To identify, secure and manage strategically-important areas of Western Australian marine waters for large-scale commercial aquaculture purposes; such that growth in the aquaculture industry is stimulated and expansion is achieved in an environmentally-sustainable manner."

Vision

"Fully utilised, fit-for-purpose Aquaculture Development Zones servicing a range of aquaculture activities that are environmentally, commercially and socially sustainable."

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[13] As defined under s.9 of the FRMA.

[14] The zone Site Allocation Policy will assist in determining the number, size and location of leases that may be established within the zone (refer the Department's website at www.fish.wa.gov.au).

Values

Our core values are:

- ***Integrity*** *- Being honest, reliable and courteous in all matters.*
- ***Transparency and Accountability*** *– Being open, responsible and accountable to stakeholders.*
- ***Responsiveness*** *– Being alert to new information and demonstrating a willingness to innovate.*
- ***Sustainability*** *– Being persistent in seeking environmentally, socially and economically sustainable outcomes.*

2.1.7 Proposal Location

The MWADZ Proposal is located within the southern part of the Abrolhos Islands Fish Habitat Protection Area (Figure 2-1), between the Southern and Easter groups of the Abrolhos archipelago, approximately 65 kilometres west of Geraldton.[15] The zone will be divided into two separate areas of water (Figure 2-2):

1. The **Southern area** comprises an 800-hectare existing licensed aquaculture site to the north of Sandy Island in the Pelsaert Group. This existing site will likely be the only aquaculture site within the Southern area.

   The Southern area has an average water depth of 35 metres.

2. The **Northern area** comprises a 2,200-hectare site east of Wooded Island in the Easter Group and north of Gee Bank reef. The final size, location and design of aquaculture sites within the Northern area will be subject to, *inter alia*, the outcomes of the tenure allocation process conducted after the zone has been declared.

   The Northern area has an average water depth of 40 metres.

[15] Fish Habitat Protection Areas are created by the Minister under the provisions of Part 11, Division 1 of the *Fish Resources Management Act 1994*.

Figure 2-1: Abrolhos Islands Fish Habitat Protection Area

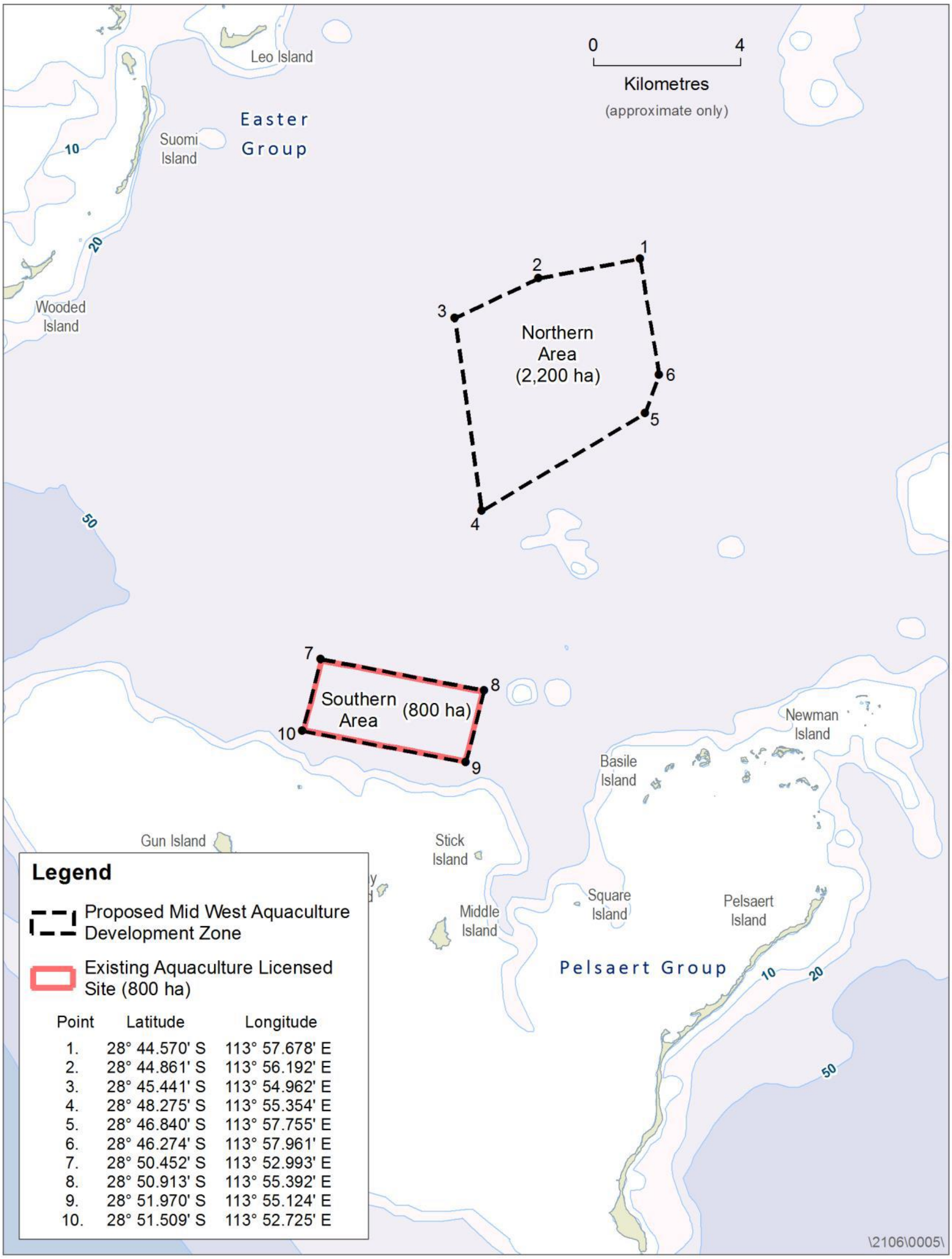

Figure 2-2: Proposed Areas - MWADZ

The MWADZ Proposal is located in a part of the Western Australian coast where there is a confluence of both temperate and tropical sea life, forming one of the State's unique marine areas. This presents a rare opportunity for the development of any of a range of marine finfish aquaculture species that occur naturally within the West Coast region of the State.[16]

2.1.8 Process to Establish the Proposal Location

The location of the MWADZ Proposal was the outcome of a lengthy process that included:

- identifying those geophysical attributes that would support the development of marine finfish aquaculture (see Table 2-1);
- using Geographic Information Systems (GIS) to analyse this information and indicate those areas within the Mid West region that meet all (or most) of the defined attributes; and
- consulting with stakeholders to establish where the MWADZ Proposal was likely to have the least impact in terms of existing activities and values.

The management objectives and values of the Houtman Abrolhos Islands Management Plan were also taken into consideration during site selection.

A GIS-based Multi-criteria Evaluation technique (MCE) was used to identify potential sites and well-established selection criteria for large marine aquaculture establishments were determined to build the MCE tool. For the purpose of this process, important environmental, social and economic factors, which determine the suitability of an area as an aquaculture development zone for marine finfish, can be divided into:

- primary selection criteria;
- secondary selection criteria; and
- tertiary selection criteria.

Primary criteria were essential broad scale attributes which can be defined within State waters using available data sets. Broad areas which could fulfil the basic requirements for marine finfish aquaculture (primary areas of interest) were identified using primary criteria (e.g. Western Australian waters with a depth of between 20 and 50 metres). The demarcation of primary areas of interest provided an essential starting point for community engagement.

Secondary criteria are important attributes which were used to refine areas of interest to discrete patches of water. Secondary criteria were essential for determining and comparing potential sites in terms of viability as an aquaculture development zone. Some of the information that comprised the secondary criteria was obtained during initial meetings with stakeholders. Some datasets were highly localised, with information existing only for specific areas. Secondary criteria refined the primary areas of interest to smaller areas expected to fulfil the economic, environmental and social requirement of a finfish sea cage aquaculture development zone.

Tertiary criteria were advantageous finer scale attributes which were used to delineate particular sites using localised data or qualitative information. Tertiary criteria will denote the

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[16] *West Coast Region* is defined in Regulation 3 *Terms used* of the Fish Resources Management Regulations 1995 as:

(c) all land in the State; and

(d) all WA waters,

that are south of 27⁰ 00' south latitude, excluding the South Coast Region;

most outstanding areas for finfish sea cage aquaculture. Tertiary criteria relied heavily on information provided by key stakeholders and technical experts.

Once primary, secondary and tertiary criteria were identified, GIS was used to conduct basic Multi-Criteria Evaluation to present three scenarios. The Department considered stakeholder feedback on the scenarios maps and used the input to develop a separate map showing the area where an aquaculture zone, up to 3,000 hectares in size, could be economically viable, yet socially and environmentally acceptable. Community engagement was fundamental to inform the Department on stakeholder values and concerns, and to provide local knowledge, prior to an ultimate location of the site being decided.

The GIS Multi-Criteria Evaluation technique was used to identify areas that were potentially suitable for finfish aquaculture; however, the ultimate decision on the location was substantially influenced by stakeholder advice. This was backed up by underwater video "ground-truthing" of the proposed sites conducted by officers of the Department and the Office of the Environmental Protection Authority (OEPA) to ensure the benthic habitat was predominately sandy bottom. Once the sites were decided, a technical environmental study was undertaken to finalise the boundaries of each site and confirm its suitability as a marine finfish aquaculture development zone.

Table 2-1: GIS Multi-Criteria Evaluation

Factor	Criteria
Jurisdiction/tenure	Avoid Port waters
Shipping	Avoid international shipping routes
Reef Observation Areas	Buffer of one kilometre around Reef Observation Areas
Gas and petroleum industry	No overlap with an area of interest to the gas and petroleum industry
Wave shadow	Areas within 20 kilometres northeast (i.e. in the wave shadow) of any island; or reef /sandbank rising to a depth shallower than the 17 metre depth contour
Proximity to population centre	Less than 85 kilometres (46 nautical miles) of Geraldton
Access to transport	Less than 20 kilometres from an airstrip or a dock
Area	Greater than 1,000 hectares
Effluent	Buffer of at least one kilometre from any effluent outfall
Water depth	Between 20 and 50 metres depth
Environmentally-valuable sites	Buffer of 100 metres around habitats of high conservation value (e.g. coral/seagrass dominated)
Megafauna	Buffer of one kilometre around breeding habitats
Historically-significant sites	Buffer of one kilometre around historically significant sites
Recreational fisheries	No overlap with principal recreational fishing grounds (based upon catch levels)
Commercial fisheries	No overlap with principal commercial fishing grounds (based upon catch levels)

2.2 Development Alternatives

Noting the key outcome sought by the MWADZ Proposal is increased commercial aquaculture production from the Mid West region of Western Australia, development alternatives were also considered. Essentially, these can be summarised in Table 2-2.

Table 2-2: Development Alternatives

	Alternative considered	Advantages	Disadvantages
Increased commercial aquaculture production	New location within the Mid West region	• Avoids the Abrolhos Fish Habitat Protection Area	• Sub-optimal environmental conditions for commercial aquaculture production • Increased conflict with other existing uses/users
	Defer until the environmental outcomes of the operation of the Kimberley Aquaculture Development Zone are known	• Increased certainty in terms of any possible environmental, social and economic impacts/benefits	• Economic benefits to the region, State and Commonwealth will be delayed • Situation in the Kimberley is different to that in the Mid West and many elements are not comparable
	No development of commercial aquaculture in the Mid West region	• Eliminates any potential environmental impacts to the Abrolhos Fish Habitat Protection Area	• Loss of economic benefits to the nation, State and the Mid West region that would increase general economic growth and sustain regional development • Loss of job opportunities and business/service income to support the operational activities and the loss of government revenue

2.3 Key Characteristics of the Proposal

2.3.1 Overview

The MWADZ Proposal has key characteristics that are common to most sea cage marine finfish aquaculture operations.

Essentially, it involves placing hatchery-raised finfish of a species valued for their biological, domestication and marketability attributes into a system of floating artificial structures (i.e. sea cages) anchored in offshore marine waters. The cages are immersed in the sea such that marine waters pass through the cages, but prevent the finfish (i.e. stock) from escaping into the surrounding sea. The stock are then fed a diet of specially-formulated, pelletised feed until such time as they have grown to the desired size. They are then harvested, processed and distributed to local and overseas markets. The cycle is repeated on an ongoing basis.

2.3.2 Key Characteristics of the Strategic Proposal

The key characteristics of the MWADZ strategic proposal are outlined in Table 2-3.

Table 2-3: Key Characteristics of the MWADZ Strategic Proposal

Element	Description
Proposal Title	Mid West Aquaculture Development Zone
Proponent Name	Minister for Fisheries
Project Life	Ongoing
Location	State waters of Abrolhos Islands Fish Habitat Protection Area, Western Australia (~65 km West of Geraldton). The Northern Site is defined by waters bounded by the coordinates: 1. 28° 44.570' S 113° 57.678' E 2. 28° 44.861' S 113° 56.192' E 3. 28° 45.441' S 113° 54.962' E 4. 28° 48.275' S 113° 55.354' E 5. 28° 46.840' S 113° 57.755' E 6. 28° 46.274' S 113° 57.961' E The Southern Site is defined by waters bounded by the coordinates: 7. 28° 50.452' S 113° 52.993' E 8. 28° 50.913' S 113° 55.392' E 9. 28° 51.970' S 113° 55.124' E 10. 28° 51.509' S 113° 52.725' E
Size of Aquaculture Development Zone	3,000 hectares
Species to be Cultured within the Zone	Marine finfish species that naturally occur within the West Coast region of Western Australia
Culture Method	Floating sea cages
Standing Fish Stock Biomass Limit	Maximum of 24,000 tonnes of marine finfish within the Aquaculture Development Zone at any one time

In assessing this strategic proposal, the EPA needs to conclude, with a high level of confidence, that future proposals can be implemented without significant detrimental impacts on the environment. With this in mind, the environmental impact assessment was designed to assess several possible future production scenarios. The Department expects future derived proposals associated with the MWADZ Proposal will have broadly similar operating requirements and environmental impacts to those within the Kimberley Aquaculture Development Zone. Fish farming technologies, management and operational procedures are similar for a range of marine species and so are the environmental impacts of these operations.

If the strategic proposal is granted approval by the Minister for Environment, future aquaculture proponents within the proposed MWADZ would need to refer their aquaculture proposal to the EPA and request that the EPA declares it a derived proposal under section 39B of the EP Act. Future derived proposals will be required to comply with all requirements as outlined in the MWADZ Management Policy (Appendix 3) and comply with the Environmental Monitoring and Management Plan (EMMP) for the MWADZ (Appendix 2).

Compliance with the EMMP will be enforced as a requirement of the Management and Environmental Monitoring Plan (MEMP) associated with the aquaculture licence and may be further strengthened by licence condition. It is also likely to be a requirement of any Notice issued by the Minister for Environment (under section 45A of the EP Act) in relation to the implementation of any declared derived proposal.

2.3.3 Key Characteristics of Future Derived Proposals

The key characteristics for future derived proposals reflect the policy settings developed for management of the MWADZ and are summarised in Table 2-4.

Table 2-4: Key Characteristics of Future Derived Proposals

Element	Description
Aquaculture Lease Location	Within the boundaries of the approved MWADZ
Operations	• Sea cages installed and maintained consistent with industry best practice • Sea cages only stocked with marine finfish species that naturally occur within the West Coast region of Western Australia • Finfish feeding, husbandry and harvesting
Sea Cage Specifications	• Only floating sea cages permitted • Sea cages fitted with anti-predator nets or equivalent to prevent predator access to stocked fish and prevent fish escapes • Minimum of two metres (at lowest astronomical tide) between the sea floor and the bottom of the sea cage • Sea cages to be deployed in clusters such that the Moderate Ecological Protection Area (MEPA) comprises no more than 50 per cent of the proponent’s aquaculture lease area • All aquaculture gear must be located within the proponent’s aquaculture lease area • Sea cages, including stock, must be located no less than 300 metres of the MWADZ boundary
Standing Fish Stock Biomass Limits	Maximum of eight tonnes per hectare averaged over the area of the lease
Feed Inputs	Only certified commercial pellet feeds that meet Australian Quarantine and Inspection Service requirements permitted
Brood Stock and Juveniles	• Movement of brood stock or juveniles into the MWADZ subject to the Department of Fisheries Translocation Policy (requirement for translocation approval dependent upon circumstances and potential biosecurity risk) • Juvenile seed stock only to be sourced from approved facilities and must be certified disease-free to the satisfaction of the Principal Research Scientist in the Department of Fisheries Fish Health Unit
Approved EMMP	Compliance with the MWADZ Environmental Monitoring and Management Plan (EMMP)

2.4 Construction Activities

2.4.1 Sea Cages

Managers and operators of modern fish farms are improving management practices, including the use of advanced farming systems, methods and equipment that can withstand the elements in unprotected offshore areas. The oligotrophic (low nutrient) waters, strong currents and depths generally characteristic of the open ocean afford better nutrient assimilation and hence increased carrying capacity.[17]

Operators within the proposed MWADZ would be likely to use circular sea cages that are 120 metres in circumference and 38 metres in diameter. In general, the sides of the proposed cages would have a drop of 18 metres; with the bottom of the cage reaching a depth of around 21 metres. The volume of each cage would therefore be at least 20,000 cubic metres.

The sea cages need to be capable of retaining the stock and providing an effective barrier to exclude predators, without posing a significant hazard to either.

Technology has advanced in recent years, to the extent that modern cage systems, such as that illustrated in Figure 2-3, can be tailored to suit the receiving environment. Well-designed sea cages are able to endure the elements over the life of the operation without major failures in their capability to contain and protect stock. The modern materials used for cage construction play an important role in this regard. Tough mesh made of ultra-high-molecular-weight (high-performance) polyethylene fibres and other modern durable plastics are proving to be safe and effective in preventing predator breaches and stock escapes.

For example, high-performance polyethylene netting is reported to be up to 40% stronger than traditional netting of a comparable weight. These nets are highly visible and extremely tear-resistant. Some manufacturers claim their product netting is shark-proof.

In summary, sea cages must be properly designed, installed and maintained to provide a suitable rearing environment that protects both the stock and wildlife. By maintaining the integrity of the cages, the risk of wildlife interactions and environmental impacts are significantly reduced.

[17] Benetti and Welsh, 2010.

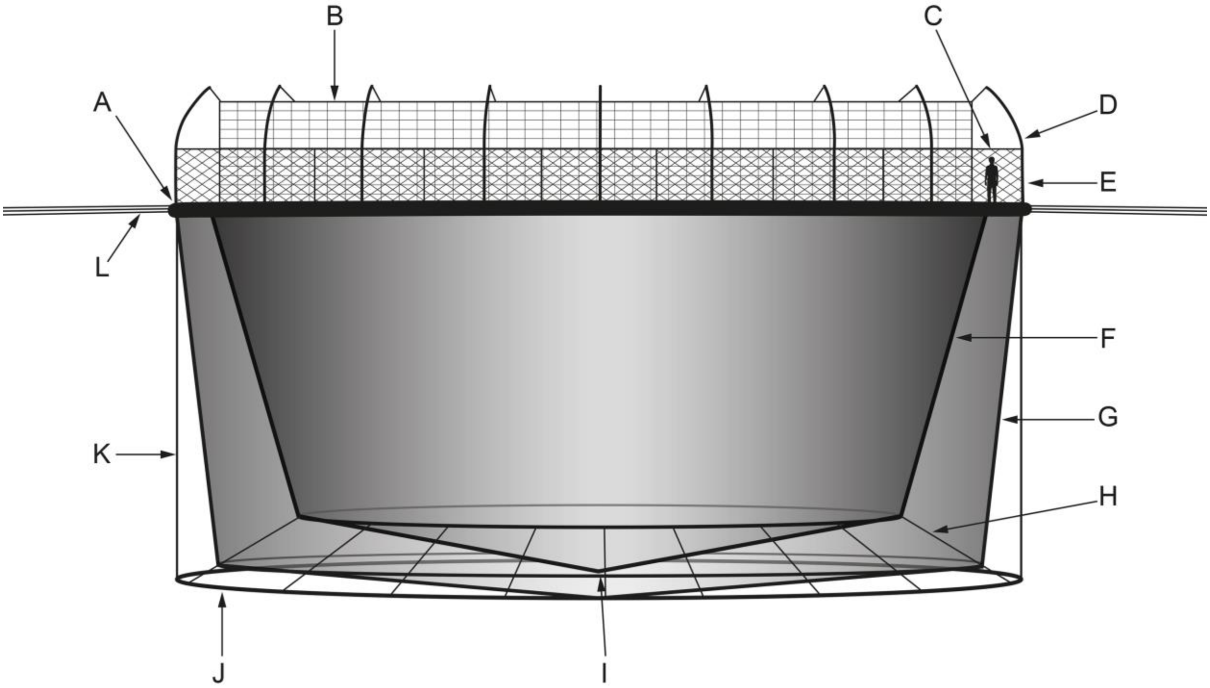

Figure 2-3: Modern Surface Sea Cage Design

Floating Sea Cage (indicative)	
A.	Floating collar to suspends nets
B.	Taut overhead net to keep seabirds away from stock and feed
C.	High sea lion-exclusion barrier to prevent wildlife from accessing the walkway
D.	Long flexible net-poles to support, suspend and maintain tension of the overhead seabird-exclusion nets several metres above the water
E.	Stanchions (posts) to support the sea lion-exclusion barrier
F.	Stock containment net (fully enclosed); a component of the double net system
G.	Marine-predator exclusion net (fully enclosed); a component of the double net system
H.	Net-baseline rope to link nets to the sinker tube
I.	False net-bottom, created by the double net system, to keep stock separated from marine predators
J.	Sinker tube, suspended from the nets, to maintain tension and support the structure of the nets
K.	Weight line to facilitate lifting the sinker tube and bottom of the nets
L.	Mooring lines, connected to the anchoring system, to hold the sea cage in position
Note:	All nets and mesh are durable and high tensile

The Norwegian Standards (Standards) provide a guide to best-management practices. They specify how to set up components of a cage system in accordance with the environmental conditions of a site and describe operational requirements to prevent stock escapes or environmental degradation.[18] The aim is to reduce any risk of stock escape caused by poor installation or failure of the infrastructure.

[18] Norwegian Standards (NS 9415:2009).

The aquaculture operations proposed for the zone will be guided by these Standards and the Environmental Code of Practice applicable to the Western Australian marine finfish aquaculture industry.[19] Cage collars, netting and weighted rings should be designed to function as integrated and balanced systems to handle environmental forces, such as waves and current, of marine environments associated with storm events. Modern nets are tensioned to minimise the impact of predators, optimise water flow, and facilitate in-situ underwater cleaning of the nets.

Modern cage systems are designed to minimise friction between the nets and the supporting structure, thereby reducing any risk of the net tearing. Computers are now used to simulate and analyse the design functionality and verify performance prior to installation of cage systems. Such systems are being used in the offshore waters of South Australia and Tasmania.[20]

Fish farms that provide a form of "reward" or advantage to the local wildlife will likely be exposed to the risk of costly ongoing interactions. Interactions with sea lions, birds and sharks generally account for losses up to 10% of aquaculture production, and further financial losses due to damages to infrastructure.[21,22]

Based upon the Tasmanian experience, sea lions are likely to be the most problematic predator attracted to marine finfish aquaculture. In recent years the Tasmanian industry has largely reduced the damage caused to stock and cages by sea lions by deploying heavy-duty nets (typically, with mesh sizes up to three centimetres in bar length[23]), perimeter fences and higher freeboards.[24] It also uses seal-proof "jump" fences, which consist of raised mesh netting with a breaking strain rating of 300 kilograms encircling the pen and suspended at a minimum of 2.4 metres above the waterline.[25]

A similar approach is expected to be adopted in the proposed MWADZ.

In summary, to avoid aquaculture-wildlife interactions, anti-predator mesh must be of suitable durability, bar-length (i.e. mesh size), and kept taught. The separation of stock from predators is fundamental to the financial viability of the business and will be a requirement of environmental management.[26, 27]

With regard to the place of construction of the sea cages that will be used in the MWADZ, it is likely that these will be fabricated in Geraldton and towed to the intended locations within the relevant lease sites.

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19 http://www.aquaculturecouncilwa.com/files/9814/0462/7532/ACWA_Marine_Finfish_Environmental_Code_of_Practice_FINAL20V4.pdf
20 www.aqualine.no/
21 Price and Morris, 2013.
22 Nash, Iwamoto and Mahnken, 2000.
23 "Bar-length" (or "bar-width") refers to the distance between the inside of adjacent knots in square or diamond shaped mesh netting.
24 Tassal, 2015.
25 Ibid
26 Ibid.
27 Price and Morris, 2013.

2.4.2 Sea Cage Anchoring Systems

The key to maintaining adequate separation between predators and stock is sufficient tensioning on all netted components. Reliable anchoring systems are fundamental to correct net tensioning (Figure 2-4) as they not only allow the potential for wildlife entanglement to be reduced, but also help prevent anchor cable "sweep" effects to the sea floor.

In the proposed MWADZ, the type of anchors used will primarily be determined by the composition of the sea floor to which the sea cage clusters will be attached. This may vary according to location within the zone. Ultimately, the relatively shallow depth of the sediments overlying the limestone platform that characterises much of the seabed in the Zeewijk Channel will most likely be the determining factor in most instances.

In any event, drilling, piling or blasting will not be employed in the anchoring process.

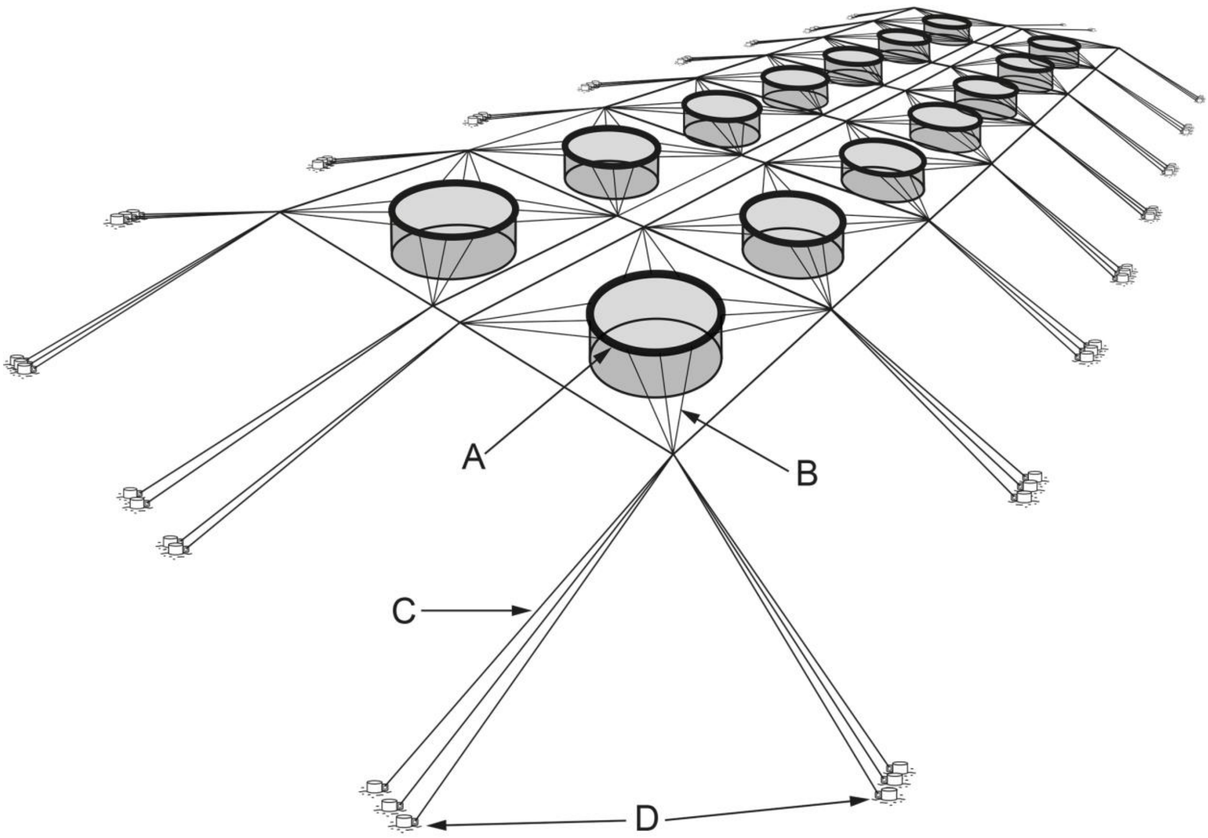

Figure 2-4: Sea Cage Cluster Anchoring Systems

Sea Cage Cluster Anchoring Systems (indicative)	
A.	Sea cage
B.	Mooring lines
C.	Anchor cables
D.	Low-profile mooring anchors
Note:	All lines and cables are durable, high tensile and appropriate for an anchoring system designed to withstand extreme loads.

2.4.3 Positioning of Infrastructure

The sea cages to be used in the zone would typically be grouped together in clusters. For operational reasons, these cage clusters would be set relatively close together on each lease within the zone.

All aquaculture gear (including mooring anchors and anchor cables) must be located within the individual proponent's lease area.[28] In addition, the sea cages themselves (including any fish farm stock held) must be located no less than 300 metres inside of the MWADZ boundary.

The Southern area will likely comprise one 800-hectare lease associated with the existing aquaculture licensed site. It is anticipated that up to two cage clusters would be deployed within this lease area.

Due to its larger area, the Northern area could hold up to four cage clusters in total. As with the Southern area, cage clusters within specific lease areas would generally be situated relatively closely together. The number of cage clusters in each lease would vary according to the lease area.

Figure 2-5 indicates the likely number of sea cages in each cage cluster and also the likely size and initial placement of cage clusters within the proposed zone (at any one time) when the zone is at maximum production.

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[28] As defined in Part 1, section 4 of the FRMA;
"***aquaculture gear*** *means any equipment, implement, device, apparatus or other thing used or designed for use for, or in connection with, aquaculture —*

> *(a) whether the gear contains fish or not; and*
> *(b) whether the gear is used for aquaculture or for navigational lighting or marking as a part of aquaculture safety,*

and includes gear used to delineate the area of an aquaculture licence, temporary aquaculture permit or aquaculture lease".

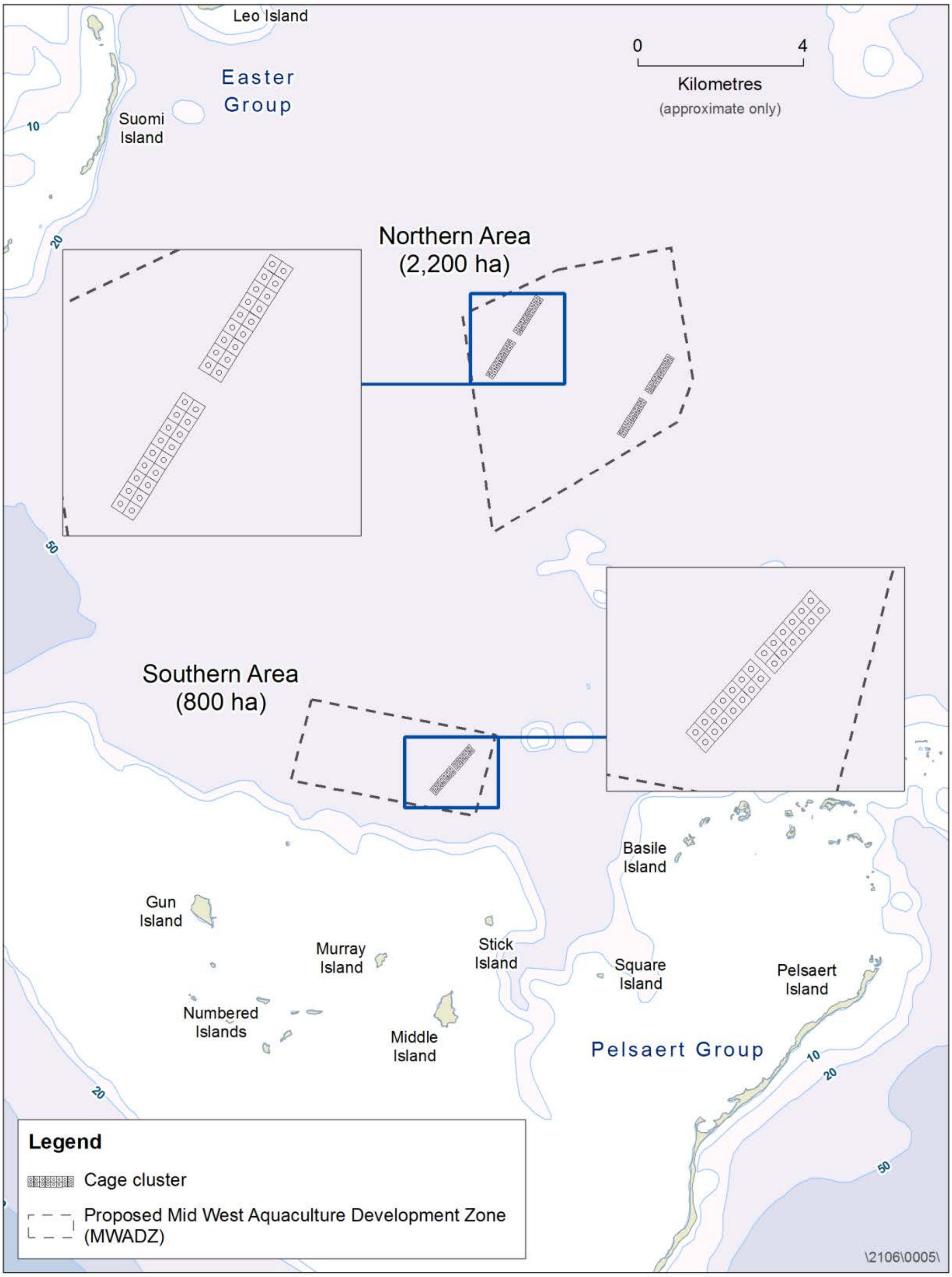

Figure 2-5: Likely Sea Cage Cluster deployment at full-scale production

The maximum standing stock biomass per hectare of lease area would be dependent on the total limit for the zone as imposed by the conditions of the strategic environmental approval. Based upon the results of the technical studies, the proposed total maximum standing stock biomass for the 3,000 hectare zone is 24,000 tonnes.

Over time, operators may relocate sea cage clusters within the leases to enable the ground that was previously near or beneath the cages to be fallowed.[29] This practice ensures the benthic environment within a lease is protected from any potential negative impacts by the aquaculture over the longer term.

2.5 Operational Activities

2.5.1 Stock

The MWADZ is being established specifically for marine finfish aquaculture. Yellowtail kingfish (*Seriola lalandii*) is one species considered likely to provide an economic return in the region (Figure 2-6). Other potentially suitable species include:

- mahi mahi (*Coryphaena hippurus*);
- pink snapper (*Pagrus auratus*);
- mulloway (*Argyrosomus japonicus*);
- cobia (*Rachycentron canadum*);
- coral trout (*Plectropomus spp.*);
- various cod (grouper) species (*Epinephelus* spp.); and
- various tropical snapper (emperor) species (*Lutjanus* spp.).

Figure 2-6: Yellowtail Kingfish

Typically, hatchery-reared fish (certified as free of any clinical disease) are stocked in sea cages as juvenile fish at an average weight of 100 grams or less, then grown to a marketable weight and potentially harvested the same year. Yellowtail kingfish, for example, could be harvested once the fish reach two kilograms. Stock density is an important determinant of financial feasibility and can also influence environmental impact and fish health. High densities can maximise production but excessive densities can result in low dissolved oxygen, increased nutrient concentrations and consequently increased stress and likelihood of disease outbreak. It is common for yellowtail kingfish to be stocked at densities of 10-20 kilograms per cubic metre in modern aquaculture systems.

Technical studies have determined the likely environmental carrying capacity of the proposed MWADZ. This carrying capacity is expected to be up to 24,000 tonnes of standing stock biomass.

[29] In aquaculture, "fallowing" describes a management technique where the production is paused for a period to reduce the impact on the benthic environment and to allow recovery of the site and benthic communities from these impacts. During fallowing, sea cages can be left on-site or moved to another location.

2.5.2 Feed

At the expected stocking densities, each sea cage in the zone would likely receive around four tonnes of feed per day. The only feeds that would currently be permitted in the zone are those that are either AQIS (Australian Quarantine Inspection Service) approved or have been produced by a manufacturer that operates in compliance with the requirements of quality standard AS/NZS ISO 9001:2008 and has in place a quality and risk management system as defined by CAC/RCP 1-1969 (Rev.4-20031). Modern fish feeds (aqua-feeds) are manufactured from ingredients such as fishmeal, vegetable proteins and binding agents such as wheat. Water is added and the resulting paste is extruded through holes in a metal plate, which determines the diameter of the pellets. The pellets are dried and oils are added. Alternative sources of protein have led to a dramatic reduction in fishmeal and fish oil use in making aqua-feeds.[30] The pellets required for aquaculture in the zone are likely to range between 50 milligrams (three millimetre diameter) and 2,000 milligrams (11 millimetre diameter).

Adjusting parameters such as temperature and pressure enables the manufacturers to make extruded feeds that suit different fish farming environments (e.g. pellets that sink more slowly or even at predetermined rates).

Feed accounts for 60 to 90% of the production cost in most fish farming industries today.[31] For this reason, operators within the zone will aim for the best-industry-practice of less than one percent wastage of the feed input (waste). Efficient feed delivery is achieved by monitoring environmental data (water temperature, dissolved oxygen etc.) measured within the cage and controlling feed delivery accordingly. Modern feed delivery systems can provide control over the quantities, timing and rates at which feed is dispensed to the sea cages. During feed delivery, the pellets are not accessible to wildlife. Such systems commonly involve the use of underwater cameras. This allows remote real-time monitoring of feeding response and also stock condition.

To feed stock most efficiently, water temperature and oxygen are considered prior to feeding. Current speed is also taken into account. When these parameters exceed set thresholds, modern systems are designed to temporarily stop feeding and resume it when conditions are optimal; for example, the current sensor system will prevent feed waste caused by currents carrying pellets out of the sea cages.

The pellets would likely be introduced at the surface of the water near the centre of each fish cage for immediate consumption by the stock. Within the sea cages, the pellets would be inaccessible to wildlife. However, before it can be consumed by the stock, up to one percent of the feed will probably sink and drift outside the sea cages.

In summary, stock will consume up to 99% of the feed pellets. Approximately 40 kilograms (i.e. 1%) of residual feed may be lost to the environment from each cage per day. In the marine environment, pellets that are not consumed by stock and exit from the sea cages will break down and be assimilated by the ecosystem. Although wild fish could consume some of the residual feed, it is unlikely that it would be accessible to other wildlife.[32]

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[30] Benetti and Welsh, 2010.
[31] Akvagroup.com, 2015.
[32] Price and Morris, 2013.

2.5.3 Harvesting

Harvesting of the farmed stock is conducted on-site from vessels specially equipped for this purpose. The harvested fish are humanely killed on-board and immediately chilled in ice water.

All waste (e.g. blood or offal) from the harvesting is retained on-board the vessel and disposed of back at the mainland (e.g. Geraldton).

2.5.4 Waste Treatment

A stand-alone Waste Management Plan (WMP) has been developed for the MWADZ Proposal (refer to Appendix 6). This WMP:

- identifies, describes and provides guidance on the various waste products that are common to aquaculture facilities including, general rubbish and sewage treatment;
- identifies potential fuel and oil spills and provides guidance for appropriate action and reporting; and
- identifies, describes and provides guidance on the disposal of biological waste common to aquaculture facilities including fish processing waste and mortalities/culls including appropriate biosecurity considerations.

The WMP encourages the use of the Waste Hierarchy detailed in the EPA's *Implementing Best Practice in proposals submitted to the Environmental Impact Assessment Process* No. 55 (2003). Specifically:

1. avoidance of waste production;
2. reuse of wastes;
3. recycling wastes to create useful products;
4. recovery of energy from wastes;
5. treatment of wastes to render them benign;
6. containment of wastes in secure, properly managed structures; and
7. disposal of waste safely in the long term.

Note: any reuse or re-cycling of aquaculture facility products must be done in accordance with biosecurity procedures.

No waste generated by the MWADZ Proposal is permitted to be disposed within the Abrolhos Islands Reserve or the Abrolhos Islands Fish Habitat Protection Area.

2.5.5 Maintenance of Sea Cages

Maintenance of sea cages includes both removal of marine fouling as well as the repair and upkeep of structural and net integrity.

Removal of marine fouling from sea cages may be undertaken in situ using physical or mechanical methods; or achieved by removing the nets and drying/cleaning on the mainland. It is likely the latter approach will be used by most operators (at least initially) in the proposed MWADZ.

Cleaning of infrastructure with heavy biofouling has the potential to result in heavy releases of biological material into the water column during the removal process. For operators cleaning in situ, the Department recommends cleaning on (essentially) a continuous basis to prevent heaving accumulation of biofouling. A regime of regular biofouling removal optimises the flow of water through the sea cages (with resulting benefits to the aquaculture stock) and reduces the potential for any marine pest to become established.

Operators will refer to the National Biofouling Management Guidelines for the Aquaculture Industry (http://www.marinepests.gov.au/marine_pests/publications/Pages/national_biofouling_management_guidelines_aquaculture_industry.aspx) for further information on recommended approaches for control of biofouling to minimise the spread of exotic species that may associated with moving aquaculture stock and equipment.

Technical testing will be conducted on a regular basis to ensure structural integrity of sea cages. Additionally, netting (including anti-predator netting) should be checked and repaired on a continuous basis to ensure the best-practice standards in sea cages (considered in the cage design) are functioning optimally. Both forms of maintenance assist in ensuring potential risks from the MWADZ Proposal (e.g. those relating to marine fauna) are appropriately managed and mitigated.

There will be requirements within individual Management and Environmental Monitoring Plans (MEMPs) to appropriately maintain infrastructure.

2.6 Decommissioning Activities

Should any licence/lease holder within the MWADZ permanently cease their operations (for whatever reason), they are required to remove all structures, equipment and fish from the lease site.

If an aquaculture lease is terminated or expires, the Department of Fisheries (Department) may direct the former lease holder to clean up and rehabilitate the former leased area. If the former lease holder contravenes the direction, the Department may clean up and rehabilitate the area and the reasonable cost of any action taken is recoverable as a debt due to the State from the former lease holder.[33]

Additionally, the former lease holder is required to complete the rehabilitation of the site within three months of the termination/expiry of the aquaculture lease. Failure to do so will result in forfeiture of the remaining structure/equipment/fish to the Crown.[34]

The terms and conditions of the aquaculture lease require that lease holders must provide and maintain security, usually in the form of a bank guarantee, so that the lessor (i.e. the Minister for Fisheries) may recover any loss which the lessor incurs arising from a default by the lessee under the lease.

[33] Section 101 of the *Fish Resources Management Act 1994* refers.
[34] Section 100 of the *Fish Resources Management Act 1994* refers.

3 OVERVIEW OF EXISTING ENVIRONMENT

3.1 Regional Setting

3.1.1 Overview

The Houtman Abrolhos Islands (referred to as "the Abrolhos") is a complex of islands and reefs located at the edge of the continental shelf between 28°15'S and 29°00'S. Situated approximately 65 kilometres offshore from the mid-west coast of Western Australia, the Abrolhos comprises three major island groups:

- North Island-Wallabi Group;
- Easter Group; and
- Pelsaert (or Southern) Group.

The islands support a diverse and unique range of marine and terrestrial flora and fauna. Located at the confluence of temperate and tropical zones, the marine ecosystems may be particularly susceptible to future climate change impacts. Abrolhos waters also harbour some of the most important historical shipwrecks in Australia, with associated historic sites located on the islands themselves.

Not surprisingly, the Abrolhos attracts significant economic and social activity, providing substantial benefits to the Western Australian community. These activities include commercial fisheries for rock lobster, scallops and finfish; aquaculture for pearls; recreational finfish fisheries; diving and associated marine-based activities; and a developing tourism industry. It is also important for scientific research and monitoring.

3.2 Physical Environment

3.2.1 Geology and Geomorphology

The Houtman Abrolhos Islands are very flat, with an elevation above sea level of three to five metres on most islands. Flag Hill, above Turtle Bay on East Wallabi Island, is the highest point in the Abrolhos, at 14 metres above sea level.

The islands of the Abrolhos have an unusual geology, as they are only around 125,000 years old.

The three main island groups are located on separate limestone platforms up to 36 metres thick with deep channels between these. North Island, which is the northernmost island at the Abrolhos, is on the same carbonate platform as the Wallabi Group. Each platform has a fringing reef system, with a windward reef on the southern and western sides and a leeward reef on the eastern side. These reefs are separated by a central shallow lagoon. The majority of the islands in the Abrolhos have formed within the central lagoons or on the eastern (leeward) reefs.

The Abrolhos are formed of solid limestone under a layer of sand, cemented coral rubble and coral shingle. The limestone is the remnants of coral reef which formed at least 125,000 years ago, during a period of high sea level. Coral shingle and sand has been deposited on the limestone during storms and cyclones. The islands continue to change shape and form today, through the same processes of erosion and deposition during storms and cyclones.

At the peak of the last glacial period (approximately 18,000 years ago), the sea level was about 130 metres lower than it is today, so it was possible to walk, hop or slither across where the Geelvink Channel is today to the Abrolhos Islands, such as East and West Wallabi Islands. At the end of the last glacial period, the ice started to melt and sea levels rose. Around 6,000 years ago, sea levels reached the current level, marooning terrestrial wildlife on the Abrolhos.

The combination of temperate and tropical species, both in the water and on the islands, is unique at the Abrolhos. This unique blend fosters unusual ecological interactions. In addition, the small tidal ponds that occur on many islands are important structures, which are rare on other offshore islands in the south-west of Australia.

3.2.2 Climate

The Abrolhos is subject to strong winds for most of the year, with calm conditions mostly in autumn and early winter. The prevailing winds are from a southerly direction and these are strongest in summer.

There is a weather station on North Island which has been recording temperature and rainfall data since 2000. Based on the data collected at this station to date, the Abrolhos Islands receive an average annual rainfall of 272 millimetres, with the majority of this occurring in April to September. In summer, the mean temperature varies from 21 to 27°C, and in winter between 16 and 22°C.

The Abrolhos is occasionally subject to cyclone activity during the cyclone season from December to May, with more than half the recorded cyclones occurring between March and May. Since 1915, on average, a cyclone passes through coastal waters within 400 kilometres of North Island approximately every 2.5 years.

3.2.2.1 Wind

At the Abrolhos Islands in the summer months winds are characterised by consistently strong south to south easterlies in the morning with generally stronger south to south westerlies in the afternoon (Webster *et al.* 2002). High wind speeds are consistently recorded in the afternoons on the Islands from September through to March, with the months of strongest wind being December, January and February (MBS Environmental 2006). In the autumn and winter months winds tend to be weaker and highly variable in terms of direction (Department of Fisheries 2000).

In the winter months, southern storms to the south of the Geraldton-Abrolhos region can bring winter gales and strong winds up to 35 metres/second (Webster, F *et al.* 2002). Squalls can also occur in the summer months (December to April) and can generate wind speeds between 25 and 30 metres/second in any direction (Webster *et al.* 2002). Occasionally, tropical cyclones may occur within the Abrolhos Islands during the summer months (January to April). Cyclones are generally infrequent occurring on average one every five years.

The Bureau of Meteorology (BoM) records wind data at the Abrolhos wind station situated on the North Island approximately 50 kilometres north of the northern area of the MWADZ Proposal (refer to Figure 3-1).

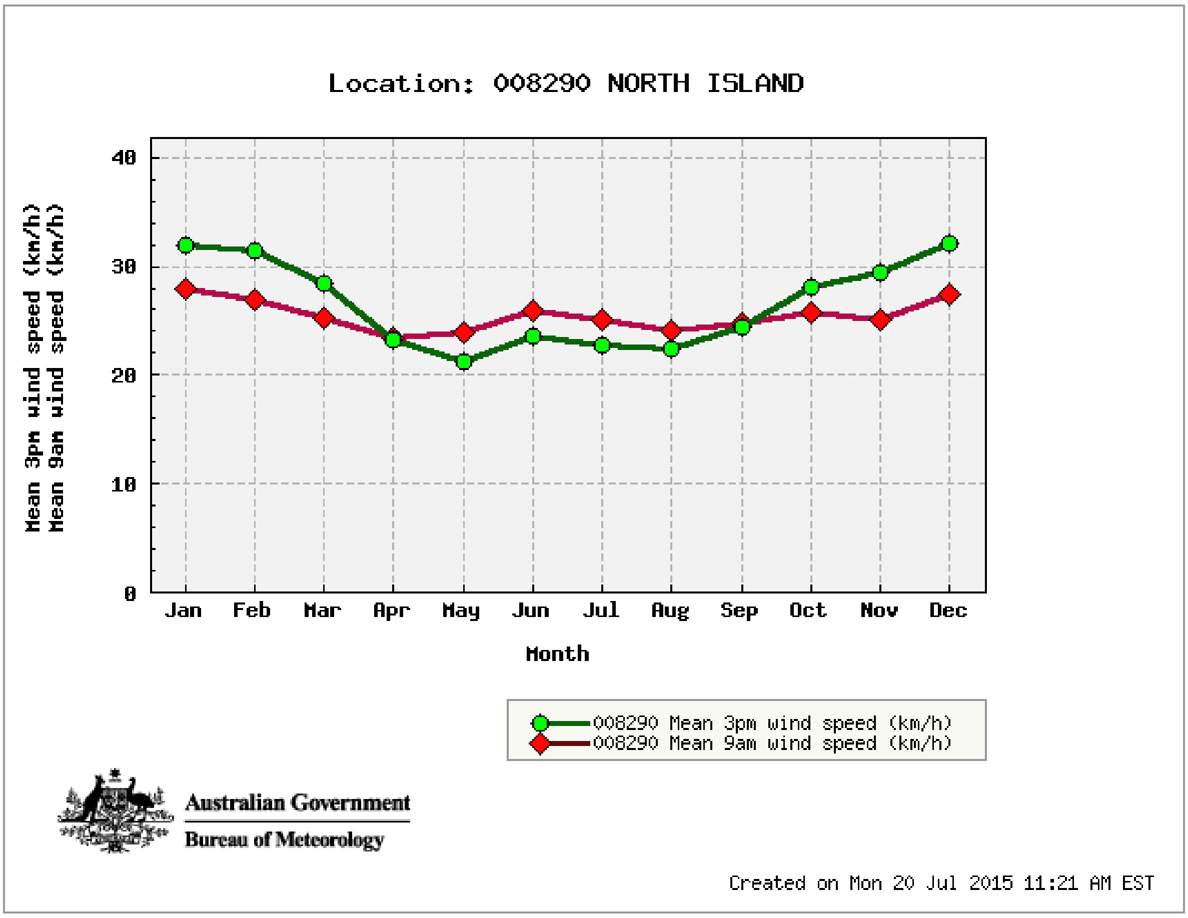

Figure 3-1: Mean Abrolhos Wind Speed – North Island (Source BoM, July 2015)

3.2.2.2 Rainfall

The average rainfall that has been recorded for the North Island of the Abrolhos from 2000 to 2015 is 281.3 millimetres per year. Most of the rainfall occurs during the winter months between May through to August (see Figure 3-2 below). No recent rainfall data has been collected from the Pelsaert Group of islands which are the islands closest to the proposed MWADZ areas. However, historical data collected from this southern group has confirmed the general trends described above with most rainfall occurring during the winter months.

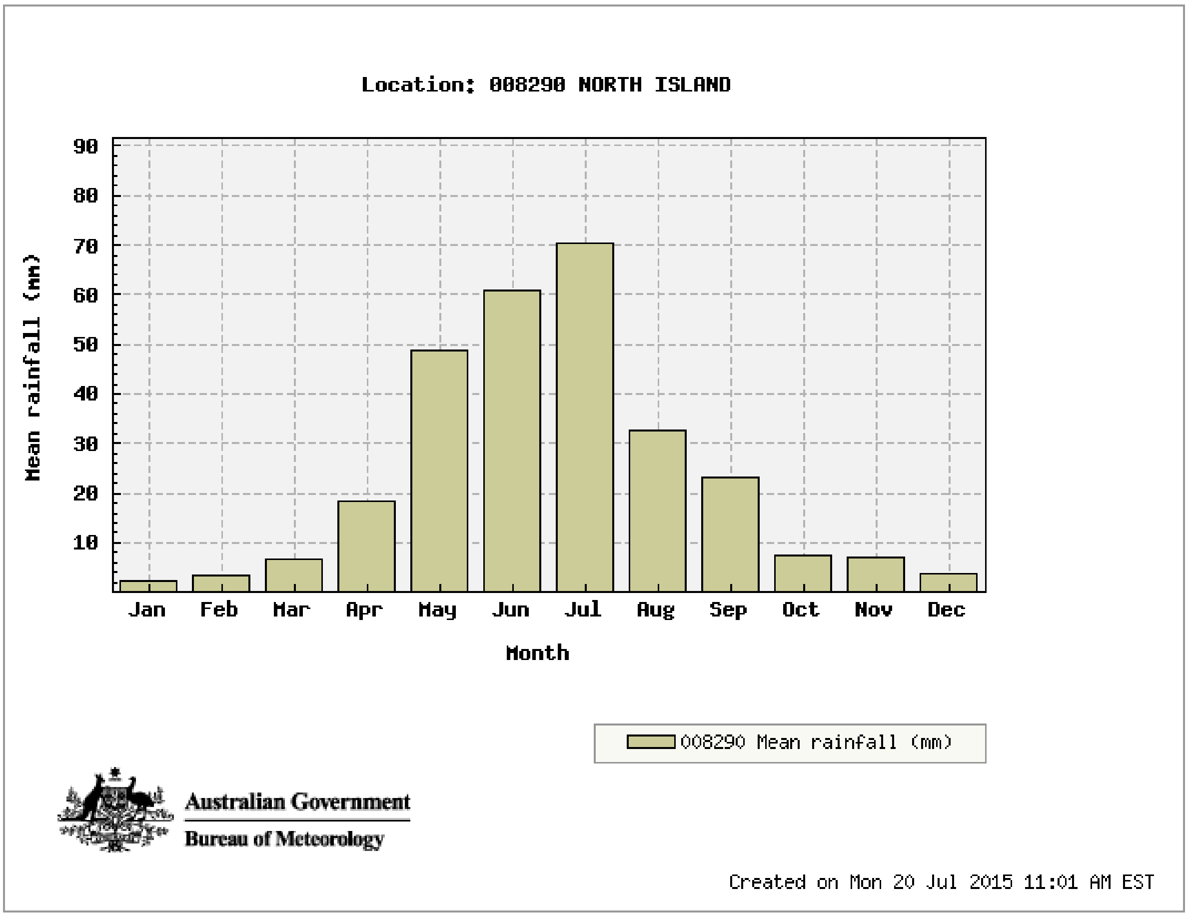

Figure 3-2: Mean Abrolhos Rainfall – North Island (Source BoM, July 2015)

3.2.2.3 Air Temperature

There is a weather station on North Island which has been recording temperature since 2000. In summer, the mean temperature varies from 21°C to 27°C, and in winter between 16°C and 22°C.

3.2.3 Oceanography

3.2.3.1 Tides

Abrolhos tides alternate between diurnal and semi-diurnal (two tide cycles per day), though they are predominantly diurnal (one high tide and one low tide per day). The daily tidal range is low - about 0.7 metres between high and low tides. While wave heights can average about two metres in the open ocean near the Abrolhos, within the island groups they are lower, dampened by the shallow reefs and islands.

The Leeuwin Current runs along the Western Australia coast and brings warm tropical water to higher latitude reefs like those at the Abrolhos. Between the islands, ocean currents are highly variable.

3.2.3.2 *Sea Temperatures and Salinities*

Sea surface temperatures at the islands are very stable, with the monthly mean minimum sea temperatures of 20.0^{o}C occurring in September and the maximum of 23.7^{o}C in March (Pearce, A *et al.* 1999). Water temperatures can drop below 20^{o}C in tidally-exposed areas and shallow pools in winter, when air temperatures drop (Department of Fisheries 2000).

The Leeuwin Current maintains water temperatures at the Abrolhos Islands at warmer levels than inshore. During the winter months the water around the islands can be up to 4^{o}C warmer than at Geraldton (Webster *et al.* 2002).

Salinity levels in the Abrolhos Islands are essentially those of the open ocean, with the monthly mean salinity at the nearby Rat Island varying only from 35.4 parts per thousand to 35.7 parts per thousand (Department of Fisheries 2000).

3.2.3.3 Waves

Wave heights in the open ocean near the south-westerly reef margins of the Abrolhos Islands average about two metres, and can exceed four metres during storm events. However, wave heights are substantially lower on the eastern (leeward) sides of the Abrolhos and in the areas near the MWADZ Proposal area with average wave height reaching approximately 1.2 metres (Webster, F *et al.* 2002). The majority of the swell approaches the islands from the south and west 78% of the time (Department of Fisheries 2000).

3.2.3.4 Currents and Circulation

The dominant oceanic currents affecting the waters of the Abrolhos Islands is a southward flowing current referred to as the Leeuwin Current. At the Abrolhos Islands the Leeuwin Current is strongest in autumn, winter and early spring; raising sea surface temperatures. The flow is greatest and most consistently south along the shelf break, a relatively short distance to the west of the Abrolhos (Webster *et al.* 2002). The currents through and inshore of the islands vary spatially and temporally. During the late spring and summer months, the current through and inshore of the islands tends to set to the north, driven by the prevailing southerly winds with occasional current reversal to the west along the shelf break (Pearce, A *et al.* 1999). During the winter months strong westerlies and north-westerlies can generate southward-setting currents inshore of the Abrolhos Islands (Pearce, A *et al.* 1999).

The waters within the MWADZ Proposal area are well flushed and experience high levels of water circulation and dispersion. Previous oceanographic work focussing on the shallow waters of the Easter Group lagoon indicated currents between 2-5 centimetres/second and fast flushing times between 0.5 and 1.5 days (Sukumaran, A 1997).

The MWADZ Proposal area is located in a more exposed area between the Pelsaert Group and the Easter Group of islands and therefore water circulation and flushing is likely to be higher than that reported in the relatively sheltered Easter Group lagoon.

3.2.3.5 Water Quality

Abrolhos waters have a history of higher nutrient levels than coastal waters at Geraldton. There are a number of theories for this, including nutrient upwelling (a phenomenon where dense, cooler and nutrient-rich water is driven from the depths toward the sea surface, replacing warmer, nutrient-poor surface water) and seagrass detritus. During autumn and winter storms, seagrass is torn from the reef substrate. This seagrass detritus accumulates in the relatively calm water in the lagoon areas and releases nutrients as it decays. The higher nutrient levels in Abrolhos waters help to support the diverse marine life.

3.2.3.6 Sediment Quality

In general, sediments in the Zeewijk Channel are predominantly composed of calcareous sands of varying proportions of different particle size fraction. Studies suggest some differences in time – fine to coarse sand dominate in the winter season, while fine clays and silts dominate in the summer season. Overall, this reflects the general high level of variability in terms of sediment composition and seasonality across all locations within the Channel.

Sediment depth is thought to be relatively shallow and overlying a flat limestone base.

3.3 Biological Communities

3.3.1 Benthic Habitats

The Abrolhos Islands supports a total of ten species of seagrass which range from small delicate species to large, more robust types that grow in large meadows. These are mainly temperate species, possibly due to the relatively low winter water temperatures. No extensive seagrass meadows are present in the Abrolhos (Webster *et al.* 2002).

Fleshy macro algae form a major component of the benthic communities of the reefs at the Abrolhos Islands. The high- energy outer reef slopes support rich and dense macrophyte communities characterised by large brown algae (e.g. *Dictyota, Glossophora, Sargassum*) including the kelp *Ecklonia radiata*, mixed with fleshy red and green algae (e.g. *Aspargopsis*, *Hypnea, Laurencia, Plocamium and Caulerpa*) (Crossland, C.J *et al.* 1984). The protected reefs are dominated by algae species such as *Turbinaria, Eucheuma and Sargassum* (MBS Environmental 2006).

The Abrolhos Islands also contains some of the southernmost coral reefs in the Indian Ocean. The coral reefs occur in the same area as lush growths of temperate marine algae, or seagrass, which are more characteristic of the south coast of Western Australia.

3.3.1.1 Marine Flora

Seagrasses are marine flowering plants that generally grow in shallow coastal areas, protected from ocean swells. In contrast to the marine fauna, which has a strong tropical component, the seagrasses in Abrolhos waters are predominately cooler water species.

In total, ten seagrass species have been recorded at the Abrolhos ranging from small, delicate species to larger, more robust types that grow in large meadows. Small paddle weeds grow in protected lagoon areas or deep waters between the islands, such as Goss Passage. The larger species may be found growing on reef as well as in sandy areas.

Thalassodendron pachyrhizum, which is encountered growing on the exposed reef crest area, has been recorded at a number of the island groups.

There are also two species of wire weed (*Amphibolis* species), endemic to southern Australia, found at the Abrolhos. The most abundant seagrass is *Amphibolis antarctica*, while *Amphibolis griffithii* appears to be restricted to bays such as Turtle Bay in the Wallabi Group.

The larger ribbon weeds (*Posidonia* species) grow in sheltered bays and lagoons where the sand cover is deeper and more stable (e.g. Turtle Bay, the Gap, East Wallabi Island, the lagoon on the west side of West Wallabi Island and around North Island).

Protection of the diverse seagrass communities in reef areas and sheltered bays at the Abrolhos is necessary for the maintenance and functioning of these productive waters. Seagrasses are not only a key benthic primary producer but also provide habitat for a diverse and abundant community of algae and small invertebrates, like juvenile Western rock lobster. Additionally, seagrasses reduce water movement and stabilise the sea floor.

There are 295 macro algae species documented as occurring in the Abrolhos where they can be found in all habitats. Of these, 13.6% are considered to be endemic (Phillips & Huisman 2009). Kelp (*Ecklonia radiate*) is one of the dominant species, particularly in the lagoonal areas (Hatcher *et al.* 1987). Other fleshy macro algae form a major component of the benthic communities in the Abrolhos, where the high-energy outer reef slopes support rich and dense macrophyte communities (Crossland *et al.* 1984).

3.3.1.2 Marine Fauna

Coral Communities

The Abrolhos are high-latitude coral reefs – some of the southernmost coral reefs in the Indian Ocean. They have a unique assemblage of tropical and temperate fish, corals, algae and other invertebrates.

The coral fauna of the Abrolhos is diverse for a high-latitude reef system, with 211 species of corals discovered so far. All but two of the coral species are tropical.

The greatest diversity and density of corals is found on the reef slopes, shallow reef perimeters and lagoon patch reefs in the more sheltered northern and eastern sides of each of the three limestone platforms that support the island groups. The growth of at least two species of coral abundant at the Abrolhos has been found to be significantly slower than at several locations in the tropics.

Invertebrates

Marine invertebrates present at the Abrolhos include:

- crustaceans
- molluscs
- echinoderms
- sponges
- cnidarians (other than hard corals)

There are 492 mollusc species and 172 echinoderm species which have been identified at the Abrolhos. Some of the species which are important for the fishing industry are Western rock lobster, saucer scallops, octopus and species that produce specimen shells.

Southern saucer scallops (*Amusium balloti*) are short-lived, benthic, filter feeding bivalve molluscs which reside on sandy bottoms. The southern saucer scallop can grow to 13 centimetres in length and live up to three years (DoF 2007). They are subject to great natural fluctuations in reproductive success from year-to-year and grow to maturity within a year. Southern saucer scallops spawn at the Abrolhos between August and March.

In all these groups of marine invertebrates there is a complex assemblage of tropical species living in close association with temperate species and species endemic to Western Australia. There are a higher proportion of tropical species in most groups, but the majority of hydroid (members of the invertebrate order Hydroida) and sponge species are usually found in temperate rather than tropical waters.

Finfish

A total of 389 finfish species have been recorded at the Abrolhos.

The Abrolhos and their surrounding coral and limestone reef systems consist of a combination of abundant temperate macro algae with coral reefs, supporting substantial populations of large species such as baldchin groper and coral trout.

Some of the species occurring in the Abrolhos are dependent on larvae carried southward by the Leeuwin Current from areas further north, such as Shark Bay or Ningaloo Reef. Similarly, populations of some of the species occurring at Rottnest Island are dependent on larvae generated from breeding populations at the Abrolhos.

Temperate fish species such as pink snapper and West Australian dhufish are also found in Abrolhos waters.

Sharks and Rays

More than twenty species of sharks have been identified at the Abrolhos, including Port Jackson sharks, tiger sharks, whaler sharks and wobbegongs. Abrolhos waters are considered to be an important food source for sharks, due to the resident fish populations.

Various species of rays have been recorded at the Abrolhos. These include the giant manta ray and the white spotted eagle ray.

Mammals

Marine mammals frequent Abrolhos waters, with a colony of Australian sea lions living and breeding at the Abrolhos. The Abrolhos represent the northernmost breeding population of Australian sea lions. The current population of approximately 90 is greatly reduced from historical times - when as many as 600 animals may have been resident at the Abrolhos. The population decline is most likely due to hunting, by the hungry crews of wrecked ships and whaling and sealing activities of early fishermen in the 19th century.

Male Australian sea lions are usually dark brown. They can grow to up to 2.5 metres in length and weigh up to 300 kilograms. Female sea lions are smaller and they usually have grey backs with yellow-to-cream underneath. The females can grow to more than 1.5 metres long and weigh up to 100 kilograms.

Australian sea lions breed approximately every 18 months, so there is no annual breeding season. The sea lion pups are dark brown at birth, with a pale-fawn crown until they moult at two months of age. Their juvenile coat is a similar colour to that of an adult female.

The Australian sea lions feed on fish, rock lobster, octopus and occasionally sea birds. They can dive to depths of up to 150 metres in search of their prey. Often they can be seen hauled out at sandy beaches throughout the Abrolhos.

There are 31 species of cetaceans which have the potential to occur within the vicinity (i.e. less than 50 kilometres) of the proposed MWADZ area (DoE 2014 a). Some of these species occasionally transit through the area at low densities (e.g. sperm whales, Antarctic minke whales and oceanic dolphins) although the information currently available is insufficient to confirm a definitive presence within the proposed MWADZ area (BMT Oceanica 2015).

Species that are likely to occur within this radius include the:

- humpback whale;
- Indo-Pacific bottlenose dolphin; and
- common bottlenose dolphin.

Species with a low likelihood of occurring include the:

- blue whale;
- Southern right whale;
- Bryde’s whale;
- killer whale; and
- dugong.

Reptiles

Four marine turtles may occur within a 50 kilometre radius of the MWADZ Proposal area, including the loggerhead turtle, flatback turtle, leatherback turtle and green turtle, with the last two species more likely to be present.

Sea snakes are not resident in the Abrolhos but may be transported to the area during storms from the north.

Seabirds

The Houtman Abrolhos is the most significant seabird breeding location in the eastern Indian Ocean. Eighty percent (80%) of the brown (common) noddy, 40% of the sooty tern and all lesser noddy found in Australia nest at the Houtman Abrolhos (Ross *et al.* 1995). It also contains the largest breeding colonies in Western Australia of wedge-tailed shearwater, little shearwater, white-faced storm petrel, white-bellied sea eagle, osprey, Caspian tern, crested tern, roseate tern and fairy tern (Storr *et al.* 1986, Surman and Nicholson 2009). The Houtman Abrolhos also represents the northernmost breeding islands for both the little shearwater and white-faced storm petrel.

3.3.2 Terrestrial Environment

3.3.2.1 Terrestrial Flora

The terrestrial flora of the Abrolhos archipelago includes a number of vegetation communities on the islands identified as being of conservation significance, including mangroves and *Atriplex cinerea* dwarf shrubland.

Mangroves are coastal plants which live in the upper intertidal zone. A single mangrove species, the grey mangrove (*Avicennia marina*), occurs in the Abrolhos. The grey mangrove provides an important source of nutrients for marine food chains, in addition to habitat for terrestrial and marine animals, including the Australian sea lion and the lesser noddy at the Abrolhos.

Mangroves also protect the Abrolhos shoreline from storm damage and erosion. Extensive stretches of mangroves can be seen on Pelsaert Island, Wooded Island and Morley Island.

The *Atriplex cinerea* dwarf shrubland occurs on sandy soils or shell grit. The deeper soils supporting the shrubland are suitable for burrowing seabirds, such as shearwaters and petrels, to use for building nests.

3.3.2.2 Terrestrial Fauna

There are 26 terrestrial reptile species on the islands, including the carpet python. One previously undiscovered worm lizard, *Aprasia* sp., the Houtman Abrolhos spiny tailed skink and the Abrolhos dwarf bearded dragon are endemic to the Abrolhos. All three species are found on East Wallabi, but the Houtman Abrolhos spiny tailed skink and Abrolhos dwarf bearded dragon occur on a number of other islands as well.

Only two species of indigenous land mammals have been recorded at the Abrolhos - the tammar wallaby and the southern bush rat.

3.4 Socio-Economic Setting

3.4.1 City of Greater Geraldton

The City of Greater Geraldton is the closest Local Government entity to the location of the MWADZ Proposal and is likely to provide the majority of the workforce, accommodation, supporting infrastructure and services associated with the MWADZ Proposal.

A summary of the socio-economic profile of the City of Greater Geraldton is outlined in Table 3-1.

Table 3-1: City of Greater Geraldton – Gross Regional Product (GRP)

GRP Expenditure Method	City of Greater Geraldton
Household consumption	$2,290.374 M
Government consumption	$683.754 M
Private Gross Fixed Capital Expenditure	$877.339 M
Public Gross Fixed Capital Expenditure	$193.999 M
Gross Regional Expenses	**$4,045.465 M**
plus Regional Exports	$1,772.662 M
minus Domestic Imports	-$2,255.405 M
minus Overseas Imports	-$489.550 M
Gross Regional Product	**$3,073.171 M**
Population	37,162
Per Capita GRP	$82,697
Per Worker GRP	$214,592

The City of Greater Geraldton's Gross Regional Product (GRP) is estimated at $3.073 billion. This represents 56.68% of the Mid West Region's GRP of $5.422 billion and 1.16% of Western Australia's Gross State Product of $264.545 billion.

It is estimated that 14,321 people work in Greater Geraldton. Greater Geraldton represents 63.58% of the 22,526 people working in the Mid West region.

The unemployment rate within the City of Greater Geraldton is currently estimated to be approximately 6.9%.

3.4.2 Tenure

The MWADZ Proposal is wholly located within Western Australian State Territorial Waters.

Additionally, the site of the MWADZ Proposal is also entirely within a Fish Habitat Protection Area (FHPA) created under the *Fish Resources Management Act 1994*.[35] Aquaculture is one of the purposes for which the FHPA was created, as specified in the gazettal of the Abrolhos Islands Fish Habitat Protection Area Order 1999.[36]

3.4.3 Sea Use

The waters within the MWADZ Proposal area are currently subject to a range of uses. These include:

- commercial fishing;
- recreational fishing;
- aquaculture;
- marine based tourism (e.g. sailing and diving charters); and
- transit between Geraldton, the Pelsaert Group and the Easter Group of the Abrolhos Islands.

Generally, however, the level of this use is not high due to the remoteness of the area and the benthic habitats within the MWADZ Proposal sites not supporting concentrations of fishing target species. A notable exception is the southern area of the MWADZ Proposal, but only in those years when commercial quantities of Southern saucer scallop (*Amusium balloti*) recruits to the area.

3.5 Key Conservation Values

3.5.1 A Class Reserve

An A Class Reserve since 1929, the Houtman Abrolhos Nature Reserve is vested in the Minister for Fisheries, for the purpose of:

"C*onservation of flora and fauna, tourism, and for purposes associated with the fishing and aquaculture industries*."

The proposed MWADZ is located outside of this Reserve.

3.5.2 Fish and Fish Habitat Protection Area

The State Territorial Waters (i.e. high water mark out to three nautical miles seaward of the Territorial Sea Baseline) of the Abrolhos Islands are a gazetted Fish Habitat Protection Area (FHPA) [37]. This FHPA was gazetted in 1999.

The FHPA is designated for the following purposes:

- *the conservation and protection of fish, fish breeding areas, fish fossils or the aquatic ecosystem;*

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[35] Fish Habitat Protection Areas are created by the Minister under the provisions of Part 11, Division 1 of the *Fish Resources Management Act 1994*.
[36] This Order was printed in Government Gazette No. 23 on 16 February 1999.
[37] Section 115 of the *Fish Resources Management Act 1994* provides that the Minister for Fisheries may, by order published in the Gazette, set aside an area of WA waters as a fish habitat protection area.

- *the culture and propagation of fish and experimental purposes related to that culture and propagation; and*
- *the management of fish and activities relating to the appreciation or observation of fish.*

Under the FRMA, the Department of Fisheries has the power to regulate fishing operations in the FHPA (Department of Fisheries 2001). Regulation of fishing operations may be undertaken for a number of purposes including conservation, fisheries management and for the preservation of areas for observation and eco-tourism pursuits. Regulations may take a number of forms, including:

- area protection
- gear restrictions
- effort restrictions
- temporal/time closures
- catch limits

The proposed MWADZ Proposal is located within this FHPA.

3.5.3 Reef Observation Areas

Within the Abrolhos Islands Fish Habitat Protection Area, special places have been set aside as Reef Observation Areas (ROAs) for the conservation and observation of marine life and habitats (refer to Figure 3-3). The four Reef Observation Areas in the Abrolhos are:

- North Island Reef Observation Area;
- Beacon Island Reef Observation Area (Wallabi Group);
- Leo Island Reef Observation Area (Easter Group); and
- Coral Patches Reef Observation Area (Pelsaert Group).

Catching fish by line, spear or any other method is not permitted in these areas. The ROAs are intended to:

- conserve and protect fish, fish breeding areas, fish fossils and the aquatic ecosystems;
- provide sites for the appreciation and observation of fish in their natural habitat; and
- boost populations of reef fish in areas adjacent to the reef.

The northern area of the MWADZ is located approximately 8.4 kilometres south east of the Leo Island ROA and nine kilometres north-west of the Coral Patches ROA. While the southern area of the MWADZ is located approximately 18 kilometres south of the Wallabi ROA and 7.6 kilometres west of the Coral Patches ROA.

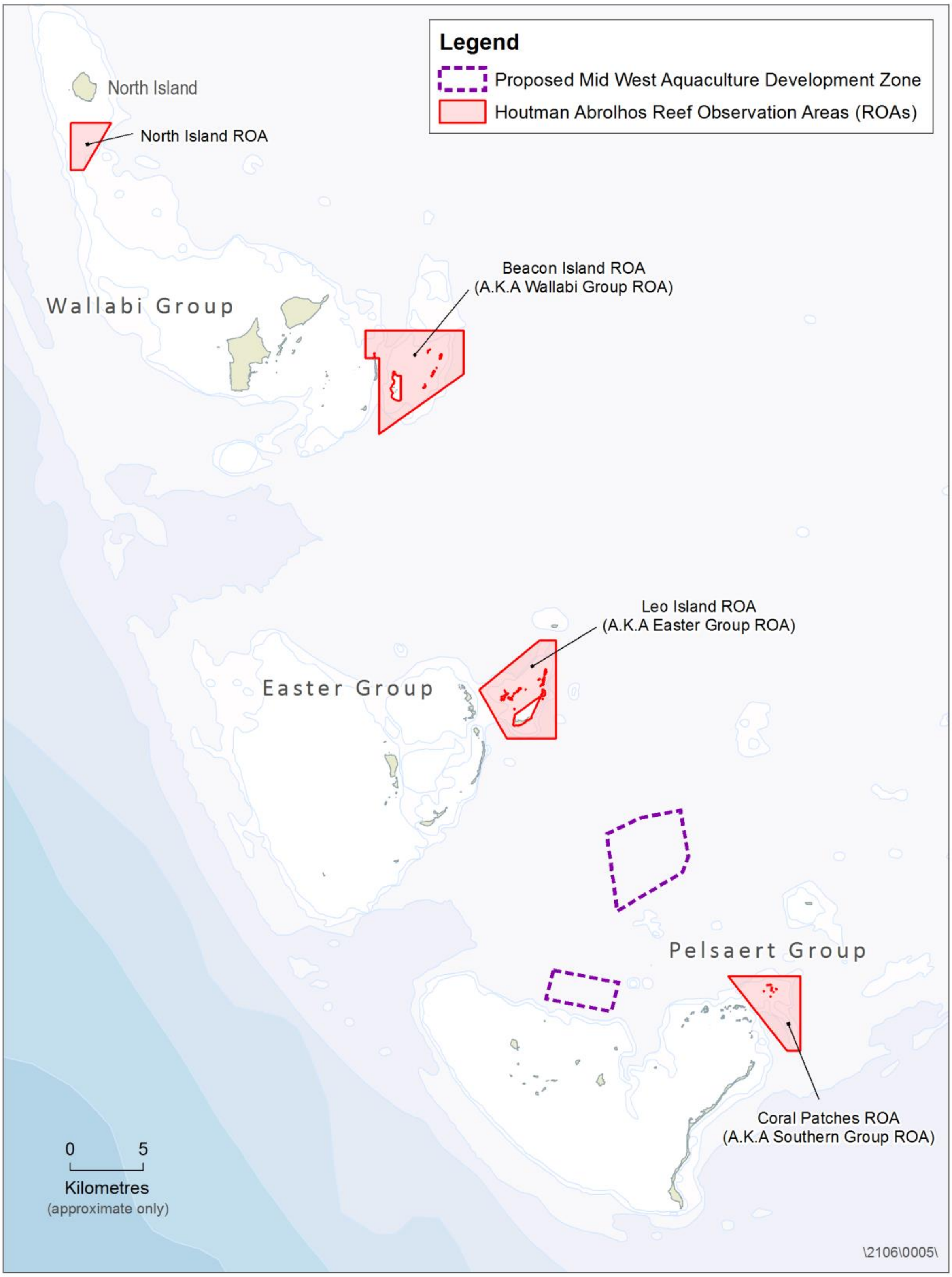


Figure 3-3: Abrolhos Islands Fish Habitat Protection Area – Reef Observation Areas

4 LEGISLATIVE FRAMEWORK

4.1 Principal Commonwealth Legislation

4.1.1 Environment Protection and Biodiversity Conservation Act 1999

The Commonwealth legislation which protects the threatened, endangered and protected species that inhabit the proposed MWADZ is the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The EPBC Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places defined in the Act as matters of national environmental significance (Department of the Environment, 2013).

The following Commonwealth Acts are also potentially applicable to the MWADZ Proposal:

Commonwealth Act	Intent
Historic Shipwrecks Act 1976	To protect historic wrecks and relics from the low water mark to the edge of the continental shelf. The Act is mirrored in State legislation with a delegate for each State and Territory taking responsibility in conjunction with their Commonwealth counterpart.
Heritage Act 1990	Encourages and provides protection and conservation of places that have significant cultural heritage value to the State.
Environmental Protection (Sea Dumping) Act 1981	To regulate the loading and dumping of waste at sea. This Act fulfils Australia's obligations under the 'London Protocol' to prevent marine pollution.

As explained in sub-section 1.2.2 of this PER, the Commonwealth (DotE) advised the Department that the proposed actions associated with the MWADZ Proposal were not of a magnitude that necessitates a "Strategic Assessment" under the EPBC Act.

However, referral to the Commonwealth of future derived proposals associated with the MWADZ Proposal could be triggered in certain circumstances.

4.2 Principal Western Australian Legislation

4.2.1 Environmental Protection Act 1986

The principal Western Australian legislation protecting the environment is the *Environmental Protection Act 1986* (EP Act).

The Department, on behalf of the Minister for Fisheries, referred the MWADZ Proposal to the EPA for assessment as a Strategic Proposal under Part IV of the EP Act. Following its assessment of the proposal, the EPA may then recommend to the Minister for the Environment that it is accepted as a strategic proposal.

A **strategic** proposal is a proposal which identifies one or more future proposals that may, individually or in combination, have a significant effect on the environment.

Generally, a strategic proposal does not, of itself, have a direct impact on the environment (although there may be circumstances when it does).

Instead, strategic proposals anticipate that there will be one or more future proposals that may have a significant environmental impact if implemented singly or in combination and which might normally be assessed on a case-by-case basis.

A **derived** proposal is a future proposal which was identified in the strategic proposal, which has been referred to and considered by the EPA, and which is then declared to be a derived proposal.

The assessment of strategic proposals provides a number of benefits. These include:

- the early consideration of environmental issues providing the ability to influence the detailed design of future proposals;
- the ability to consider the cumulative impacts of more than one proposal;
- greater certainty for local communities regarding the maximum extent of cumulative impacts of future developments, and greater confidence for proponents of future developments;
- more flexible timeframes for consideration of environmental issues; and
- potential efficiencies in the approvals process.

Overall approval timeframes can be improved if a strategic proposal is approved, as future proposals can be determined more quickly when they are referred. Certainty for future proponents is also improved if a strategic proposal is approved.

Generally, assessment of strategic proposals aims to establish acceptable environmental parameters within which the derived proposals, individually and in combination, are expected to operate.

4.2.1.1 Process for Assessing Strategic Proposals

Following the EPA's assessment of the strategic proposal, the EPA reports to the Minister for Environment on:

1. the key environmental factors identified during the assessment;
2. whether or not the future proposals, identified in the strategic proposal, may be implemented; and
3. any conditions which should apply to those future proposals, if they are subsequently referred to the EPA and declared to be derived proposals.

As with other proposals, any person may appeal to the Minister for Environment if they disagree with the content of, or any recommendations in, the EPA's report.

After determining any appeal, the Minister for Environment consults with other relevant decision-making authorities for the purposes of deciding whether the future proposals, identified in the strategic proposal, may be implemented. The Minister also consults on any conditions which will apply to the implementation of the future proposals and the strategic proposal.

If the Minister for Environment and relevant decision-making authorities decide that the future proposals may be implemented, with or without conditions, the Minister publishes a "Ministerial Statement". However, it is not until after the EPA has declared a future proposal, identified in the strategic proposal, to be a derived proposal, that the future proposal can be implemented.

4.2.1.2 Process for Declaring and Implementing Derived Proposals

Once the Ministerial Statement has been issued, the proponent of a future proposal (identified in the Ministerial Statement), may then refer their proposal to the EPA along with a request that it be declared a derived proposal.

Any person may refer a future proposal, identified in a strategic proposal, to the EPA. However, it is not until after the Ministerial Statement has been issued, and the proponent has requested the referred proposal be declared a derived proposal, that the EPA can consider whether to declare it to be a derived proposal.

After receipt of the referral and a request, the referral (and the proponent's request for it to be declared a derived proposal) is advertised for public comment. The EPA can only consider public comment in the context of its decision on whether or not to declare the proposal to be a derived proposal.

After considering public comment and the proposal documentation, the EPA then considers whether or not to declare the referred proposal to be a derived proposal. To do so, the Act requires that the:

- proposal was identified in the strategic proposal; and
- Ministerial Statement provides that the referred proposal may be implemented, subject to any conditions.

The EPA may refuse to declare the referred proposal to be a derived proposal if it considers that:

- the environmental issues raised by the referred proposal were not adequately assessed when the strategic proposal was assessed;
- there is significant new or additional information that justifies the reassessment of the issues raised by the referred proposal; or
- there has been a significant change in the relevant environmental factors since the strategic proposal was assessed.

If the EPA declares the referred proposal to be a derived proposal, it does not assess that proposal. Instead, the Ministerial Statement, together with any accompanying conditions, takes effect and applies to the declared derived proposal. The Minister is required to issue a notice stating this.

If the Ministerial Statement relates to two or more future proposals, the Minister's notice may specify which of the conditions of the Ministerial Statement apply to the derived proposal.

Alternatively, the Minister may request the EPA to inquire into the conditions which apply to the derived proposal or the EPA may decide to inquire into the conditions and, if so, the EPA may recommend changes to conditions and make any other recommendations that it thinks are appropriate.

There are no appeal provisions relating to the EPA's decision to declare a derived proposal, to refuse a declaration, or its determination as to whether or not to inquire into conditions. There is also no appeal in relation to the Minister's notice which specifies the coming into effect of the Ministerial Statement and any conditions which relate to the derived proposal.

If the EPA enquires into the conditions which apply to the derived proposal there is no appeal in respect of the EPA's report to the Minister, however the proponent can appeal any conditions which are set following that enquiry.

4.2.1.3 Summary

To ensure that the benefits of strategic assessments are realised, the EPA takes the following approach to assessing strategic proposals and deciding on derived proposals.

1. The assessment of a strategic proposal should enable the EPA to confidently define the overall environmental outcomes that must be achieved through implementation of any derived proposals identified in the course of the assessment of the strategic proposal.

2. Information submitted with a request that the EPA declare a derived proposals will need to demonstrate how the proposal will meet the environmental outcomes defined through the assessment of the strategic proposal, including any Ministerial conditions.

3. Referrals of future proposals must contain sufficient information to enable the EPA to determine whether the proposals can be declared as derived proposals.

4. Proponents of future proposals should undertake thorough stakeholder consultation.

For further procedural detail, refer to the EPA's Environmental Impact Assessment Administrative Procedures 2012.

4.3 Other Relevant Environmental Management Legislation and Instruments

4.3.1 Fish Resources Management Act 1994

While the State-level environmental impact assessment of the MWADZ Proposal and the principal object of this PER is to address the requirements of the EP Act, it is also important to describe how the provisions of the *Fish Resources Management Act 1994* (FRMA) interact with and support the EP Act in the management of the potential environmental impacts of the proposal. In this context, the following provisions are relevant.

Section 101A (2A) of the *Fish Resources Management Act 1994* (FRMA) provides the power for the Minister to declare an area of Western Australian waters to be an aquaculture development zone.

Section 92 of the FRMA provides the power for the Chief Executive Officer (CEO) of the Department to grant an aquaculture licence, which authorises the licence holder to conduct aquaculture in Western Australia.

There is a requirement that applicants for aquaculture licences demonstrate they have, or will have, appropriate tenure over the area proposed for the aquaculture activity. In most cases, tenure over State waters may be granted through an aquaculture lease, issued under Section 97 of the FRMA. In the zone, an aquaculture lease and an aquaculture licence will both be required for establishing and undertaking aquaculture.

An aquaculture licence authorises the specific aquaculture activity undertaken within a defined site, whereas a lease provides tenure for the specified area of land or water. There is a nexus between the aquaculture licence and the aquaculture lease under the FRMA. For example, under:

- s.99(1), an aquaculture lease does not authorise the use of the leased area without an aquaculture licence;
- s.99(2), if an aquaculture licence authorising the activity being carried out in the leased area is cancelled or not renewed, the lease is terminated; and
- s.99(3), if an aquaculture lease is terminated or expires, an aquaculture licence authorising the activity being carried out in the leased area is cancelled.

The main purpose of this interrelationship is to prevent speculation or investment at a particular site for a purpose other than aquaculture.

The legislative framework also allows for adaptive management to achieve the best management outcomes. Licence and lease conditions may be imposed. For example, the CEO has the power to add a condition to an existing aquaculture licence to set initial carrying capacity or stocking density limits. Conditions may also extend to matters such as applying performance criteria to address any instances of non-use of aquaculture leases.

The FRMA also establishes an environmental management and monitoring framework for all sectors of aquaculture. Under the provisions of Section 92A of the FRMA, unless exempt under Section 92A(4), applications for an aquaculture licence must be accompanied by a Management and Environmental Monitoring Plan (MEMP). The MEMP is the principal instrument by which the Department gives effect to this environmental management and monitoring framework. It relates to and is attached to the aquaculture licence.

Aquaculture activities inside an aquaculture zone require a Category 1 MEMP.[38] As these activities are subject to the provisions of the strategic proposal approval for the zone (see below), a Category 1 MEMP must incorporate (and refer to) the requirements specified in the following documents:

- Ministerial Statement/notice (issued by the Minister for Environment)
- Department of Fisheries EMMP for the zone
- Department of Fisheries Management Policy for the zone

Contravention of a MEMP or condition of an aquaculture licence or lease is an offence under the FRMA and penalties may apply. Further, the FRMA provides the power for the CEO to cancel, suspend or not renew an aquaculture licence.

[38] The methodology for determining the appropriate category of MEMP is outlined in the Department's MEMP Policy document. This may be accessed at http://www.fish.wa.gov.au/Fishing-and-Aquaculture/Aquaculture/Aquaculture-Management/Pages/default.aspx.

In this fashion, the FRMA, through the MEMP, supports the EP Act by reinforcing the importance of the conditions of the Ministerial Statement/notice (issued by the Minister for Environment) and providing an alternative regulatory mechanism for enforcing compliance with those conditions.

4.3.2 Environmental Code of Practice for the Sustainable Management of Western Australia's Marine Finfish Aquaculture Industry

With input by the Department, the Aquaculture Council of Western Australia (ACWA) produced a number of Environmental Codes of Practice (ECoP), including the *Environmental Code of Practice for the Sustainable Management of Western Australia's Marine Finfish Aquaculture Industry*, which is particularly relevant to the MWADZ Proposal. These ECoPS are intended to create a tool for industry that promotes continued improvement of the environmental integrity of farms. It represents industry "best practice" and is promoted as such by the Department and ACWA.

Although compliance with ECoPs is voluntary, it is expected operators will model their aquaculture businesses and activities to be compliant with them. Compliance with the ECoPs will ultimately lead to benefits for both the operator and the environment.

4.3.3 Other Legislation and Instruments

The Commonwealth, State and local environmental legislation, policies, plans and guidelines relating to individual areas of assessment (e.g. biosecurity) are outlined within the relevant sections of this PER.

5 STAKEHOLDER CONSULTATION

5.1 Introduction

The Department is committed to open and accountable processes that encourage ongoing stakeholder engagement during all stages of the MWADZ Proposal.

Stakeholder engagement in the MWADZ Proposal commenced in 2013 and will continue to do so throughout the PER process. This section outlines stakeholder involvement to date, issues raised during this process and plans for ongoing stakeholder engagement for the MWADZ Proposal.

5.2 Purpose of Stakeholder Engagement

The purpose of engaging stakeholders during the planning and assessment of the MWADZ Proposal is to:

- inform stakeholders about the MWADZ Proposal by providing accurate and accessible information;
- provide adequate opportunities and timeframes for stakeholders to consider the MWADZ Proposal;
- engage stakeholders in meaningful dialogue and provide adequate opportunities to be involved in the decision making processes during the development of the proposal;

- identify and attempt to resolve potential issues;
- consider and address issues raised by stakeholders and provide feedback; and
- consider stakeholder views in planning future engagement.

5.3 Key Stakeholders

A range of stakeholders has been engaged as part of the MWADZ Proposal. Broadly, stakeholders can be categorised into the following groups:

- Commonwealth Government
- State Government
- Local Government
- community groups and environment Non-Government Organisations (eNGOs)
- industry groups and representatives
- internal stakeholders

Aboriginal groups have not been included in the above list on the basis that there are no existing or pending Native Title claims relating to the area applicable to the MWADZ Proposal.[39] However, the PER public comment period will provide an opportunity for any matters relating to this community group to be raised. If any cultural heritage material is uncovered within the proposed MWADZ at any time in the future, the appropriate authorities (e.g. Department of Aboriginal Affairs) will be immediately contacted for advice.

5.4 Methods of Stakeholder Engagement

Stakeholder engagement activities for the MWADZ Proposal to date have included:

- consulting with other decision-making authorities identified in the EPA-prepared Environmental Scoping Document (ESD) on the works required to address the requirements of the ESD;
- conducting stakeholder meetings, briefings and presentations;
- posting periodic newsletters on the Department's website outlining the progress of the project; and
- mailing letters to eNGOs and interest groups.

5.4.1 State Government

In April 2013, the Department referred the MWADZ strategic proposal referral form to the Western Australian EPA for determination of whether the strategic proposal was valid, whether or not to assess the proposal and (if so) the level of environmental assessment. The referral was accepted and set at the public environmental review level of assessment.

An ESD (Appendix 7) for the MWADZ Proposal was subsequently issued by the EPA in July 2013. The ESD was used to guide the preparation of this PER.

State Government agencies (including Decision Making Authorities) were sent project progress status newsletters and provided opportunities for briefings throughout the

[39] National Native Title Tribunal website - http://www.nntt.gov.au/Maps/WA_Geraldton_NTDA_schedule.pdf (as at 25 June 2015).

development of the PER. These relevant agencies will have further input through the final stages of the strategic proposal assessment process.

5.4.2 Commonwealth Government

Officers of the Department contacted the Commonwealth DotE (formerly SEWPaC) to discuss the referral of the MWADZ Proposal to that agency for assessment under the EPBC Act. The DotE Environmental Assessment and Compliance Division advised the Department that the proposed actions associated with the MWADZ Proposal were not of a magnitude that necessitates a "Strategic Assessment" at the Commonwealth level. DotE further advised that, in view of the fact that the Department (on behalf of the Minister for Fisheries) is not itself proposing to undertake aquaculture operations within the MWADZ (in other words, will not be a derived proponent under the strategic proposal), the Department is not required to refer a proposed action under the EPBC Act.

5.4.3 Non-Government Organisations

During the preparation of this PER, a letter was sent to the eNGOs and interest groups. The purpose of this correspondence was to inform the groups of the MWADZ Proposal to enable them to prepare for the public review period of the PER. Some eNGOs also took up the opportunity provided by the Department to attend briefings on the MWADZ Proposal ahead of this public review period.

5.4.4 Local Government

Both the Shire of Northampton (initially) and the City of Greater Geraldton (more recently since the inclusion of the Abrolhos Islands within the City's boundaries) have been consulted through newsletters and briefings in relation to the MWADZ Proposal.

Table 5-1 summarises key stakeholder engagement activities. Future engagement activities for the MWADZ Proposal during the PER period are outlined in Section 5.6.

Table 5-1: Summary of Stakeholder Engagement during the Development of the MWADZ Proposal

Stakeholder Group	Date	Method
Relevant Commonwealth departments [e.g. Department of the Environment (DotE)]	Feb. 2013 Jun. 2013 Feb. 2014 Aug. 2014 Sep. 2015	Periodic newsletters to introduce and provide an update on the progress of the MWADZ Proposal and other relevant issues. Opportunities provided to comment on proposal.
	July 2013	Zones Project manager consulted with DotE with regard to the referral of the MWADZ Proposal under the EPBC Act and provided an opportunity to discuss relevant issues.
Relevant State departments	Feb. 2013 Jun. 2013 Feb. 2014 Aug. 2014 Sep. 2015	Periodic newsletters to introduce and provide an update on the progress of the MWADZ Proposal and other relevant issues. Opportunities provided to comment on proposal.
	Dec. 2012 Sep. 2013 Mar. 2013 Oct. 2015	Opportunity provided to meet with the zone project management team.

Stakeholder Group	Date	Method
	Oct. 2015	Meeting to introduce/discuss the MWADZ Proposal and relevant issues.
Relevant local governments	Feb. 2013 Jun. 2013 Feb. 2014 Aug. 2014 Sep. 2015	Periodic newsletters to introduce and provide an update on the progress of the MWADZ Proposal and other relevant issues. Opportunities provided to comment on proposal.
	Dec. 2013 Mar. 2013 Oct. 2015	Meetings to introduce/discuss the MWADZ Proposal and relevant issues.
Community groups	Feb. 2013 Jun. 2013 Feb. 2014 Aug. 2014 Sep. 2015	Periodic newsletters to update on the progress of the MWADZ Proposal and other relevant issues. Opportunities provided to comment on proposal.
	Feb./Mar. 2013 Oct. 2015	Opportunity provided to meet with the zone project management team.
Environmental non-government organisations	Jan. 2013	Periodic newsletters to introduce and provide an update on the progress of the MWADZ Proposal and other relevant issues. Opportunities provided to comment on proposal.
	Jul. 2013	Meeting to discuss relevant issues.
	Feb./Mar. 2013 Oct. 2015	Opportunity provided to meet with the zone project management team.
Industry groups and representatives	Feb. 2013 Jun. 2013 Feb. 2014 Aug. 2014 Sept. 2015	Periodic newsletters to introduce and provide an update on the progress of the MWADZ Proposal and other relevant issues. Opportunities provided to comment on proposal.
	Dec. 2012 Jan. 2013 Feb. 2015 Sep. 2015	Periodic meetings to discuss the progress of the MWADZ Proposal and other relevant issues.
	2012 - 2015	Other occasional meetings to discuss specific issues.
Others (e.g. interested individuals)	Feb. 2013 Jun. 2013 Feb. 2014 Aug. 2014 Sep. 2015	Periodic newsletters to introduce and provide an update on the progress of the MWADZ Proposal and other relevant issues. Opportunities provided to comment on proposal.
	2012 - 2015	Other occasional meetings to discuss specific issues.

5.5 Stakeholder Issues

A number of key issues were raised by stakeholders during consultation on the MWADZ Proposal and are addressed in Table 5-2. These key issues have been considered in the preparation of this PER.

Table 5-2: Key issues identified through stakeholder consultation

EPA Factor	Issue	Stakeholder	Comment	Response
Benthic Communities and Habitat	Dragging anchors and operations will be detrimental to wild scallops.	Abrolhos Islands and Mid West Trawl Managed Fishery licencees	Machinery and any dragging anchors associated with the MWADZ will be detrimental to the Abrolhos Islands and Mid West Trawl Managed Fishery.	Addressed in Section 2.4 Also refer to Section 4.6.2 of the EMMP (Appendix 2)
	Coral reef and island habitats may be impacted	Western Australian Fishing Industry Council	There needs to be benthic monitoring sites on the southern side of the proposed southern area of the MWADZ to detect any impacts on coral reef and island habitat.	Addressed in Section 2.5 and Sections 8.4 – 8.6 Also refer to Section 4.1 of the EMMP (Appendix 2)
	Environmental impacts associated with the aquaculture of carnivorous finfish will impact marine ecosystem of the Abrolhos Islands	Northern Agricultural Catchments Council	At large operational scales, finfish aquaculture can destroy aquatic habitats. Scientific evidence has demonstrated that sea cage aquaculture of carnivorous finfish have the largest environmental impacts, compared to other types of aquaculture. It is inappropriate to locate finfish sea cages within highly valuable marine ecosystems such as those at the Abrolhos Islands. Finfish aquaculture may be more appropriate at an alternative site, such as Port Gregory. An ecological survey of the proposed location would be required.	Addressed in: Section 2.5.2 Section 7.5 Section 8 Also refer to Section 4.1 of the EMMP (Appendix 2)
Marine Environmental Quality	Environmental impact on fishery-targeted species	Western Australian Fishing Industry Council	The Abrolhos Islands FHPA is vital to the scallop fishery. Small, isolated patches of sand have previously supported large scallop populations. Biological waste, increased predators and poor water quality are potential impacts of finfish aquaculture that could impact on scallop recruitment or the adult stock by stunting the growth or causing mortality.	Addressed in: Section 11 Section 14
	Level of waste produced	Abrolhos Coral and Live Rock aquaculture licencees	There is no control monitoring sites for in the shallow water south of the southern side of the proposed southern area of the MWADZ to detect any impacts on water quality.	Addressed in: Section 6.6.1 Section 6.6.2 Section 8 Also refer to Section 4.1 of the EMMP (Appendix 2)

EPA Factor	Issue	Stakeholder	Comment	Response
	Water quality monitoring	Abrolhos Coral and Live Rock aquaculture licencees	Are water quality monitoring arrangements for the proposed MWADZ adequate to detect any possible changes that may impact on Abrolhos Island coral communities?	Addressed in: Section 6.6.1 Section 6.6.2 Also refer to Section 4.1 of the EMMP (Appendix 2)
	Disclosure	Western Australian Fishing Industry Council	How will the broader community know whether aquaculture operators within the proposed MWADZ are complying with their environmental monitoring and management obligations?	Addressed in: Section 7.1 of the EMMP Appendix 2) and the MWADZ Management Policy (Appendix 3)
	Organic matter and nutrients could impact on wild scallops.	Abrolhos Islands and Mid West Trawl Managed Fishery	Waste from finfish farming, including dissolved nutrients, uneaten fish feed, and fish faecal material, would have a negative effect on wild scallops.	Addressed in: Section 11.4 Also refer to Section 8.2 of the Modelling and Technical Studies (Appendix 1) and Section 4.2 and 4.3 of the EMMP (Appendix 2)
Marine Fauna	Parasites	Conservation Council of Western Australia	Marine finfish aquaculture could harbour fish parasites that may affect natural fish populations within the Abrolhos Islands FHPA.	Addressed in: Section 9.3 Section 9.5 Section 10 Also refer to Section 4.7 of the EMMP (Appendix 2) and the Biosecurity Risk Assessment (Appendix 4)
	Genetics	Western Australian Fishing Industry Council	What are the potential impacts to marine finfish wild populations (e.g. yellowtail kingfish) resulting from farm stock "escapees"?	Addressed in: Section 10 Also refer to Section 4.7 of the EMMP (Appendix 2) and the Biosecurity Risk Assessment (Appendix 4)
	Disease	West Coast Rock Lobster Managed Fishery (Zone A)	Finfish aquaculture could bring fish disease to the Abrolhos.	Addressed in: Section 9.3 Section 9.5

EPA Factor	Issue	Stakeholder	Comment	Response
		licencees		Section 10 Also refer to Section 4.7 of the EMMP (Appendix 2) and the Biosecurity Risk Assessment (Appendix 4)
	Indirect impacts on seabird populations	Conservation Council of Western Australia	Tuna farming in Port Lincoln suggests that that aquaculture could attract and increase the abundance of silver gulls, thereby negatively affecting other fauna. The Abrolhos Islands supports a population of 1.5 million shearwaters that are likely to be affected by the presence of fish farming in the FHPA. A major concern is the potential for populations of cormorants, silver gulls, pacific gulls (and other scavenger types known to benefit from aquaculture activity) to increase with ecological consequences for terrestrial ecosystems.	Addressed in: Section 3.4 Section 9 Also refer to EIA on seabirds (Appendix 1D), Section 4.4 of the EMMP (Appendix 2) and the Marine Fauna Interaction Plan (Appendix 5)
	Finfish aquaculture has not undergone any trial	Conservation Council of Western Australia	Most of the seabird monitoring over the last decade is of diminishing value because it was not consistently collected during periods of environmental and industrial changes at the Abrolhos Islands. There is no data available on the foraging patterns for key receptor species (i.e. cormorants, gulls etc.), which is important baseline data for assessing aquaculture-seabird interactions. A previous yellowfin tuna proposal for the Zeewijk Channel was granted an experimental program (trial) to quantify the extent of wildlife interactions. To date the trial has not commenced and monitoring of interactions has not been undertaken, thus the effects of aquaculture on marine fauna are unknown. The main concerns were: • Potential aquaculture-seabird interactions cannot be pre-empted; and • The proposal is favouring old technology [i.e. surface (rather than sub-surface) sea-cages] that may influence	Addressed in: Section 3.4 Section 9 Also refer to EIA on seabirds (Appendix 1D), Section 4.4 of the EMMP (Appendix 2) and the Marine Fauna Interaction Plan (Appendix 5)

EPA Factor	Issue	Stakeholder	Comment	Response
			seabird behaviour or affect seabird populations.	
	Source of feed	Recfishwest	Where will food for the grow-out cages come from?	Addressed in: Draft Management Policy (Appendix 3) and Section 4.7 of the EMMP (Appendix 2)
	Source of stock	Recfishwest	Where will the source stock come from?	Addressed in: Draft Management Policy (Appendix 3) and Section 4.7 of the EMMP (Appendix 2)
	Attraction of wild fish	Recfishwest	The sea cages and feeding will cause changes in wild fish behaviour (e.g. attract wild fish to the site).	Addressed in: Sections 8.1 and 8.2 of the Modelling and Technical Studies (Appendix 1), Section 4.6 of the EMMP (Appendix 2) and the Marine Fauna Interaction Plan (Appendix 5)
	General comments on the preliminary environmental impact assessment (EIA) of the MWADZ Proposal in relation to marine mammals and turtles	Department of Parks and Wildlife	• The conservation status of the various species of marine fauna, in particular the Australian sea lion, should be considered in relation to State legislation. • The population history, current status and trends, as well as the extent and size of genetic management units to which fauna of the Abrolhos Islands belong, would provide valuable information for determining the importance of individuals at the Abrolhos, particularly for species at greatest risk from the proposed aquaculture. • Loss or degradation of habitat would be of significance to fauna populations of the Abrolhos Islands, particularly of species that are potentially susceptible to influence. • Presentation of the aquaculture zone of influence in relation to wildlife feeding habitats would illustrate the level of significance of any loss of these habitats. • The proponent needs to describe, in sufficient detail, the type and magnitude of potential impacts on species that are identified as being at greatest risk. Infrastructure design and operational requirements should be stated. • The EIA should consider the merits of various mesh sizes	Addressed in: Section 2.4 Section 9.2.4 Section 9.2.5 Also refer to in Section 8.3 of the Modelling and Technical Studies (Appendix 1), Section 4.5 and Section 4.6.2 of the EMMP (Appendix 2) and the Marine Fauna Interaction Plan (Appendix 5)

EPA Factor	Issue	Stakeholder	Comment	Response
			likely to be used in the proposed aquaculture operations.	
	Marine mammals	Department of Parks and Wildlife	Marine mammals are highly vulnerable to adverse impacts of poorly-managed fish farms. In relation to marine mammals and turtles, the Australian sea lions are of primary concern. The PER document needs to identify the key design and operational aspects of the proposal that create the greatest risk to Australian sea lions and which, therefore, need to be a focus for mitigation. These include: • use of predator nets; • net tension; • preventing access between predator nets and fish cages; • optimal mesh sizes; • fit-for-purpose net material; • maintenance regimes (including during periods when cages are fallow); • prompt removal of infrastructure that is not being monitored and maintained; • minimising Australian sea lion attraction through controlled feeding regimes; • prompt removal of dead fish; and • fish harvesting practices that do not discharge offal. Management options to capture and relocate fauna, or the use of harassment techniques such as acoustic deterrents, may not be supported. The PER document should present a comprehensive management framework addressing all potential impacts that were identified by the EIA.	Addressed in: Section 2.4 Section 9.2.4 Section 9.2.5 Also refer to in Section 8.3 of the Modelling and Technical Studies (Appendix 1), Sections 4.5 and 4.6.2 of the EMMP (Appendix 2) and the Marine Fauna Interaction Plan (Appendix 5)
	Australian sea lion	Department of Parks and Wildlife	Every Australian sea lion colony must be protected for biodiversity conservation purposes, as the WA Australian sea lion population is not recovering. The EIA has underestimated the occurrence of Australian sea lion in the proposed MWADZ. All available information on the Australian sea lion (at a local, regional and population scale) should be considered in the EIA. In considering habitat usage patterns, the proponent should also consider the potential changes to abundance as a result of pinniped attraction to fish	Addressed in: Sections 2.4 Section 9.2.4 Section 9.2.5 Also refer to in Section 8.3 of the Modelling and Technical Studies (Appendix 1), Sections 4.5 and 4.6.2 of the EMMP (Appendix 2)

EPA Factor	Issue	Stakeholder	Comment	Response
			farms. The PER document must present a comprehensive management framework of design and operational commitments. These must demonstrate that the minimum standards will be best practice and reduce risks to acceptable levels, ensuring protection of the vulnerable Abrolhos population of Australian sea lion. The Abrolhos Islands Australian sea lion population is important and all risks associated with the proposal need to be eliminated or reduced to very low levels. The management framework should employ a combination of minimum design standards, operational procedures, proposed monitoring and contingency measures and future derived proposals to ensure the proposed aquaculture does not threaten the Abrolhos Islands Australian sea lion population.	and the Marine Fauna Interaction Plan (Appendix 5)
	Whales	Department of Parks and Wildlife	Abrolhos Islands are a well-known resting area used by humpback whales with their calves and escort males.	Addressed in: Section 2.4 Section 9.2.4 Section 9.2.5 Also refer to in Section 8.3 of the Modelling and Technical Studies (Appendix 1), Section 4.5 and Section 4.6.2 of the EMMP (Appendix 2) and the Marine Fauna Interaction Plan (Appendix 5)
	Dolphins	Department of Parks and Wildlife	The EIA has underestimated the occurrence of Indo-Pacific bottlenose dolphin in the proposed MWADZ. In considering habitat usage patterns the proponent should also consider the potential changes to abundance as a result of dolphin attraction to fish farms. Small pods of Indo-Pacific bottlenose dolphins may be displaced by the proposed strategic proposal and dolphin species are known to interact with fish farms, which can lead	Addressed in: Section 2.4 Section 9.2.4 Section 9.2.5 Also refer to in Section 8.3 of the Modelling and Technical Studies (Appendix 1), Section 4.5 and Section 4.6.2 of the EMMP

EPA Factor	Issue	Stakeholder	Comment	Response
			to entanglement and drowning.	(Appendix 2) and the Marine Fauna Interaction Plan (Appendix 5)
	Dugongs	Department of Parks and Wildlife	The EIA should investigate whether the strategic proposal area contains significant feeding habitat for Dugongs.	Addressed in: Sections 2.4 Section 9.2.4 Section 9.2.5 Also refer to in Section 8.3 of the Modelling and Technical Studies (Appendix 1), Section 4.5 and Section 4.6.2 of the EMMP (Appendix 2) and the Marine Fauna Interaction Plan (Appendix 5)
	Turtles	Department of Parks and Wildlife	The EIA should investigate the likely impacts of the proposed aquaculture on any species of turtle that may occur or be attracted into the area. The occurrence of green, loggerhead and hawksbill turtles in the strategic proposal area should be considered in the context of habitat types, noting that turtles may be attracted to fish farms. This would increase their vulnerability to entanglement and falling prey to predators. Lighting is only considered problematic in relation to onshore lighting.	Addressed in: Sections 2.4 Section 9.2.4 Section 9.2.5 Also refer to in Section 8.3 of the Modelling and Technical Studies (Appendix 1), Section 4.5 and Section 4.6.2 of the EMMP (Appendix 2) and the Marine Fauna Interaction Plan (Appendix 5)
Amenity	Attraction of sharks	Specimen Shell Managed Fishery licencees	The strategic proposal area overlaps with area that is suitable for specimen shell licensees to work. There is concern that the proposed aquaculture could attract sharks and would make diving operations more hazardous. Commercial diving operations (Specimen Shell Fishery) may be hampered if sites are more hazardous for divers.	Addressed in: Section 9
	Responsibility for recovery of “lost” (e.g. through storm damage) aquaculture gear	Geraldton Air Charters Pty Ltd	Who is responsible for recovering any aquaculture gear that may have broken loose or otherwise drifted outside of the MWADZ?	Addressed in: Section 13
	Discarded	Recfishwest	In case of a future proposal being shut-down, removal of	Addressed in:

EPA Factor	Issue	Stakeholder	Comment	Response
	infrastructure	Conservation Council of Western Australia	infrastructure should be a condition of approval for derived proposals.	Section 3.5
	Sense of ownership over the land	Recfishwest	Concerned that the approval of future derived proposal may lead to a sense of ownership over the land at the Abrolhos Islands. Land-based facilities associated with the proposed aquaculture may impact upon the amenity of the Abrolhos Islands.	Not applicable to this PER
Terrestrial Environmental Quality	Abrolhos Island Reserve habitats	Western Australian Fishing Industry Council	Reserve habitats may be impacted.	Addressed in: Section 2.5 Also refer to Section 4.4 of the Modelling and Technical Studies and the EIA on seabirds (Appendix 1D)
	Location inconsistent with conservation status of the Abrolhos Islands Reserve	Northern Agricultural Catchments Council Conservation Council of Western Australia	Aquaculture is in conflict with the environmental values of the Abrolhos Islands. The Abrolhos Islands Reserve is an A-Class Reserve and, while the MWADZ Proposal is not within this Reserve, it may impact upon it.	Addressed in: Section 2 Section 6 Section 11 Section 14
Decommissioning and Rehabilitation	Performance criteria	Western Australian Fishing Industry Council	What is to prevent aquaculture operators establishing infrastructure (e.g. sea cages) within the proposed MWADZ but then fail to commence fish culture operations or otherwise cease to use that infrastructure?	Addressed in: Section 4 Section 2 Section 15
Non-environmental factor (i.e. socio-economic matter)	Navigation	West Coast Rock Lobster Managed Fishery (Zone A) licencees	The presence of aquaculture gear in the area identified in the MWADZ Proposal may pose a risk to navigation (e.g. vessels could collide with the sea cages).	Addressed in: Section 11 Section 14 Also refer to Section 7.6 of the Draft Management Policy (Appendix 3)
	Workforce safety	Western Australian Fishing Industry Council	How will the Department and aquaculture operators within the proposed MWADZ provide for the safety of the workforce?	Addressed in: Section 9 Section 11

EPA Factor	Issue	Stakeholder	Comment	Response
				Section 12
	Area exclusion by management	West Coast Rock Lobster Managed Fishery (Zone B) licencees	Will future derived proponents create exclusion zones around sea cages?	Addressed in the Draft Management Policy (Appendix 3)
	Liability for damage caused to aquaculture infrastructure	Geraldton Air Charters Pty Ltd	Who is responsible for any damage to the infrastructure?	Not applicable to this PER. However, other than the FRMA provisions relating to interference with aquaculture gear, the usual criminal, civil and maritime laws of the State would apply.
	Physical obstruction	Abrolhos Islands and Mid West Trawl Managed Fishery licencees	The proposed strategic assessment area overlaps with important fishing grounds for the scallop fishery. Any areas that have a sandy seafloor are considered to be scallop grounds. The scallop fishery is fickle. That is, recruitment and catch of scallops is highly variable and unpredictable. Small patches of sand can suddenly be important scallop grounds. The presence of aquaculture gear in the area identified in the MWADZ Proposal will result in a reduction in the area available to be fished by the Abrolhos Islands and Mid West Trawl Managed Fishery. Anchoring systems associated with sea cages are hazardous to trawling activities. Alternative locations, such as Horrocks and Port Gregory, are of lesser concern to the scallop fishery.	Addressed in: Section 11
	Location inconsistent with conservation status of the Abrolhos Islands Fish Habitat Protection Area (FHPA)	Northern Agricultural Catchments Council Conservation Council of Western Australia	Aquaculture is in conflict with the environmental values of the Abrolhos Islands. Water surrounding the Abrolhos Islands contains some of the most highly valued marine systems in the State. Finfish aquaculture is incompatible with the biologically-significant habitats of the Abrolhos Islands. This will impact on ecotourism and public visitation. Alternative sites should be considered.	Addressed in: Section 2 Section 6 Section 11 Section 14
	Economic impact on wild-catch fisheries	Western Australian Fishing Industry Council	Marine finfish aquaculture will have a major economic impact on finfish wild-catch fisheries in the Mid West region.	Addressed in: Section 11
	Cumulative regional	Recfishwest	Recreational fishers are concerned that the approval of the	Not applicable to this PER

EPA Factor	Issue	Stakeholder	Comment	Response
	effects of multiple Aquaculture Development Zones		MWADZ could set a precedent for approval of other Aquaculture Development Zones (ADZ) in the Mid West, thus reducing access to recreationally important locations. Suggested that the Minister for Fisheries place a caveat over the total number of ADZ permitted in the Mid West region.	
	Alternative sites	Recfishwest Conservation Council of Western Australia Northern Agricultural Catchments Council	The proponent should consider alternative areas, such as Dongara and Port Gregory.	Addressed in: Section 2.2
	The pre-existing licenced aquaculture site	Recfishwest	The proponent should incorporate the existing aquaculture site to the north of the Pelsaert Group of the Abrolhos Islands. This area was already earmarked for aquaculture in the region and is likely to be a viable site.	Addressed in: Section 1.2.5
	Economic competition	West Coast Demersal Scalefish Fishery	Concern that finfish aquaculture would have a major economic impact on the wild-catch demersal scalefish fishery.	Not applicable to this PER

5.6 Ongoing Stakeholder Engagement

The PER presents an opportunity for all stakeholders to provide feedback and comment on the MWADZ Proposal and the Department will respond to these inputs in the Response to Submissions in the final PER.

In addition to direct engagement with stakeholders, other communication methods will be used to inform the broader community of the PER process. These communications will include the MWADZ Project Update newsletter (available on the Department's website at: http://www.fish.wa.gov.au/Fishing-and-Aquaculture/Aquaculture/Pages/default.aspx, and website postings of relevant public documents.

The Department is currently reviewing its consultation processes to provide greater opportunity for stakeholder involvement. This may include public forums, targeted consultation with key interest groups, or a regional approach, depending on the fishery or issues under consideration.

6 ENVIRONMENTAL IMPACT ASSESSMENT FRAMEWORK

6.1 Methods of Assessment

This section describes the method used to identify and assess the potential impacts of the MWADZ Proposal, to determine the mitigation and management measures the Department proposes to implement to address these potential impacts, and to determine the environmental acceptability of the MWADZ Proposal. The results of the assessment are presented and discussed in Sections 7 to 12 of this PER.

6.2 Scope and Approach

The assessment approach has been developed to ensure that it addresses the scope of assessment required under (principally) the Western Australian *Environmental Protection Act 1986* (EP Act) and (to the extent of potential application to future derived proposals) the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The EP Act provides for the EIA of proposals likely, if implemented, to have a significant effect on the environment. The EPA uses a framework of environmental principles, factors and associated objectives as the basis for assessing whether a proposal's impact on the environment is acceptable. They therefore underpin the EIA process. The framework is shown in Figure 6-1 and is further described below. For further detail refer to the EPA's EAG 8.

Environmental principles

The environmental principles are the principles of the *Environmental Protection Act 1986* and other principles adopted by the EPA which provide overall guidance for its decision-making.

Environmental policies

Environmental policies are international, national and State policies, agreements or treaties which provide a position or establish obligations on environmental protection. They include environmental protection policies and other policies and strategies adopted by Government.

Environmental factors

An environmental factor is a part of the environment that may be impacted by an aspect of the proposal. There are five environmental factors which have been selected to be relevant to the MWADZ Proposal and practical for the EIA process. In addition to these environmental factors, there is one integrating factor.

Environmental objectives

The related environmental objective for each factor is the desired goal that, if met, will indicate that the proposal is not expected to have a significant impact on that part (factor) of the environment.

Environmental guidance

Environmental guidance is the relevant environmental policies, guidelines, or standards that provide advice (to proponents and the public) on the policy position, procedures and minimum requirements that the EPA expects to be met for proposals through the environmental impact assessment process.

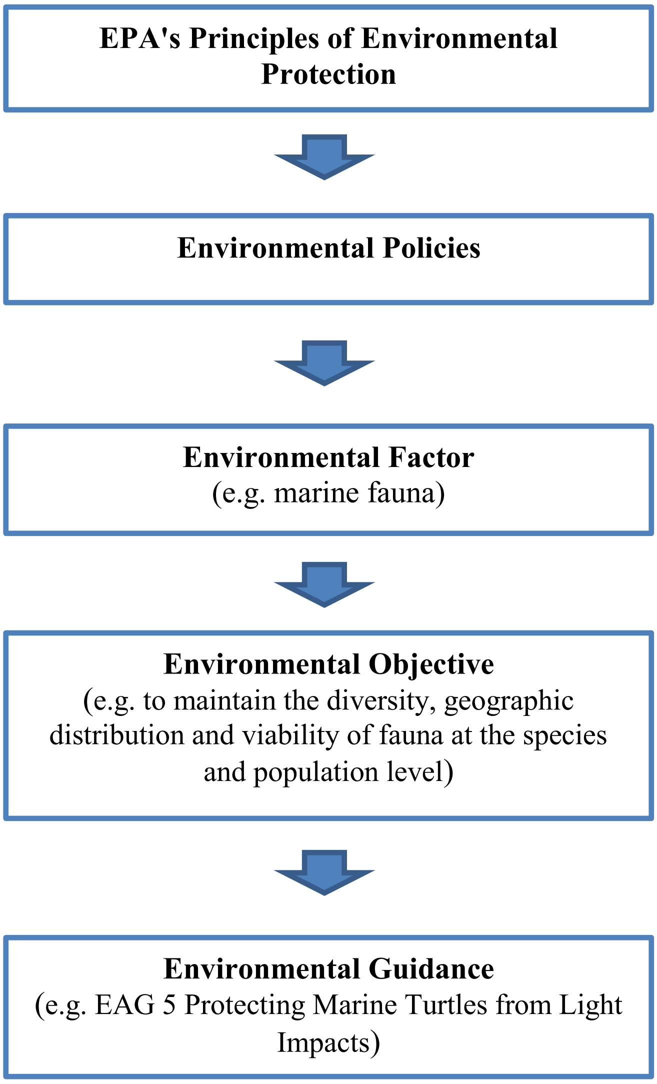


Figure 6-1: The EPA's framework for environmental principles, policies, factors, objectives and guidance

The environmental principles specified in the EP Act and the two additional environmental principles adopted by the EPA are described in Table 6-1.

Table 6-1: Consideration given to the environmental principles of the *Environmental Protection Act 1986 and of the EPA* (EAG 8)

Principle	Relevance	Consideration (if yes)
1. *The precautionary principle* Where there are threats of serious or irreversible damage, lack of scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, decision should be guided by: (a) careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and	yes	Comprehensive investigations, including modelling, technical studies, literature searches, risk assessments and field work, have been conducted to provide sufficient information to address potential environmental impacts and inform the EIA. Where uncertainty or information gaps have been encountered, the more

Principle	Relevance	Consideration (if yes)
(b) an assessment of the risk-weighted consequences of various options.		conservative "most likely worst case" scenario has been consistently adopted. This principle is also embedded in the FRMA.
2. *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.	yes	See item "*3.*" below.
3. *The principle of the conservation of biological diversity and ecological integrity* Conservation of biological diversity and ecological integrity should be a fundamental consideration.	yes	The EQMF (EAG 15) and related components of the EMMP addresses the conservation of ecosystem integrity and this is supported by the information outlined in item "*1.*" above. The relevant environmental values (EAG 8) are addressed in this PER.
4. *Principles relating to improved valuation, pricing and incentive mechanisms* (a) Environment factors should be included in the valuation of assets and services. (b) The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement. (c) 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 wastes. (d) Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solutions and responses to environmental problems.	no	Not applicable.
5. *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.	yes	This principle has been addressed and embedded in the Waste Management Plan and further supported by the arrangements in the Zone Management Policy.
*Best practice** When designing proposals and implementing environmental mitigation and management actions, the contemporary best practice measures available at the time of implementation should be applied.	yes	The principles outlined in EPA's Guidance for the Assessment of Environmental Factors Implementing Best Practice in proposals submitted to the *Environmental Impact Assessment process No. 55 (EPA, 2003)* have been incorporated in the EMMP, Zone Management Policy and ACWA Code of Conduct.
*Continuous improvement**	yes	The EMMP is designed to promote continuous

Principle	Relevance	Consideration (if yes)
The implementation of environmental practices should aim for continuous improvement in environmental performance.		improvement through the environmental monitoring program implemented for the MWADZ Proposal and the adaptive management tools available to the OEPA and the Department. This is also supported by the Aquaculture Development Zone Management Framework. Collectively this will ensure a rapid and effective response to the information gathered as aquaculture development in the zone progresses.

Note: * indicates an adopted environmental principle of the EPA used in conjunction with the five principles specified in the EP Act.

6.2.1 Assessment Scope

The scope of assessment was established following referral of the MWADZ Proposal under the EP Act. The scope is presented in an Environmental Scoping Document (No. 1972) for the MWADZ Proposal (ESD), which was approved by the EPA on 24 July 2013 (refer to Appendix 7).

The scope of the assessment covers the identification, prediction and evaluation of the potential direct and indirect impacts of the MWADZ Proposal. Potential cumulative impacts of the MWADZ Proposal were also identified and assessed.

The ESD requires that the MWADZ Proposal proponent should provide sufficient detail in the PER for the EPA to not only assess the strategic proposal, but also understand the likely characteristics of future (i.e. derived) proposals, and their associated impacts, that will result from the implementation of the MWADZ Proposal. This includes information that should:

- define, as far as possible, the key characteristics of the future proposals, recognising that the assessment may provide opportunities to refine these characteristics;
- define the maximum extent or limits to the scope of any future proposals (e.g. maximum capacity of each individual proposal);
- identify the key environmental factors associated with the future proposals, at a scale commensurate with the nature and extent of those future proposals;
- define the maximum disturbance (impact) footprint of the future proposals (terrestrial and marine) and the envelope within which any future proposals will occur;
- define the potential maximum cumulative environmental impacts and risks from the future proposals, and demonstrate the acceptability of those impacts/risks;

- define potential best practice management principles and strategies to be applied to any future proposal to avoid and minimise impacts to the greatest extent possible; and

- define the proposed governance of future proposals. This should include but not be limited to clearly setting out the legislative process and approval under the *Fish Resources Management Act 1994* that would apply to the establishment of the aquaculture zone and the licencing of the individual aquaculture operations within the zone.

The ESD also identified a number of preliminary key environmental factors, objectives and work required relevant to the MWADZ Proposal (refer to Table 1 of the ESD). The environmental factors and associated objectives identified are among those described in the EPA's Environmental Assessment Guideline for Environmental Principles, Factors and Objectives No. 8 (EAG 8) as outlined in Table 6-2.

Table 6-2: EPA environmental factors and objectives (EAG 8) and relevance to the MWADZ Proposal

Theme	Factor	Objective	Relevance
Sea	Benthic Communities and Habitat	To maintain the structure, function, diversity, distribution and viability of benthic communities and habitats at local and regional scales.	yes
	Coastal Processes	To maintain the morphology of the subtidal, intertidal and supratidal zones and the local geophysical processes that shape them.	no
	Marine Environmental Quality	To maintain the quality of water, sediment and biota so that the environmental values, both ecological and social, are protected.	yes
	Marine Fauna	To maintain the diversity, geographic distribution and viability of fauna at the species and population levels.	yes
Land	Flora and Vegetation	To maintain representation, diversity, viability and ecological function at the species, population and community level.	no
	Landforms	To maintain the variety, integrity, ecological functions and environmental values of landforms and soils.	no
	Subterranean Fauna	To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.	no
	Terrestrial Environmental Quality	To maintain the quality of land and soils so that the environment values, both ecological and social, are protected.	no
	Terrestrial Fauna	To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.	no
Water	Hydrological Processes	To maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected.	no
	Inland Waters Environmental Quality	To maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected.	no
Air	Air Quality	To maintain air quality for the protection of the environment and human health and amenity.	no
People	Amenity	To ensure that impacts to amenity are reduced as low as reasonably practicable.	possible*
	Heritage	To ensure that historical and cultural associations, and natural heritage, are not adversely affected.	yes

Theme	Factor	Objective	Relevance
	Human Health	To ensure that human health is not adversely affected.	no
Integrating Factors	Offsets	To counterbalance any significant residual environmental impacts or uncertainty through the application of offsets.	no
	Rehabilitation and Decommissioning	To ensure that premises are decommissioned and rehabilitated in an ecologically sustainable manner.	possible*

Note: "possible*" indicates a factor that was not specified in the ESD but may be of interest to the public and has therefore been included in this PER.

For the purposes of this PER, the environmental factors identified in the ESD, or emerging from the stakeholder consultation conducted thus far, have been addressed as outlined in Table 6-3.

Table 6-3: Location in the PER of EPA environmental factors relevant to the MWADZ Proposal

EPA Factor	PER Section	Comment
Marine Environmental Quality	Section 7	
Benthic Communities and Habitat	Section 8	
Marine Fauna	Section 9	The biosecurity and fisheries components of this factor have been addressed in Sections 10 and 11 respectively.
Heritage	Section 12	
Amenity	Section 13	
Rehabilitation and Decommissioning	Sections 2 and 15	

6.2.2 Assessment Approach

It is widely recognised in the practice of environmental impact assessment that strategic or "big picture" approaches, rather than case-by-case assessments, can lead to more efficient planning and better environmental outcomes.

One way to take a more strategic view is to utilise the provisions in the EP Act for the assessment of "strategic proposals" by the EPA. Under these provisions, the assessment of a strategic proposal may give rise to more streamlined "derived" proposals that fall within the parameters of the strategic proposal. Such an outcome would be of significant benefit, in terms of efficiency, to the developing marine aquaculture industry in Western Australia. It also takes into account the cumulative effects of such development on the environment, so that any potential future impacts can be assessed and effectively managed.

For these reasons, the Department has adopted the strategic proposal approach for the environmental impact assessment of the MWADZ Proposal as outlined in the EPA's policies and guidelines.

6.2.3 Terms Used

For the avoidance of doubt, the impact assessment terms used in this PER have the meaning described in the adjacent column in Table 6-4.

Table 6-4: Definitions of Impact Assessment Terms Used in this PER

Term	Definition
Consequence	The implication of the potential impact on a factor/s.
Cumulative impact	Potential incremental impacts of the MWADZ Proposal when combined with other present and reasonably foreseeable future actions.
Direct impact	An impact that occurs as a direct result of the MWADZ Proposal (e.g. change in sediment quality due to organic enrichment of sediments directly below the sea cages.
Factor	Includes physical environmental resources (e.g. marine waters) that are valued by society for their intrinsic worth and/or their social, cultural or economic contribution; and receptors (e.g. people, communities, ecological entities – such as naturally-occurring fish populations).
Hazard	A source of potential harm or a situation with a potential to cause loss or adverse effect. Hazard has the same meaning as "threat".
Impact	Interaction of a stressor with an environmental or social factor(s).
Indirect impact	An impact that is not a direct result of the MWADZ Proposal and that may include offsite or downstream impacts, such as impacts on the population dynamics of certain species of seabird as a result of increased populations of other seabirds potentially benefiting from the MWADZ Proposal.
Likelihood	The probability of a stressor impacting on an environmental factor.
Likely impact	An impact that has a real or not remote chance or probability of occurring.
Local/Localised	Impacts restricted to the area directly affected by the MWADZ Proposal and in its immediate vicinity.
Long term	More than five years.
Permanent	Impacts that may arise from irreversible changes in conditions caused by the MWADZ Proposal.
Potential Impact	An impact that can be reasonably expected or is likely to occur in the lifetime of the MWADZ Proposal.
Receptor	A biophysical entity (e.g. species, population, community and habitat) or social/community entity (e.g. people, a community, local businesses).
Residual impact	Impact remaining after the application of proposed mitigation and management measures.
Short-term	Less than five years.
Stressor	A source of potential harm or a situation with a potential to cause loss or adverse effects.
Widespread	Impacts extending beyond the limits of the area directly affected by the MWADZ Proposal and its immediate vicinity.

6.3 Scoping Phase – Establishing the Assessment Context

6.3.1 Identification of Relevant Activities

The first step in the assessment process was to establish the assessment context. This involved:

- determining which MWADZ Proposal activities could potentially result in environmental impacts, but also noting any potential social and economic impacts that may be of public interest;
- identifying MWADZ Proposal stressors, environmental factors and potential impacts that would require examination in the PER;
- identifying potential impacts of the MWADZ Proposal and scoping the investigations and studies required to support their assessment; and
- establishing the MWADZ Proposal assessment framework to determine environmental acceptability.

<u>Note</u>: Potential impacts associated with the activities of third-party facilities were not considered in this assessment. It is assumed that these facilities will operate under their own relevant approvals and/or licences.

6.3.2 Identification of Environmental Stressors that Could Cause Potential Impacts

In addition to the stressors associated with the potential environmental impacts specified in the ESD, other environmental stressors likely to be relevant to the MWADZ Proposal were identified by also comparing the scope of activities associated with the MWADZ Proposal to those examined for the Kimberley Aquaculture Development Zone Proposal (KADZ Proposal) and adopting the same stressors where the activities aligned. Environmental stressors relevant to the MWADZ Proposal were determined based on whether they may:

- pose direct or indirect impacts;
- be of high community/public interest; and
- contribute to cumulative impacts.

Decision-making authorities were also engaged in this identification process to ensure that the selected stressors reflected their expectations. The resulting stressors are listed in Table 6-5.

Table 6-5: Stressors Relevant to the MWADZ Proposal

Stressor	MWADZ Proposal Infrastructure and Activities Associated with Stressor	Considerations
Physical presence of infrastructure	• Preparing, locating, anchoring and operating of aquaculture sea cage clusters. • Feed barge and/or floating staff accommodation. • Marine vessel movements during construction and operation.	• Sea use • Visual amenity • Habitat modification • Navigation • Current alteration
Physical interaction	• Preparing, locating, anchoring and operating of aquaculture sea cage clusters. • Feed barge and/or floating staff accommodation. • Marine vessel movements during construction and operation.	• Entanglement interactions • Marine fauna and vessel collisions
Discharges to sea	• Marine vessel discharges. • Fish stock feed drift outside of sea cages. • Fish stock faeces excretion. • Release of pharmaceuticals. • In-situ removal of bio-fouling from sea cages.	• Residual hydrocarbons • Provisioning • Nutrients • Residual pharmaceuticals • Suspended solids • Shading • Residual trace metals
Noise and vibration	• Marine vessel engine operation. • Feed barge and/or floating staff accommodation. • Operational marine vessel movements. • Automated fish stock feeding systems.	• Anthropogenic noise • Vibration
Seabed disturbance	• Anchoring of aquaculture sea cage clusters. • Movement of aquaculture sea cage clusters. • Anchoring of marine vessels, including feed barges and/or floating staff accommodation.	• Habitat disturbance • Suspended solids • Smothering • Abrasion
Artificial light	• Marine vessel lighting.	• Light spill

Stressor	MWADZ Proposal Infrastructure and Activities Associated with Stressor	Considerations
	• Feed barge and/or floating staff accommodation lighting.	• Glow
Solid and liquid waste	• General waste. • Wastewater. • Biosecurity-risk material. • Blood water from harvesting of stocked fish.	• Potential for spills and leaks associated with storage, transport or disposal
Spills and leaks	• Storing, transporting and handling of chemicals, fuels, wastes and other potentially hazardous materials. • Refuelling. • Marine vessel collision.	• Introduction of toxic, persistent or non-biodegradable substances
Introduction and/or spread of non-indigenous marine species and/or marine pests	• Marine vessel movements. • Moving personnel, equipment and materials. • Translocation and security of farm stock.	• Potential for fish introductions, pests or diseases • Genetics

6.3.3 Preliminary Identification of Potential Impacts

Identification of potential impacts associated with the MWADZ Proposal began during the scoping phase of this PER. Potential impacts were initially identified by considering how each broad activity of the MWADZ Proposal could result in a stressor that could impact upon an identified environmental factor. Identified potential impacts were then analysed by comparing them to those assessed for the KADZ Proposal. The objective was to establish the scope of assessment, data collection, and predictive studies needed to support the assessment.

The preliminary identification of potential impacts relevant to Western Australian (State) jurisdiction was presented in the Environmental Scoping Document (ESD) for the MWADZ Proposal approved by the EPA (July 2013).

Potential impacts relevant to the Commonwealth (i.e. matters of national environmental significance) were also identified through the preliminary identification process.

6.3.4 Establishing the Assessment Framework

The scoping phase also established the framework for determining the acceptability of impacts. This involved:

- establishing the legal and policy context for the assessment of impacts;
- identifying environmental objectives against which impacts would be assessed for their acceptability;
- considering any potential socio-economic matters that may result from the MWADZ Proposal; and
- consulting with relevant stakeholders on this assessment framework.

6.3.4.1 Environmental Objectives

Environmental objectives were identified for each factor. Objectives were derived from the EPA’s EAG 8.

The resulting objectives were presented to and approved by the EPA in the ESD issued for the MWADZ Proposal (2013). The established objectives are described under each environmental factor in Sections 7 to 13. These objectives were used to assess the acceptability of potential MWADZ Proposal impacts.

6.4 Assessment Phase

Following finalisation of the ESD a more detailed assessment was undertaken during the preparation of this PER during which the identified stressors, factors and potential impacts were reviewed, confirmed, and/or amended.

The approach adopted to assess the potential impacts of this MWADZ Proposal follows that used by the KADZ Proposal (notwithstanding that these two zones were subject to different levels of assessment) and is based on determining the likelihood and consequence of potential impacts occurring following exposure to one or more stressors. The assessment phase enables the level of potential impact to be determined and quantified (where practicable) and mitigation and management efforts to be prioritised so that an overall acceptable level of potential impact can be achieved.

The assessment method was based on an internal Department of Fisheries process aimed at managing risks associated with development opportunities. The assessment method is consistent with the standards International Organization for Standardisation (ISO) 31000:2009 Risk Management – Principles and Guidelines (ISO 2009), and HB203:2006 Environmental Risk Management – Principles and Process (Standards Australia 2006). The method adopted involved:

- systematically identifying potential incremental and additional impacts of the MWADZ Proposal on environmental and social factors;
- collecting and recording any experience and lessons learnt that could affect the assessment of incremental or additional impacts of the MWADZ Proposal and/or the mitigation measures implemented for the KADZ Proposal; and
- determining the consequence and likelihood of the identified incremental and additional potential impacts occurring and subsequently categorising each residual impact as High, Medium, Low, or Negligible.

6.4.1 Determining the Consequence of Potential Impacts

The following elements were considered in determining the consequence of each identified potential impact:

- the duration, frequency, and reversibility of the potential impact;
- the size, scale, geographic extent, and geographic distribution of the potential impact; and
- the sensitivity of the potentially impacted factor, including its nature, its importance (e.g. whether it is protected under Commonwealth or State legislation) and how adaptable or resilient the factor is to the impact. The legal and policy context that was relevant to protecting environmental and social factors was also considered in determining sensitivity.

The terminology used to describe these elements of consequence is defined in Table 6-4. The approach adopted to address any uncertainties around consequences is described in Section 6.4.4.

Wherever practicable, the magnitude of environmental stressors and of potential impacts was predicted quantitatively. These predictions have drawn on the results of predictive modelling and technical studies (described in Sections 6.5, 6.6 and 6.7) conducted specifically for the MWADZ Proposal and external research reports and papers.

Where relevant, prediction methods have also reflected guidelines (e.g. Guidance Statement No. 8 – The Assessment of Environmental Factors, Environmental Noise [EPA 2007]) and specialist technical studies undertaken by reputable industry specialists using recognised methods and approaches. Potential impacts are based on worst-case scenarios that reflect any uncertainty in design options still being considered.

Where potential impacts could not be quantified, a qualitative approach was applied; for example, Figure 6-1a describes the levels of consequence applied to ETP species.

Objective	Minor (1)	Moderate (2)	Major (3)	Severe (4)
Sustainability of endangered, threatened and protected (ETP) species (including the impacts on social acceptability)	Few individuals directly impacted in most years (i.e. no impact on sustainability) and well below that which will generate public concern.	Catch or impact at the maximum level that will not impact on recovery or cause unacceptable public concern.	Recovery of a vulnerable population may be impeded and/or some clear (but short term) public concern is generated.	Further decline of a vulnerable population and/or significant, widespread and ongoing public concern generated.
Maintenance of Ecosystem Structure and Function	Measurable but minor changes to ecosystem structure, but no measurable change to function.	Maximum acceptable level of change in the ecosystem structure with no material change in function.	Ecosystem function now altered with some function or major components now missing and/or new species are prevalent.	Extreme change to structure and function. Complete species shifts in capture or prevalence in system.
Conservation of Habitat	Measurable impacts very localised. Area directly affected well below maximum accepted.	Maximum acceptable level of impact to habitat with no long-term impacts on region-wide habitat dynamics.	Above acceptable level of loss/impact with region-wide dynamics or related systems may begin to be impacted.	Level of habitat loss clearly generating region-wide effects on dynamics and related systems.

Figure 6-1a: Levels of consequence relating to the environmental management objectives of the MWADZ Proposal (modified from Fletcher, 2015)

6.4.2 Determining the Likelihood of Potential Impacts

The likelihood of a potential consequence occurring took into account the implementation of the mitigation and management measures adopted by the KADZ Proposal. Likelihood is determined based on experience that a consequence has occurred.

The likelihood criteria used are shown in the assessment matrix (Figure 6-1b).

Level	Descriptor
Remote (1)	The consequence not heard of in these circumstances, but still plausible within the time frame (indicative probability 1-2%)
Unlikely (2)	The consequence is not expected to occur in the time frame but some evidence that it could occur under special circumstances (indicative probability of 3-9%)
Possible (3)	Evidence to suggest this consequence level may occur in some circumstances within the time frame (indicative probability of 10 to 39%)
Likely (4)	A particular consequence is expected to occur in the timeframe (indicative probability of 40 to 100%)

Figure 6-1b: Levels of likelihood for each of the main risks analysed in this assessment (modified from Fletcher, 2015)

6.4.3 Determining the Residual Potential Impact

The residual potential impacts of the MWADZ Proposal were determined by evaluating the likelihood and consequence when mitigation and management measures are implemented. The size, extent, and/or duration of the residual impacts were used to determine the degree of potential impact to environmental or social factors. The level of each residual impact was determined by plotting the assigned consequence and likelihood levels onto an assessment matrix (Figure 6-1c).

Where potential impacts on a factor from any particular stressor were not likely to occur or were not likely to have any discernible consequence different to background levels, an impact rating of ‘not significant’ was assigned. Table 6-7 identifies the potential impacts that were assessed as being not significant during the preparation of this PER, including a justification for their exclusion from further assessment in this PER.

		Likelihood Level			
Consequence level		Remote	Unlikely	Possible	Likely
		1	2	3	4
Minor	1	1	2	3	4
Moderate	2	2	4	6	8
Major	3	3	6	9	12
Severe	4	4	8	12	16

Figure 6-1c: Hazard/Risk Analysis Matrix. The numbers in each cell indicate the Hazard/Risk Score; the colour indicates the Hazard/Risk Rankings

Table 6-7: Potential Impacts Screened Out from Further Assessment

Factor	Stressor	Potential Impact	Activity	Justification for Exclusion from Further Assessment
Marine Environmental Quality	Spills and leaks	Reduction in water quality	Accidental spill of fish stock feed	Aquaculture fish stock feed is non-toxic and will be quickly absorbed by the receiving environment.
	Discharges to sea	Change in seabed profile and changes to sediment characteristics	Discharge of deck drainage and cooling water from marine vessels	Discharges to sea are of very low toxicity and short term. They will be released into a highly dissipative marine environment, so are unlikely to migrate to sediments where they could impact sediment quality. Given the very small volumes of discharge involved, the potential for any observable impact on water quality is considered remote.
Benthic Communities and Habitat	Physical interaction	Change in seabed profile and direct physical injury to, or crushing of, benthic flora and fauna causing loss of species abundance and habitat and an increase in turbidity	Anchoring/mooring of aquaculture support vessels and sea cage clusters	Anchoring/mooring could impact benthic fauna living in or on the seabed. However, given the relatively static nature of sea cage aquaculture and the lack of any notable benthic faunal communities in these areas, any potential impact is expected to result in a highly localised loss and rapid recolonisation following the completion of the anchoring/mooring activities.
Marine Fauna	Physical interaction	Injury or mortality to marine fauna resulting from anchoring of vessels or sea cages	Anchoring/mooring of aquaculture support vessels and sea cage clusters	The relatively static nature of sea cage aquaculture operations and the general agility of the marine fauna likely to be present in the MWADZ Proposal area are expected to result in no measurable impacts from anchoring/mooring activities.
	Physical presence	Creation of artificial habitats causing a change in population densities, composition, and distribution	Deployment of aquaculture sea cage clusters and their associated anchoring systems	Sea-cage clusters will be located offshore and any impact will be highly localised. There may be some attraction of marine organisms (e.g. benthic fauna and pelagic fish, sessile encrusting organisms).
Amenity	Physical presence	Change in aesthetics	Introduction of floating sea cages to the seascape	The surface profile of aquaculture sea cages is relatively low and of a design that minimises drag from

Factor	Stressor	Potential Impact	Activity	Justification for Exclusion from Further Assessment
				both wind and waves. The sea cages are aligned and secured within a rectangular grid anchoring system. Even at full production, a maximum of six sea cage clusters will be situated within the MWADZ Proposal area. This equates a total surface structure profile of less than 84 hectares within the 3,000 hectares of the MWADZ Proposal area (i.e. ~3%).
	Physical interaction	Anchor snagging hazard to recreational fishers	Deployment of sea cage cluster anchoring systems	The location of the MWADZ is remote from areas known to be regularly used by recreational fishers. It is acknowledged that there may be an increase in recreational fishing in the MWADZ as a result of the deployment of aquaculture gear in the water column. However, any such fishing activity is likely to target pelagic species and the depths involved would discourage anchoring in any event.

6.4.4 Dealing with Uncertainty

The impact assessment was undertaken based on available evidence, current knowledge, and through the application of professional judgement. However, some scientific uncertainty still exists with respect to the actual impacts that may occur; this uncertainty may be a result of a number of factors including variation in natural systems, limited understanding of complex systems and interactions between components, and unknowable or uncontrollable factors that may affect an impact pathway.

Any scientific uncertainty regarding the potential impact and its seriousness or reversibility resulted in the application of a conservative approach to the assessment and to the definition of mitigation and management measures. Where any identified potential impacts are likely to be unknown, unpredictable, or irreversible, a conservative approach was adopted by considering the ‘worst-case’ situation. For example, this applies to:

- predicting the consequence of unplanned events in which the realistic worst-case scenario has been predicted and evaluated;
- uncertainties over the exact presence of a factor (e.g. a protected marine fauna) within an area of potential impact; the assessment has assumed those factors they are present and could potentially be affected; and

- multiple consequence scenarios that were identified for a stressor, or uncertainties over a consequence or likelihood categorisation, in which case the higher (i.e. more conservative) category was selected.

6.4.5 Mitigation and Management of Impacts

Many of the mitigation and management measures illustrated in this PER are based on those contained in the current approved version of the KADZ Proposal EMMP and Subsidiary Documents (including the KADZ Proposal Management Policy) as relevant to MWADZ Proposal activities. Mitigation and management measures for the MWADZ Proposal were also identified by considering the experience gained from their implementation by the KADZ Proposal and taking into account any more recent developments in alternative techniques or technologies since the approval of the KADZ Proposal.

The approved KADZ Proposal EMMP is designed within an adaptive management framework, with required changes being identified through either the performance reporting process, the ecological monitoring management trigger process, or the incident response process. The EMMP and Subsidiary Documents (requiring regulatory approval) may also be updated from time to time to reflect any changing circumstances, experience, and lessons.

Any amendments to the EMMP or Subsidiary Documents must be approved and must still meet the objectives and specific requirements in the Ministerial Conditions.

When developing the mitigation and management measures for the KADZ Proposal, a hierarchy of mitigation and management options was considered to identify a preferred approach. This same approach was adopted for the MWADZ Proposal and includes avoidance, minimisation, and restoration/remediation.

The selection of mitigation and management measures for the MWADZ Proposal also reflects the objects and principles of both the EPBC Act and the EP Act, where relevant (refer to Section 6).

Illustrative mitigation and management measures relevant to each stressor, factor, and controlling provisions are described in Sections 7 to 13. Further detail on the environmental management framework the Department intends to implement for the MWADZ Proposal is provided in Section 15.

6.4.6 Predicted Environmental Outcome

The acceptability of potential MWADZ Proposal impacts was evaluated as a ‘predicted environmental outcome’. The predicted environmental outcome of the MWADZ Proposal on each environmental factor was determined by taking into account:

- compliance of the MWADZ Proposal with the environmental objectives established for the assessment of impacts;
- compliance of the MWADZ Proposal with regulatory standards;
- compatibility of the MWADZ Proposal with established government policy, guidelines, and plans; and

- extent to which best practicable means have been applied to manage impacts of the MWADZ Proposal [in accordance with EPA Guidance Statement No. 55 (EPA 2003)].

In addition, the predicted environmental outcome reflects the cumulative impacts of the different stressors on each environmental factor.

6.5 Technical and Environmental Studies

A key component of the EIA was to accurately identify and describe cause-effect-response pathways which lead from the proposed aquaculture to potential environmental impacts. The oceanographic and ecological components of the proposed MWADZ are described in Sections 4 and 5 of the Modelling and Technical Studies; while Sections 6, 7 and 8 of the document provide an overview of the ecological changes which may result from the proposal.

To fully appreciate the risks presented by the MWADZ Proposal, it was first necessary to understand the type and magnitude of the environmental pressures introduced by the proposal, and their likely effect. This understanding, together with a desktop risk evaluation, was subsequently used to identify the key cause-effect-response pathways (Section 4.4 of Modelling and Technical Studies) and to select thresholds that query the model for new information (Section 4.5 of Modelling and Technical Studies).

6.5.1 Identification of Relevant Pressures and Risks

6.5.1.1 Noise

Noise generated by vessel movement and other aquaculture activities has the potential to disturb marine fauna, causing temporary or long-term avoidance of an area. Depending on their magnitude and frequency, underwater sounds may interfere with communication systems, mask important biological cues or cause behavioural disturbances (Richardson et al. 1995, National Research Council 2005, Southall et al. 2007). Underwater noises associated with aquaculture are expected to be limited to engine noises generated by service vessels (i.e. feeding barges) and intermittent low intensity sounds such as those generated by infrastructure maintenance. Engine noises are expected to be of similar frequency and intensity to those of commercial fishing boats (Olesiuk et al. 2012). For marine mammals, the effects of these vessels are transitory and the animals can generally habituate to these sounds with regular exposure. Risks associated with underwater noise are therefore considered low (Appendix 1). Mitigation strategies for managing the effects of underwater noise are included in the Environmental Monitoring and Management Plan (EMMP - Appendix 2).

There will not be a need for drilling, piling or blasting in relation to aquaculture operations associated with the MWADZ Proposal.

6.5.1.2 Physical Presence

Finfish will be grown in large floating sea cages. The design, construction and materials of sea cages will incorporate modern technology and best-practice to minimise environmental impacts. Sea cages will be anchored to the sea floor using equipment and techniques appropriate to marine conditions in the proposed MWADZ.

Where possible, anchoring on the sea cages is undertaken with low profile auger/screw/pin type anchors (e.g. helix anchors, which are embedded in the sea-floor). Low profile anchor points that are flush with the seabed have less impact on the seafloor flora and fauna. Larger weighted anchors (e.g. concrete blocks) might be required as a short-term fix in situations where it is impractical to penetrate the limestone bed-rock beneath the seafloor. Permanent losses of small areas of benthic habitat may occur in instances where weighted anchors are utilised.

The project infrastructure may act as an obstacle to migrating marine life, an artificial substrate that is attractive to seabirds seeking to roost and as an impediment to ambient water currents. The presences of large networks of sea cages may in some circumstances obstruct or disrupt cetacean migration. Placement of sea cage structures should be based on a review of the significance of the region as a migration corridor, as well as the likelihood that the configuration and placement of the infrastructure may act as an obstacle. Ideally, sea cage and/or lease placement should be organised to avoid such interactions. Section 9 provides further discussion on the interactions between wildlife and sea cages.

In addition, floating sea cages may affect local hydrodynamics. Model results show that sea cages restrict water-flow and reduce its speed in the top layer of the ocean. However, the presence of the sea cages increases the flow of water beneath the cages. The effect of the sea cages on the flow of water beneath the cages is dependent on the distance between the bottom of the sea cages and the seafloor. Bottom currents are maximised where the distance to the bottom of the sea cages is roughly half of the depth of the site (BMT-O 2015).

6.5.1.3 Organic Wastes

The cause-effect-response pathways relevant to inputs of fish faeces and uneaten feed (organic waste) are a key consideration in this assessment. Sea cage aquaculture has the potential to impact the sediment due to the settlement of organic wastes beneath or in close proximity to the sea cages (BMT-O 2015). The deposition of organic waste may lead to local organic enrichment or, under worst-case conditions, excessive nutrients enrichment (eutrophication) at a regional scale. Total community respiration increases due to increased organic loads to the sediments, which in turn increases oxygen consumption. Gray (1992) emphasises that the critical effects of eutrophication are experienced when water column oxygen concentrations become depleted. Increased nutrient loadings are generally associated with increased episodes of depleted oxygen (hypoxia) or an absence of oxygen (anoxia), particularly in waters that are not well-mixed. This leads to detrimental effects on the fauna living in the sediment (infauna) or on the seafloor (Baden *et al.* 1990, Schaffner *et al.* 1992). Hypoxia may cause local extinction of seafloor populations of flora and fauna (Gaston & Edds 1994) and changes in biological communities at the seafloor (Pearson & Rosenberg 1978, Josefson & Jensen 1992, Hargrave *et al.* 2008; Hargrave 2010).

Infauna is 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). Impacts to infauna communities commonly occur along gradients of sediment organic enrichment, as shown by numerous studies [following Pearson and Rosenberg 1978 (e.g. Hargrave 2010). Cromey *et al.* (1998) reviewed the fate and effects of sewage solids added to mesocosms. Organic loading rates produce degraded conditions (Cromey *et al.* 1998). Deposition rates above 700 grams of carbon per metre squared per year are widely believed to represent a critical value.

Sediments exposed to this rate of deposition are considered degraded [i.e. diversity of seafloor fauna is significantly reduced (Cromey *et al.* 1998)].

Finfish farming has the potential to impact the sediments beneath and immediately adjacent to sea cages (Carroll *et al.* 2003). Case studies of finfish aquaculture in Tasmania and Europe found that impacts are generally restricted to within 10–100 metres of sea cages. However, the magnitude of impact depends largely on the depth of the water and the rate of water flow through the site (Carroll *et al.* 2003, Crawford 2003, Borja *et al.* 2009). Prevailing water currents through the proposed MWADZ are adequate to promote environmental conditions that usually correspond to ecosystems which are either "moderately" or "not sensitive" to impact. Currents speeds above ten centimetres per second are widely considered "ideal" for sea cage aquaculture and current speeds less than six centimetres per second are generally considered "not ideal" for sea cage aquaculture (Tables 6-8 and 6-9).

Table 6-8: Average Surface and Bottom Water Current Speeds through the MWADZ

Current speeds (cm/s)				
	Northern area		Southern area	
Month	**Surface**	**18 metre water depth**	**Surface**	**18 metre water depth**
Summer	13.2-14.1	10.4-11.0	8.7-9.4	5.8-7.0
Winter	14.0-14.5	9.0-11.5	10.5-11.0	6.1-8.0

Table 6-9: 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)

6.5.1.4 Inorganic Nutrients

The cause-effect-response pathways relevant to inputs of inorganic nutrients are another key consideration in this assessment. Finfish aquaculture in open water sea cages may, in some circumstances, cause deterioration in local water quality due to inputs of inorganic nutrients from fish faeces and uneaten food. Aquaculture may contribute inorganic nutrients to the water column, either directly through secretion of ammonia by fish or indirectly through organic matter deposition and remineralisation.

Inorganic nutrients in the form of ammonia, nitrite/nitrate and orthophosphate may lead to adverse environmental effects via a number of environmental cause-effect pathways, whereby aquaculture affects marine plants on the seafloor.

Habitat studies in the proposed MWADZ have revealed a diverse array of benthic habitats, including the presence of vast areas of mixed ecological communities comprising macro-algae, rhodoliths, filter feeders, corals and other primary producers (Section 8.2.1). Macro algae and corals in particular are known to be sensitive to sources of inorganic nutrients. For example, prolonged exposure to nutrients may lead to conditions where living corals are slowly replaced by macro algae (e.g. Littler & Littler 1984, Jackson *et al.* 2001, Bellwood *et al.* 2004, Hughes *et al.* 2010, Rasher *et al.* 2012).

6.5.1.5 Metals and Other Contaminants

If metal concentrations are elevated to threshold levels, marine organisms can be affected by the associated level of toxins (Parsons 2012). Sources of metals include contaminated sites, agricultural and urban runoff, discharges from sewage treatment plants, and copper-based anti-foulants sometime used on sea cages (Parsons 2012).

Metals form a small constituent of commercial aquaculture feeds as trace elements. The trace elements are consumed by finfish and excreted in the faeces. A study of the metal content of trout faeces by Moccia *et al.* (2007) found that zinc and iron were present in the highest concentrations, with relatively low proportions of copper (see Section 7.2.3). 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 cage sites (DPIPWE 2011).

Antibiotics are sometimes used to treat bacterial disease occurring in farmed finfish and are generally administered in feed. Antibiotics deposited to the seafloor as faeces may reduce or change the numbers of bacteria in the sediment, thereby affecting broader ecological processes. Oxytetracycline is the most common antibiotic used to treat farmed salmon in Tasmania (Parsons 2012). The use of antibiotics in Tasmania was shown to be highest in the summer months when water temperatures are elevated and pathogens tend to be most virulent.

6.5.2 Ecosystem Nutrient Budget

The nutrient budget of the region is relatively simple in that it currently comprises only discharge of nutrients from the seafloor sediments and the transfer of the nutrients via the flow of the ocean. These environmental processes are both considered minor, in that the existing environment is essentially nutrient-poor. In support of this, monitoring data collected as part of this study showed that water column nutrient concentrations were generally very low (Section 7.3.3).

The addition of large-scale finfish aquaculture creates a considerable disturbance to the existing nutrient cycle, which is a key subject of investigation in this study. The proposed aquaculture presents an immediate nutrient load to the water column (via waste and feed excess) and a delayed load (nutrient discharges via the seafloor sediment).

A diagrammatic representation of existing and impacted conditions, with approximate annual nutrient flows (flux), is included in Figure 6-2 and Table 6-10. These quantities were computed from measurements and model predictions.

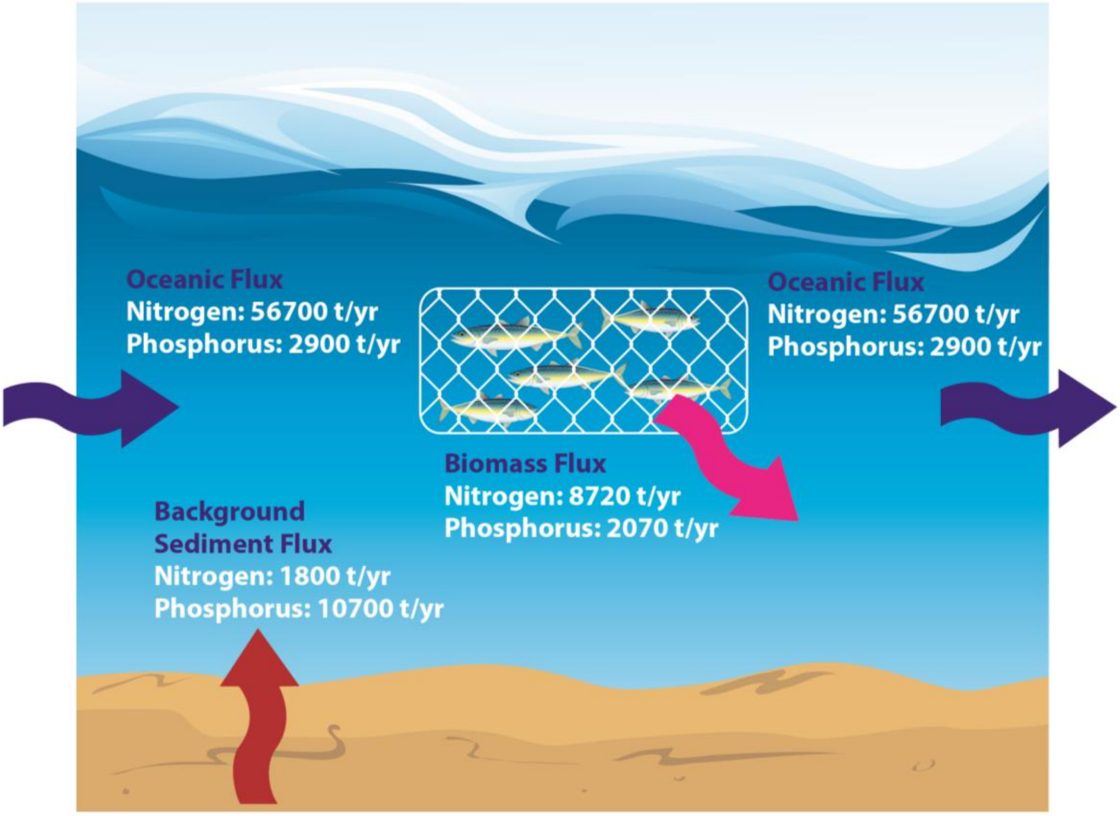


Figure 6-2: Conceptual Diagram of the Baseline and Post-Operation Nutrient Budget under Scenario 1

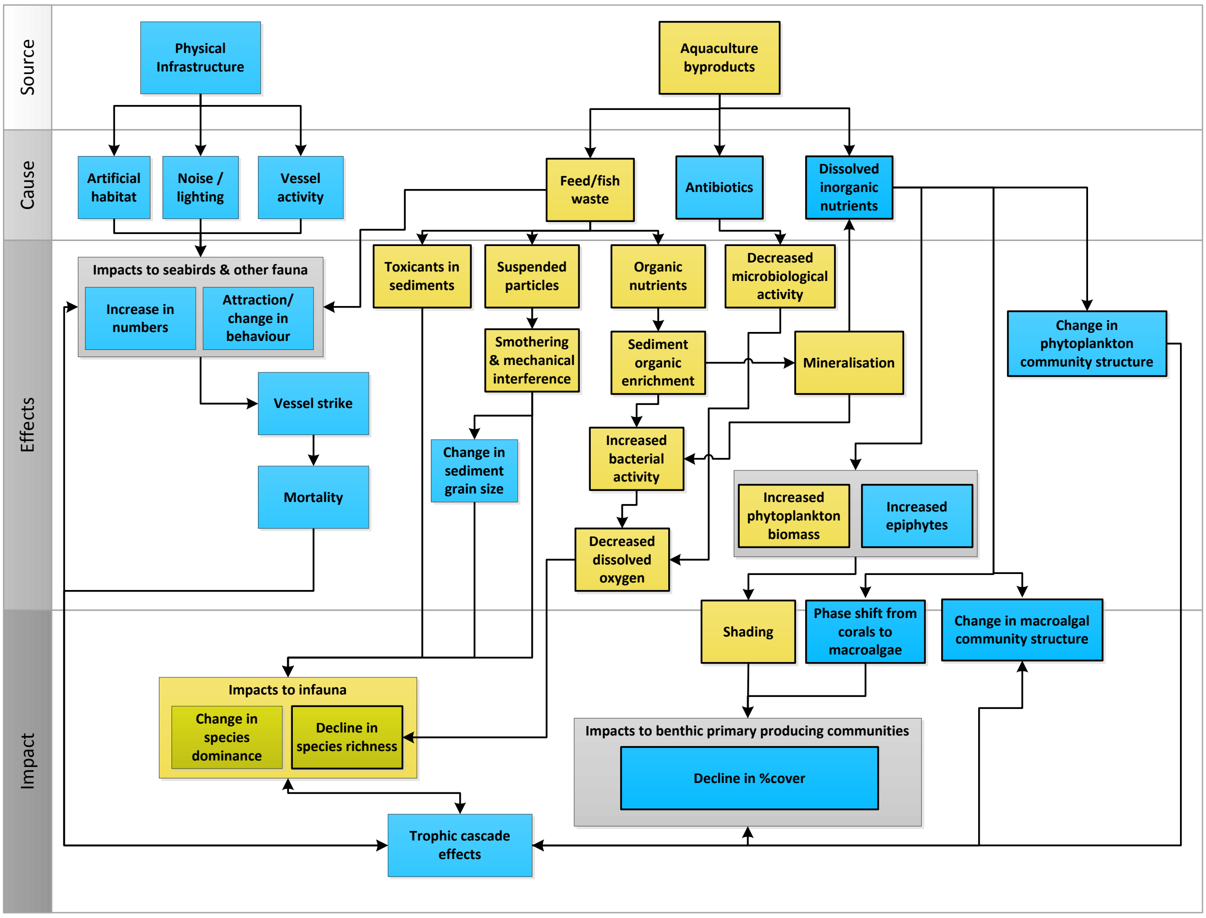
Table 6-10: Baseline and Post-Operation Nutrient Budgets

Scenario	Source (tonnes per year)		
	Aquaculture (biomass)	Oceanic	Background sediment
1-2	Nitrogen 8720 Phosphorus 2070	Nitrogen 56 700 Phosphorus 2900	Nitrogen 1800 Phosphorus 10700
3-4	Nitrogen 13950 Phosphorus 3310		
5-6	Nitrogen 17440 Phosphorus 4130		

6.5.3 Cause-Effect-Response Pathways

The pathways of cause, effect and response between the proposed aquaculture (as a source of stressors) and environmental indicators (the receptors) were identified by following the step-wise approach of Gross (2003). The objective of this approach was to identify the cause-effect-response pathways most likely to be affected by the proposed MWADZ. Receptors exhibiting measurable changes in response to stressor inputs were identified as environmental variables to be monitored (indicators). The understanding gained by this process was used to develop the thresholds described in Section 6.6.

The cause-effect pathways of most concern are presented in the conceptual diagram (Figure 6-3). It shows the relationship between the most important stressors, ecosystem components, effects and biological receptors. The environmental indictors and thresholds were ultimately derived from this conceptual model. It is hierarchical in nature, with the stressors and their sources shown in the upper strata of the model. The receptors are shown in the middle and the effects in the bottom strata of the model.



Notes:

1. Key cause-effect-response pathways. Pathways shown in yellow represent those captured by the modelling and those for which thresholds were developed.

Figure 6-3: Hierarchical Stressor Model showing the Key Cause-Effect-Response Pathways and those chosen for Model Interrogation

6.6 Thresholds for Interrogation of the Ecosystem Model

6.6.1 Application of EAG 3

Environmental Assessment Guidelines No.3 (EAG 3) is concerned with the protection of ecological integrity and biodiversity through a framework for assessing the cumulative loss of, or serious damage to, benthic communities and habitat (BCH) in Western Australia. BCHs are seabed communities within which algae, seagrass, mangroves and corals are prominent components. BCH also include areas of seabed that can support these communities (EPA 2009).

"Irreversible loss" of BCH is commonly associated with excavation or burial. Such activities modify BCH so significantly that the impacted community would not be expected to recover to the pre-impact state and therefore the loss is considered irreversible.

"Serious damage" is also intended to apply to damage to BCH that is effectively irreversible or where recovery would not occur for at least five years (EPA 2009).

EAG 3 (refer to Section 8.2.1) provides guidelines which outline cumulative losses of BCHs that may be acceptable, provided all other options have been exhausted. The waters of the Abrolhos Islands, including the proposed MWADZ, are gazetted as a Fish Habitat Protection Area (FHPA) under Section 115 of the *Fish Resources Management Act 1994*. The FHPA has the following purposes:

- *conservation and protection of fish, fish breeding areas, fish fossils or the aquatic ecosystem;*
- *culture and propagation of fish and experimental purposes related to that culture and*
- *propagation; and*
- *management of fish and activities relating to the appreciation or observation of fish.*

The Management Plan for the FHPA does not identify any areas of high conservation value that would be Category A (Extremely Special Areas) under EAG 3 (Table 7.1). Therefore, the proposed MWADZ should be Category C (Other Designated Areas) under EAG 3. The Cumulative Loss Guidelines (EAG 3) recommend that cumulative loss of BCH within areas deemed to be Category C do not exceed a benchmark of two percent of the BCH within the local assessment unit (LAU) (Section 8.4.1).

6.6.2 Application of EAG 7

The potential for the proposed MWADZ to impart adverse effects on the benthic marine environment (particularly soft sediments) are described (below) in the context of EAG 7 (refer to Section 8.2.1). EAG 7 includes three predefined levels of impact:

- zone of high impact (ZoHI);
- zone of moderate impact (ZoMI); and
- zone of influence (ZoI) (EPA 2015).

EAG 7 was developed to assess the impacts of capital dredging activities to benthic habitats in the State's Northwest, and its application to aquaculture EIA is new (BMT-O 2015).

6.6.2.1 Soft Sediments

The recovery of sediments at the point of fallowing was determined using a sediment biogeochemical model, linked to a hydrodynamic and a particle transport model. The period of recovery was determined across a range of scenarios (Table 6-14). Conditions were simulated in which sediments, beneath and near the sea cages, had received inputs of waste for a period of two, three and five years. At the completion of the two, three and five year periods, the sea cages were fallowed to allow recovery of the sediments.

6.6.2.2 Oxygenation

Recovery was deemed to have occurred when sediment chemical conditions, represented by the concentration and depth of oxygenation and hydrogen sulphide, returned to pre-aquaculture conditions (Table 6-11). Three zones were defined based on threshold criteria for recovery (defined in more detail in Appendix G of the PER). This included consideration of oxygen and sulphide concentrations within the top five centimeters of sediment. The ZoHI was applied when sediment conditions took greater than five years to recover; the ZoMI was applied when sediment conditions took less than five years to recover, and the ZoI was applied when sediments received waste material, but not in proportions great enough to alter the sediment chemistry. Chemical recovery was investigated instead of biological recovery because its path of recovery has readily identifiable beginning and end points and can be quantified and tracked. A path of biological recovery would be too complicated to model and actual recovery would be difficult to define and unlikely to match a quantitative endpoint.

6.6.2.3 Metals

Recovery thresholds for metals were based on the time taken for metal concentrations in the sediment to return to values lower than the EQG trigger values (EPA 2014). The zones of high and moderate impact and zone of influence in for metals in the sediments were applied in accordance with EAG 7 as presented in Table 6-11.

Table 6-11: Thresholds Applied to Soft Sediments

Parameter	Zone of high impact (ZoHI)	Zone of moderate impact (ZoMI)	Zone of influence (ZoI)
Hydrogen sulphide	Concentrations deteriorate and do not recover to baseline levels within a 5 year period	Concentrations deteriorate but recover to baseline levels within a 5 year period	Concentrations not to exceed baseline levels Top 5 cm of sediment remain oxygenated
Oxygenation			
Metals (Zn and Cu)1	Sediment concentrations of Zn and Cu do not recover to values lower than the EPA EQGs with a period of five years	Sediment concentrations of Zn and Cu recover to values lower than the EPA EQGs within a 5 year period	Sediment concentrations of Zn and Cu not to exceed the EPA EQGs

6.6.3 Application of Other Impact Criteria

6.6.3.1 Mixed Assemblages

The thresholds for smothering are based on PIANC (2010). The thresholds for water column oxygenation, suspended particles, algal growth potential, nutrient enrichment and shading are based on EPA (2015). The EPA's criteria were used to compensate for uncertainties relating to lethal and sub-lethal thresholds, and timing of recovery for endemic species, following exposure to nutrient loadings from aquaculture.

6.6.3.2 Smothering

Thresholds for smothering (Table 6-12) are based on the sensitivities of coral published in PIANC (2010) as described in Table 6-13. The thresholds have been used as a best estimate, in place of measurements of coral responses to aquaculture derived nutrient loadings.

Table 6-12: Thresholds based on PIANC (2010)

Effect	Major impact (ZoHI)	Moderate impact (ZoMI)	No impact (ZoI)
Smothering[1]	Sedimentation rate not to exceed 500 $g/m^2/day$	Sedimentation rate not to exceed 100 $g/m^2/day$	Sedimentation rate not to exceed 50 $g/m^2/day$

Table 6-13: Impact Assessment Categories for the Effects of Smothering

Severity of impact	Description
Minor impact	Changes are likely to be detected in the field as localised mortalities, but to a spatial scale that is unlikely to have any secondary consequences.
Moderate impact	Changes are detectable in the field. Moderate impacts are expected to be locally significant.
Major impact	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.

6.6.3.3 Suspended Particles

Thresholds for suspended particles were developed to be consistent with the moderate and high levels of marine ecological protection described in EAG 15 (refer to Section 8.2.1). The thresholds are respectively based on the 95th and 80th percentile values obtained during baseline studies. In this context, the 80th percentile is aligned with the criteria used for a high level of ecological protection and the 95th percentile a moderate level of ecological protection. For contextual purposes, Table 6-14 also outlines the limits of acceptable change under a low level of ecological protection. Low ecological protection areas are typically applied to ocean outfalls, where moderate and high levels of ecological protection are not always achievable.

Table 6-14: Levels of ecological protection

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).
Moderate	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).

Note:

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

6.6.3.4 Oxygenation

The thresholds for oxygenation [dissolved oxygen levels (DO)] of the water column are based on EPA EAG 15 (2015) (Table 6-15). The thresholds are equivalent to the Environmental Quality Standards (EQS) for achieving moderate and high levels of ecological protection (EPA EAG 15, 2015), which require that DO levels are maintained at 60% and 90% saturation respectively for a period greater than six weeks.

Table 6-15: Thresholds based on EPA (2015)

Factor	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
Suspended particles[2]	TSS concentration not to exceed 8.4 mg/L more than 50% of the time	TSS concentration not to exceed 2 mg/L more than 50% of the time
Algal growth potential[2]	DIN concentration not to exceed 40 µg/L more than 50% of the time	DIN concentration not to exceed 29 µg/L more than 50% of the time
Nutrient enrichment[2]	Chlorophyll-a not to exceed 0.45 µg/L more than 50% of the time	Chlorophyll-a not to exceed 0.30 µg/L more than 50% of the time
Shading[2,3]	Light intensity at the benthos not to fall below the 5th percentile more than 50% of the time	Light intensity at the benthos not to fall below the 20th percentile more than 50% of the time

Notes:

1. Thresholds for the ZoHI/ZoMI and the ZoI are based respectively on the EPA's EQSs for moderate and high ecological protection (EPA 2005). Threshold assumes continuous exceedance for a period greater than six weeks.
2. Thresholds for the Zone of moderate impact (ZoMI) and Zone of influence (ZoI) are based respectively on the EPA's EQGs for moderate (95th percentile baseline data) and high (80th percentile baseline data) ecological protection (EPA 2015). The threshold for the Zone of high impact (ZoHI) is based on the 99th percentile of baseline data.
3. During daylight hours (8am–6pm).

6.6.3.5 Algal Growth Potential and Shading

Thresholds for inorganic nutrients were developed to address the effects of algal growth potential, nutrient enrichment and shading (Figure 6-4). The thresholds for algal growth potential and nutrient enrichment are based on the 95th and 80th percentile values of the data obtained during the baseline studies (Section 8.2). The thresholds for shading by contrast are based on the 5th and 20th percentile values of the data obtained during baseline studies. In this context, the 20th and 80th percentiles (ZoI) are in alignment with the criteria used for a high level of ecological protection. The 5th and 95th percentiles align to the criteria for a moderate level of protection.

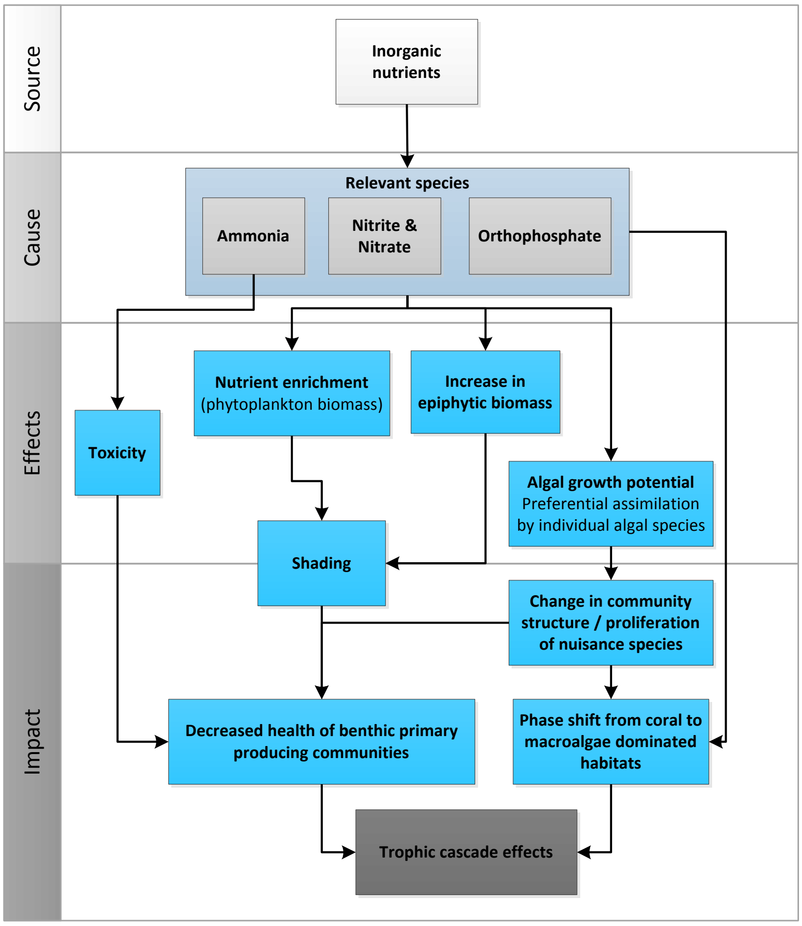


Figure 6-4: Cause-Effect-Response Pathways Relevant to Inorganic Nutrients

6.6.4 Aquaculture Scenarios Chosen for Modelling

Modelling scenarios were agreed in consultation with the Department and the Aquaculture Industry Reference Group at a technical workshop held in October, 2014. Aquaculture production scenarios were developed based on production of yellowtail kingfish (*Seriola* *lalandi*) using industry best-practice farming methods, including use of the standard infrastructure as described in Table 6-16.

Table 6-16: Aquaculture Scenarios Chosen for Modelling

Infrastructure component	Details
Cage diameter (metres)	38
Cage circumference (metres)	120
Cage depth (metres)	18
Cage volume (m^3)	20 641
No. cages per cluster	14
Other assumptions	• Two to three clusters in the southern location • Four to six clusters in the northern location • Percentage of uneaten feed = 1%

Six scenarios were modelled in total (Table 6-17). All scenarios assumed the zone was constantly stocked with 15,000; 24,000 or 30,000 tonnes standing biomass and assumed static food consumption and growth rates. No allowances were made for variations in the volume of stock due to growth and/or harvesting of stock. Feed inputs and waste outputs were kept constant.

The effect on the benthic environment of increasing and decreasing stocking densities was examined by manipulating the number of cage-clusters between six and nine. This was undertaken in recognition of the economic-environmental trade-offs between infrastructure requirements and the aquaculture industries desire to maintain higher stocking densities, wherever resources and/or the biology of the target species allows. The numbers of sea cage cluster on a lease will be proportionate to the size of the lease. For the purpose of examining the environmental model, the numbers of sea cage cluster across the two areas making up the proposed MWADZ resembles the likely allocation of infrastructure by potential future proposals based on advice from the Aquaculture Industry Reference Group.

Table 6-17: Modelled Production Scenarios

Scenario No.	S1	S2	S3	S4	S5	S6
Total standing biomass (tonnes)	15,000		24,000		30,000	
Standing biomass north (tonnes)	10,000		16,000		20,000	
Standing biomass south (tonnes)	5,000		8,000		10,000	
No. clusters south	3	2	3	2	3	2
No. clusters north	6	4	6	4	6	4

6.7 Integrated Model Components

The ESD required the development of fully-integrated environmental models to represent biological and chemical ecosystem processes, the influence of the physical surroundings and forces exerted by waves and water currents at the location for the proposed zone, collectively, an Integrated Ecosystem Model (Model). This required the incorporation of several discrete environmental models, accounting for waves, fish waste, particle transport and hydrodynamics, within a model of the sediment biogeochemistry and water quality of the site. The purpose of the Model was to predict the cumulative environmental effects of the proposed aquaculture, operating across a range of potential production scenarios. The ecosystem Model was capable of simulating regional oceanographic water movements, the deposition and dispersal of wastes from sea cages, the effects of these wastes on the marine environment, and the rate of environmental recovery.

As with all environmental models, the Model developed for the strategic proposal involves many complex driving factors and interactions of those factors. Consequently, there were numerous sources of error that needed to be carefully controlled. The modellers adopted a conservative approach to developing the model to ensure all assumptions were well-educated and based on the literature and professional experience. Although this precautious approach to the modelling avoided under-predicting the impacts, predictions are within the realms of possibility. Outputs from the Model were within the upper range of impacts reported in the aquaculture literature (i.e. Brooks et al. 2004). The Model provided useful predictions of the potential for impacts under "most likely worst case" conditions.

In recognition of the complexity of the Model, the consultants commissioned a staged process of review, in which an independent external reviewer examined the assumptions and individual stages of Model development. The approach to examining the individual modelling components and the assumptions underpinning the modelling are documented in the Modelling and Technical Studies (Appendix 1). The reviewer's comments are included in Appendix 1E of the Modelling and Technical Studies.

6.7.1 Hydrodynamics

Oceanographic data, consisting of conductivity-temperature-depth (CTD), current speeds, current direction, wave height, wave direction, and peak wave period, were collected over a ten month period at a total of four sites and captured for four seasons. The data were collected using Acoustic Doppler Current Profilers (ADCP) equipped with additional data loggers. Four ADCPs were deployed in total: one in each of the northern and southern areas, and one in each of two regional locations north-east and south-east of the proposed zone.

The modelling computer program TUFLOW FV was used as the hydrodynamics modelling engine (http://www.tuflow.com). The primary aim of the hydrodynamics model was to represent the characteristics of the water currents and waves in the proposed zone and to determine the dispersal and distribution of wastes released from aquaculture (e.g. residual feed, stock faeces and associated nutrients). The role of the hydrodynamics model was to inform the models of sediment biogeochemistry and water quality (refer to Modelling and Technical Studies – Appendix 1).

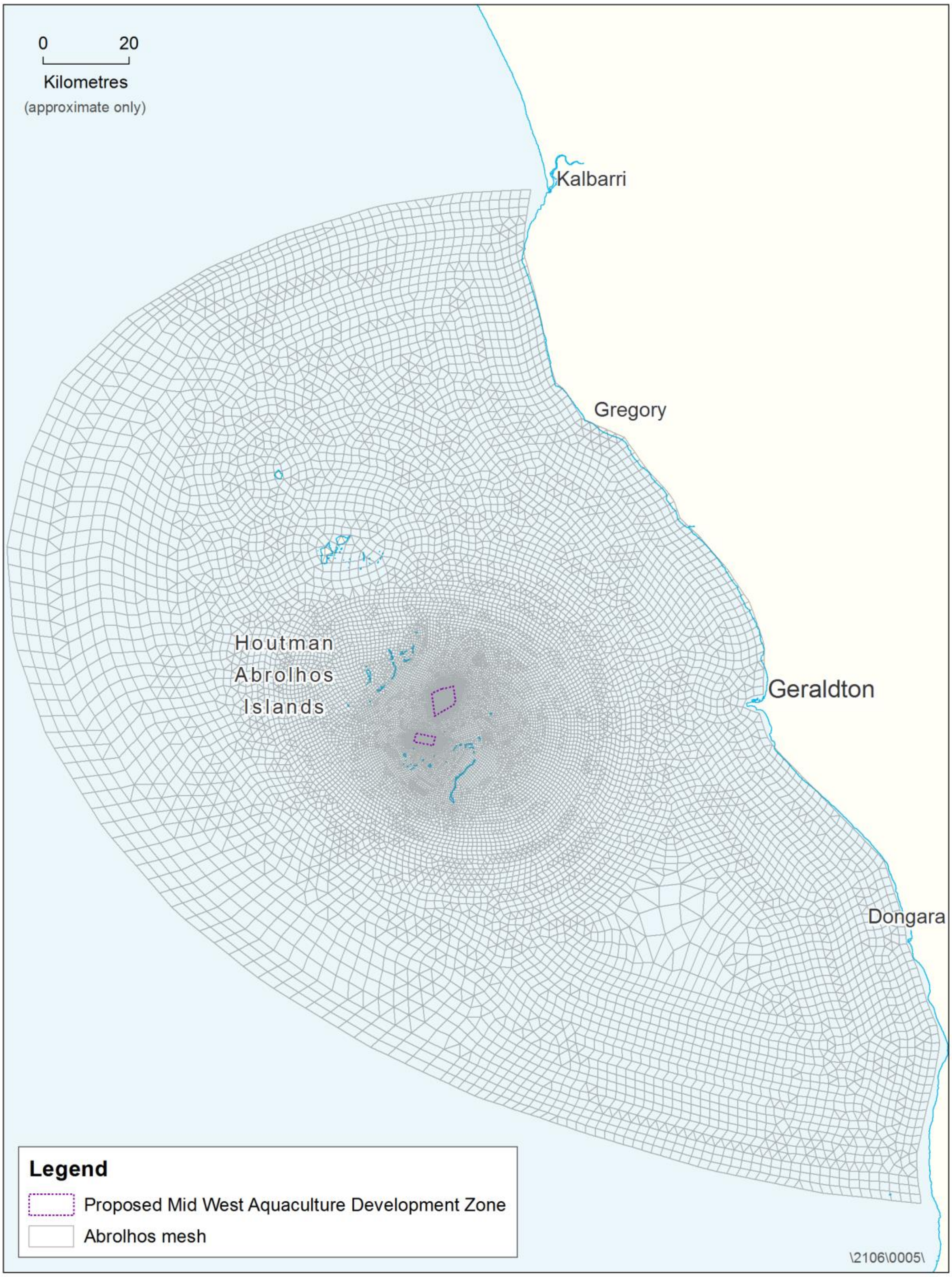


Figure 6-5: The Model Mesh

6.7.2 Wave Model

To account for the influence of wave-driven currents on the suspension and deposition of particles, a wave field was applied to the hydrodynamics model using the model SWAN. In addition to wind data, SWAN also required regional swell data. This was sourced from WAVEWATCH III, which is a global wave prediction model developed by the National Oceanic and Atmospheric Administration (NOAA). The SWAN model was run on a spatial grid of 500 metres resolution.

6.7.3 Fish Waste Model

A fish waste model was developed to predict the volume of waste for a given volume of fish, including the proportional nitrogen, phosphorus and carbon in the solid and dissolved fractions of waste. Outputs from the fish waste model were utilised by the particle transport model to predict the fate of the organic particles once discharged from the sea cages.

The fish waste model was based on the collective works of Tanner *et al.* (2007), Fernandes and Tanner (2008) and Tanner and Fernades (2010). The model assumes an average fish size of 1.5 kilograms and an average water temperature of 20°C, representing Abrolhos winter temperatures. Respiration, feed conversion ratios (FCR) and specific growth ratio (SGR) values are based on Tanner *et al.* (2007).

6.7.4 Particle Transport Model

The Particle Transport Model (PTM) was used to characterise both the vertical and horizontal transport of aquaculture wastes, while accounting for differing size fractions and settling rates of waste. The science of particle transport through the water column is complex. The model also needed to account for processes of deposition and resuspension from the seabed associated with wave and current energy, and was run over a twelve month simulation period so as to make allowance for a diverse set of environmental conditions.

The PTM calculated the transport of particles away from the sea cages, and quantified the rate of waste deposition near and far from the cages. The PTM was also able to characterise the transfer, dispersion, deposition and resuspension dynamics of particle. Particles were tracked by the model to determine thresholds for settlement of particles on the seabed and resuspension by wave and current energy. No particle breakdown or burial processes were considered in the PTM simulations.

The settling rate of fish waste as it leaves a sea cage will vary according to an extensive array of variables including feed type, fish health, species, fish size, and general farming practices (Chen *et al.* 1999, Felsing *et al.* 2005, Moccia *et al.* 2007, Moran *et al.* 2009). The speed at which fish waste sinks and leaves a sea cage varies depending on many variables, for example, feed type, farming practices and the stock, species, size and health (Chen *et al.* 1999, Felsing *et al.* 2005, Moccia *et al.* 2007, Moran *et al.* 2009). In addition, the difference between the volume of waste leaving a sea cage and the volume reaching the seafloor is complex to determine, and depends on biological and physical factors (e.g. current speeds and the extent of secondary consumption by scavengers beneath the sea cages (Felsing *et al.* 2005). For this study, fish waste was partitioned into waste feed (commercial aquaculture pellets) and fish faeces. Three size fractions of fish faeces was considered, following Chen *et al.* (1999), Cromey *et al.* (2002) and DHI (2013; Table 4.18).

Deposition of waste in this study was based on the understanding that the largest proportion of organic particles falls beneath or close to the sea cages. The smaller the particles, the further they are carried from the sea cages. Modelling accounted for the prevailing currents, which tended to skew the distribution of the finer particles in one direction over another. This concept is illustrated in Figure 6-6, which shows the rate of particle deposition over one year at equal levels of standing biomass, but at differing stocking densities. Higher volumes are depicted directly under the sea cages (red to orange shading), with decreasing volumes depicted further from the sea cages (yellow to blue shading).

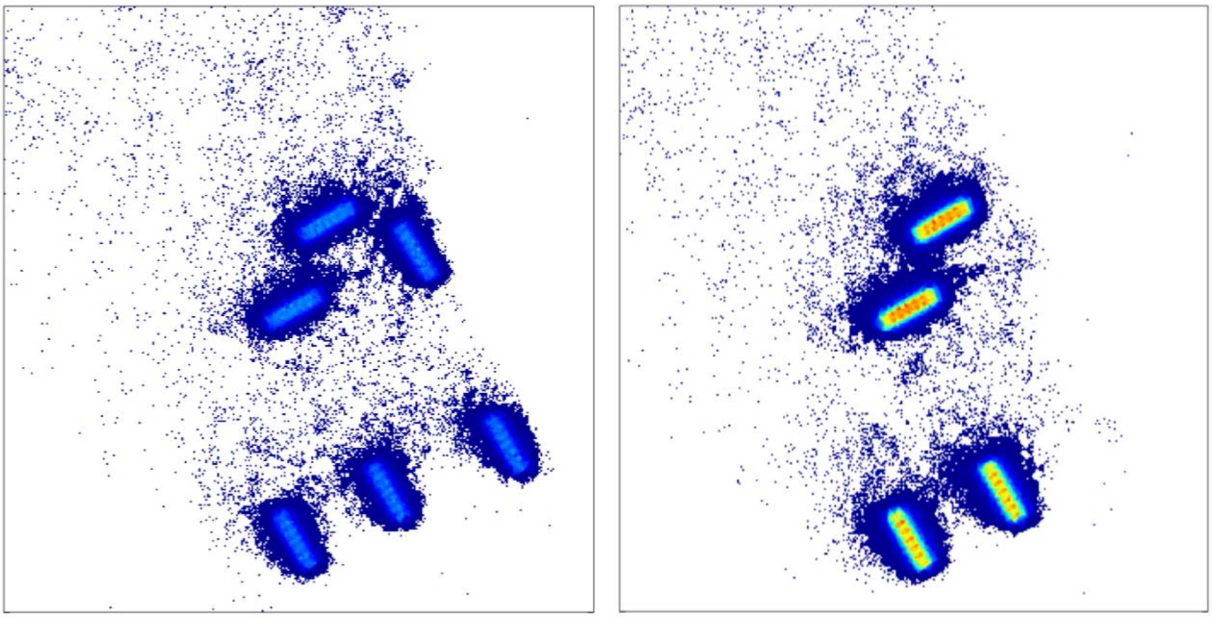


Figure 6-6: Deposition of Waste Material Following Twelve Months of Aquaculture Production under Differing Stocking Densities

6.7.5 Water Quality Model

The water quality model utilised the Aquatic Ecodynamics (AED2) model library developed at the University of Western Australia (http://aed.see.uwa.edu.au/research/models/AED/). In this study it simulated a number of biogeochemical processes relevant to water quality; including sediment organic matter, inorganic nutrients and phytoplankton dynamics. The hydrodynamic and the water quality models were used together to characterise the release, dispersion and dilution of inorganic nutrients from the sea cages, and subsequent intake and growth of phytoplankton. The model was also used to characterise the potential for changes in dissolved oxygen and light attenuation at the bottom of the water column.

6.7.6 Biogeochemical Processes

The biogeochemical processes occurring in the sediments and water at the seafloor were described and considered by developing a model of biological, chemical and geographic characteristics of the seafloor (Diagenesis Model). The Diagenesis Model (CANDI-AED model) was used to estimate the flow of nutrients into and out of the sediments (Appendix 1). The understanding of biogeochemical processes was applied when working with the hydrodynamics and water quality models. This was to ensure the phytoplankton response was based on the cumulative sources of nutrients, both directly from fish respiration and indirectly via chemical processes occurring in the sediments. Importantly, the diagenesis model was also used to determine the recovery of sediments beneath the sea cages. The understanding of sediment recovery beneath the sea cages was a key to mapping the spatial distribution of the zones of impact and influence (ZoHI, ZoMI and ZoI) associated with the proposed aquaculture.

Based on field observations, the model assumes sediment physical properties to be highly porous and permeable sediment of approximately 15 centimetre depth, with hard rock beneath. In order to simulate the vertical mixing of the sediment, a relatively high bioturbation rate was used, with a constant value from the sediment-water interface to the deepest layer at 15 centimetres.

Chemical concentrations at the sediment-water interface are subject to a mix of competing forces at different spatial and temporal scales. The chemical reactions simulated in the model can be broadly defined as primary and secondary reactions; these are summarised in Section 4.1 of the Modelling and Technical Studies. Primary reactions, driven by bacterial breakdown of organic matter, are the driving force of most of the other chemical reactions that occur in the sediment. Inputs of fish feed and faecal matter serve to quickly unbalance the normal chemical concentrations that occur in marine waters. This is accentuated in marine waters that are naturally nutrient poor (e.g. waters of the Abrolhos Islands).

The diagenesis model was applied to sediment in the proposed MWADZ, firstly under existing environmental conditions, then with two, three and five years of organic deposition from aquaculture, then 7+ years with no deposition (post-fallowing) to simulate a recovery period.

The resulting quantities of organic matter and corresponding chemical concentrations were investigated to characterise the environmental response to a range of stocking densities, near and far from the sea cages. The resulting recovery time of the sediment and absolute concentrations of key sediment variables were calculated to determine the zones of high and moderate impacts, and the zones of influence, as per EAG 7.

6.7.6.1 Metal Accumulation and Recovery

In simulating the biogeochemistry of the sediments, the diagenesis model investigated the chemical processes leading to the accumulation and compound-forming transition of metals (Zn, Cd and Cu). The purpose of the modelling was to determine the potential for metal accumulation in the sediments beneath sea cages and the time required for recovery after fallowing. Chemistry determines that metal concentrations in the sediments are strongly correlated to the presence of sulphides. Accordingly, the diagenesis model simulated the accumulation of metals under conditions where the sediments are low in oxygen and high in sulphide concentrations. The sediments would discharge metals into solution when oxygen and sulphides concentrations returned to normal.

This study assessed the potential for trace metals in commercial feeds to accumulate in the sediment and have environmental consequences. Modelling undertaken for this study focused on the metals in greatest supply (Zinc and Copper) and for which there are EPA triggers (EPA 2014). There are two biochemical processes that could lead to the release of metal as a free solute from the organic matter. This can occur if the organic material undergoes microbial oxidation. Alternatively, metals which precipitate out of solution as metal sulphides can be oxidised due to the sediment being exposed to oxygen and released as a free solute. The criteria for metal contamination are 200 and 65 milligrams/kilogram dry weight for Zn and Cu respectively, or 7.7 and 2.5 millimoles metal/L.

6.7.6.2 Model assumptions

The modelling approach adopted here was to build an integrated environmental model, which comprised simulations of the hydrodynamic, water quality, particle transport and sediment diagenesis of the study area. The integrated model captured the key environmental processes and their interactions. A conservative approach was adopted towards developing the model. This aimed to ensure outputs were equivalent to "most likely worst case" outcomes, as required by the ESD (EPA 2013) (Table 1). As such, the impacts predicted in this document are more extensive than might be expected on average, but are nevertheless within the upper range of impacts reported in the literature (i.e. Brooks *et al.* 2004). The assumptions underpinning the development and execution of the integrated model are summarised below:

- The hydrodynamic and the wave models were calibrated and validated against metocean data collected over a ten month period, encompassing each of the calendar seasons.
- The Feed Conversion Ratio (FCR) and Specific Growth Rate (SGR) values used in the development of the fish waste model (Section 4.6.1) are based on the collective works of Tanner *et al.* (2007), Fernandes and Tanner (2008) and Tanner and Fernandes (2010). The outputs produced by the model are conservative, and aquaculture proponents have a vested interest to achieve the lowest feed conversion ratios achievable.
- Modelled estimates of the total volume of fish waste expected to reach the seafloor are based on the physical and hydrodynamic properties of several different waste fractions: pelletised feed, and size fractions for stock faeces. The two largest fractions were assumed to settle rapidly and the smallest, slowly. Smaller particles tended to settle further from sea cage infrastructure, and larger particles settled closer.
- The faecal matter generated by cultured fish is known to be 'sticky', meaning it has a tendency to clump where it is depositing. Relative to inorganic waste produced by the stock, fish faeces is less likely to be resuspended by strong currents (BMT Oceanica 2015). As the fish faeces was deposited from sea cages most of the carbon was consumed by microscopic flora in the sediment. The assimilation of this organic waste by the environment caused rapid changes to the sediment chemistry.
- In the model context, the smallest fractions of fish faeces remained in suspension indefinitely. Fine particles had a high capacity for dispersion and were expected to dissolve over the twelve months for which the model was run. As a result, the particles were transported over long distances and dispersed widely. However, the volumes were not expected to result in impacts to flora and fauna living in or on the sediment.
- Each cluster of 14 sea cages is anchored within a grid that occupies 14 hectares.

6.7.6.3 Peer review

Doug Treloar of Cardno Water and Environment was engaged throughout the project to provide independent peer reviews of the environmental modelling, during development and on completion. The peer review assessed the approach to modelling, setting of thresholds and the general conclusions of the Modelling and Technical Studies (Appendix 1).

7 ASSESSMENT OF POTENTIAL IMPACT ON MARINE ENVIRONMENTAL QUALITY

7.1 Assessment Framework

7.1.1 Environmental Objective

The environmental objective established in this PER for marine environmental quality is as specified in EAG 8, namely:

"*To maintain the quality of water, sediment and biota so that the environmental values, both ecological and social, are protected.*"

7.1.2 Relevant Legislation, Policies, Plans and Guidelines

Table 7-1: Legislation, Policies, Plans, and Guidelines Relevant to Marine Environmental Quality

Legislation, Polices, Plans and Guidelines	Intent
State	
Environmental Protection Act 1986	This State Act provides for an EPA, for the prevention, control and abatement of pollution and environmental harm, and for the conservation, preservation, protection, enhancement and management of the environment.
Fisheries Resources Management Act 1994	Provides a legal framework to conserve, develop, and share fish resources for the benefit of current and future populations in WA. This legislation also provides the management framework for the Abrolhos Islands reserve and for the establishment and management of the Fish Habitat Protection Areas.
The Management Plan for the Houtman Abrolhos Islands. Fisheries Management Paper 260. (Department of Fisheries 2012)	The Houtman Abrolhos Islands Management Plan outlines both the vision and strategic objectives of management of the Abrolhos for the next ten years. It aims to conserve and promote the unique environmental and cultural heritage values of the Abrolhos Islands. The Plan's management objective for water quality is: "*To minimise the impact on water quality in the waters of the Abrolhos Islands Fish Habitat Protection Area as a result of human activities, such that water quality is maintained within relevant standards, consistent with the purposes for which the waters are used.*"
Environmental Assessment Guidelines (EAG)	
Environmental Assessment Guidelines No.8 (EAG 8) Environmental Assessment Guideline for Environmental Principles, Factors and Objectives (EPA 2015)	The EAG 8 provides guidance for proponents to help them understand the need to consider environmental principles, factors and objectives for the purpose of environmental impact assessment. Environmental principles, factors and objectives are critical to the environmental impact assessment process as they underpin the EPA's decision on the environmental acceptability of a proposal or scheme. In making its decisions, the EPA also takes a holistic approach to assessing environmental acceptability based on a number of broader considerations including whether the proposal aligns with broader international, national and State policies and agreements and takes

	account of the interconnected nature of the environment.
Environmental Assessment Guidelines No.3 (EAG 3) – Protection of Benthic Habitats in Western Australia's Marine Environment December 2009 (EPA 2009	EAG 3 recognises the fundamental importance of the Benthic Primary Producer Habitats (BCH) and the potential consequences of their loss for marine ecological integrity. The EAG 3 expects the following hierarchy of principles to be addressed by proponents when assessing proposals that could damage/ loss of BCH: • Consideration of options to avoid damage or loss of BCH; • Design that minimises damage or loss of BCH; • Best practice in design, construction methods, and environmental management aimed at minimising indirect impacts; • Consideration of environmental offset where substantial cumulative losses of BCH have already occurred; and • Risk to ecosystem integrity within a management unit is not substantial. The EAG 3 also provides a risk-based spatial assessment framework for evaluating cumulative irreversible loss of and/or serious damage of BCHs (EPA 2009). The EPA has termed within which to calculate cumulative losses 'Local Assessment Units'.
Environmental Assessment Guidelines No.7 (EAG 7) Environmental Assessment Guideline for Marine Dredging Proposals (EPA 2011)	The EAG 7 sets out guidance for predicting impacts to benthic communities and habitats due to significant dredging activities. The EPA has developed a spatially-based zonation scheme for proponents to use as a common basis to describe the predicted extent, severity and duration of impacts associated with the dredging proposals. The scheme consists of three zones that represent different levels of impact (EPA 2011) : • Zone of High Impact (ZoHI) - the area where impacts on benthic communities are predicted to be irreversible (defined as lacking capacity to return or recover to a pre-dredging state within a timeframe of five years. • Zone of Moderate Impact (ZoMI) - the area where predicted impacts on benthic communities are expected to be sub lethal and/or the impacts recoverable within a period of five years following completion of the dredging activities. • Zone of Influence (ZoI) - the area where changes in environmental quality associated with dredge plumes are predicted, but these changes are not expected to result in a detectable impact on benthic communities.
Environmental Assessment Guidelines No. 15 (EAG 15) *Protecting the Quality of Western Australia's Marine Environment*	As part of the PER document, an environmental quality management framework (EQMF) has been developed in accordance with EAG 15 (EPA 2015) to protect the environmental values of the marine environment from any organic waste and, or, contaminants associated with the proposed aquaculture. Consistent with EAG 15, the environmental impact assessment (EIA) for the MWADZ Proposal involved modelling the distribution and fate of aquaculture waste. This information informed the development of specific environmental quality criteria for the purpose of monitoring the effects of organic enrichment on the marine environment. For this sea cage aquaculture, EAG 15 suggests the most appropriate level of ecological protection is a Moderate Ecological Protection Area (MEPA). The EQMF developed for the MWADZ Proposal will manage sea cage aquaculture within 'floating' MEPAs which are proportionate to fifty per cent of any given lease area. The EQMF is devised to maintain the

	existing environmental quality of remaining fifty per cent of the MWADZ and the surrounding area at a high level of ecological protection (HEPA).
Commonwealth	
Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2000)	Provides water quality standards for marine waters and a guide for setting water quality objectives to sustain current or likely future environmental values for natural and semi-natural waters in Australia and New Zealand. Provides trigger values for a range of organic and inorganic compounds that, if exceeded, should be addressed.
National Water Quality Management Strategy - Water Quality Management (ANZECC and ARMCANZ 1994)	Aims to achieve sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development.

7.2 Existing Environment

7.2.1 Baseline Sampling

Sampling of marine sediment and water quality was conducted in the marine waters within the MWADZ Proposal study area and the surrounding waters to describe the biogeochemistry of the strategic proposal area and the region for the purpose of establishing a baseline and to inform environmental modelling for the proposal.

The experimental design includes multiple sampling sites at the impact location (north and south), and reference locations to provide multiple sets of data over multiple seasons. The baseline dataset provides a comprehensive context to future monitoring results.

In addition to sediment and water quality parameters, the following phyisco-chemical parameters (below) were logged through the water column:

- temperature (°C)
- pH/oxidation/reduction potential (pH units, mV)
- conductivity/salinity (mS/cm, ppt)
- dissolved oxygen (DO, mg/L)
- turbidity (NTU)
- depth (metres)
- incident irradiance (photosynthetically active radiation [PAR])
- metocean data (hydrodynamics).

7.2.2 Hydrodynamics and Wave Climate

Currents around the Abrolhos Islands are dominated by the Leeuwin Current system, primarily consisting of the Leeuwin Current (an offshore, southward-flowing current, usually stronger in winter and weaker in summer) and the Capes Current (a nearshore, northward-flowing current, strongest in summer) (Pattiaratchi & Woo, 2009).

Current speeds and wave heights were measured in the Northern and Southern Areas of the proposed MWADZ (refer to Appendix 1) with the aid of Acoustic Doppler Current Profilers (ADCPs). These were deployed as described in Table 7-2.

Table 7-2: Timing of the Deployment of ADCPs within the proposed MWADZ

Metocean conditions	Autumn		Winter		Spring		Summer	
	May	**Jun**	**Aug**	**Sep**	**Nov**	**Dec**	**Feb**	**Mar**
ADCPs (Department of Fisheries)	In	Out	In	Out	In	Out	In	Out

Rose plots of depth-averaged current speed measured by the ADCPs are presented in (Figures 7-1 and 7-2). The currents in the Southern Area flowed primarily east and west, influenced by the presence of the adjacent Pelsaert Group of the Abrolhos Islands. Current flow was predominantly westward during the May-June deployment, switching to eastward during the November-December deployment, with no dominant current direction during the August-September or February-March deployments.

Currents in the Northern Area are typically stronger than those in the Southern Area, but with no dominant direction of flow during the May-June (Figure 7-1) and August-September deployments. During the summer deployments, the direction of flow was typically to the northwest, with current speeds of approximately 0.1-0.3 metres per second (Figure 7-2).

The wave climates were similar between the areas in the proposed MWADZ, although with lower significant wave height in the Northern Area. Mean significant wave height was 1.6 metres (northern site) and 2.2 metres (southern site) during the July-November deployment, and 1.5 metres (northern site) and 2.1 metres (southern site) during the November-March deployment.

Mean wave periods were approximately 11-12 seconds during the July-November deployment and 8-10 seconds during the November-March deployment in both areas. Peak wave direction was from the south-southwest.

For further details on the hydrodynamics investigations undertaken, refer to Appendix 1.

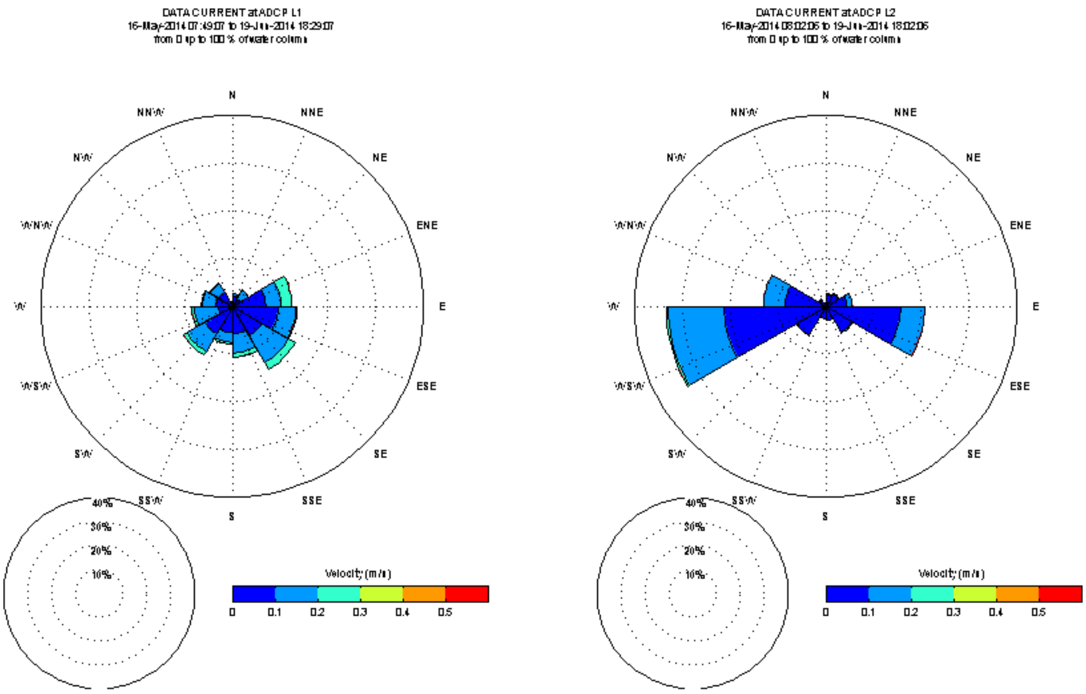


Figure 7-1: Current directions and speeds in the Northern and Southern Areas of the proposed MWADZ between May and June 2014

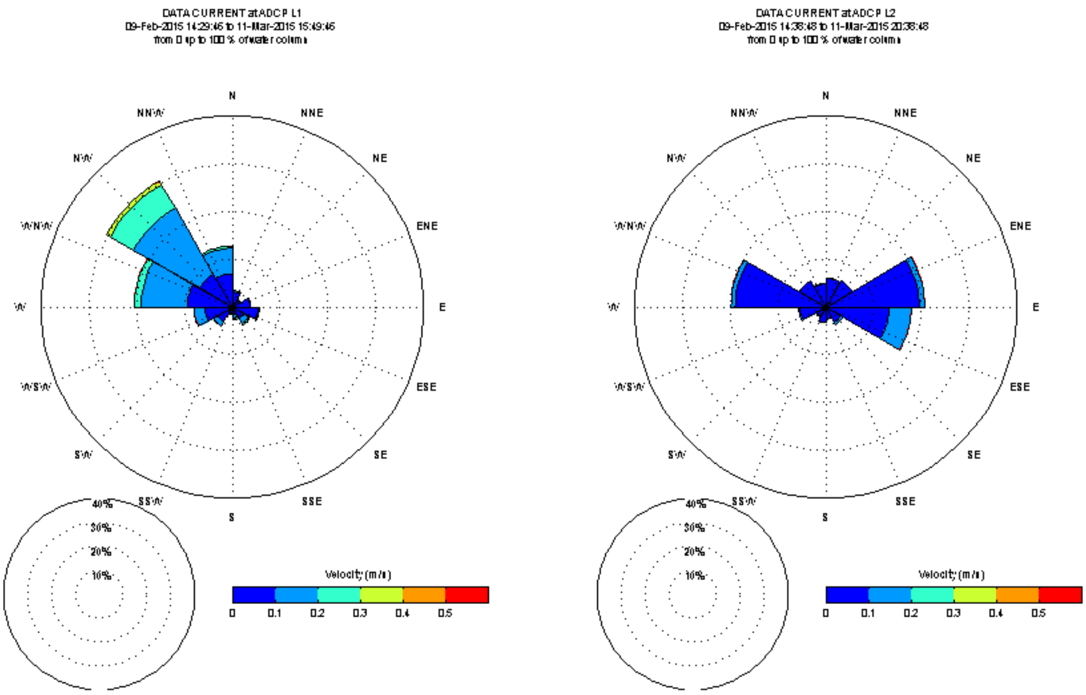


Figure 7-2: Current directions and speeds in the Northern and Southern Areas of the proposed MWADZ between February and March 2014

7.2.3 Marine Sediment Quality

Marine sediment quality measurements and samples were taken in the marine waters at the MWADZ study area and the surrounding waters (Figure 7-3).

7.2.3.1 Baseline Sediment Quality Sampling and Analysis Methods

Sediment samples were obtained at a total of 33 sites comprising of 12 sites in the northern area and 9 sites in the southern area, and an additional 12 reference sites, located at least three kilometres away from the proposed MWADZ. As with the water quality sites, sites were positioned to allow for future Multiple-Before-After-Control-Impact (MBACI) framework of Keogh and Mapstone (1997) and stratified to capture the presence of sediment quality gradients, if present. Refer to Table 7-3 for a list of sediment quality parameters.

For details of the sampling and analysis methodologies, refer to the Modelling and Technical Studies (Appendix 1).

Table 7-3: Timing of Sampling for Baseline Sediment Quality

	Summer	Winter
	August	February
Sediment quality sampling		
Total nitrogen / Total phosphorus	✓	✓
Total organic carbon / Dissolved organic carbon	✓	✓
Trace metals (Ag, As, Cd, Co, Cr, Cu, Ni, Pb, Sb, Se, Zn, Hg, Fe, Li, Mn)	✓	✓
PAH/TPH	✓	✓
pH/oxidation–redox potential	✓	✓
Particle size distribution	✓	✓
Infauna community composition	✓	✓

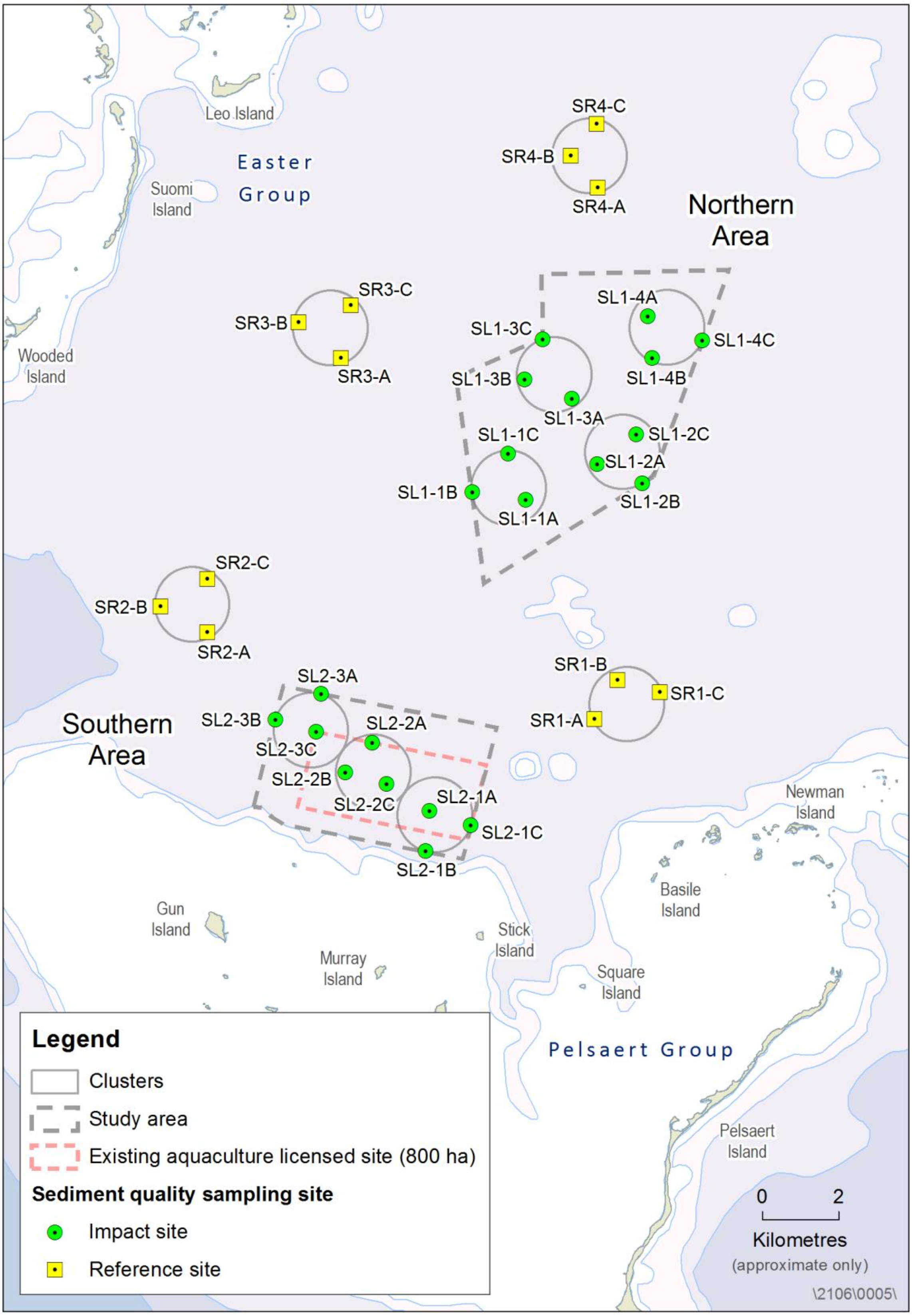


Figure 7-3: Baseline Sediment Quality Sampling Sites

7.2.3.2 Baseline Sediment Quality Sampling and Analysis Results

Particle Size Analysis

In general, there were no major differences in sediment particle sizes between the MWADZ and reference locations (Figure 7-4). However, a high level of variability was observed across locations and seasons. Sediments at all locations were composed of varying proportions of different particle size fractions. Some differences were detected across seasons. Fine to coarse sand particles were dominant fractions in the winter, while fine clays and silts were dominant in summer. Proportions of sediment particle sizes differed across all locations, and across the winter and the summer season.

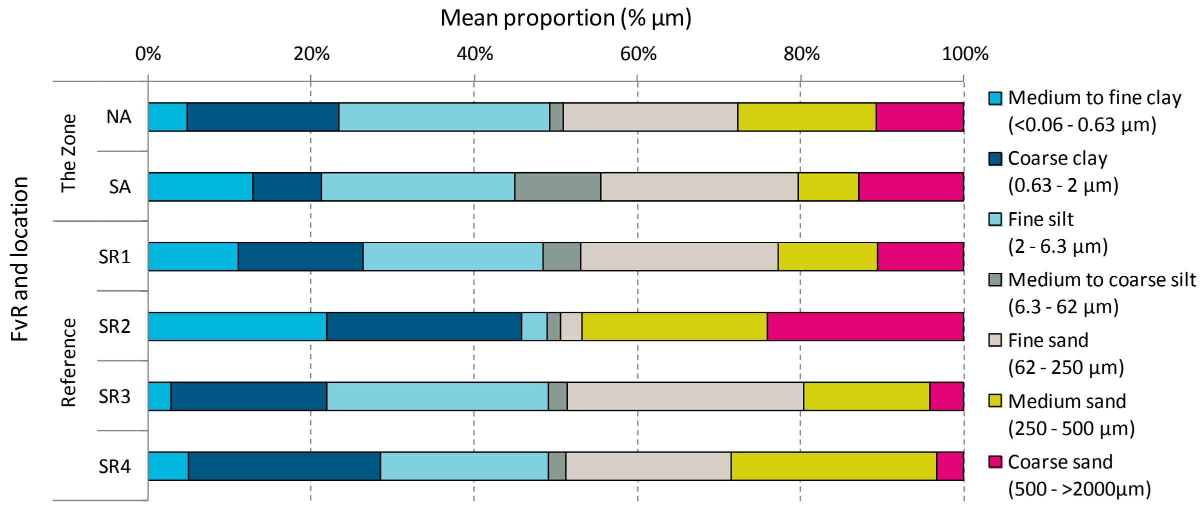


Figure 7-4: Particle Size Results

In relation to sediment composition, the combined northern and southern areas (represented by the proposed MWADZ) differed to the reference locations during the winter. The reference locations were generally dominated by clays (<0.06–0.63 µm) to coarse sands (500>2000 µm). During the summer months both the zone and reference locations were characterised by coarse clay (0.63–2 µm) and medium-sized sand (250–500 µm).

Nutrients

Significant differences were observed between the seasons for ammonium, nitrogen and Total Organic Carbon (TOC) concentrations (Figure 7-5). Phosphorus and TOC concentrations between locations were different. TOC concentrations were higher in the southern area during both summer and winter compared to the northern area.

Ammonium and nitrogen concentrations differed between summer and winter. On average, higher concentrations of ammonium were reported in winter (1.61 mg/kg) relative to summer (1.06 mg/kg). In contrast, a higher percentage of nitrogen was observed in sediments during summer (0.022%) than during winter (0.018%; Figure 7-5). While no seasonal variations were detected for phosphorus concentrations, phosphorus varied across locations.

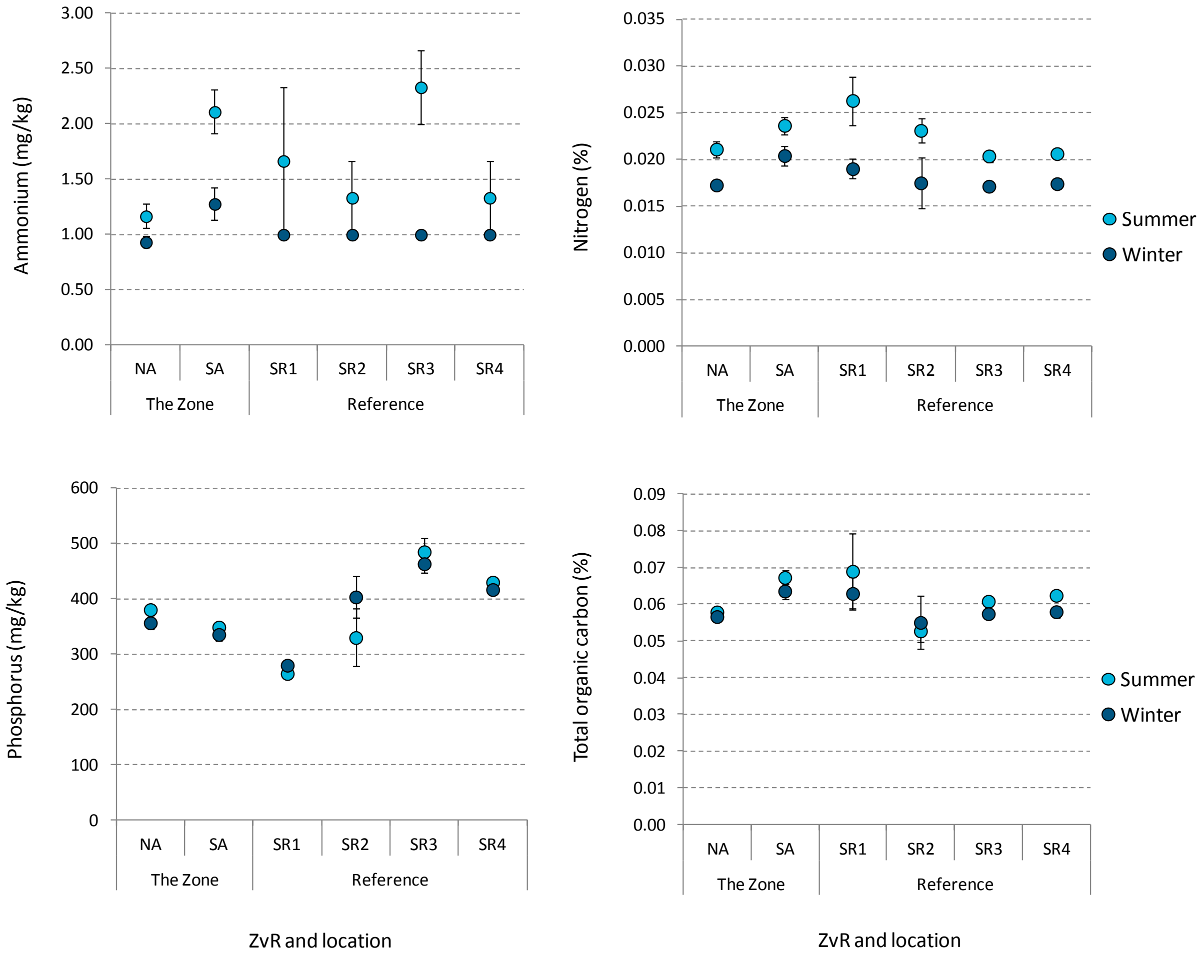


Figure 7-5: Ammonium, Nitrogen, Phosphorus and Total Organic Carbon Concentrations (Mean ± Standard Error) across Seasons and Locations

Metals

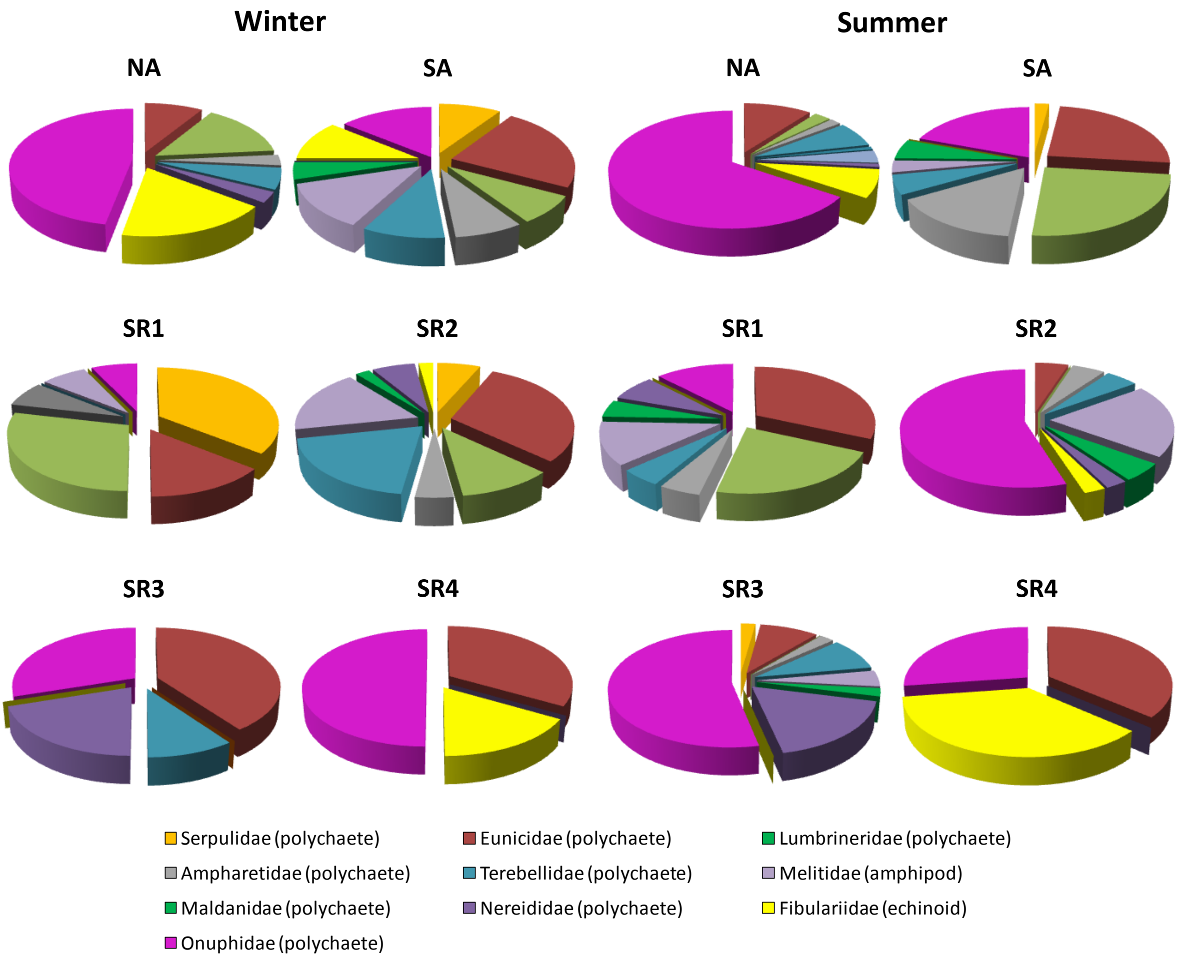
The top five trace metals were aluminium (Al), iron (Fe), chromium (Cr), manganese (Mn) and Cobalt (Co). Trace metals in the MWADZ Proposal area sediments were variable, but low in concentration, across the locations and sampling times. Differences were observed between the zone and the reference locations, but only at certain times. These differences were restricted to the summer sampling period. Differences were detected between the northern and the southern area, and among the reference locations reference locations SR1 and SR4. Reference locations SR2 and SR3 displayed similar characteristics to one another. There was some variability in trace metal concentrations within sampling locations. Reference location SR4 had greater concentrations of Mn, Cr, Fe and Al compared to other locations, while the southern area recorded greater Co concentrations relative to other locations (Appendix 1).

Infauna

Analysis of infauna samples revealed a diverse community, comprising 10 Phyla (Arthopoda, Chordata, Echinodermata, Mollusca, Nematoda, Nemertea, Phoronida, Platyhelminthes, Polychaeta and Sipuncula) and 129 families.

Sampling recorded 36 families of polychaete worms (accounting for 45% of the infauna sampled), 33 families of molluscs (25% of the infauna sampled), 41 families of Arthropods (e.g. crustaceans; 18% of the infauna sampled) and 10 families of echinoderms (e.g. starfish, sea urchins, sand dollars; 7% of the infauna sampled). There was a high level of variability in community structure which was influenced by both season and location.

There were no clear differences in community structure attributable to location only. In general, higher counts of polychaete fauna were reported in summer than winter (Figure 7-6). The southern area contained higher numbers of polychaetes and amphipods in both seasons compared to the northern area; however, the northern area reported higher counts of echinoids, Nereididae and Onuphidae than the southern area.



Note:
2. NA (northern area); SA (southern area); SR (sediment reference locations)

Figure 7-6: Percentage Representation of the Top Ten Most Abundant Infauna Families

Differences in family 'richness' were observed among locations and seasons. In general, higher family richness was observed in summer (17.9 family richness) than in winter (10.1 family richness; Figure 7-7). The southern area reported higher number of families (15.9 family richness) relative to the northern area (11.5 family richness).

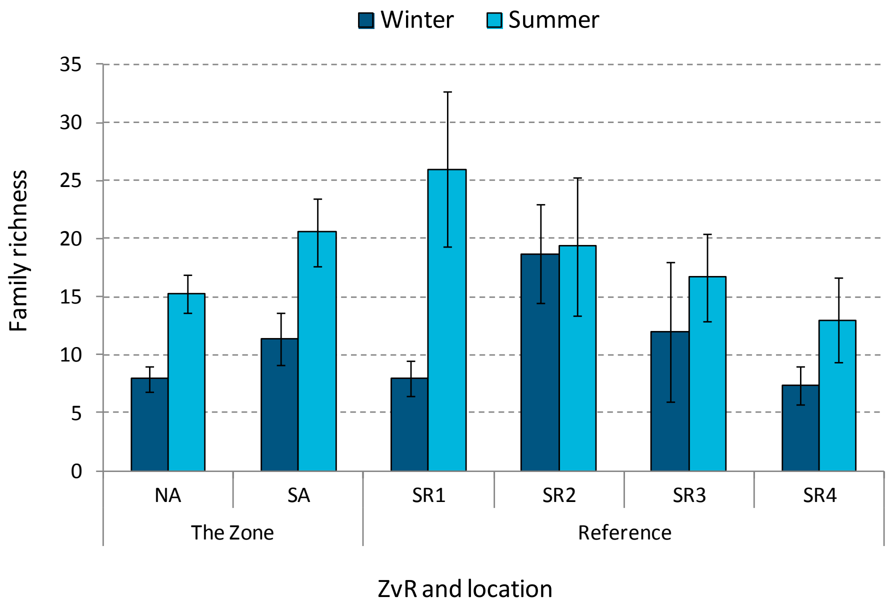


Figure 7-7: Family Richness (Mean ± Standard Error) of Benthic Infauna across Seasons and Locations (Within Zone Vs Richness)

Family abundances were influenced by season, that is, family abundance was greater in summer across all locations (35.39 individual animals) compared to winter (16.09 individual animals; Figure 7-8).

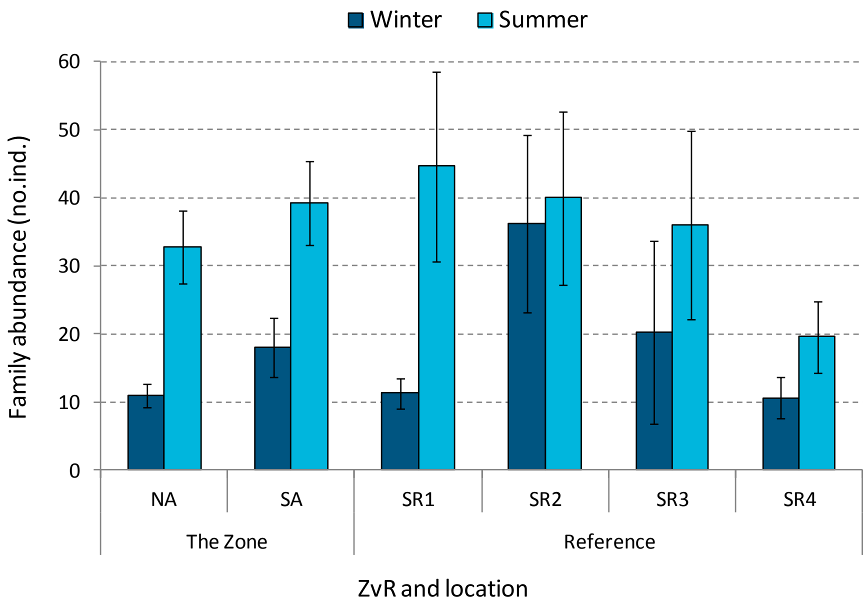


Figure 7-8: Family Abundance (Mean ± Standard Error) of Benthic Infauna across Seasons and Locations

Total Petroleum Hydrocarbons / Polycyclic Aromatic Hydrocarbons

Total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAH) in marine sediments were generally below the laboratory limit of reporting (LOR). For further results refer to Modelling and Technical Studies (Appendix 1).

7.2.4 Marine Water Quality

Marine water quality measurements and samples were taken in the marine waters at the MWADZ study area and the surrounding waters.

7.2.4.1 Baseline Water Quality Sampling and Analysis Methods

Water samples were obtained at a total of 27 sites comprising of 9 sites in the northern area and 6 sites in the southern area, and an additional 12 reference sites, located at least 3 kilometres away from the perimeter of the proposed MWADZ (Figure 7-9). The water quality sites were positioned to allow for future Multiple-Before-After-Control-Impact (MBACI statistical analysis of the data).

The water samples for chemical analyses were collected at two time points within each season, and from the surface (0–1 metre depth) and bottom (~1 metre from seafloor) of the water column (Table 7.4).

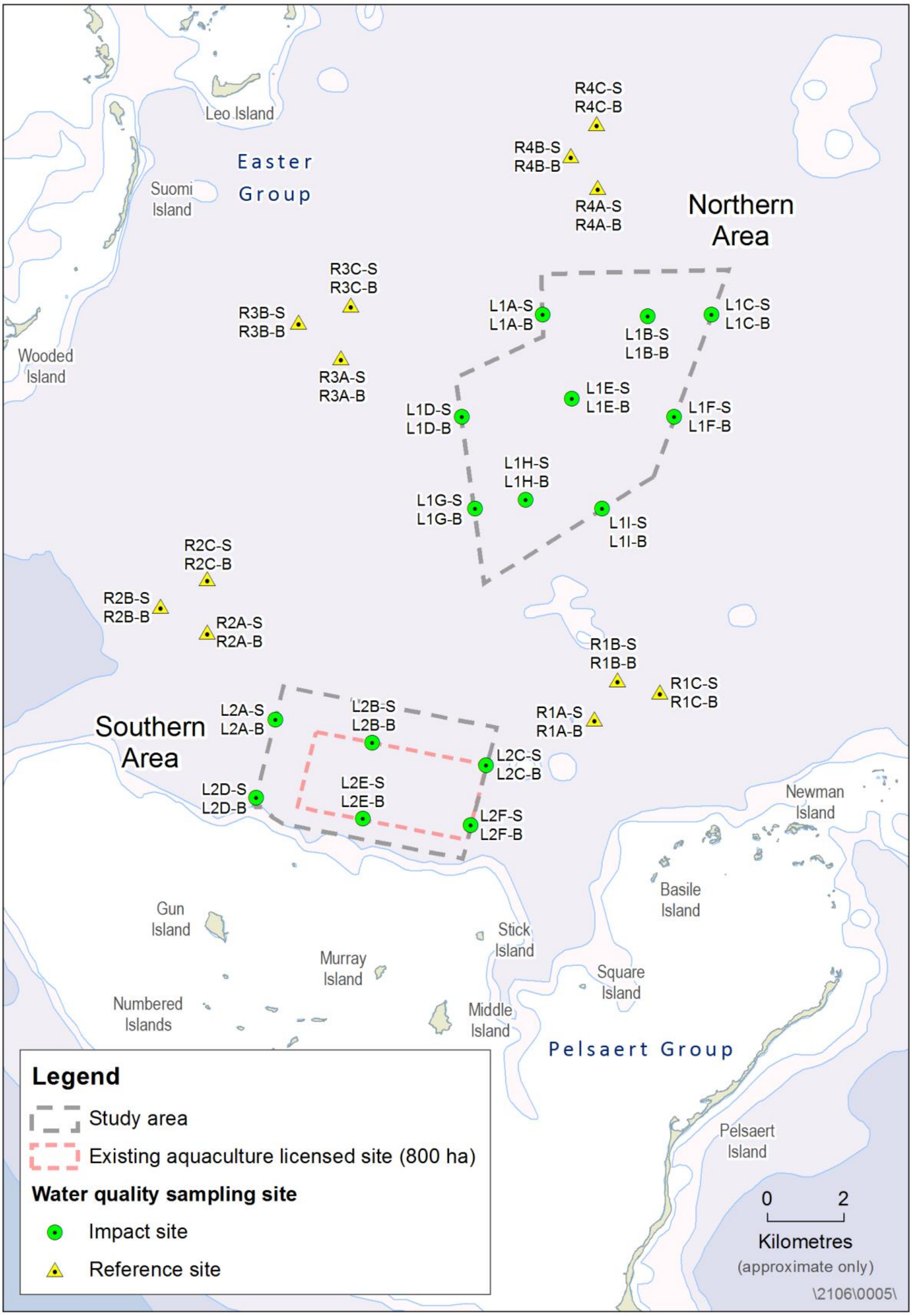


Figure 7-9: Baseline Water Quality Sampling Sites

Table 7-4: Timing of Sampling for Baseline Water Quality (S = surface, B = bottom)

	Autumn				Winter				Spring				Summer			
	May		Jun		Aug		Sep		Nov		Dec		Feb		Mar	
	S	B	S	B	S	B	S	B	S	B	S	B	S	B	S	B
Light intensity																
In situ PAR data loggers	In		Out		In		Out		In		Out		In		Out	
Water quality sampling																
Physical water quality profiling	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ammonium / Nitrite + Nitrate / Filterable Reactive Phosphorus	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Total nitrogen / Total phosphorus	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Total organic carbon	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Total suspended solids	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Chlorophyll-a	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Polycyclic Aromatic Hydrocarbon / Total Petroleum Hydrocarbon	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Total sulphides						✓								✓		
Phytoplankton community composition	✓				✓				✓				✓			

7.2.4.2 Baseline Water Quality Sampling and Analysis Results

Salinity

Salinity readings confirmed that the water column was well-mixed at all locations throughout the year. During winter 2014, the northern and southern (SA) MWADZ areas and reference locations had slightly lower salinities throughout the water column [~35.5 g/L (parts per thousand or ‰)] than peak salinities measured in autumn 2014 (~36.2‰) and summer 2015 (~36.0‰; Appendix 1).

Temperature

A temperature gradient was observed at the deeper northern reference location R3 (~43 metres deep) particularly during autumn and summer, when temperatures dropped ~0.36–1.31°C between 15 metres and 25 metres (refer to Appendix 1). The most northern locations displayed similar decreasing trends in water temperatures during autumn and winter. Across all locations, surface temperatures (0–10 metres) were typically lower during spring than summer.

Dissolved Oxygen

Across all locations and sampling periods, mean surface DO saturation was always >96%, while mean bottom DO saturation was always >95%. There was a slight decreasing trend in DO saturation with increasing depth across all locations over all four seasons (Table 7-5).

Table 7-5: Dissolved Oxygen Statistics at All Locations

Season	Autumn			Winter			Spring			Summer		
MWADZ	N	S	R	N	S	R	N	S	R	N	S	R
Mean surface DO (%)	98	98	98	97	96	98	98	99	98	97	98	97
Standard deviation	2	1	2	1	1	2	1	1	1	0	1	1
Mean bottom DO (%)	96	97	95	95	96	96	98	98	97	97	97	97
Standard deviation	3	1	4	1	2	2	1	1	1	0	1	1

Notes:

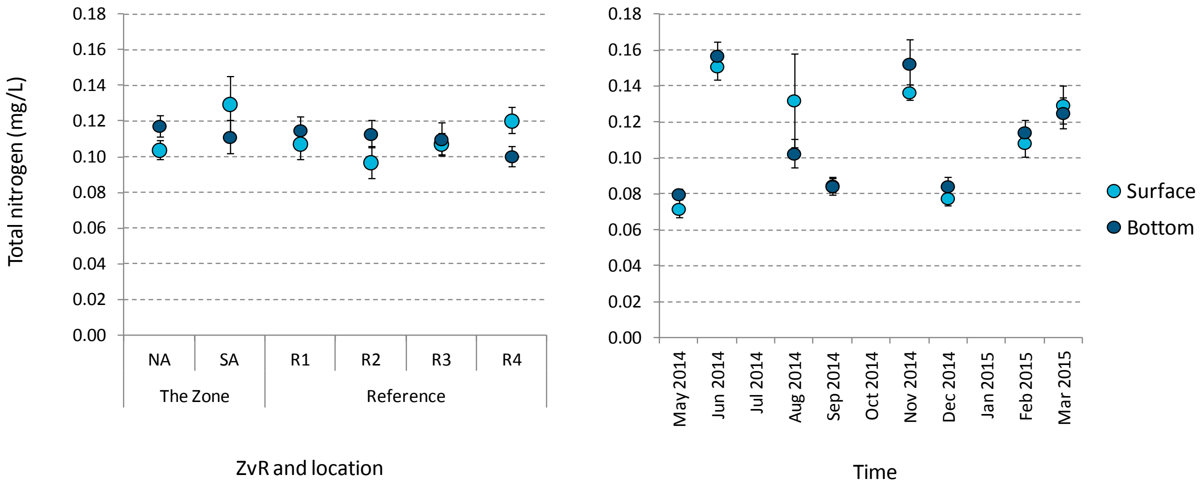
1. MWADZ = Mid West Aquaculture Development Zone; N = northern area of MWADZ, S = southern area of MWADZ, R = reference locations
2. DO = dissolved oxygen

Light attenuation and irradiance

During winter (August-September 2014), light attenuation through the water column across the northern and southern areas was similar (0.04–0.19 per metre). During summer (November-December 2014), light attenuation was slightly reduced (0.04–0.15 per metre), from levels seen in winter (above). However, variations in the data across areas were similar.

Total Nitrogen

Total nitrogen (TN) concentrations in both surface and bottom waters fluctuated over time (Figure 7-10). The highest TN concentrations in the water column were reported during winter (June 2014; surface = 0.151 mg/L, bottom = 0.16 mg/L). Generally, the northern and southern study areas (of the proposed MWADZ) recorded slightly higher TN concentrations than the reference locations.



Note:
1. ZvR = Zone locations vs Reference

Figure 7-10: Total Nitrogen (Mean ± Standard Error) Sampled at the Surface and Bottom of the Water Column across Locations (Within ZvR and Time)

Total Phosphorus

Spatial and seasonal fluctuations in total phosphorus (TP) concentrations were apparent (Figure 7-11). In general, both surface and bottom concentrations in TP remained relatively similar across the locations. Generally, surface and bottom waters at all locations recorded higher TP concentrations during summer (February 2014; surface = 0.019 mg/L, bottom = 0.022 mg/L).

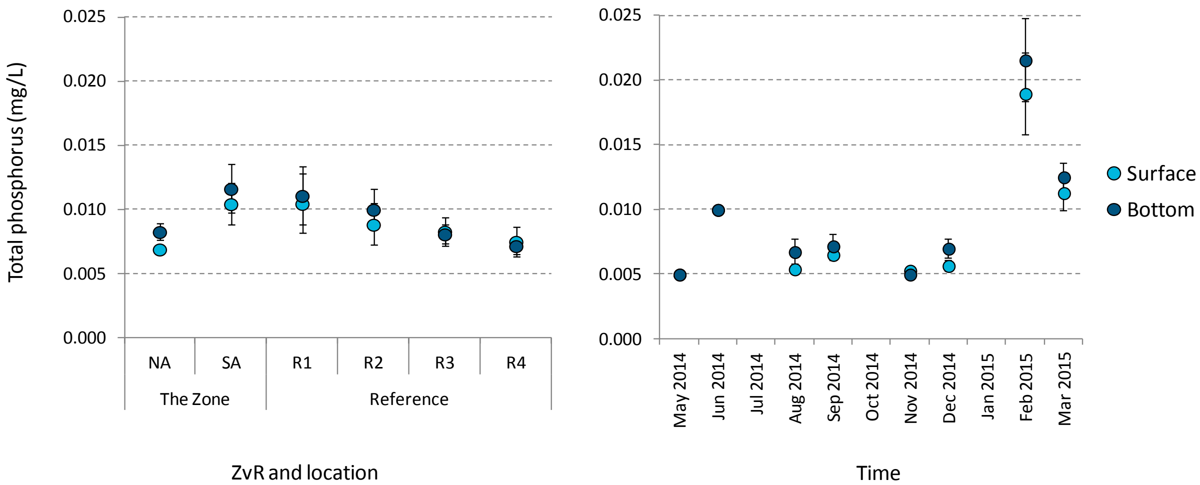


Figure 7-11: Total Phosphorus (Mean ± Standard Error) Sampled at the Surface and Bottom of the Water Column across Locations (Within ZvR and Time)

Total Organic Carbon

Concentrations of total organic carbon (TOC) at all locations varied across sampling times (Figure 7-12). The greatest concentrations of TOC (surface = 1.40 mg/L, bottom = 1.47 mg/L) were recorded during winter (August 2014).

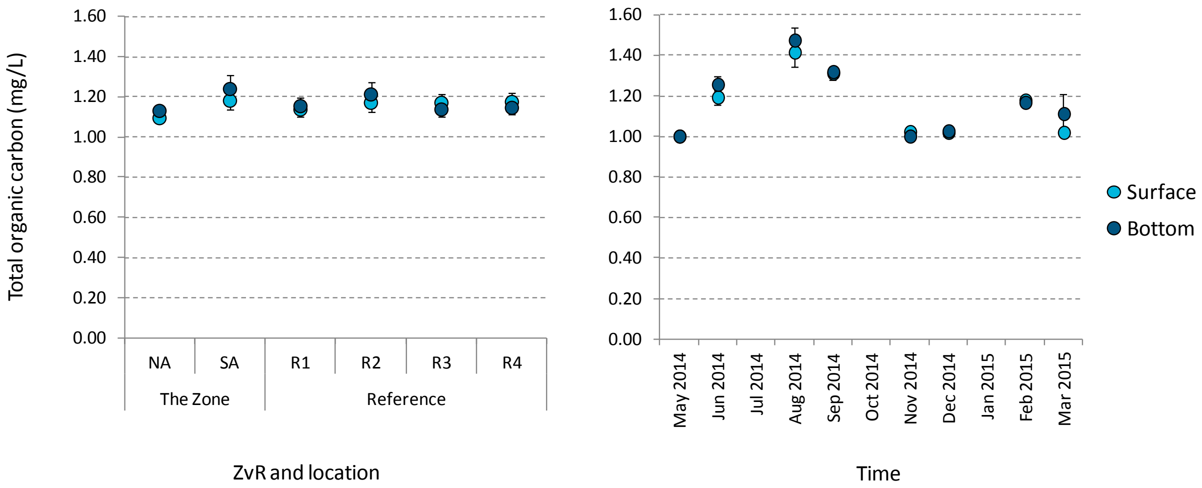


Figure 7-12: Total Organic Carbon (Mean ± Standard Error) Sampled at the Surface and Bottom of the Water Column across Locations (Within ZvR and Time)

Total suspended solids

Concentrations of total suspended solids (TSS) remained relatively constant across all locations, varying between 1.05 mg/L and 2.62 mg/L in surface and bottom waters (Figure 7-13). No differences in TSS concentrations were observed in bottom waters across the sampling locations and times. However, some differences were observed in the surface waters across the sampling times.

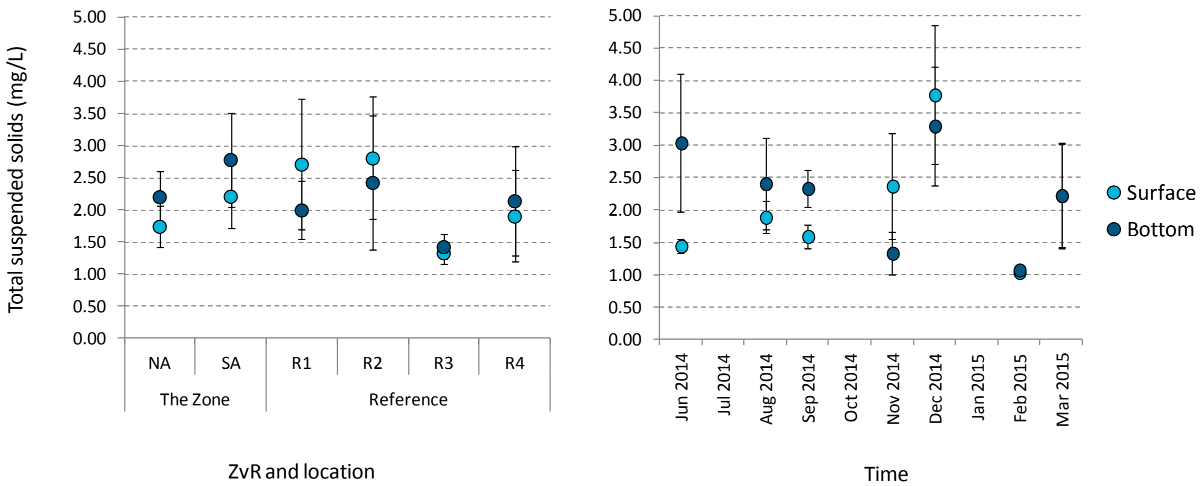


Figure 7-13: Total Suspended Solids (Mean ± Standard Error) Sampled at the Surface and Bottom of the Water Column across Locations (Within ZvR and Time)

Volatile suspended solids

Concentrations of volatile suspended solids (VSS) varied over time and across locations (Figure 7-14). The highest VSS concentrations in surface waters were recorded during summer (December 2014; 1.26 mg/L), and the lowest concentrations in bottom waters were recorded in winter (August 2014; 1.30 mg/L). Notably elevated VSS concentrations were recorded at the reference location R1 (2.33 mg/L) during spring (November 2014).

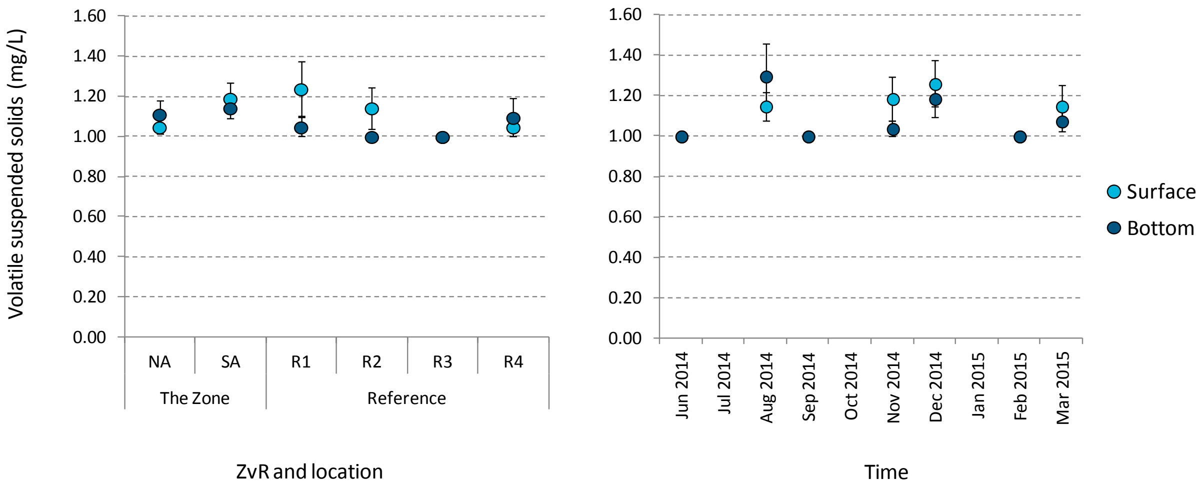


Figure 7-14: Volatile Suspended Solids (Mean ± Standard Error) Sampled at the Surface and Bottom of the Water Column across Locations (Within ZvR and Time)

Ammonia

Ammonia concentrations at the surface of the water column were relatively consistent across locations. However, concentrations were slightly elevated at locations in the northern and southern areas (Figure 7-15). Higher concentrations were also recorded during winter (June 2014; 5.56 µg/L and August 2014; 7.00 µg/L). Similar results were observed for the bottom of the water column. The concentrations were highest in the northern area during winter (June 2014; 9.67 µg/L).

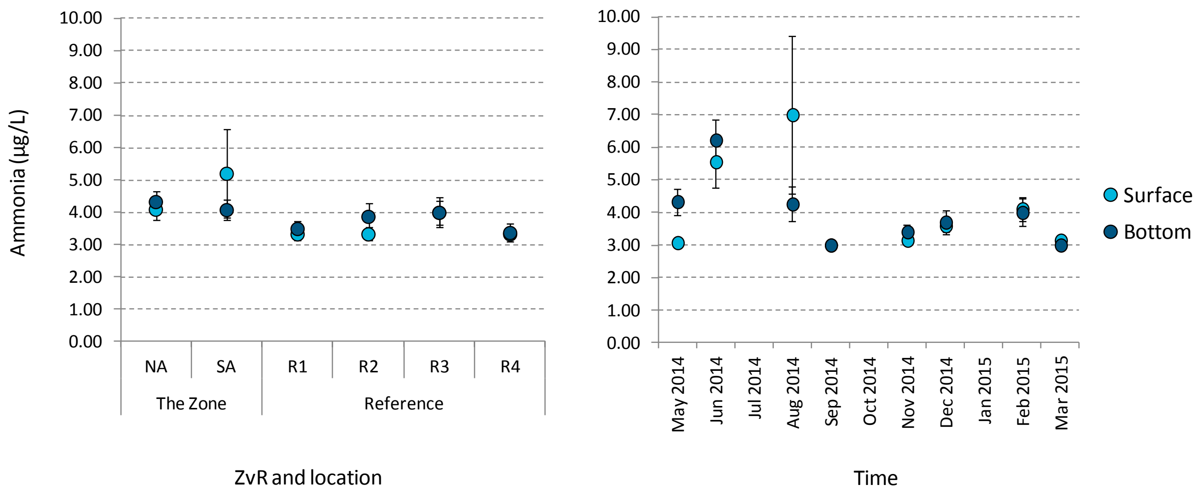


Figure 7-15: Ammonia (Mean ± Standard Error) Sampled at the Surface and Bottom of the Water Column across Locations (Within ZvR and Time)

Orthophosphate

Fluctuations in orthophosphate concentrations were apparent across various locations and sampling times. In general, similar surface concentrations were recorded across the northern and southern areas and the reference locations (Figure 7-16). The highest orthophosphate concentrations (4.52 µg/L) in the surface waters were reported during winter (August 2014) in the southern area and reference location R3.

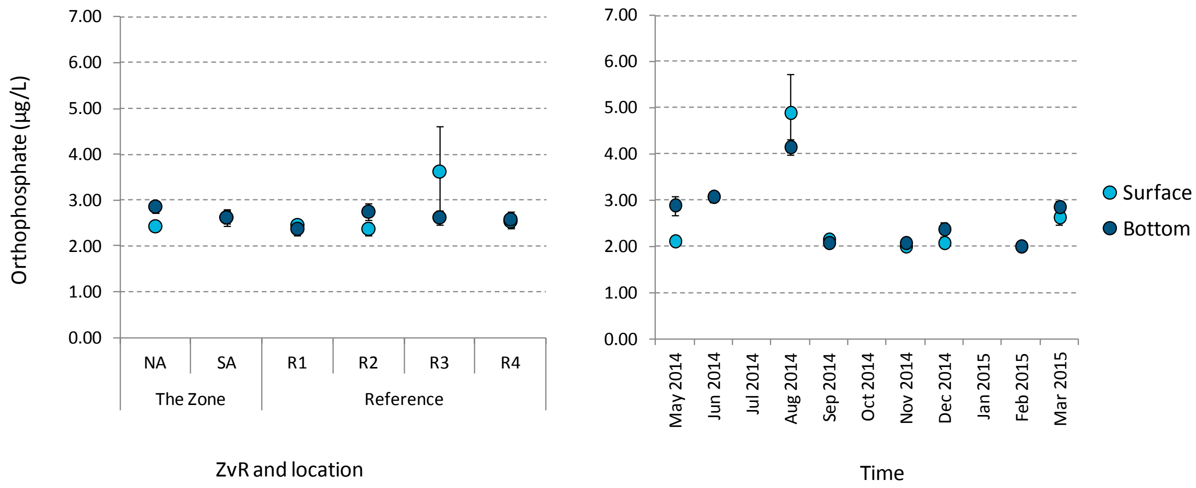


Figure 7-16: Orthophosphate (Mean ± Standard Error) Sampled at the Surface and Bottom of the Water Column across Locations (Within ZvR and Time)

Dissolved inorganic nitrogen

Seasonal variations in concentrations of dissolved inorganic nitrogen (DIN) were observed in the surface and bottom of the water column. DIN concentrations at the surface were highest during winter (August 2014; 39.67 µg/L), but also relatively high in summer (December and February). Bottom waters concentration were highest during winter (August 2014; 30.59 µg/L), and lowest during autumn (March 2015; 7.78 µg/L). The combined northern and southern areas recorded the higher concentrations of DIN (zone locations = 22.58 µg/L) compared to combined reference locations (17.60 µg/L; Figure 7-17).

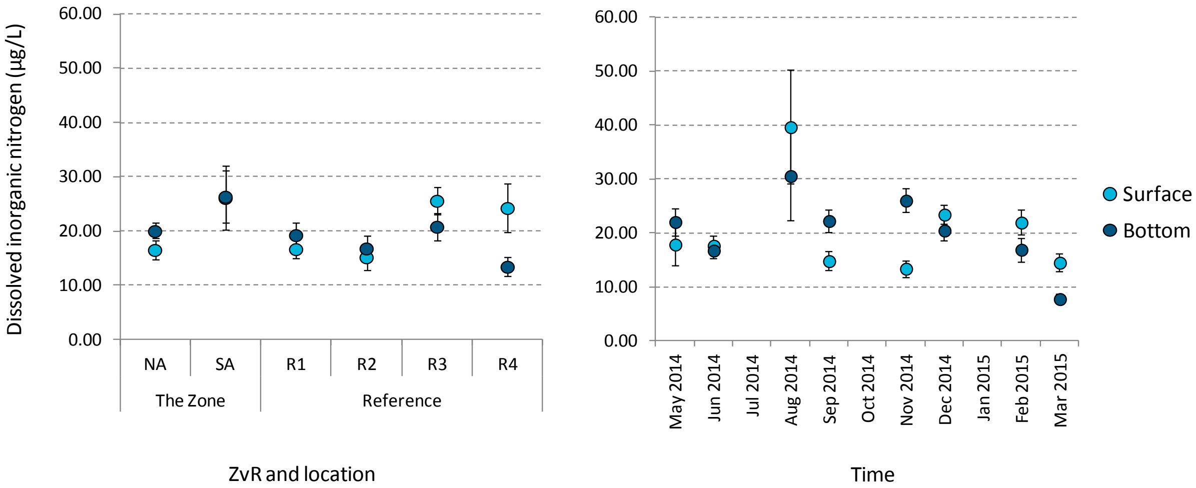


Figure 7-17: Dissolved Inorganic Nitrogen (Mean ± Standard Error) Sampled at the Surface and Bottom of the Water Column across Locations (Within ZvR and Time)

Nitrate and nitrite

Concentrations of nitrate and nitrite (NOx) at the top and bottom of the water column were greatest during winter (August 2014; surface 32.67 µg/L and bottom 26.33 µg/L). There was also some variation in concentrations across the locations. On average, reference locations R3 and R4 recorded the greatest surface waters concentrations (21.63 µg/L and 20.96 µg/L). A decline in bottom water concentrations was recorded over the warmer months, between spring (November 2014) and autumn (March 2015; Figure 7-18).

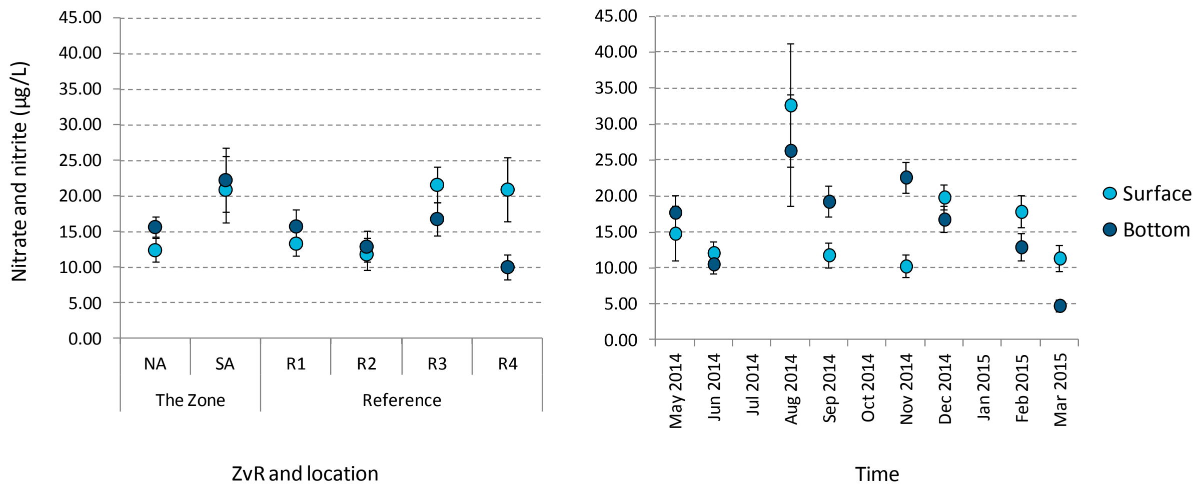


Figure 7-18: Nitrate and Nitrite (Mean ± Standard Error) Sampled at the Surface and Bottom of the Water Column across Locations (Within ZvR and Time)

Hydrogen sulphide

Concentrations of hydrogen sulphide were below the limit of reporting (0.01 mg/L) in all samples.

Total Petroleum Hydrocarbons / Polycyclic Aromatic Hydrocarbons

Total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAH) were generally below the laboratory limit of reporting (LOR). For further results refer to Modelling and Technical Studies (Appendix 1).

Chlorophyll-a

Generally, chlorophyll-a concentrations at the surface and bottom of the water column increased during the warmer months, between spring (November 2014) and autumn (March 2015; Figure 7-19). Reference location R1 had greater concentrations of chlorophyll-a at the surface (0.27 µg/L) and bottom (0.25 µg/L) of the water column in comparison to other locations.

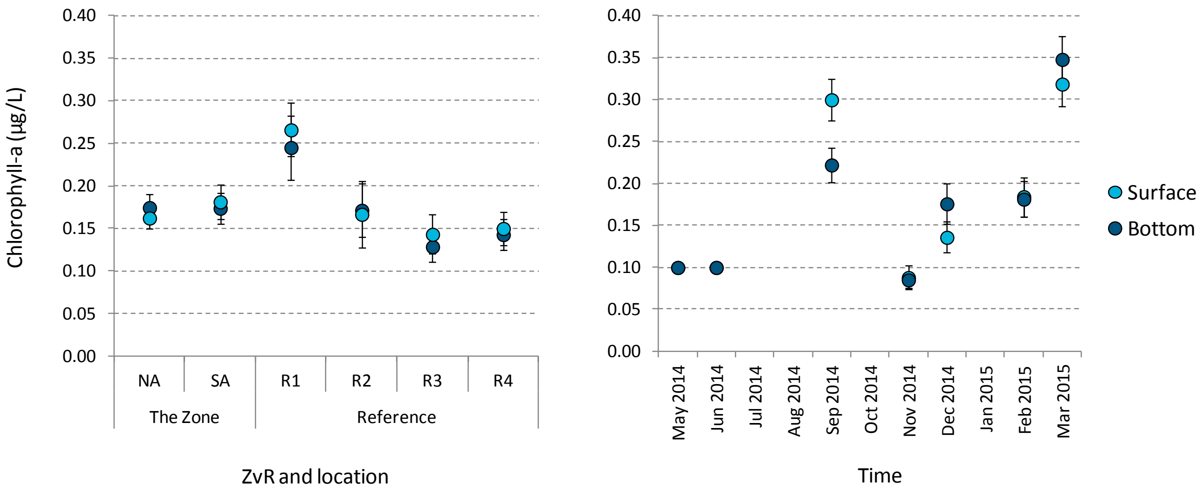


Figure 7-19: Chlorophyll-A (Mean ± Standard Error) Sampled at the Surface and Bottom of the Water Column across Locations (Within ZvR and Time)

Phytoplankton

Phytoplankton belonging to six divisions/phyla (Bacillariophyta, Chlorophyta, Chrysophyta, Cryptophyta, Cyanophyta, Dinophyta), plus unidentified others, were sampled across all locations. Counts were notably dominated by the diatoms (Bacillariophyta represented ~90.8% of the total counts), followed by dinoflagellates (~3.5% of the total counts). Of the total counts, 12.4% of taxa were classified as potentially toxic algae and 1.6% as potentially toxic blue green algae.

Large scale fluctuations and differences in community assemblages were evident across locations and sampling times. Phytoplankton counts differed between locations and sampling times. In addition, greater counts of Chlorophyta (green), Cryptophyta (monad), Cyanophyta (blue green) and Dinophyta (dinoflagellates) were reported during autumn (May 2014) and greater counts of Bacillariophyta were recorded during summer (December 2014; 92.93 cells/millilitre; Figure 7-20).

Community assemblages in the northern and southern areas were different to each other; particularly in relation to counts of Dinophyta. Dinophyta was recorded in higher numbers in the southern areas relative to northern area. Reference location R1 recorded phytoplankton counts that were different to counts at reference locations R2, R3 and R4. This difference was primarily driven by relatively high numbers of Bacillariophyta at reference location R1.

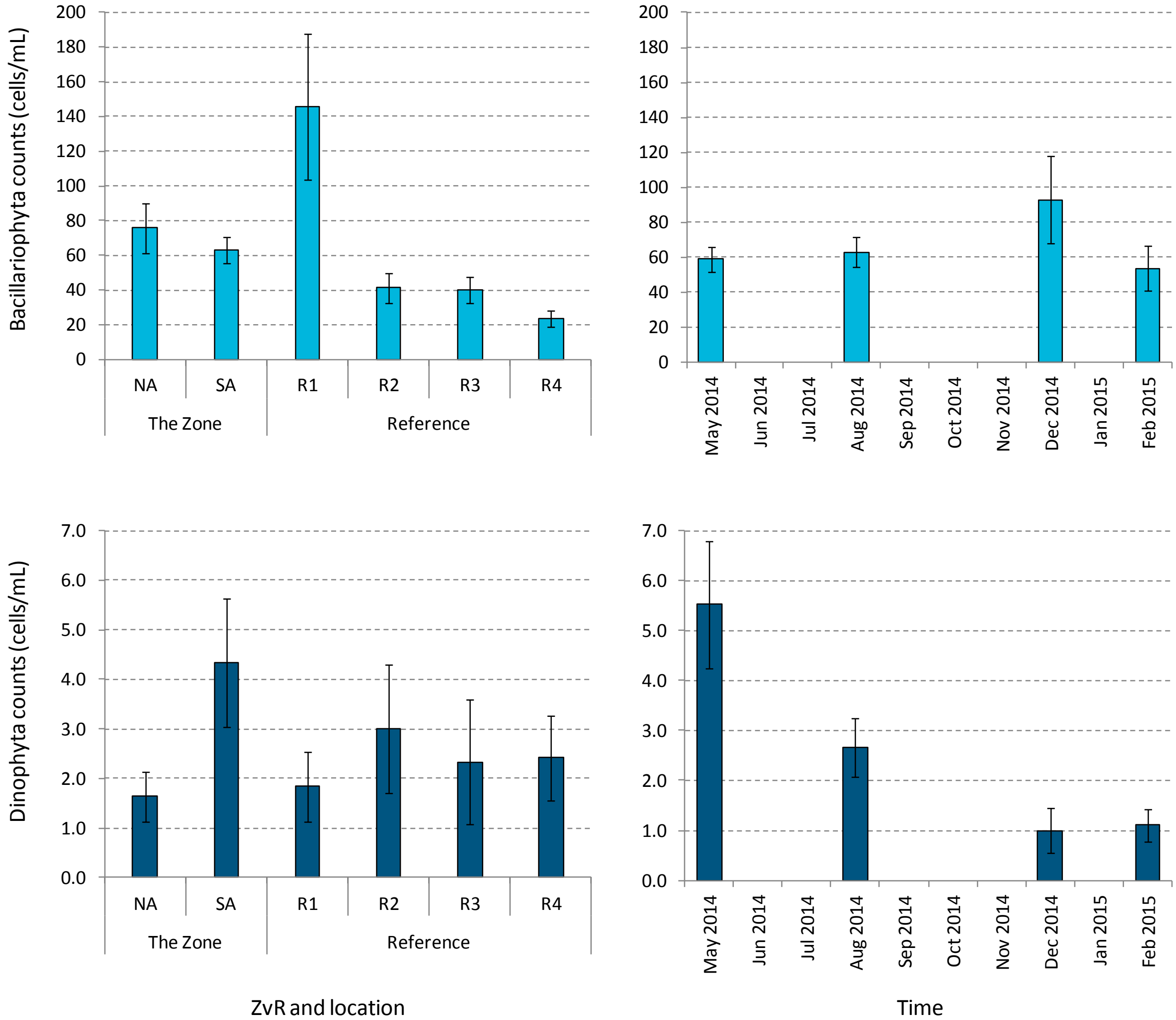


Figure 7-20: Bacillariophyta (Diatoms; Top) and Dinophyta (Dinoflagellates; Bottom) Counts (Mean ± Standard Error) across Locations and Time

Differences in phytoplankton bio-volumes over sampling times and between References locations R1 and R4 were also recorded (Figure 7-21). The reference location R1 recorded notably high bio-volumes of Bacillariophyta and Dinophyta relative to other locations.

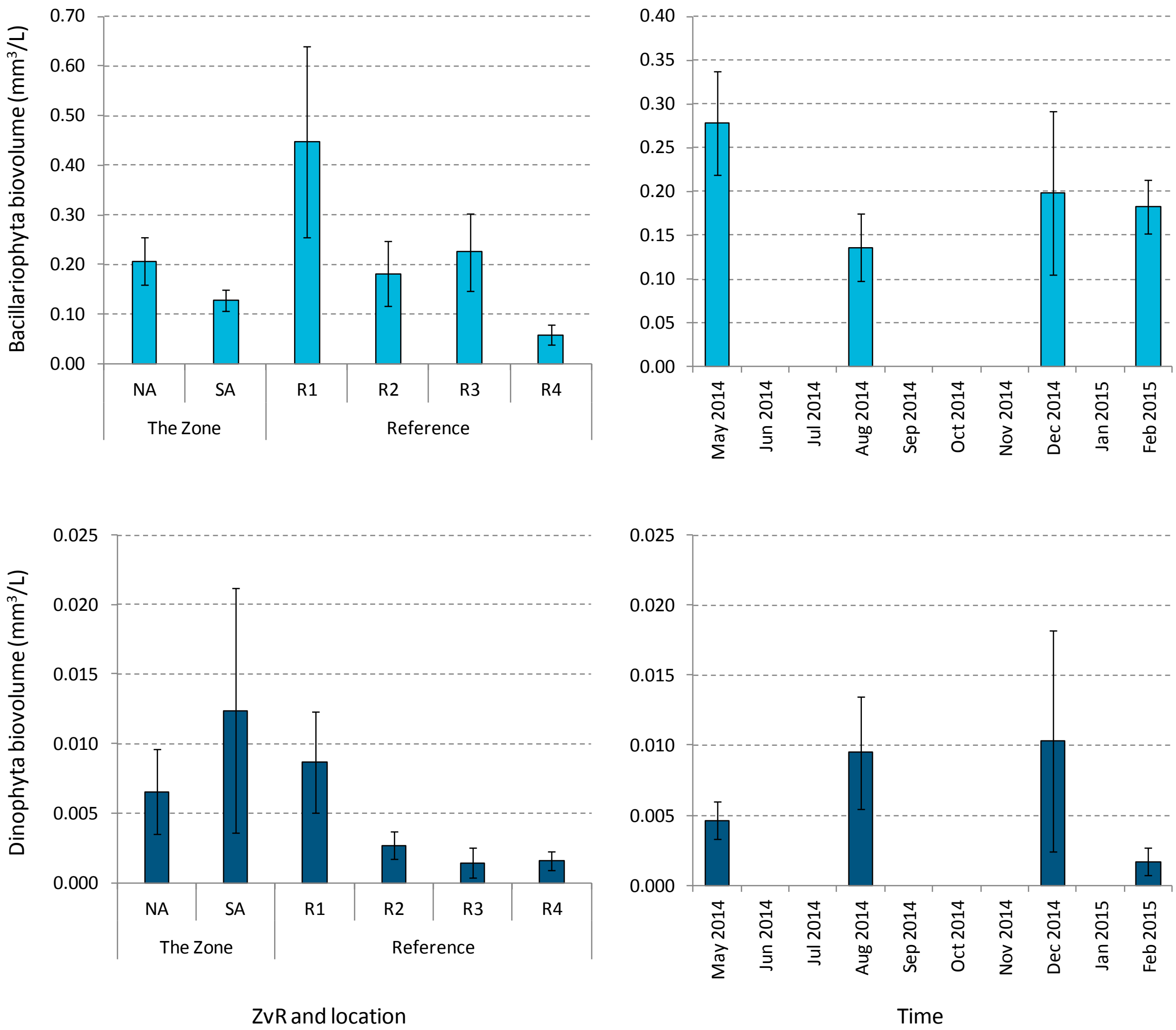


Figure 7-21: Bacillariophyta (Diatoms; Top) and Dinophyta (Dinoflagellates; Bottom) Bio-Volumes (Mean ± Standard Error) across Locations and Time

Total algal and potential toxic algal counts showed differences between locations and sampling times. Differences in algal counts between Reference locations R1 and the other three reference locations (R2, R3 and R4) were recorded. Total algal counts were highest during summer (December 2014; 99.56 cells/millilitre). The greatest counts of potentially toxic algae were recorded during Spring (May 2014; 11.81 cells/millilitre; Figure 7-22).

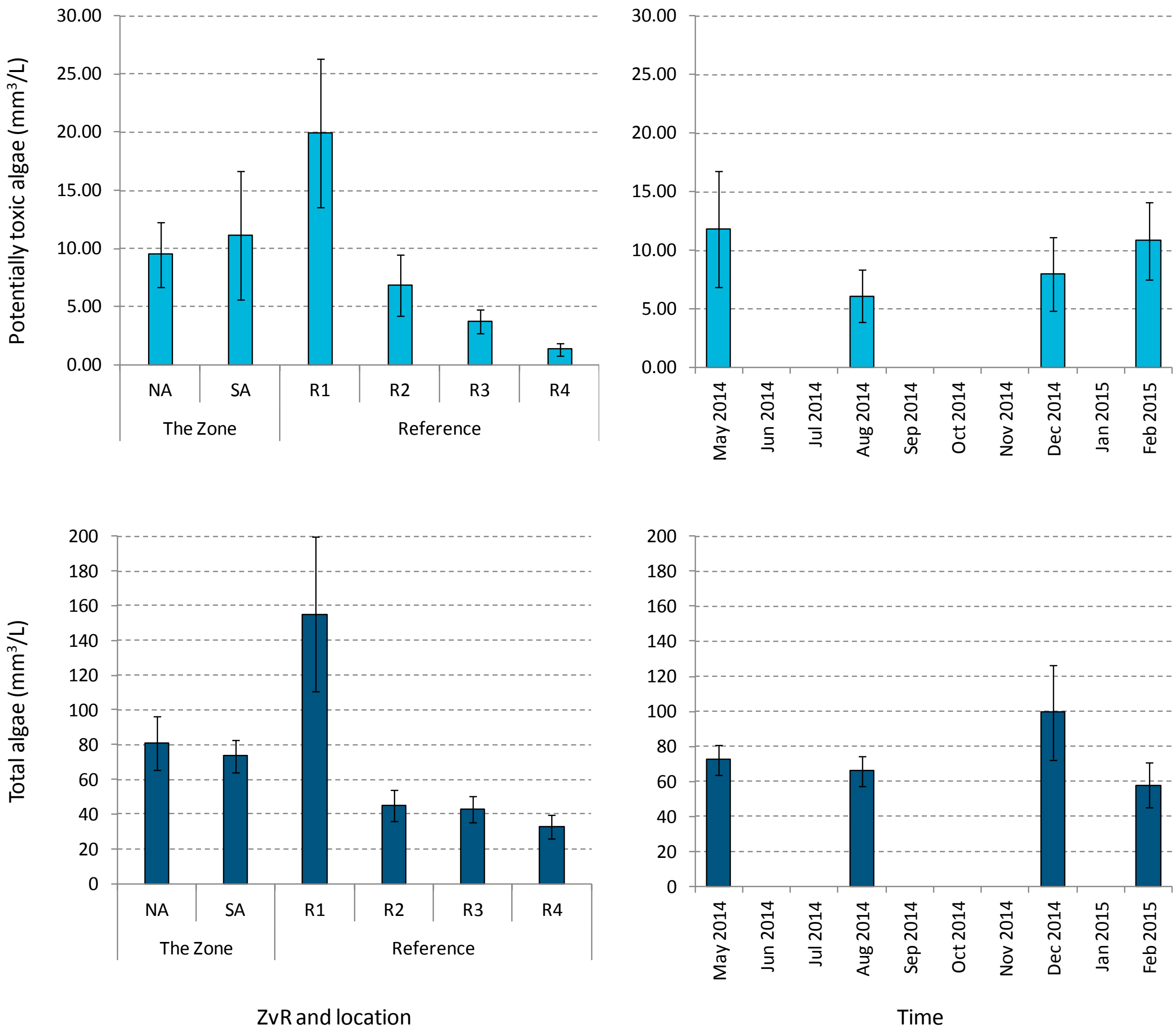


Figure 7-22: Bio-Volumes (Mean ± Standard Error) of Potentially Toxic Algae (Top) and Total Algae (Bottom) across Locations and Time

7.3 Potential Impacts

7.3.1 Organic wastes

Sea cage aquaculture has the potential to impact the sediment when organic wastes settle beneath, or in close proximity to, the sea-cages (Mazzola et al. 2000, Carroll et al. 2003). The deposition of organic material may lead to local organic enrichment or, under worst-case conditions, regional eutrophication. Gray (1992) emphasises that the critical effects of eutrophication are experienced when water column oxygen concentrations become depleted as total community respiration increases due to increased organic loads to the sediments.

Increased nutrient loadings are generally associated with increased episodes of hypoxia (low oxygen) or anoxia (no oxygen). Hypoxia may cause local extinction of benthic populations (Gaston & Edds 1994) and changes in benthic communities (Pearson & Rosenberg 1978, Josefson & Jensen 1992, Hargrave et al. 2008; Hargrave 2010). Changes in communities are typically driven by the sensitivities of infauna, with rare and more sensitive species disappearing first.

More resilient species such polychaetes are known to be resistant to hypoxic or near-hypoxic conditions (Pearson & Rosenberg 1978, Gray 1992, Dauer et al. 1992). Sediment infauna communities generally becomes increasingly degraded (diversity of benthic fauna is significantly reduced) as levels of organic enrichment are increased.

Although finfish farming has the potential to impact sediments beneath, and immediately adjacent to sea cages (Carroll et al 2003), impacts are generally restricted to within 10–100 m of sea cages. 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). The current speeds in the MWADZ are conducive to conditions described as either “moderately” or “not sensitive” to impact on the seafloor sediments and associated communities (Appendix 1).

7.3.2 Inorganic nutrients

Finfish aquaculture in open water sea cages may, in some instances, cause deterioration in local water quality due to inputs of inorganic nutrients from fish faeces and uneaten food. Aquaculture may contribute inorganic nutrients to the water column either directly through secretion of ammonia by fish, or indirectly through organic matter deposition and remineralisation. Inorganic nutrients in the form of ammonia, nitrite + nitrate and phosphate may lead to adverse environmental effects via a number of cause-effect pathways, all of which lead to impacts on BCH. Increased levels of nutrients such as ammonia, nitrite + nitrate and phosphate can stimulate plant growth (i.e. phytoplankton levels in the water column could be elevated). However, the water current speeds in the MWADZ are conducive to conditions unlikely to results in impacts to regional water quality (Appendix 1).

7.3.3 Ecosystem nutrient budget

The level of nutrients in the ecosystem is influenced by the release and uptake of substances from seafloor sediments and the flow of oceanic currents through the region. In Abrolhos Islands FHPA, both of these processes are considered to be in balance (in the absence of sea cage aquaculture) relative to other locations [i.e. the existing environment is essentially oligotrophic (naturally low in nutrients)].

The addition of the proposed fish cages causes an imbalance to the natural nutrient budget of the ecosystem, and has been a key subject of investigation in this study. This disturbance takes the form of both an immediate nutrient load to the water column (via waste and feed excess) and a delayed load via impacted sediment nutrients converting back into minerals (Appendix 1). Water current speeds in the MWADZ facilitate the natural assimilative capacity of the ecosystem to maintain acceptable water quality within and surrounding the zone (Appendix 1).

7.3.4 Metals and other contaminants

Toxic effects on marine organisms are likely when metal concentrations exceed certain levels (Parsons 2012); such effects can be intensified via biomagnification. Sources of metals include copper-based anti-foulants, which were historically used on sea-cage infrastructure (Parsons 2012). The use of copper-based anti-foulants will not be permitted within the MWADZ.

Metals form a small constituent of commercial aquaculture feeds as trace elements. The metals are consumed by the stock and excreted in the faeces. The metal content of stock faeces are likely to be highest in zinc and iron, with relatively low proportions of copper; however the concentrations of these elements are not expected to build up in the sediments of the MWADZ (Appendix 1).

Occasionally, when required to manage any incidence of bacterial disease, antibiotics are used to treat the stock. Generally, the antibiotics are administered via the stock feed. Antibiotics may impart pressure on the marine environment by degrading sediment bacterial communities, which in turn could affect their ecological functions. Any concentrations of antibiotics would deplete over several seasons, and are not expected to build up in the sediments of the MWADZ (Appendix 1).

7.4 Assessment of Potential Impacts

7.4.1 Overview

An Integrated Ecosystem Model was used to simulate a total of six scenarios (Scenario 1 – Scenario 6) as per the criteria detailed in Section 6.6.4 and Tables 6-14 and 6-15. Sections 7.4 to 7.6 describe the predicted impacts of each of these scenarios on the marine environment in terms of hydrology, sediments, BCH and regional water quality. Results are described in the context of EAG 3 (EPA 2009) and EAG 7 (EPA 2011), which describe the concepts around acceptable loss of BCH and zones of impact.

7.4.2 Hydrodynamics

Sea cages or any other floating structures at sea invariably impart some resistance to flows acting to slow or deflect waters that surrounds the cages. The effect of MWADZ sea cages on the surrounding hydrodynamic regime was extrapolated using the findings of Wu *et al.* (2014) together with the known characteristics of the MWADZ environment (12–50 metres depth) and the proposed infrastructure (18 metre depth cages).

Generally, current speeds in the lower part of water column (bottom) is expected to increase by approximately 20%, while current speeds within the cages in the upper part of the water column (surface) is expected to reduce by approximately 80%. Modelling indicated that natural current speeds at the bottom were somewhat slower than those at the surface, in both the summer and winter (Table 7-5).

Within the proposed MWADZ, sediment erosion and deposition is affected by shear stress between water currents and the seafloor. The modelling has indicated that this shear stress originates principally from wave action, with current speed a minor influence. While the sea cages potentially increase the speed of the currents near the seabed by 20%, it is not expected that this will substantially affect the erosion of the seafloor sediments beneath the sea cages.

Table 7-6: Current Speeds through the MWADZ before and after the Introduction of Sea Cage Infrastructure

	Summer		Winter	
	Surface	**Bottom**	**Surface**	**Bottom**
Before the introduction of sea cages	8.7–14.1 cm/s	5.8–11.0 cm/s	10.5–14.5 cm/s	6.1–11.5 cm/s
After the introduction of sea cages	1.8–2.8 cm/s	6.9–13.2 cm/s	2.1–3.0 cm/s	7.3–13.8 cm/s

7.4.3 Seafloor Sediments

An integrated ecosystem model (Section 6.7) was used to determine the distribution and impacts of organic wastes leaving the sea cages. Deposition of organic waste at the seafloor was referred to as "organic deposition", expressed in terms of millimoles of carbon per metre squared per year. Organic deposition was used as a surrogate for organic enrichment of the sea floor sediment and as an indicator of potential secondary effects including deoxygenation and accumulation of sulphides in the seabed. EAG 7 was applied with consideration to the potential secondary effects relating to sediment dissolved oxygen and sulphide content of the sediments (Section 7.4.1.4). The results of the modelling of organic deposition are reported here to provide context for the potential secondary effects of organic enrichment.

Accumulation of organic material occurred under each of the scenarios, and commenced rapidly once production has commenced. Organic deposition beneath sea cages was observed to build rapidly, even under biomasses much lower than those modelled here (less than 1,000 tonnes of stock per 14-cage cluster; Appendix 1). Figures 7-21 to 7-24 show the predicted rate of organic deposition at the seafloor, under a range of scenarios (S5, S1, S6 and S2), after twelve months of continuous finfish production. Organic deposition increased with increasing standing biomass (Scenario 5 and Scenario 6 are greater than Scenario 1 and Scenario 2; Figures 7-21 to 7-24) and increasing stocking density (Scenario 6 is greater than Scenario 5, and Scenario 2 is greater than Scenario 1; Figures 7-21 to 7-24). Organic deposition levels greater than background were detectable beneath and near to the sea cages in each of the modelled scenarios. The highest organic depositional values beneath the sea cages corresponded with the highest levels of standing biomass (Scenario 5 is greater than Scenario 1, and Scenario 6 is greater than Scenario 2).

Modelling showed an intense (highly concentrated) deposition of organic waste that is mainly confined to the area of seafloor immediately beneath the sea cages. The highest organic deposition concentrations were immediately beneath the sea cage clusters. The confinement of the majority of organic deposition to the area immediately beneath the sea cages is indicated in the colour change from light blue to red between Scenario 2 (15,000 tonnes) and Scenario 6 (30,000 tonnes), representing a change in organic deposition that is more than seven-fold higher (Figures 7-23 and 7-24). Areas beyond the sea cage clusters maintained similar levels of organic deposition, despite an increase in standing biomass.

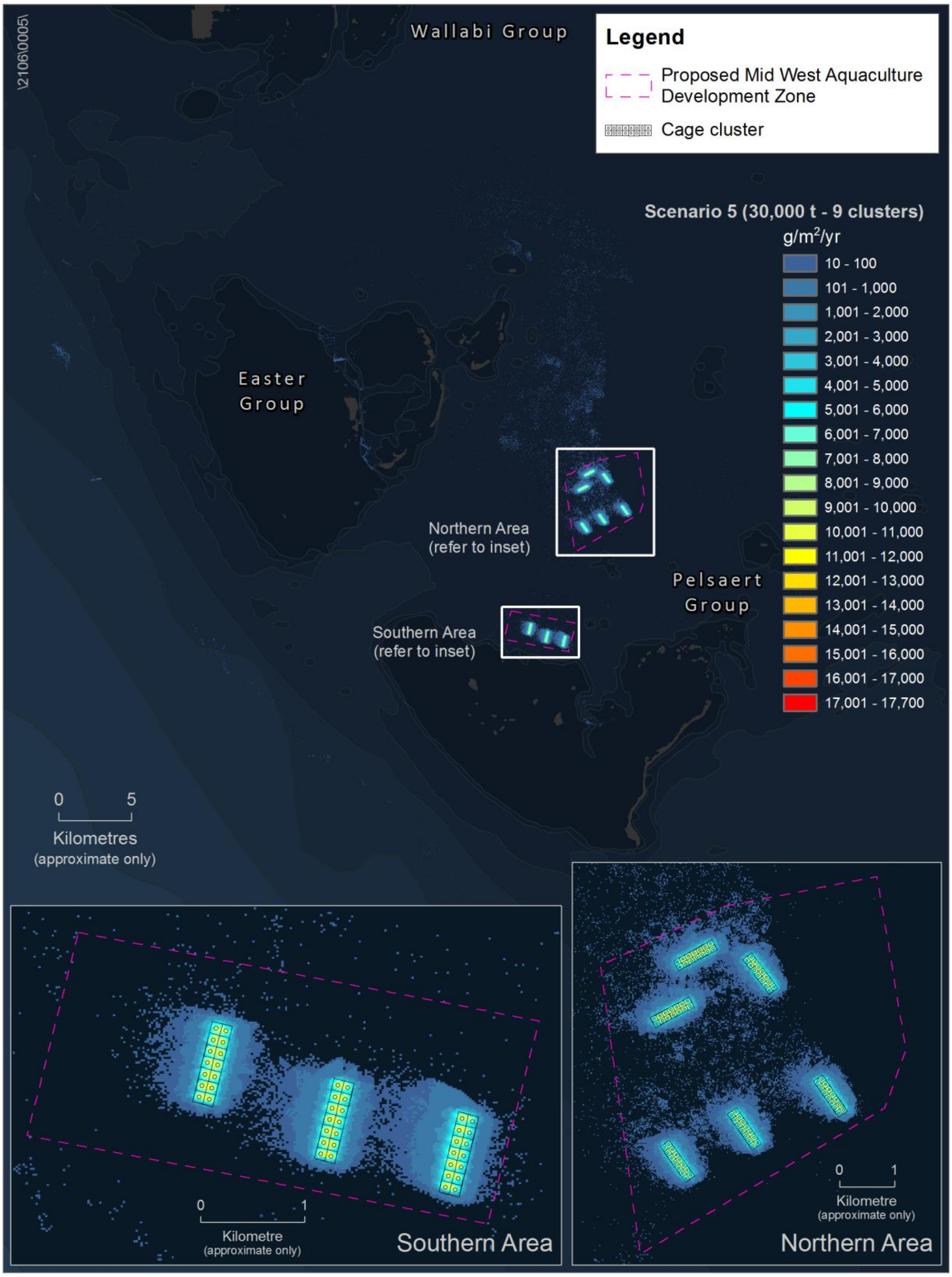


Figure 7-21: Inputs of Organic Carbon under Scenario 5 (30,000 tonnes over 9 clusters)

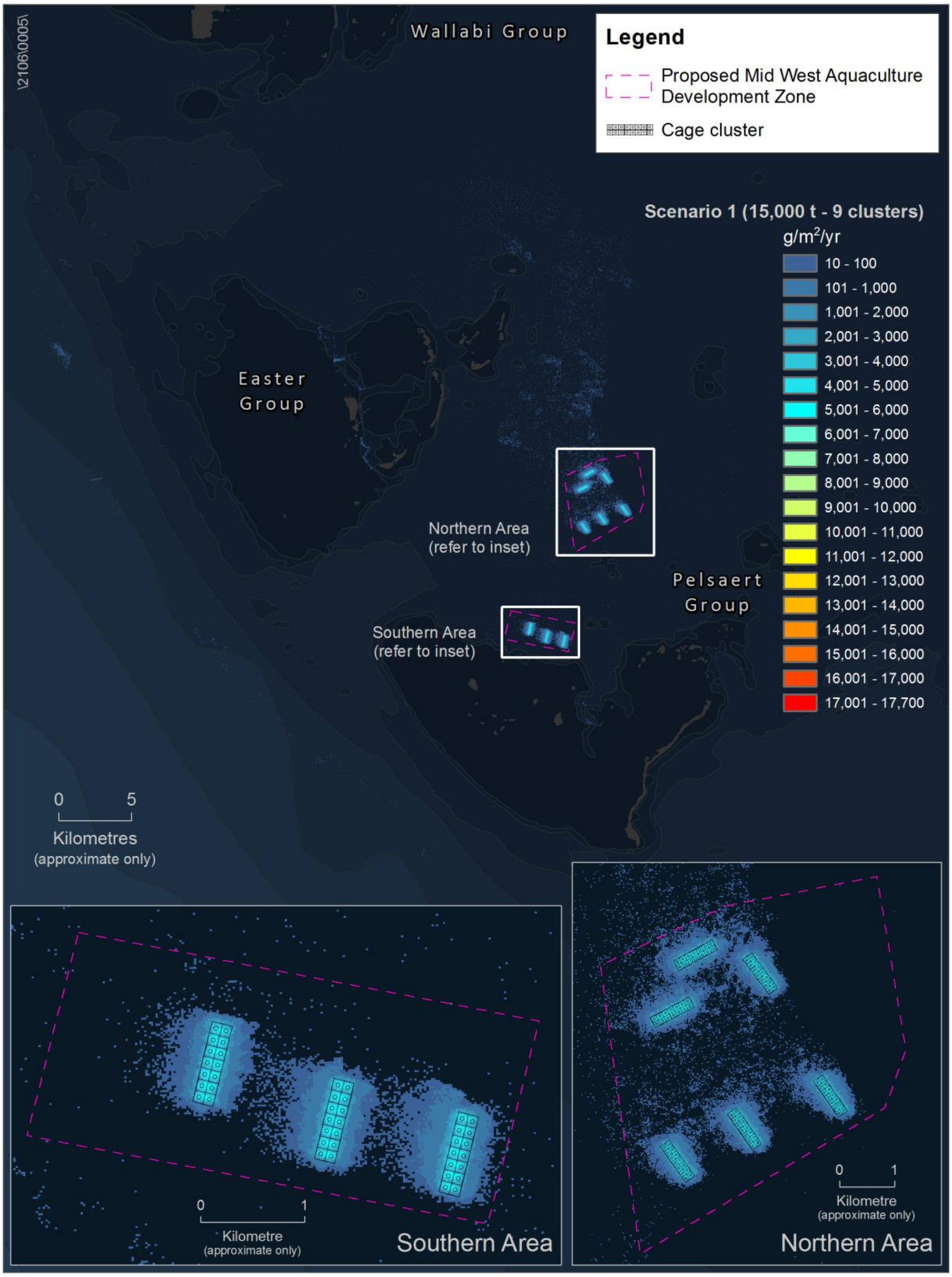


Figure 7-22: Inputs of Organic Carbon under Scenario 1 (15,000 tonnes over 9 clusters)

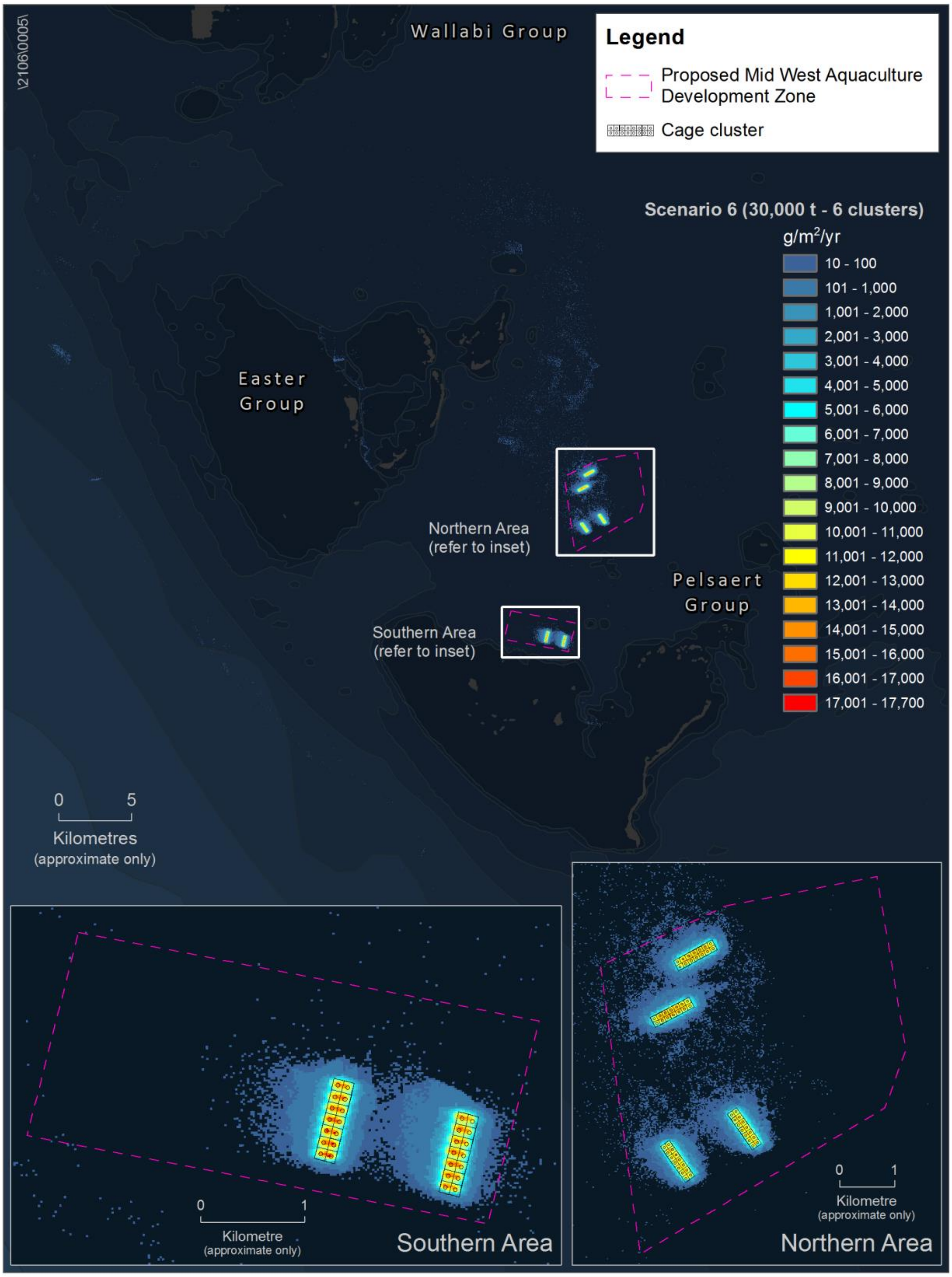


Figure 7-23: Inputs of Organic Carbon under Scenario 6 (30,000 tonnes over 6 clusters)

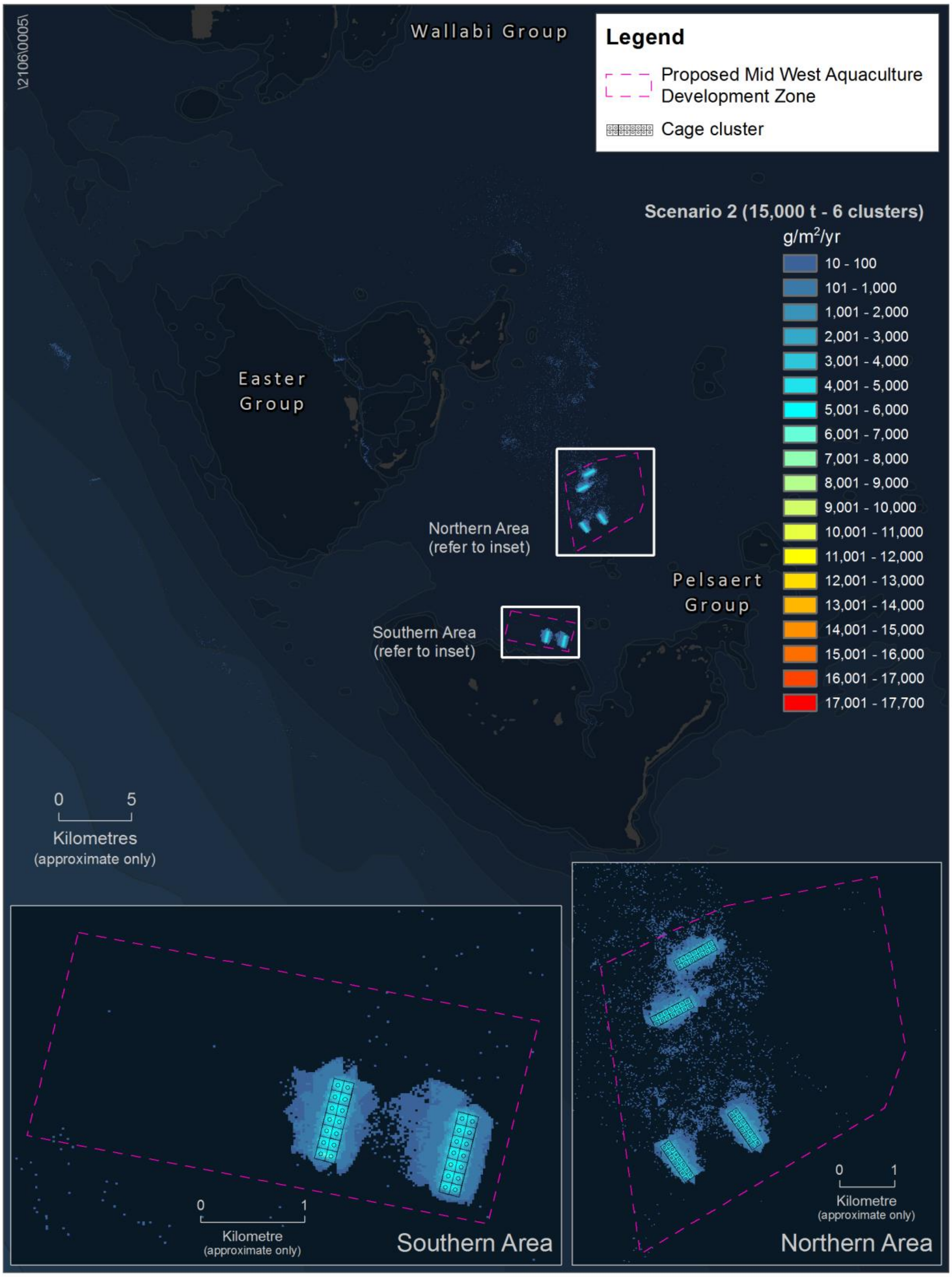


Figure 7-24: Inputs of Organic Carbon under Scenario 2 (15,000 tonnes over 6 clusters)

7.4.3.1 Dissolved Oxygen and Sulphide Content of the Sediment

Applying the criteria in EAG 7 (EPA 2011), spatial extents of three zones of impact were determined (Figure 7-25 to Figure 7-30).

After three and five years of finfish production across the full range of production scenarios (Table 6-15) the modelling identified zones of impact and influence based on the time required for oxygen and sulphide concentrations in the sediment to return to baseline levels. In accordance with EAG 7, habitats requiring greater than five years to recover to baseline levels were designated zones of "high" impact (ZoHI - red colouration), and habitats requiring less than five years were designated zones of "moderate" impact (ZoMI - amber colouration). Areas expected to receive waste, but not in concentrations great enough to alter the sediment chemistry, were designated zones of "influence" (ZoI - green colouration). Areas classified as ZoI are expected to maintain sediment oxygen and sulphide levels that are equivalent to sites located beyond the influence of aquaculture activities, and therefore not impacted.

7.4.3.2 Dispersed Effects – Nine Cage Clusters

The aerial extent of the ZoHI, ZoMI and ZoI in Scenario 1, Scenario 3 and Scenario 5, are illustrated in Figure 7-25 to Figure 7-30 and outlined (in hectares) in Table 7-6. These three scenarios captured the effect of spreading the stock (standing biomass) across a total of nine cage clusters (simulating a "dispersed" effect). The effect of concentrating the stock standing biomass across a reduced number of cage clusters (six) is explored in the subsequent section.

ZoHI were observed in Scenario 1, Scenario 3 and Scenario 5 after three and five year's production. The area occupied by the ZoHI increased in response to increasing standing biomass and the length of finfish production (Table 7-6). After five year's continuous production the ZoHI (as indicated by the red coloured pixels in Figure 7-25, Figure 7-27 and Figure 7-29) extended respectively ~70 metres, ~55 metres and ~40 metres from the cage cluster boundaries in Scenario 5, Scenario 3 and Scenario 1, as measured along the maximum radius down-current from the cage clusters.

The aerial extent of the ZoHI was smaller in the northern area relative to the southern area. This is likely a result of the higher current speeds in the northern MWADZ area, which when simulated in the model, imparted a strong influence on the transportation of depositing particles and resuspension. Both processes, particle transport and resuspension, affected the retention of organic material near the sea cages. Particles tended to disperse under higher current speeds, but tended to sink, deposit and remain close to the sea cages under lower current speeds. This is reflected in Figure 7-25 to Figure 7-30 by the greater spread of particles away from the sea cages in the northern MWADZ area and a tendency of organic deposition to be concentrated, resulting in more intense impacts beneath the cages in the southern MWADZ area.

ZoMI (as indicated by the amber coloured pixels in Figure 7-25 to Figure 7-30) were observed in all scenarios irrespective of the length of the aquaculture production period. With some exceptions, the area occupied by the ZoMI increased with increasing stock standing biomass and increasing length of production; however, the changes were less dramatic than those predicted for the ZoHI. For example, the area occupied by the ZoHI over the range of model settings was between one hectare and 177 hectares, representing an entire order of magnitude increase; whereas the area occupied by the ZoMI over the same modelling treatments was between 239 hectares and 349 hectares, representing a smaller increase (less than an order of magnitude change).

The ZoI (as indicated by the green coloured pixels in Figure 7-25 to Figure 7-30) was the largest (in area) and the most dispersed of the three impact categories. In the northern area of the MWADZ, the higher current speeds acted to increase the dispersion of organic particles, which in turn increased the area occupied by the ZoI. The prevailing north-westerly currents in the northern area of the MWADZ are reflected in the dispersal of particles to the north-west and away from the sea-cages. In the southern area of the MWADZ, the ZoI was generally more constrained and centred on the individual cage clusters. Dominant westerly currents in the southern area of the MWADZ resulted in a tendency for particles to disperse to the west of the cage clusters.

Table 7-6: Areas Occupied by the Zones of High and Moderate Impact and the Zone of Influence under Scenarios S1, S3 and S5 after three and five year's Production

Years of production	Scenario No.	Standing biomass (t)	ZoHI (ha)	ZoMI (ha)	ZoI (ha)
5	S1	15,000	117	239	1,150
	S3	24,000	132	235	1,005
	S5	30,000	177	270	1,226
3	S1	15,000	1	346	1,159
	S3	24,000	11	349	1,012
	S5	30,000	105	334	1,235

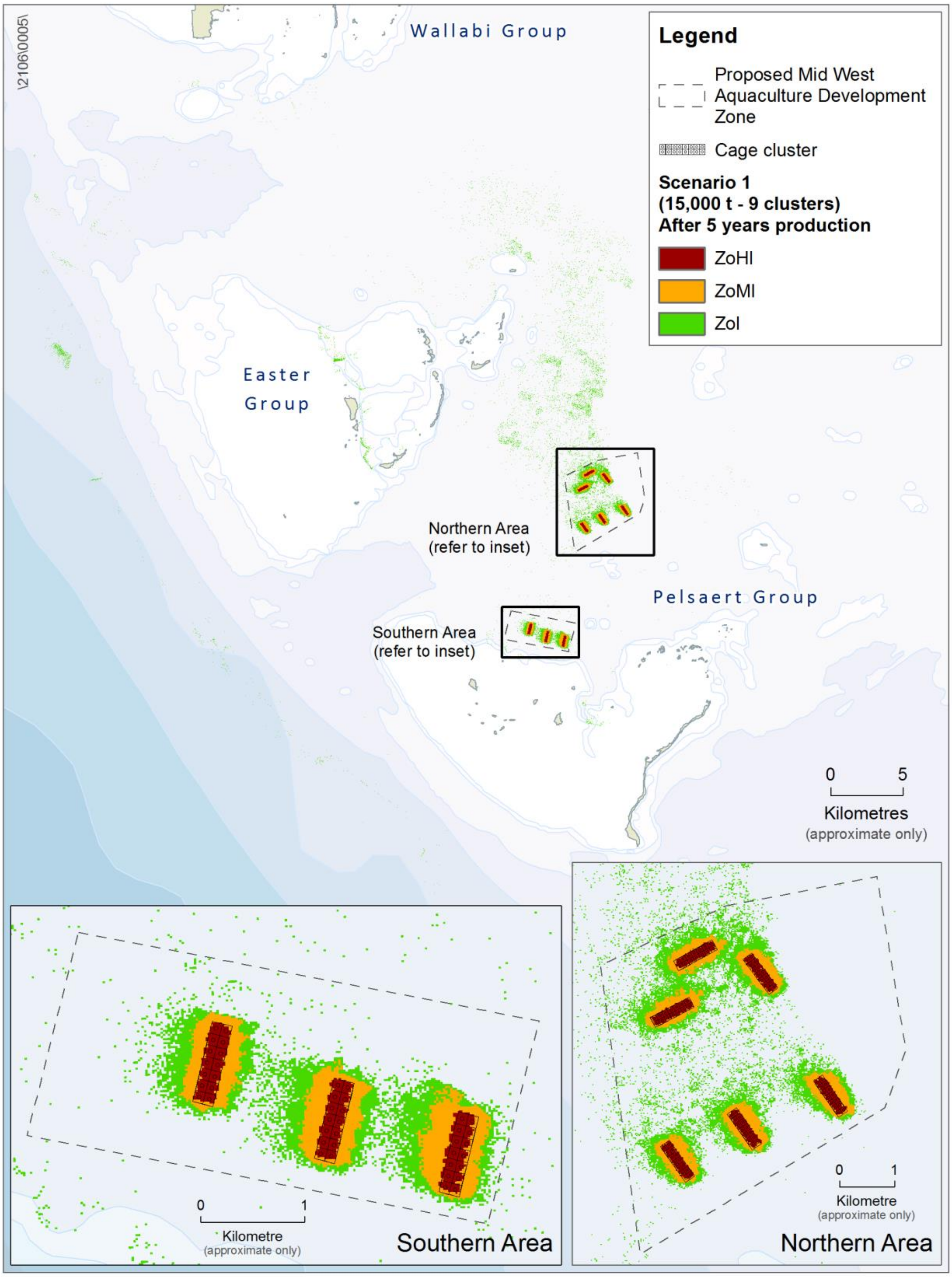


Figure 7-25: Zones of Impact under Scenario 1 (15,000 tonnes) after five years of production

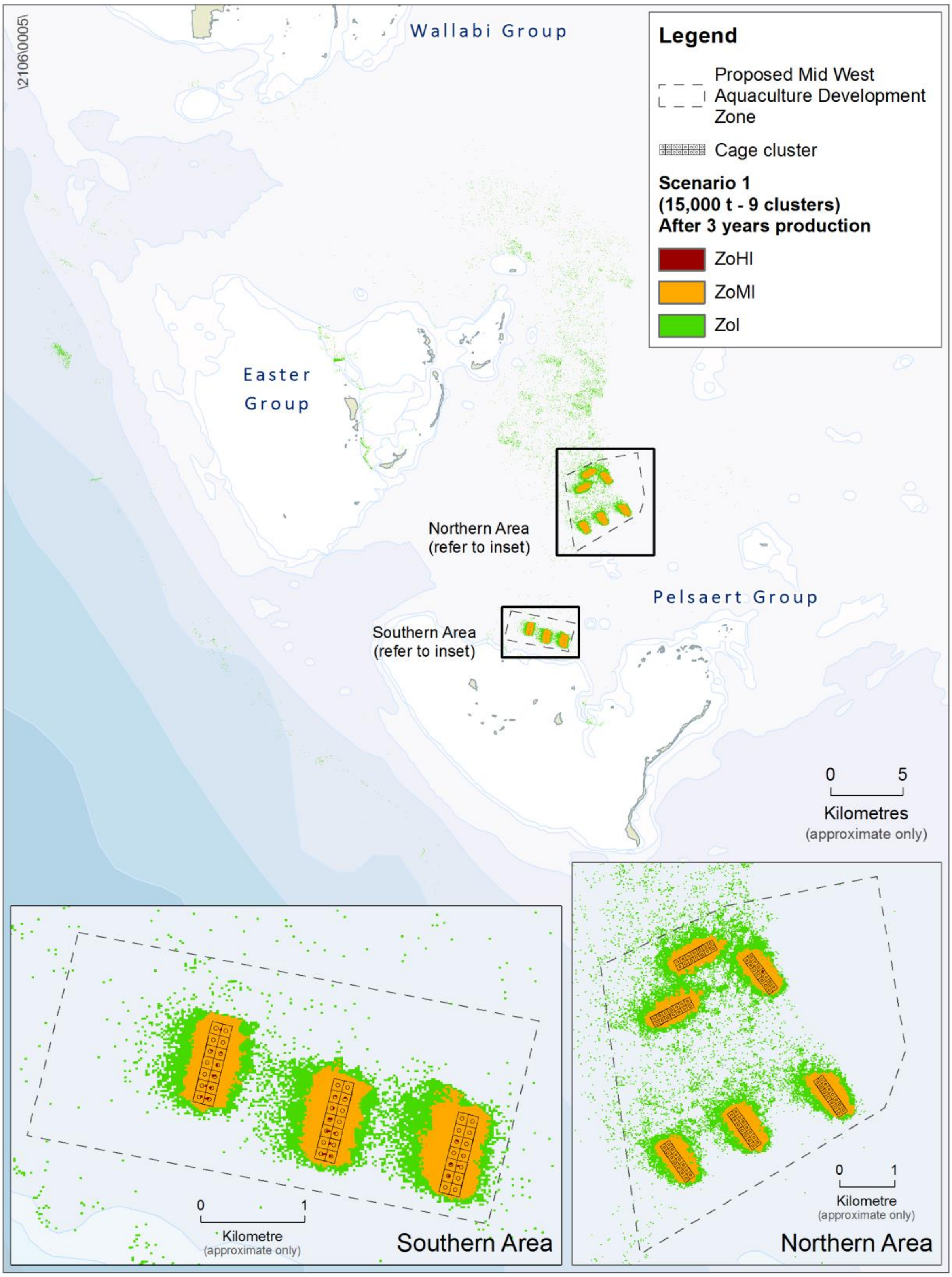


Figure 7-26: Zones of Impact under Scenario 1 (15,000 tonnes after three years of production

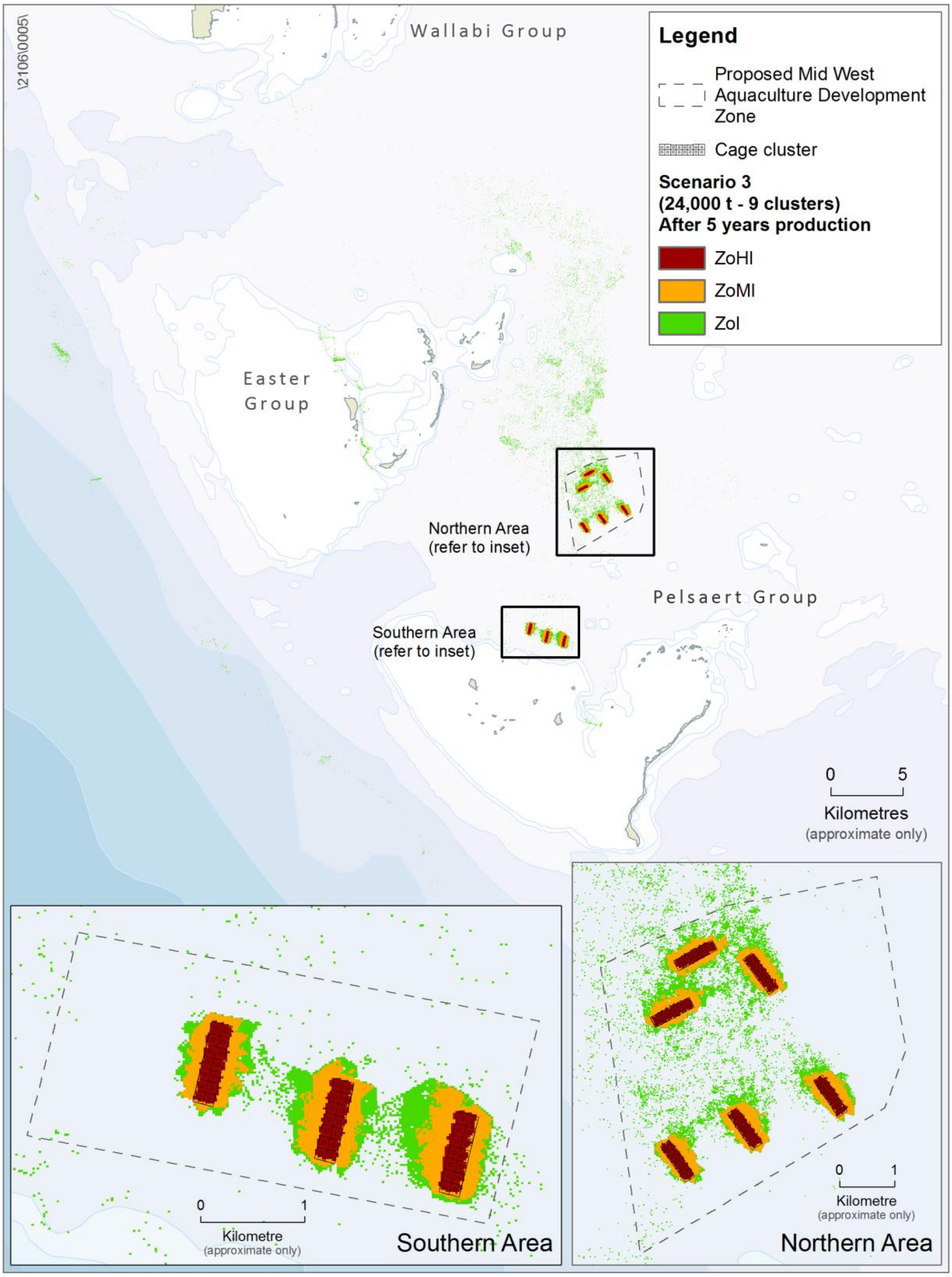


Figure 7-27: Zones of Impact under Scenario 3 (24,000 tonnes after five years of production

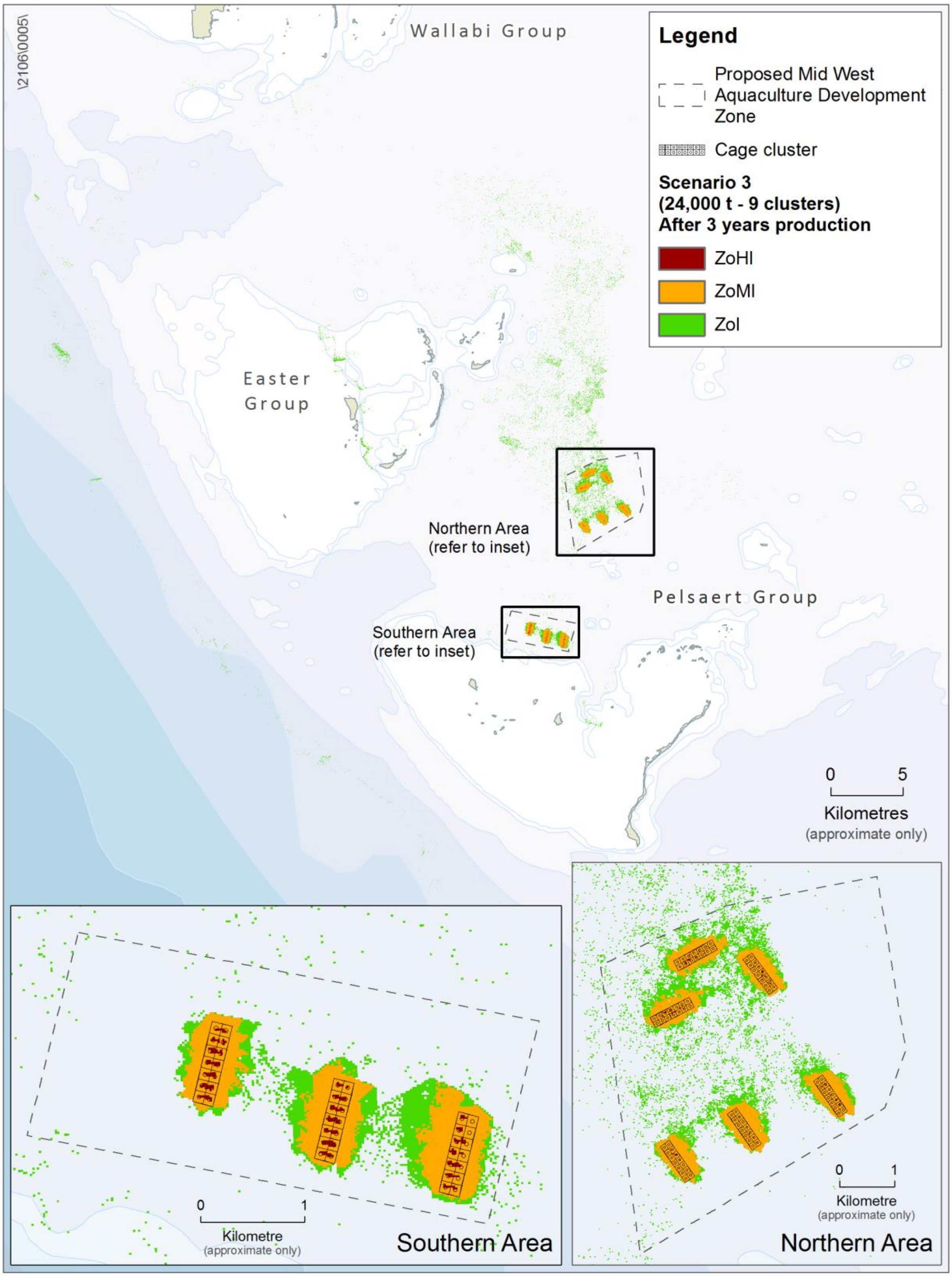


Figure 7-28: Zones of Impact under Scenario 3 (24,000 tonnes) after three years of production

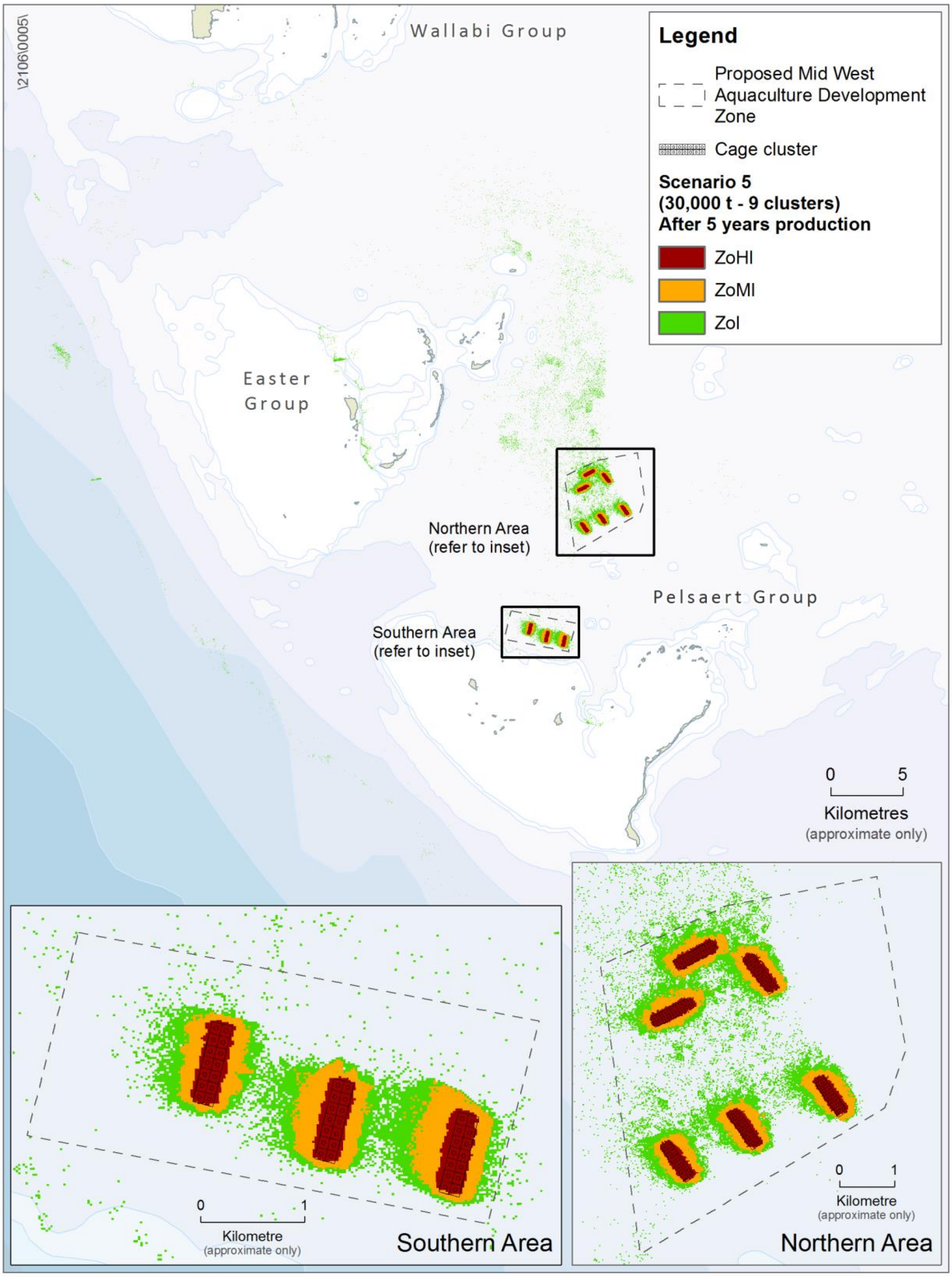


Figure 7-29: Zones of Impact under Scenario 5 (30,000 tonnes) after five years of production

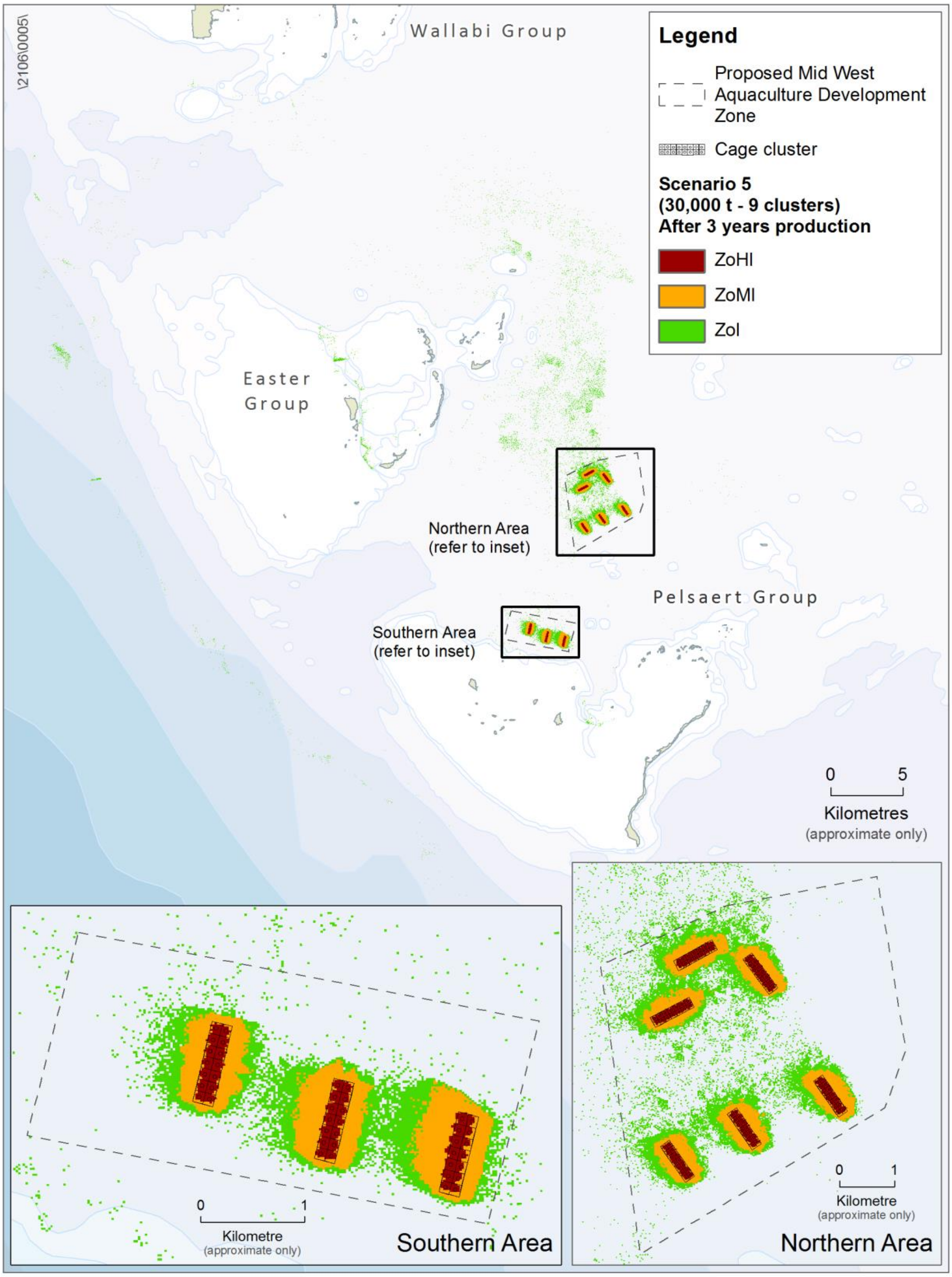


Figure 7-30: Zones of Impact under Scenario 5 (30,000 tonnes) after three years of production

7.4.3.3 Concentrated effects - six cage clusters

The aerial extent of the ZoHI, ZoMI and ZoI, in Scenario 2, Scenario 4 and Scenario 6 is illustrated in Figure 7.31 to Figure 7.36 and outlined (in hectares) in Table 7-7. These scenarios captured the effect of concentrating the standing biomass across a total of six cage clusters, three less than in the "dispersed" effects simulations (described in the chapter above).

As with the results for the "dispersed effects", the ZoHI (as indicated by the red coloured pixels in Figure 7.31 to Figure 7.36) increased with standing biomass and the length of finfish production. Zones of high impact were observed in Scenario 6, Scenario 4 and Scenario 2 after five and three years of production.

Significant reductions in the areas of the ZoHI were achieved by reducing the length of production from five to three. For example, by reducing the length of production from five to three years, close to a 100% reduction was achieved in Scenario 2, a 45% reduction was achieved in Scenario 4 and a 31% reduction was achieved in Scenario 6. Greater reductions were achieved for the dispersed effects scenarios, Scenario 1, Scenario 3 and Scenario 5: corresponding to reductions of 100% for Scenario 1, 92% for Scenario 3 and 41% for Scenario 6 (Table 7-6 and Table 7-7).

Reductions in both the standing biomass and the length of production also reduced the maximum extent of the ZoHI, as measured along the maximum radius down-current from the cage clusters. After five years continuous production, the ZoHI (as indicated by the red coloured pixels in Figure 7.31 to Figure 7.36) extended ~110 metres, ~60 metres and ~50 metres from the cage cluster boundaries in Scenario 6, Scenario 4 and Scenario 2 respectively. However, the maximum distances reduced after three years production: with predictions of 10 metres under Scenario 4, and 55 metres under Scenario 6. Under Scenario 2, the ZoHI did not breach the area beneath the cage cluster.

Increasing the stocking density while maintaining the standing biomass (i.e. stocking density in Scenario 4 was greater than the stocking density in Scenario 3; standing biomass for Scenario 4 was equal to standing biomass Scenario 3) had the effect of reducing the total area occupied by the ZoHI across the zone. This effect was particularly strong after five years production (Table 7-6 and 7-7), but less so after three years production. For example, after five years the total area occupied by the ZoHI was 177 hectares and 139 hectares for Scenario 5 and Scenario 6, respectively; 132 hectares and 113 hectares for Scenario 3 and Scenario 4 respectively; and 117 hectares and 82 hectares for Scenario 1 and Scenario 2, respectively. After three years production, the results were more variable: the total area occupied by the ZoHI was higher in Scenario 2 (two hectares) relative to Scenario 1 (one hectare); higher in Scenario 4 (62 hectares) relative to Scenario 3 (11 hectares) but lower in Scenario 6 (95 hectares) relative to Scenario 5 (105 hectares).

Reducing the number of cage clusters also reduced the total area occupied by the ZoMI and the ZoI. By reducing the number of cage clusters, reductions in the footprints of both zones were achieved irrespective of the standing biomass or the production period modelled (Table 7-6 and Table 7-7). This is a useful finding indicating that reductions in the spatial extent of impacts, as measured under EAG 7 (ZoHI, ZoMI and ZoI), can be achieved by concentrating finfish in individual cage clusters, without a corresponding need to reduce the total standing biomass across the zone. It was noted, however, that while the spatial extent of the impacts can be reduced based on the criteria in EAG 7, the effect of this is to increase the intensity of impacts immediately under the sea cages. Intensifying the impacts, as Scenario 2, Scenario 4 and Scenario 6, translate to longer recovery periods, as shown in Figure 7.31 to Figure 7.36. The difference in the areas occupied between the dispersed (9 clusters) and concentrated (6 clusters) scenarios is shown in (Table 7-6 and Table 7-7), and illustrated in Figure 7-31 to Figure 8-36.

As observed in Scenario 1, Scenario 3 and Scenario 5, the area occupied by the ZoHI in Scenario 2, Scenario 4 and Scenario 6 also increased in response to increasing standing biomass and the length of finfish production. Zones of high impact were observed in Scenario 6, Scenario 4 and Scenario 2 after five and three years of production. The area occupied by the ZoHI in Scenario 2 after two years production was marginal at less than 1 hectare (Figure 7.31 to Figure 7.36).

The area occupied by the ZoHI after three and five years production increased proportionally with increases in standing biomass, increasing from 82 hectares in Scenario 2 to 139 hectares in Scenario 6 after five years, two hectares in Scenario 2 to 95 hectares in Scenario 6 after three years. Similar increases were apparent with the ZoMI, which increased in size from 160 hectares in Scenario 2 to 203 hectares in Scenario 6, after five years. The area occupied by the ZoI was also observed to increase in response to increasing standing biomass, reaching a maximum coverage in Scenario 6, irrespective of the length of production (Table 7-7).

Significant reductions in the areas of the ZoHI were achieved by reducing the length of production from five to three. For example, by reducing the production period from five to three years close to 100% reductions were achieved in Scenario 2, 45% reductions were achieved in Scenario 4 and 31% reductions were achieved in Scenario 6. Greater reductions were achieved for the dispersed effects; Scenario 1, Scenario 3 and Scenario 5: corresponding to reductions of 100% for Scenario 1, 92% for Scenario 3 and 32% for Scenario 6.

Table 7-7: Areas occupied by the zones of high and moderate impact and the zone of influence under scenarios S2, S4 and S6 after 3 and five years production

Years of production	Scenario No.	Standing biomass (t)	ZoHI (ha)	ZoMI (ha)	ZoI (ha)
5	S2	15,000	82	160	616
	S4	24,000	113	173	697
	S6	30,000	139	203	861
3	S2	15,000	2	234	621
	S4	24,000	62	219	701
	S6	30,000	95	241	868

Note:
ZoHI = zone of high impact, ZoMI = zone of moderate impact, ZoI = zone of influence

The ZoMI (as indicated by the amber coloured pixels in (Figure 8-13 to Figure 8-18) were observed in all scenarios irrespective of the length of the production period. The ZoMI was restricted to the area immediately adjacent to the sea cage clusters, but extended further than the ZoHI. As with the ZoHI, the area occupied by the ZoMI increased with increasing standing biomass and the length of production; however, the changes were less distinct than those observed for the ZoHI. Unlike the ZoHI, which was near absent in Scenario 2 after three years production, moderate impacts were detected irrespective of the model settings.

The ZoI (as indicated by the green coloured pixels in Figure 7.31 to Figure 7.36) was the largest (in area) and the most dispersed of the three impact categories. In the northern area of the proposed MWADZ, the higher current speeds acted to increase the dispersion of organic particles, which in turn increased the area occupied by the ZoI. The prevailing north-westerly currents in the northern area of the MWADZ are reflected in the north-westerly dispersion of the ZoI away from the sea cages. In the southern area of the MWADZ, the ZoI was generally more constrained, and centred on the individual cage clusters. Refer to the Modelling and Technical Studies (Appendix 1) for further details in relation to the modelling.

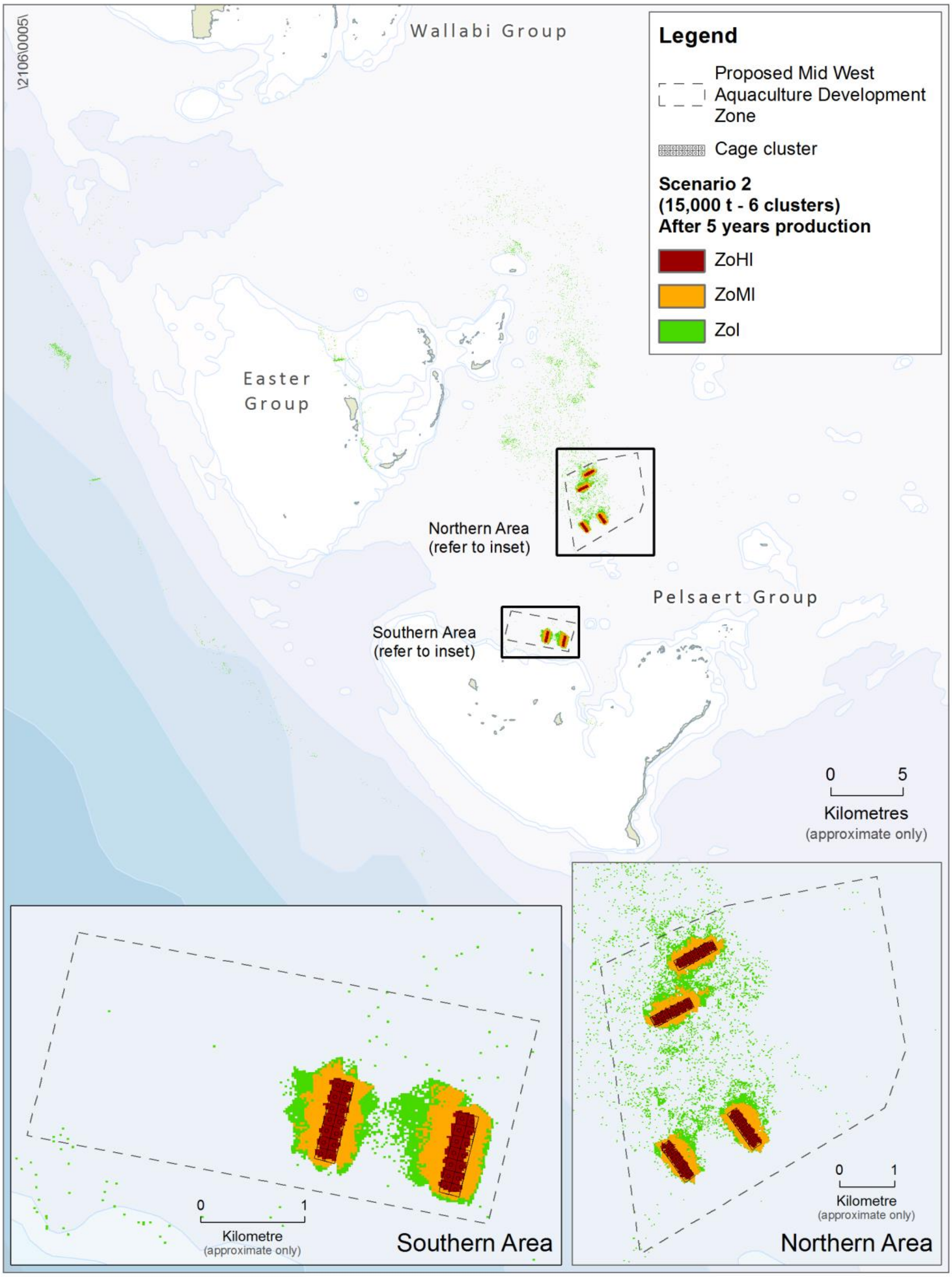


Figure 7-31: Zones of Impact under Scenario 2 (15,000 tonnes) after five years of production

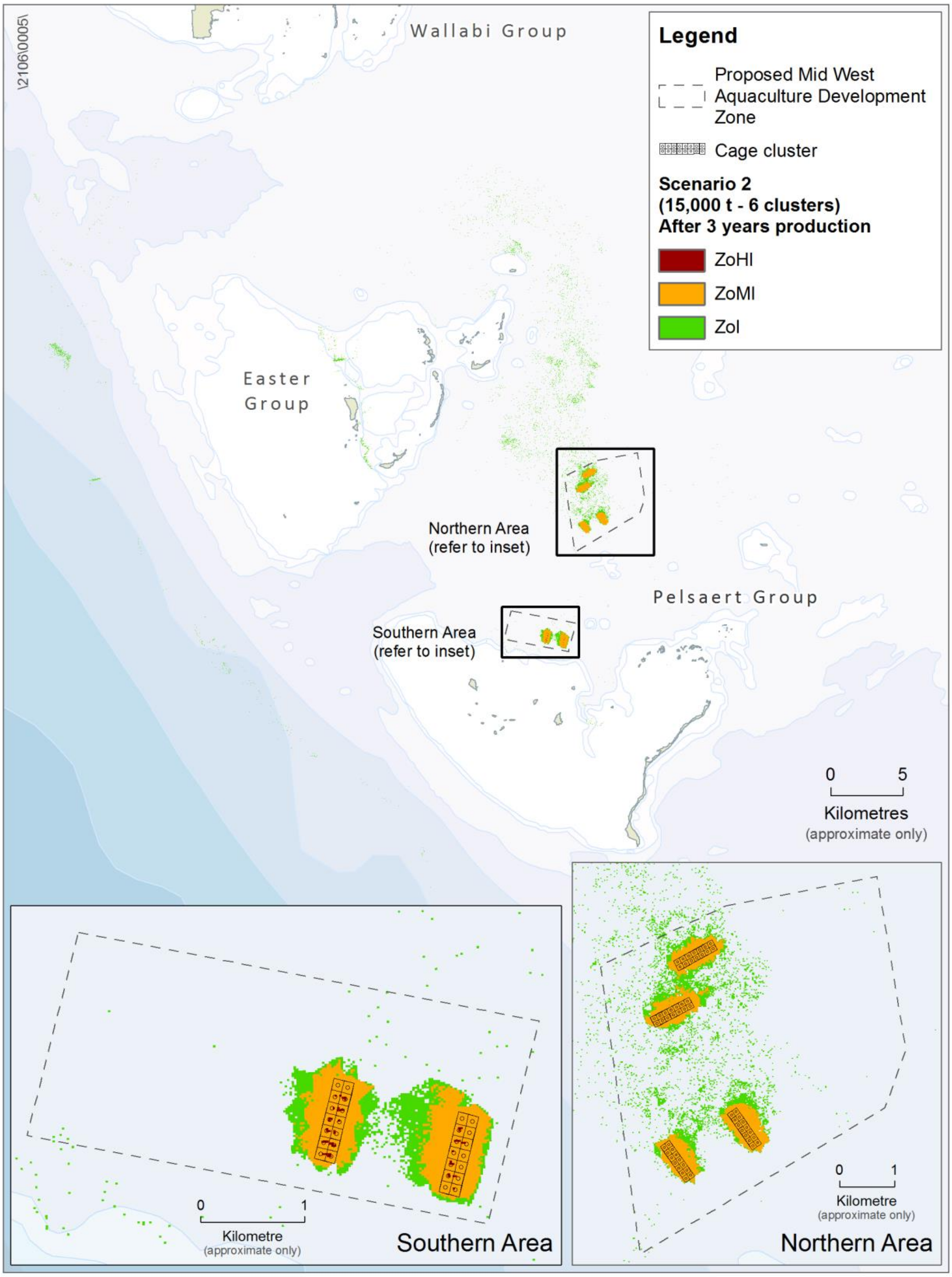


Figure 7-32: Zones of Impact under Scenario 2 (15,000 tonnes) after three years of production

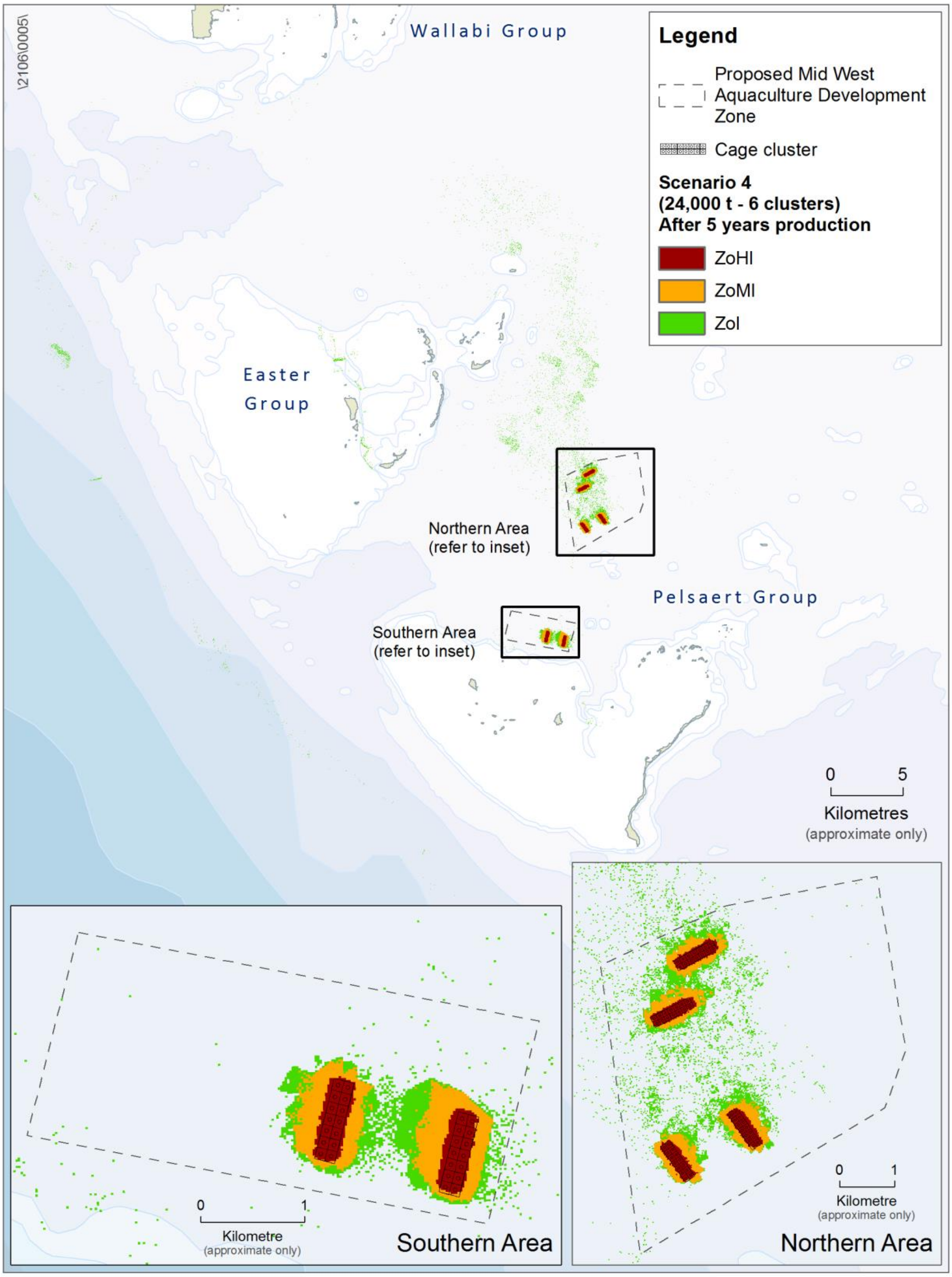


Figure 7-33: Zones of Impact under Scenario 4 (24,000 tonnes) after five years of production

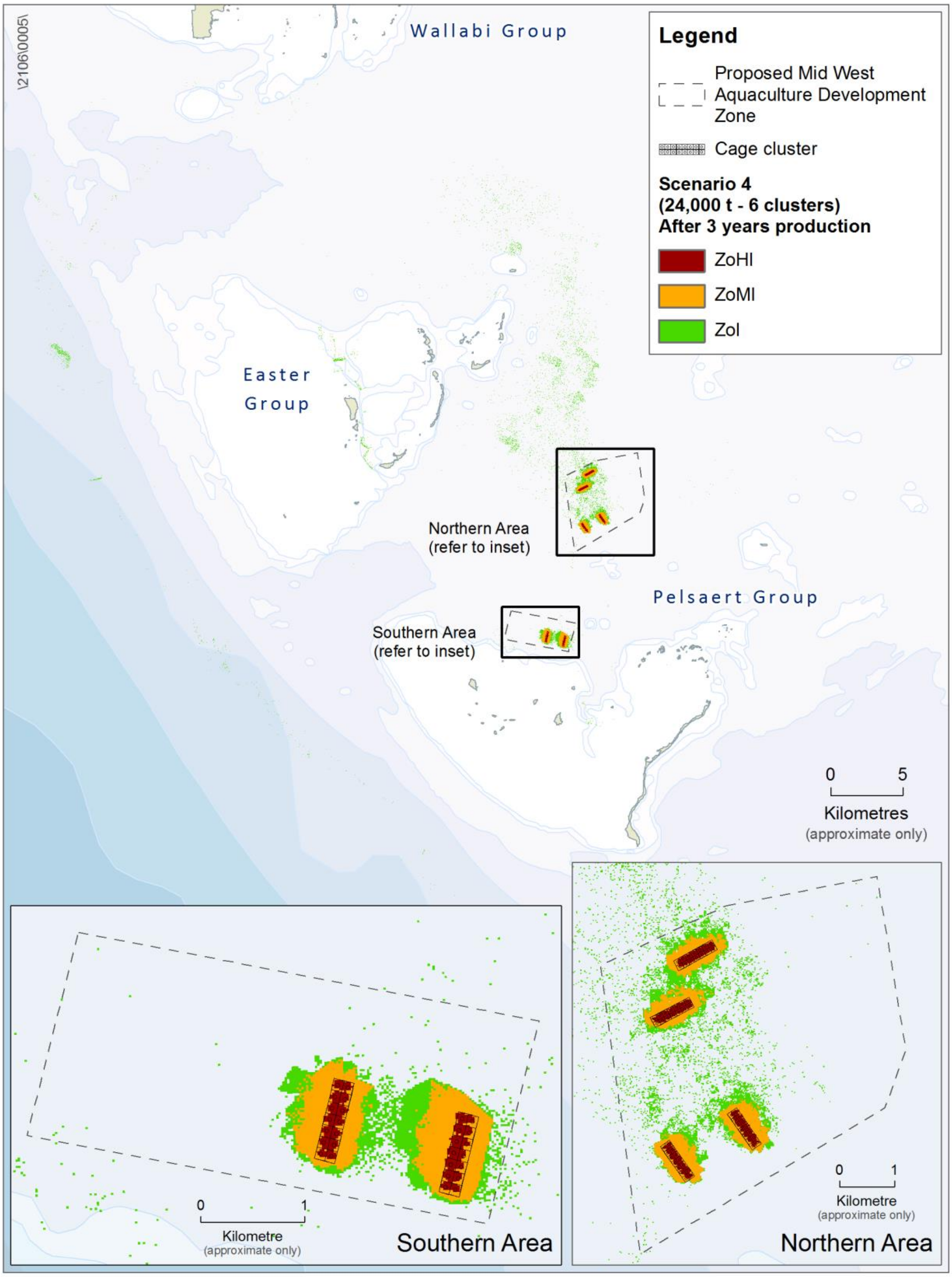


Figure 7-34: Zones of Impact under Scenario 4 (24,000 tonnes) after three years of production

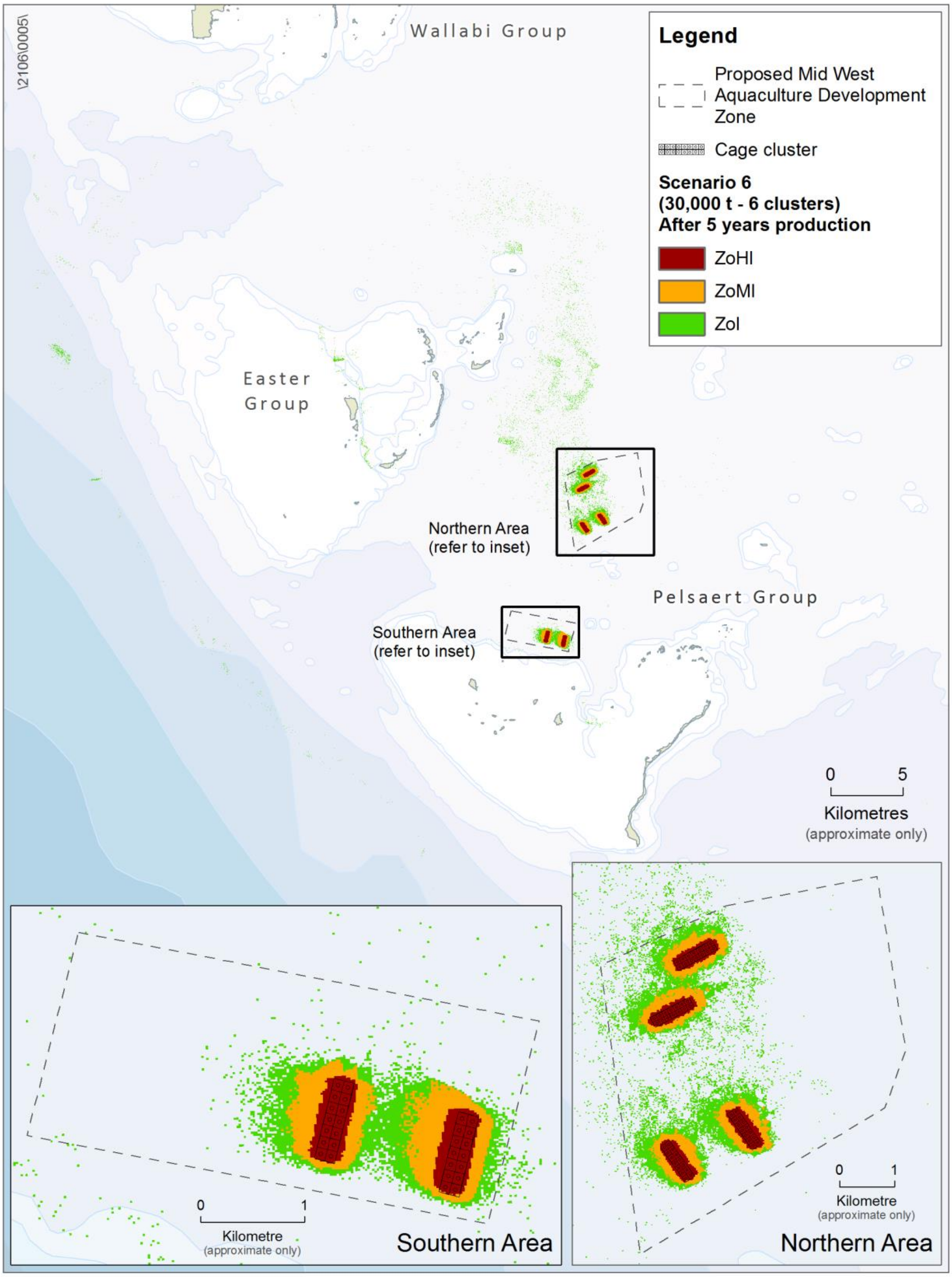


Figure 7-35: Zones of Impact under Scenario 6 (30,000 tonnes) after five years of production

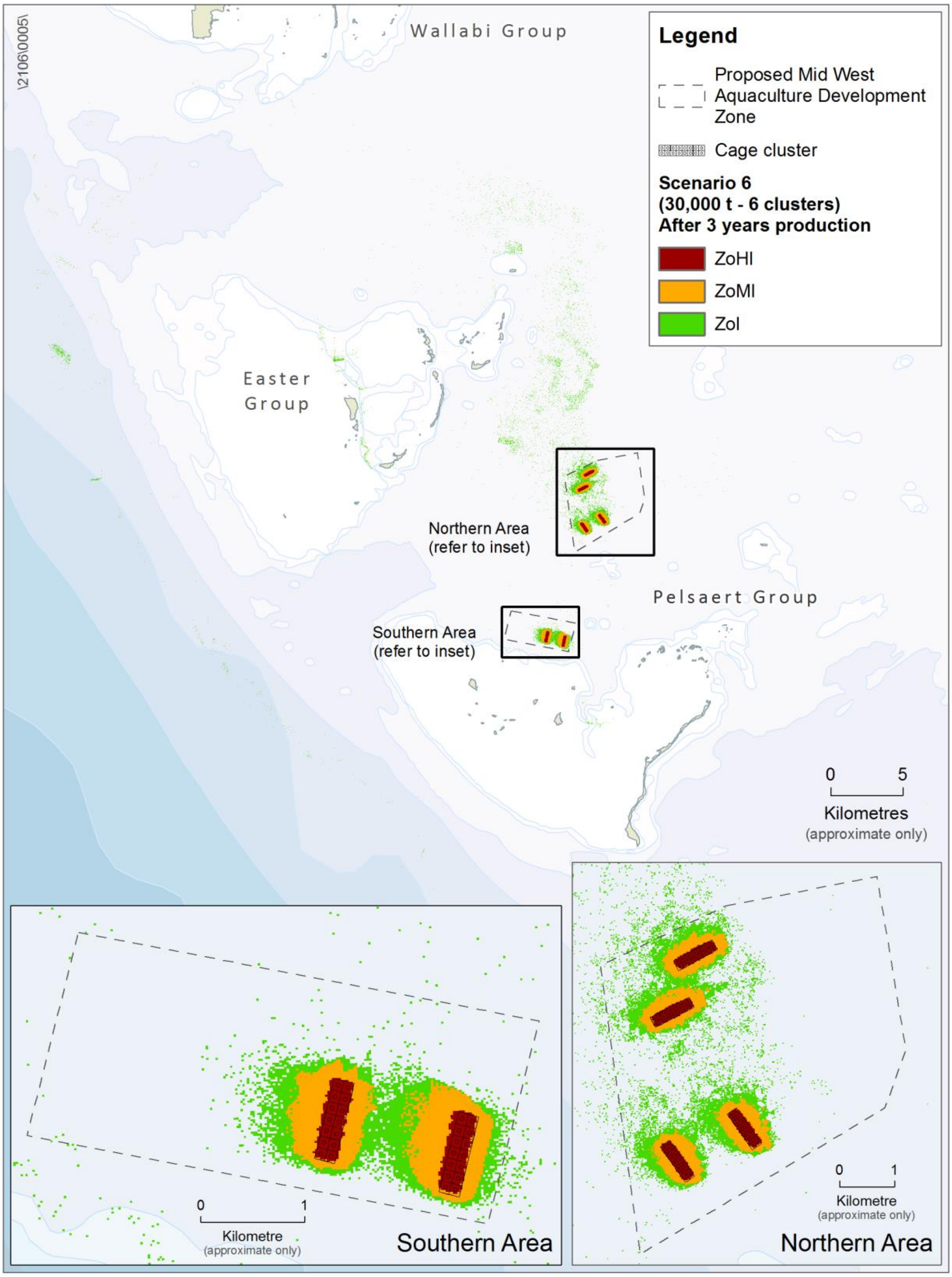


Figure 7-36: Zones of Impact under Scenario 6 (30,000 tonnes) after three years of production

The ZoHI is the area where impacts on benthic habitats are predicted to be irreversible, as per EAG 7. The term "irreversible" is defined as "*lacking a capacity to return or recover to a state resembling that prior to being impacted within a timeframe of five years or less*".

Despite the use of the term irreversible, it is noted that sea cages are not permanent structures and can be moved to facilitate benthic rehabilitation. Recovery times in the ZoHI and ZoMI ranged between one and seven+ years, depending on the scenario and distance from the sea cages. Immediately under the sea cages, sediments required greater than seven years to achieve full recovery. However, this reduced to six after 3 years of production (Figure 7-37 to Figure 7-42).

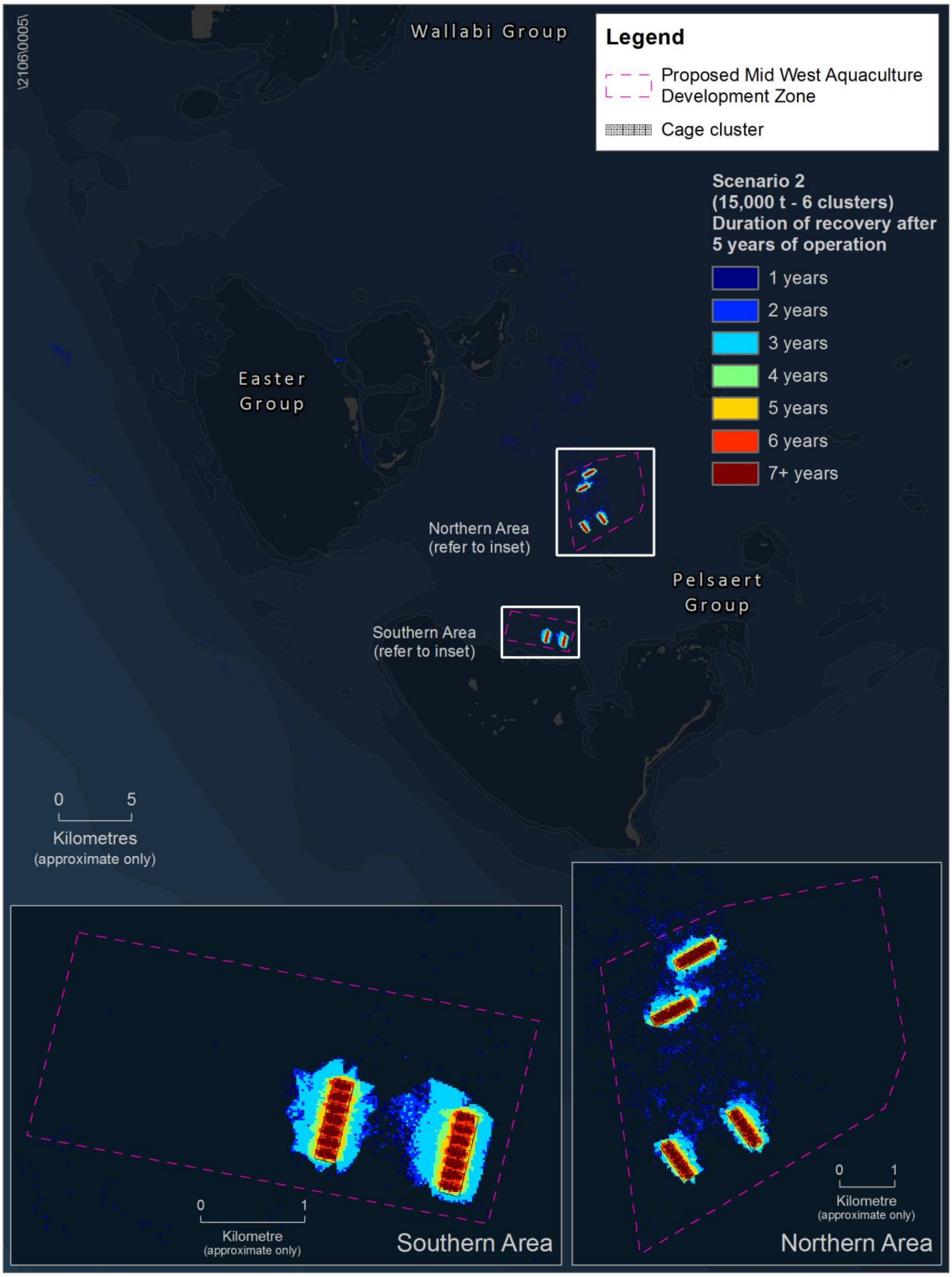


Figure 7-37: Duration of Recovery under Scenario 2 (15,000 tonnes) after five years of operation

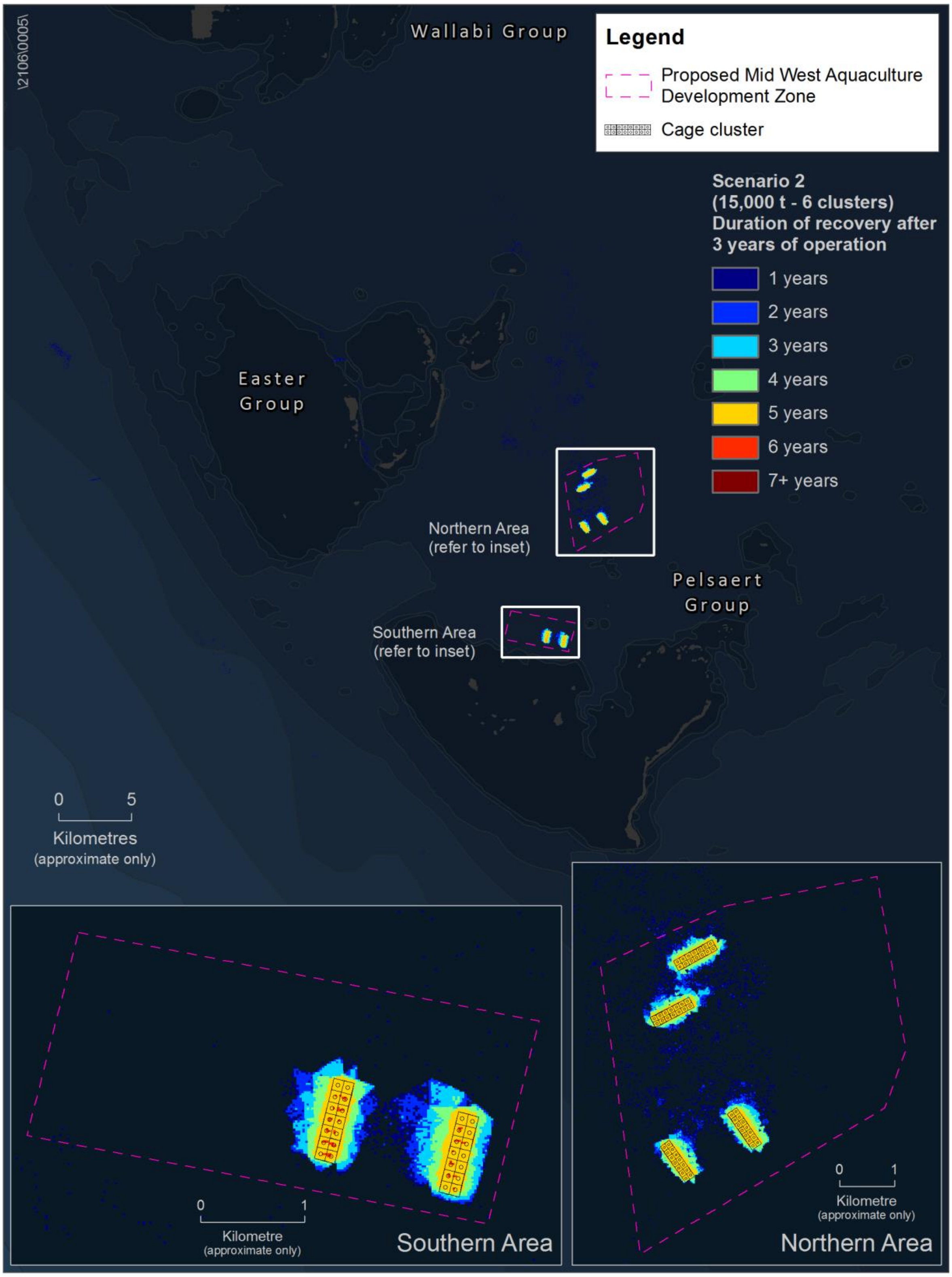


Figure 7-38: Duration of Recovery under Scenario 2 (15,000 tonnes) after three years of operation

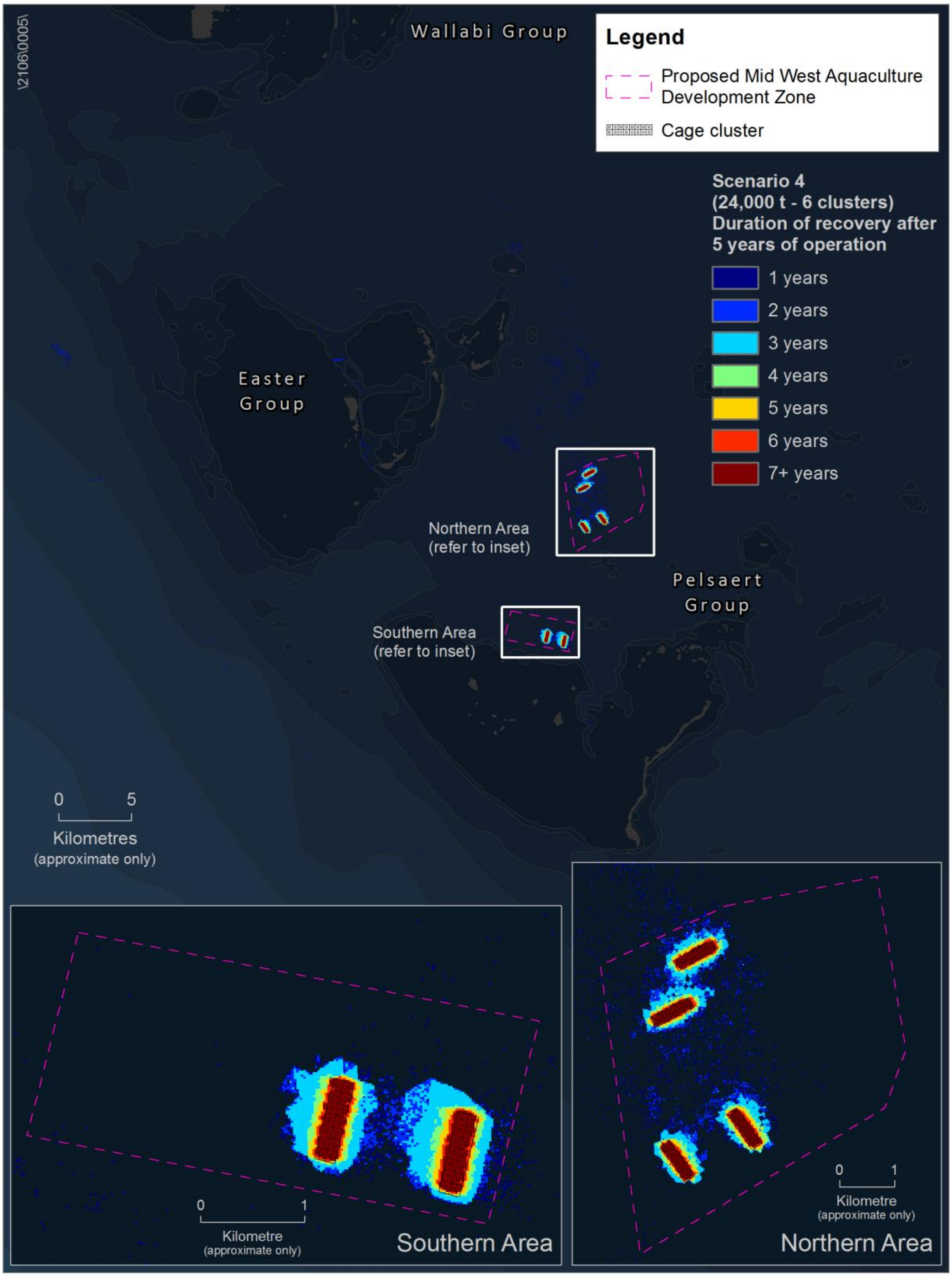


Figure 7-39: Duration of Recovery under Scenario 4 (24,000 tonnes) after five years of operation

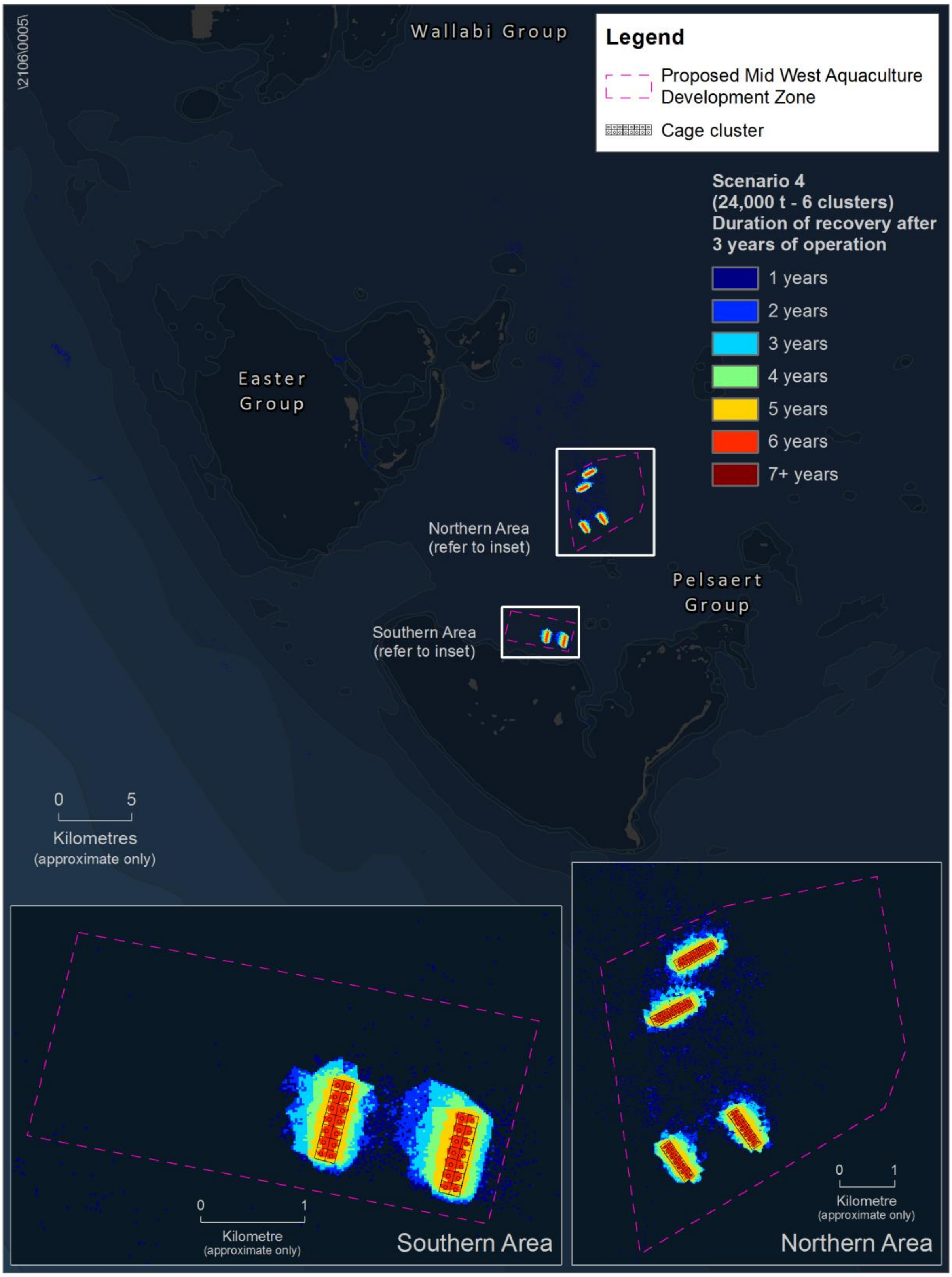


Figure 7-40: Duration of Recovery under Scenario 4 (24,000 tonnes) after three years of operation

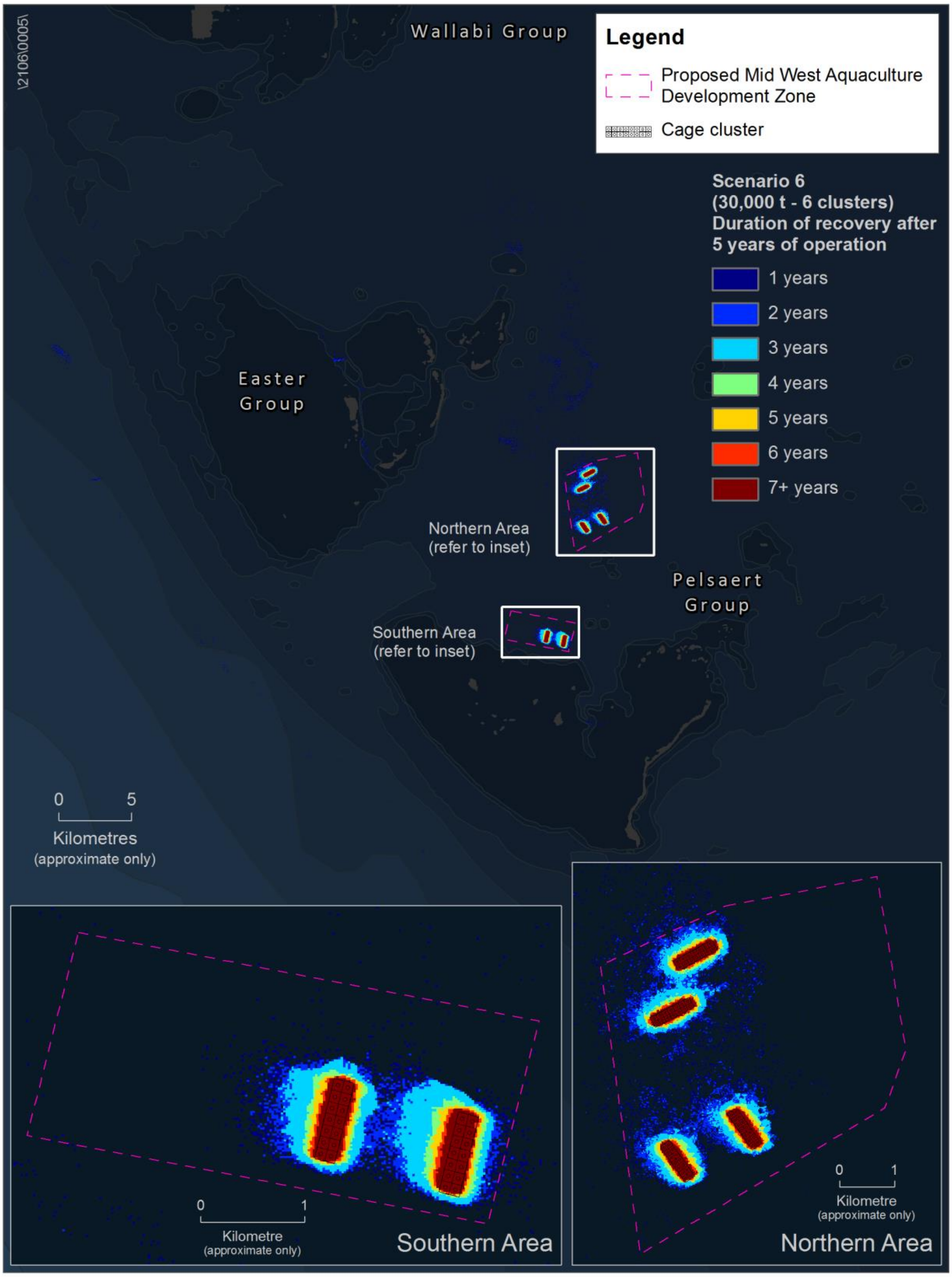


Figure 7-41: Duration of Recovery under Scenario 6 (30,000 tonnes) after five years of operation

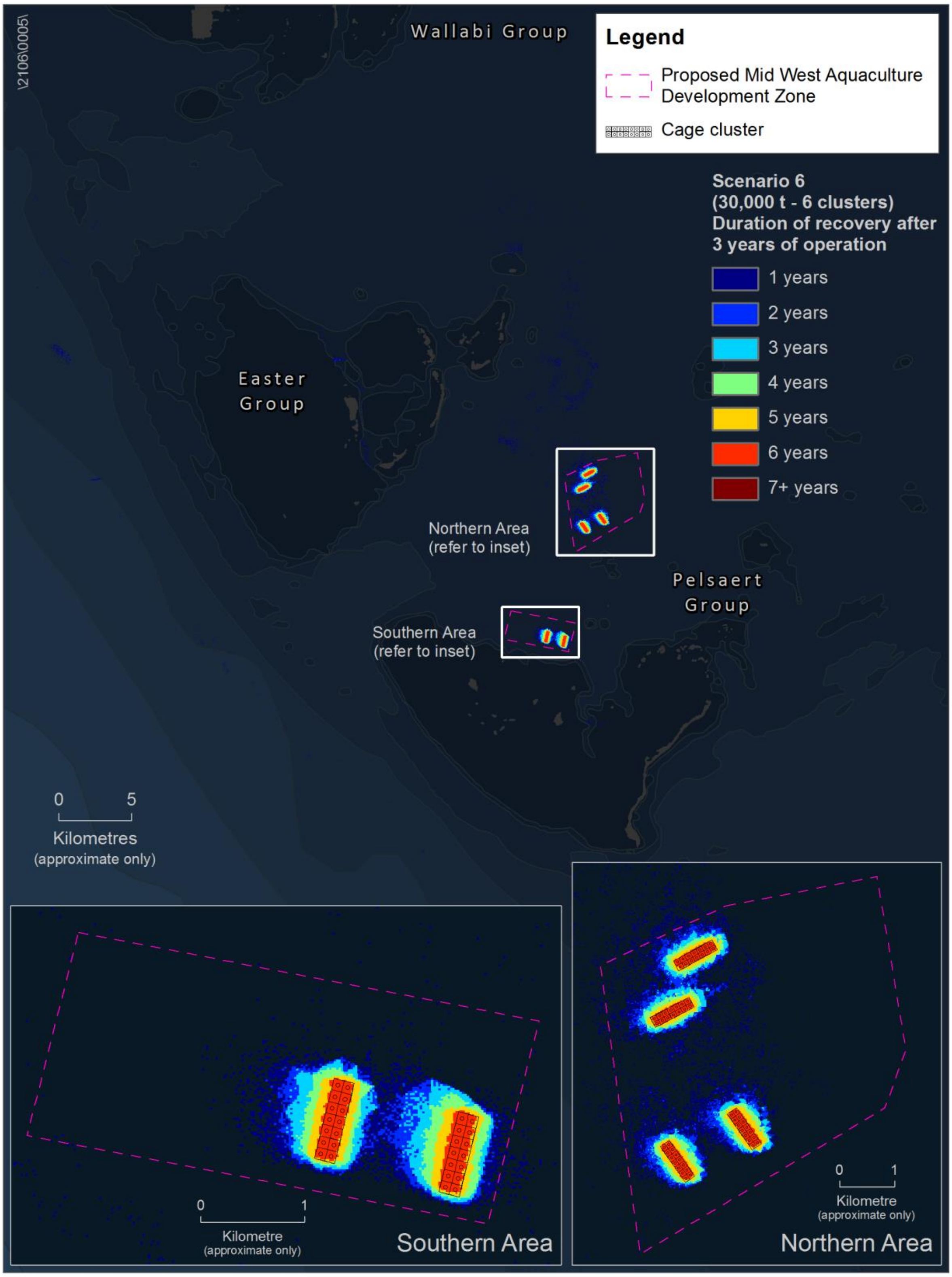


Figure 7-42: Duration of Recovery under Scenario 6 (30,000 tonnes) after three years of operation

7.4.3.4 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 fraction of stock faeces.

The extremities of its distribution in the north, the south-west, and particularly in the deeper lagoon areas of the Abrolhos Islands Easter Group, are product of the design and settlings of the model (i.e. an artefact). Particles may travel this distance from the cages 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 (Appendix 1).

7.4.3.5 Comments on the Modelled Rate at which the Sediment Chemistry Returned to Natural Levels

The rates at which organic matter underwent mineralisation were dependent on the location and other factors, such as the assimilative capacity of the ecosystem (Findlay et al. 1995). A review by Brooks et al. (2003) found that the time required for the fauna in the sediment to recover (biological recovery) varied significantly from a few months to several years (Mahnken 1993, Morrisey et al. 2000, Karakassis et al. 1999). Recovery typically occurred rapidly in the months directly after fallowing, but often slowed over time, presumably due to the different rates and which discrete infauna taxa recolonise recovering sediments (e.g. Mahnken 1993).

Brooks et al. (2004) examined recovery in sediments after more than 2,000 tonnes of salmon were harvested and the cages left to fallow. At peak farming biomass, benthic sediments at the study site were black in colour and characterised by bubbles of hydrogen sulphide and beds of the sulphide-oxidising bacterium *Beggiatoa spp.*, with the effects extending between 18 and 145 metres down-current of the sea cage perimeter. In this worst-case scenario, and following four years of fallowing, biological recovery was nearing completion at distances more than 80 metres from the sea cages but was not complete within this distance. Within 80 metres, it was predicted that the sediment chemistry would require 5.4 years from the start of fallowing to return to background levels (chemical recovery) that are sufficient to support half of the common taxa observed at reference sites. Complete biological recovery would require a longer period.

The observations described in Brooks et al. (2004) validate in part the recovery times reported here, in which it was predicted that between six and seven+ years would be required for sediments directly beneath the sea cages to achieve chemical recovery (Figure 7-37 to Figure 7-42). The longer periods of chemical recovery reported in this assessment are not surprising given the levels of standing biomass examined (between 2,600 and 5,000 tonnes of finfish per 14-cage cluster), and the fact that we adopted a highly conservative approach for estimating the volumes of fish waste (EPA - Appendix 1).

Variability in the timing of recovery is widely reported in the literature: Macleod et al. (2002) reported chemical remediation after two years (with sulphide levels returning to background levels) but incomplete biological recovery (infauna were in a transitionary recovery phase and still significantly different compared to the communities observed at reference sites). Subsequent work by these authors (Macleod et al. 2006) found that sediment returned to its original condition after a three-month period, but did not return to background conditions. Despite similarities in the way the exposure of the impact sites in these studies to aquaculture (i.e. stocking levels and feed inputs) there were differences in the chemical recovery and in the rates of change in the structure of infauna communities. This implies that the link between organic deposition and biological recovery is not straightforward.

Different locations may need different management strategies, particularly with regard to timing of fallowing (Macleod et al. 2006).

As indicated in Section 7.4.1.3 (Figure 7-37 to Figure 7-42), rates of chemical recovery as predicted by the sediment biogeochemical model were assumed to proceed free of major physical disturbances. Although the model incorporated some capacity for biological and physical disturbance and reoxygenation via biologically-driven diffusion and irrigation, neither of these processes could bring about an extreme occurrence which could result in rapid renewal of sediment habitats (e.g. during major scour events such as those which may occur during major storm events or cyclones, the latter of which affects the proposed MWADZ area approximately every 2.5 years). The recovery times presented herein are therefore conservative and longer than those which may occur in reality, especially if the five to seven year recovery period modelled in this assessment was affected by a significant storm event and, or, exceptional levels of biological activity.

7.4.3.6 Metals

The sediment diagenesis model was also used to determine the time taken for sediments to recover following inputs of waste, including trace elements (Zn and Cu). Triggers were set following the EPAs EQG for high ecological protection (EPA 2014). Although present in commercial feeds, and therefore also present in fish faeces, the low molar ratios of Zn and Cu in the fish waste were insufficient to result in sediment concentrations in excess of the EQG, even after five years production at the upper end of the scenarios modelled (Scenario 6).

7.4.4 Water Column

7.4.4.1 Dissolved Oxygen

The potential for deoxygenation of the water column beneath and near the sea cages was investigated using the integrated ecosystem model. Simulations focused on the bottom half of the water column, which for the project area ranged between 12–25 metres and 25–50 metres depth. Modelling also simulated ecosystem processes in the deeper parts (at more than 50 metres depth) of the Abrolhos Islands FHPA to the west of the proposed MWADZ, including the leading edge of continental shelf slope. Median dissolved oxygen concentrations at the edge of the continental shelf were lower than the 80th percentile of background concentrations. Oxygen concentrations in the MWADZ maintained normal levels across all six of the scenarios. There was no evidence of significant levels of oxygen depletion, even at the peak of standing biomass (i.e. Scenario 6). Results of the sediment biogeochemical model, however, point to high levels of biological oxygen demand (BOD) at the sediment water interface. Under these conditions the model predicted that sediment would be anoxic, and waters at the sediment water interface are likely to experience some oxygen consumption by the sediments. However, the extent of water movement through the system is such that the level of oxygen consumption by the sediment is unlikely to have ecological consequence because oxygen levels are quickly resupplied by steady renewal of the overlying seawater.

7.4.4.2 Suspended Particles

Sea cage aquaculture produces volumes of organic wastes which settle to the seafloor. A proportion of these wastes are capable of being resuspended in the water column, where it can interfere with the mechanical processes that sustain filter feeding organisms.

The potential for suspended particles to exceed the thresholds in Table 6-15 was investigated using the hydrodynamic model coupled to the particle transport model (refer to Section 6.7).

Under the range of production scenarios (Scenario 1 – Scenario 6) simulated by the model, none produced Total Suspended Solid concentrations high enough, or over a sufficient durations of time to exceed the thresholds in Table 6-15 (Section 6.6.2). However, subsequent investigations with a threshold using longer time-periods revealed that there was potential for Total Suspended Solid concentrations in the proposed MWADZ to reach levels higher than background on occasion. Nevertheless, the duration and level of exceedance was not sufficient to exceed the published major impact thresholds for filter feeding communities (PIANC 2010).

7.4.4.3 Smothering

Anecdotal observations, and the results of modelling presented here, suggest that the majority of finfish aquaculture waste settles to the sea floor immediately beneath the sea cages. Under conditions of low shear stress, some of this material may accumulate, leading to smothering of resident benthic communities.

The potential for impacts from smothering was investigated using the hydrodynamic model coupled to the particle transport model (refer to Section 6.7) and was assessed using thresholds developed for corals (PIANC 2010; Table 6-10). Corals were chosen because they exhibit poor tolerance to sedimentation relative to other invertebrates (Oceanica 2013), thus providing for a conservative assessment.

Modelling indicated potential for exceedances of both the minor and moderate impact categories, but there were no exceedances of the major impact category (Table 6-11). Moderate impacts were seen only for Scenario 6 and were confined to very small areas immediately under the sea cages (Figure 7-42). Minor impacts were more prevalent and were recorded in Scenario 5 and Scenario 6 (Figure 7-43 and Figure 7-44). The zone of minor impact, although proportionally larger than the zone of moderate impact, was nevertheless predicted to be confined to area of sea floor corresponding to the outer boundary of the sea cage clusters.

Under the PIANC (2010) criteria, areas of the seafloor subjected to exceedances of the minor impact criteria could be expected to result in localised mortalities of coral, but not at a spatial scale expected to flow on to more serious secondary consequences. Under the same criteria, areas subjected to exceedances of the moderate impact criteria could result in locally significant mortalities. Both the zones of minor and moderate impact were predicted to be confined to the area of the sea cage clusters. While no significant corals reefs were observed in the proposed MWADZ (Section 8.5.1) the potential for impact to sensitive filter-feeding communities should be considered during placement of the sea cages.

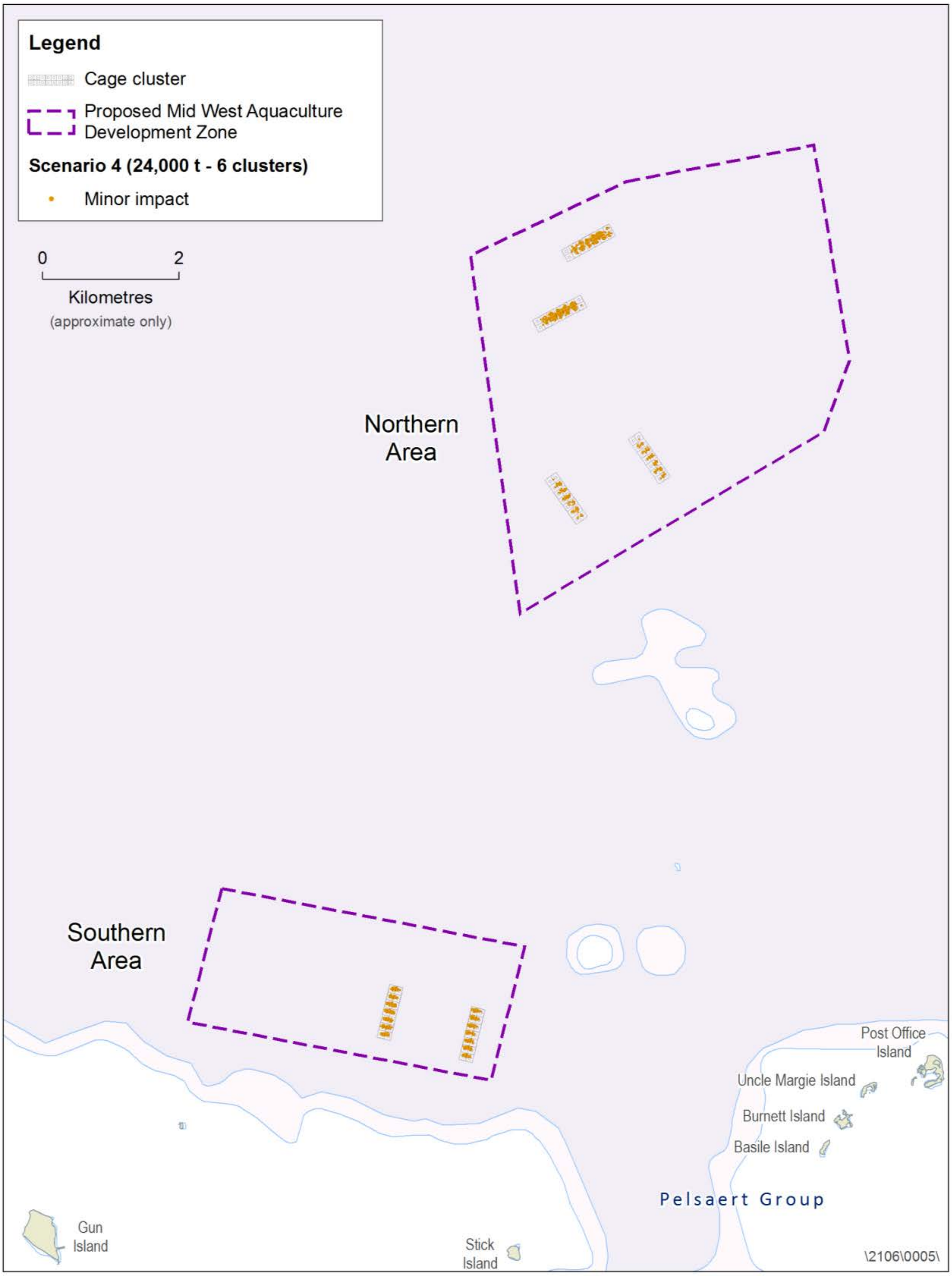


Figure 7-43: Zones of Impact based on the rate of material deposition under Scenario 4 (24,000 tonnes)

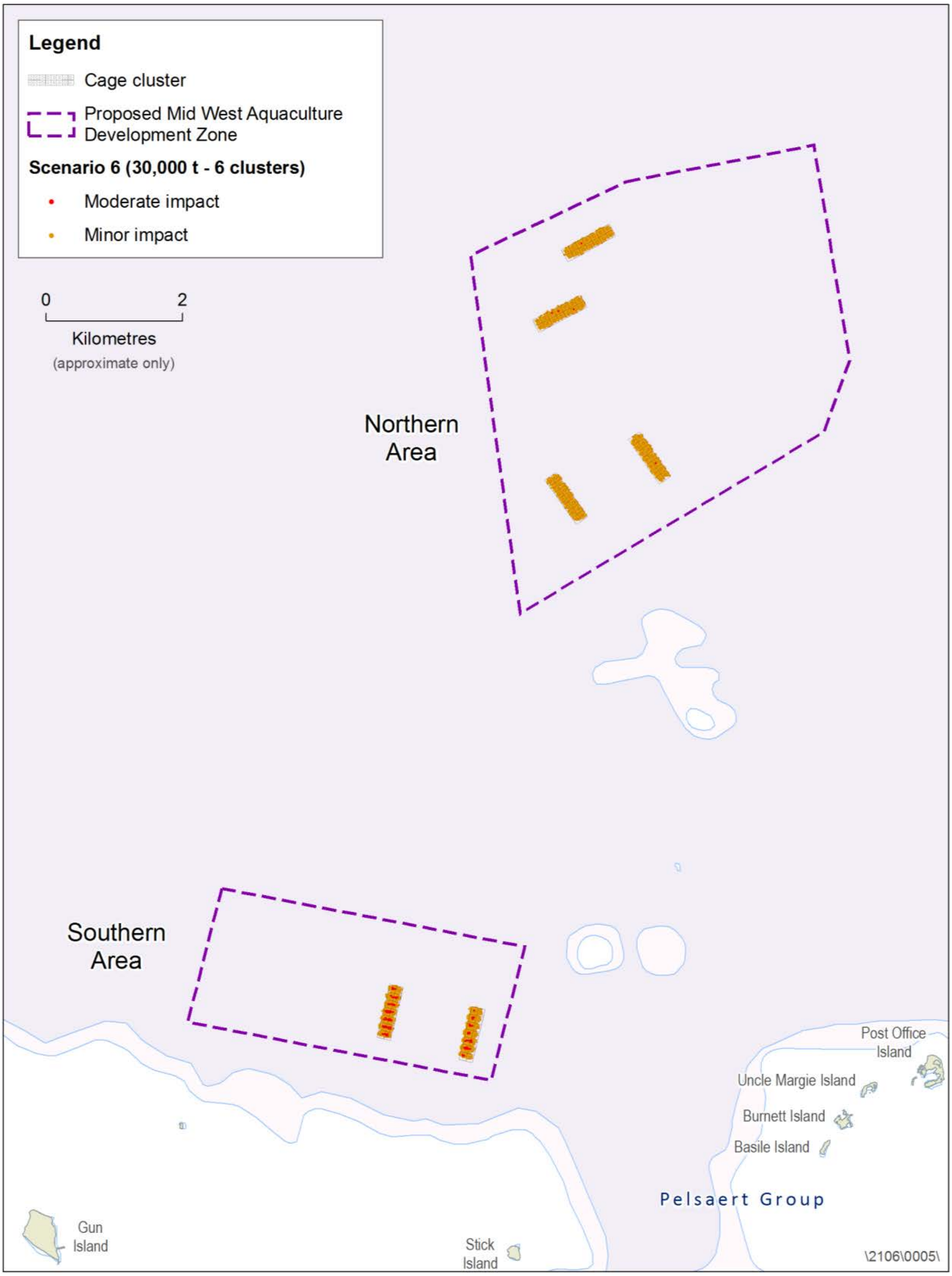


Figure 7-44: Zones of Impact based on the rate of material deposition under Scenario 6 (30,000 tonnes)

7.4.4.4 Light Intensity

Sea cage aquaculture has the potential to lead to increased light attenuation through the water column via a number of cause-effect pathways: typically via increases in suspended particles and, or, increases in phytoplankton biomass. The potential for light intensity to be reduced at the bottom strata of the water column was investigated using the hydrodynamic and water quality model components of the integrated ecosystem model. The potential for environmental impacts was investigated in the context of the thresholds listed in Table 6-13.

Reductions in Photosynthetically Active Radiation (PAR) of ~15% and ~4% were observed, respectively, immediately under the sea cages and to a distance of 100 metres from the sea cage perimeter. However, under the range of production scenarios (Scenario 1 – Scenario 6) simulated by the model, none produced conditions sufficient to reduce PAR to levels exceeding the moderate and high protection thresholds in Table 6-13. The observed reductions in PAR near the sea cages were the combined result of shading of the sea cage infrastructure, and the shading effect of suspended particles (fish wastes). None of the observed declines in PAR resulted from 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 7.4.2.5.

7.4.4.5 Algal Growth Potential (DIN)

The spatial extent and concentration of DIN released from sea cage infrastructure was investigated under the higher range of production scenarios (Scenario 4 and Scenario 6; Section 6.6.4). Concentrations of DIN near the sea cages increased with increasing biomass and increasing stocking density. Scenario 6 produced the highest concentrations and the largest DIN “footprint”, while Scenario 4 produced lower DIN concentrations and a smallest environmental “footprint” (Figure 7-45 and Figure 7-46). The decrease in DIN with distance was driven partly by far-field dilution processes and partly by biological assimilation, both processes simulated in the CANDI-AED-model.

For the purposes of defining zones of impact, acute thresholds were developed following the criteria for high and moderate levels of ecological protection, respectively, under which large and moderate changes would be expected to ecosystem health (Table 6-12). Concentrations of DIN in and immediately adjacent to the sea cage structures exceeded the moderate ecological protection criterion (95th percentile of background) in both scenarios (Scenario 4 and Scenario 6), though the areas occupied by this zone were small and typically restricted to within 150 metres of the sea cage perimeter. The spatial extent of the area exceeding the high protection criterion (80th percentile of background) was more extensive, but varied markedly depending on the scenario and the position of sea cages within the zone. The area exceeding the high protection criterion was greater in the northern MWADZ, where the stronger currents acted to carry the plume farther and more rapidly.

Although the area exceeding the moderate protection criteria was small and restricted to the proposed MWADZ, the area exceeding the high protection criteria encroached (and in some cases breached) the boundaries of the northern MWADZ. This was most pronounced in Scenario 6 (Figure 7-45) but was mitigated in S4 by reducing the stocking density (Figure 7-46).

The area exceeding the combined moderate and high protection criteria represents the area not expected to meet a high level of ecological protection and highlights the potential for algal growth. The extent to which the simulated elevations in DIN translated to algal growth were examined using the water quality model packages (Section 6.7.5).

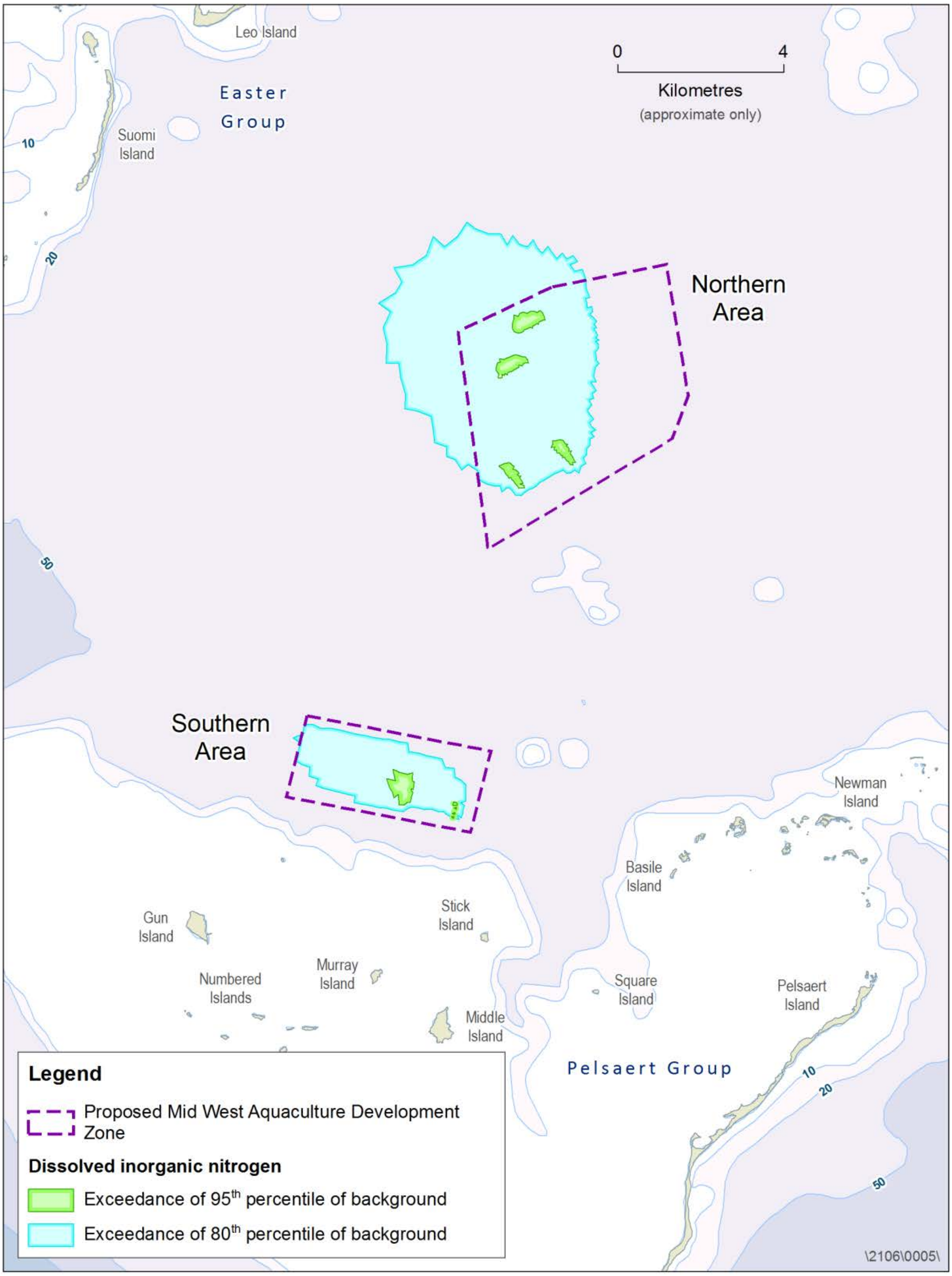


Figure 7-45: Zones of Impact based on Dissolved Inorganic Nitrogen in the water column under Scenario 6

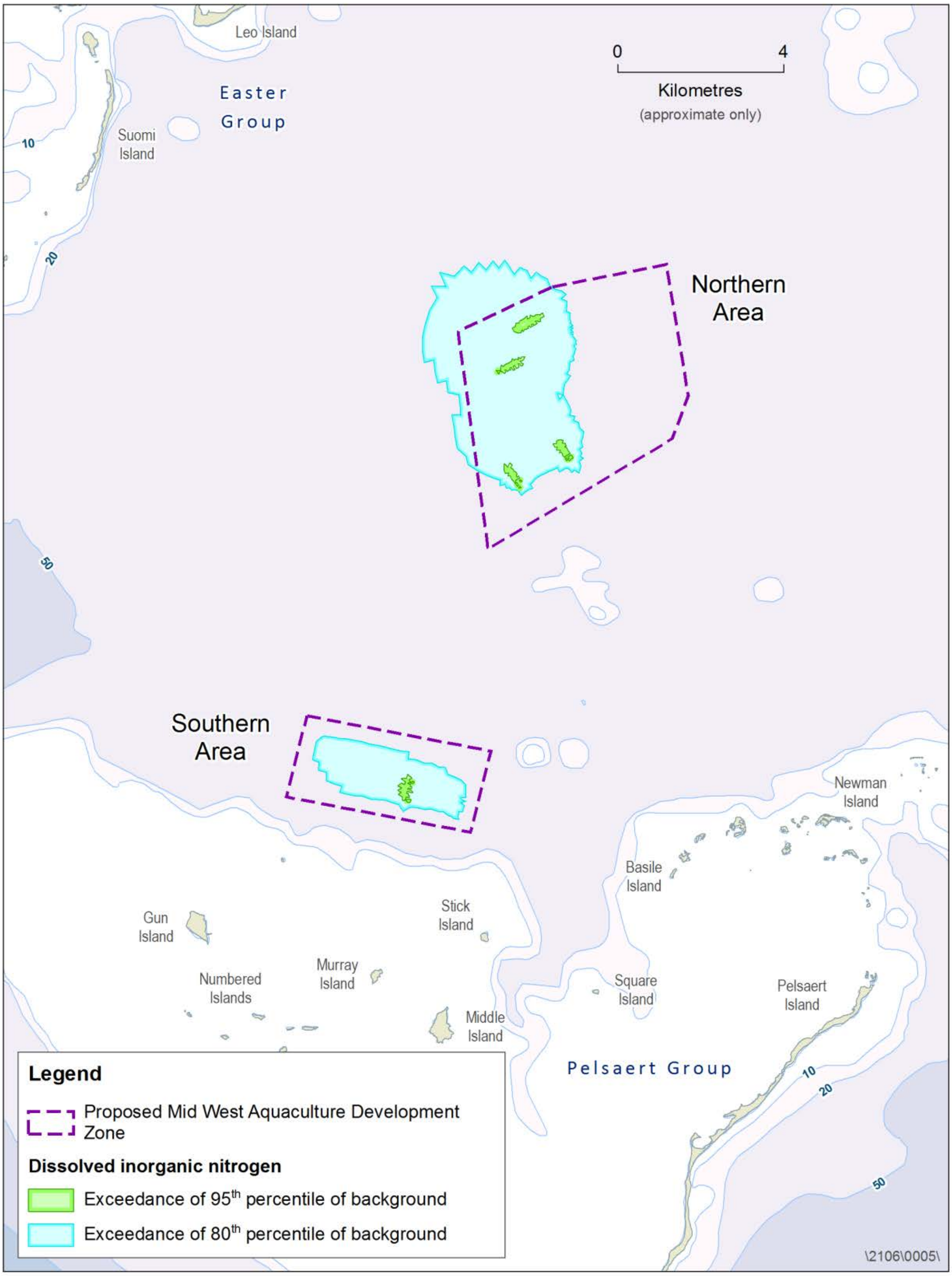


Figure 7-46: Zones of Impact based on Dissolved Inorganic Nitrogen in the water column under Scenario 4

7.4.4.6 Nutrient Enrichment and Chlorophyll-a

Despite significant inputs of Dissolved Inorganic Nitrogen (DIN), there were no discernible increases in chlorophyll-a (the surrogate for phytoplankton biomass) that could be attributed to aquaculture. Furthermore, there were no exceedances of the moderate and/or high ecological protection criteria in the waters surrounding the proposed MWADZ. A natural gradient of chlorophyll-a was detected between deep waters of the MWADZ and shallow waters of the mainland. Chlorophyll-a in coastal waters sustained concentrations higher than the 95^{th} percentile of background oceanic conditions, even when baseline conditions were simulated by the model. This confirmed the observed pattern was not a result of aquaculture activities.

The high concentrations of chlorophyll-a displayed via model simulation are not surprising given the volume and level of water movement through the MWADZ study area and surrounds. Perth's coastal waters, like those of the project area, are oligotrophic and well flushed (but differ in that that they are shallower; 10–20 metres depth). Inputs of DIN for Scenario 1 and Scenario 2 are roughly equivalent to the annual total DIN inputs to Perth's coastal waters via three widely separated ocean outfalls (BMT Oceanica 2015c). Over ten years of intense summer water quality monitoring near these outfalls has not detected long-lasting increases in chlorophyll-a due to these regular DIN inputs. Where chlorophyll-a increases have been detected, they have only persisted for a short time (days) and were typically associated with extended periods of low wind (Oceanica, unpublished data). Although Scenario 4 and Scenario 6 represent inputs of DIN in higher volumes than the combined inputs of Perth’s three ocean outfalls, the scenarios indicate the very high assimilative capacity of the water within the Abrolhos Islands FHPA. The assimilative capacity is likely enhanced by the depth of the water column and associated large receiving volume of the Zeewijk channel and adjoining waters.

7.5 Management Measures

7.5.1 Environmental Quality Management Framework

Marine environmental management in Western Australia is undertaken according to the environmental quality management framework (EQMF) described in EAG 15 (EPA 2015). The Environmental Monitoring and Management Plan (EMMP) (refer to Appendix 2), that has been developed to provide proponents with an appropriate EQMF for managing the potential impacts of stocking up to 24,000 tonnes of marine finfish across the proposed MWADZ, is described in general terms in Section 15.3.1.1.

The EQMF for Western Australian coastal waters defines five environmental values (EVs) as particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health, and which require protection from the effects of pollution, waste discharges and deposits (EAG 15). These EVs are:

- ecosystem health;
- fishing and aquaculture;
- recreation and aesthetics;
- industrial water supply; and

- cultural and spiritual.

All five of these EVs are generally expected to apply throughout Western Australian marine waters (including those associated with the MWADZ Proposal).

These values are essentially of two types: ecological and social. The first of these EVs (i.e. ecosystem health) is an ecological value because it relates to the protection of the inherent characteristics of the natural ecosystem. It can also be regarded as a fundamental value because practically all human uses ultimately depend on the condition of the natural system. The other four EVs are regarded as social or utilitarian values because they relate to specific human uses of coastal waters (EPA 2000).

While each of these EVs is separate from each other in that they have different environmental quality objectives (EQOs), there is a degree of connectivity between them in so far as their environmental quality criteria (EQC) often are expressed in similar units of measurement.[40] Where this coincidence of EQC occurs, it is possible to rationally argue (for a particular EQC) that if the EQC for (say) the EQO of "ecosystem integrity" is met and the threshold value for that EQC is **lower** than that of the same EQC for one of the other EQOs, such as "water safe for swimming" (recreation and aesthetics EV), then the EQOs and EQCs of **both** the EVs will be protected. In other words, for similar EQC, to meet the requirements of the lower threshold is to automatically meet the requirements of the higher threshold.

Using this rationale, the Department is of the view that in the case of the MWADZ Proposal, most of the EVs and their associated EQOs can be demonstrated to be met if the EQC for the "primary" EV of ecosystem health is met; noting the EQC for ecosystem health generally have significantly more conservative (i.e. stringent) thresholds than the other EVs. By satisfying the requirements of the EV ecosystem health [even in those areas designated a Moderate Level of Ecological Protection (MEPA)], this also satisfies the requirements of the other EVs. The map at Figure 15-1 illustrates where the EQOs relevant to the MWADZ Proposal will be met. This figure also illustrates where the EQOs for all the other marine environment EVs will be met (i.e. all areas).

7.5.2 Ecosystem Health

The ecologically-based EV "ecosystem health" is concerned with maintaining the structure and functions of marine ecosystems to an appropriate level. It has the EQO of "maintain ecosystem integrity" and four associated levels of ecological protection (LEPs). This structure allows areas identified as important for conservation and biodiversity protection to be maintained in their natural state while recognising that in other parts of the marine environment there are societal uses that may preclude a high level of ecological protection from being achieved (EAG 15).

While aquaculture proponents have an obligation to meet each of the EQOs, only a small number of EQOs are at risk due to aquaculture operations.

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[40] An Environmental Quality Objective (EQO) is a specific management goal for a part of the environment. EQOs can be either *ecologically-based* and describe the desired level of health of the ecosystem (e.g. in terms of limits of acceptable change from natural conditions), or *socially-based* and describe the specific human uses to be protected (e.g. swimming or boating) (EPA 2000).

The cause-effect pathways related to finfish aquaculture are outlined in Section 3.2.2 of the Environmental Monitoring and Management Plan (EMMP - Appendix 2).

The key pressures associated with aquaculture are inputs of nutrients and organic material derived from finfish metabolic processes and feeding. As such, none of the pressures identified in Section 3.2.2 of the EMMP are expected to compromise the EQOs for these EVs.

The EQO, to “maintain ecosystem integrity”, is unique in that it encompasses differing levels of ecological protection (LEP): maximum, high, moderate and low (EAG 15). Differing levels are applied in recognition of the competing environmental, societal and industrial uses of the marine environment. Because of competing interests, it is recognised that not all areas can achieve (or retain) high to maximum levels of ecosystem protection, and that some areas must instead be given either moderate or low ecological protection status (EPA 2015), with corresponding limits of acceptable change.

The framework allows for small localised effects, while aiming to maintain overall environmental integrity (EPA 2015). This is important in the context of the MWADZ Proposal EMMP, which includes strategies to manage the expected reduction in environmental quality beneath and immediately adjacent to the MWADZ sea cages, while maintaining broader regional environmental quality (Section 3.2.4 of the EMMP).

The EQO for maintenance of ecosystem integrity requires the spatial definition of four or less LEPs – maximum, high, moderate and low (EAG 15). The rationale for designation of LEPs is based on the expectation that aquaculture operations will reduce environmental quality on a local scale, such that a maximum or high LEP may not be achievable immediately beneath and adjacent to operational infrastructure. The EPA expects the cumulative size of the areas designated as moderate or low ecological protection areas to be proportionally small compared to the areas designated high and maximum.

Guidance provided by the EPA suggests that marine finfish aquaculture (defined as sea cages) in Western Australia should be managed to achieve a “moderate” LEP (Table 3 of EAG 15). In areas assigned a moderate LEP, operational pressures are expected to result in small changes to the abundance and biomass of marine life, and in the rates but not the types of ecosystem processes. Under the same LEP, there should be no detectable and persistent changes in biodiversity due to waste discharges or contamination.

Environmental modelling undertaken for this project predicted that any organic enrichment resulting from aquaculture would be locally constrained, with no resulting regional scale adverse effects (BMT Oceanica 2015). For example, modelling predicted that the most severe impacts from the 24,000 tonne maximum standing biomass of marine finfish (spread over six cage clusters) would be restricted to within a distance of less than 100 metres after three year’s production.

While changes to the sediment chemistry and resident biological assemblages are expected to occur at this stocking level, the changes are predicted to be locally constrained, with no resulting detectable impacts beyond 100 metres from the sea cages (under full production). Furthermore, any changes to the sediment chemistry and the resident invertebrate fauna are expected to be fully reversible under a program of routine fallowing (Section 6 of the EMMP).

Based on the above, it is proposed to establish moderate ecological protection areas (MEPA), comprising no more than 50 percent of each MWADZ lease, within a broader high ecological protection area (HEPA). The framework has been designed to be moderately protective of habitats within the MEPA (with a decreasing gradient of effect between the sea-cages and the HEPA boundary) and highly protective of habitats outside of the MEPA, including sensitive coral reef habitats.

Proponents will be expected to demonstrate they are meeting the designated LEPs for the life of the project by complying with the EQC for moderate and high ecological protection as outlined in Sections 4.1 and 4.2 of the EMMP. The proposed MEPA will comprise of both "active" and "recovery" footprints that, when operational, will be assigned a moderate LEP. At the commencement of fallowing, the recovery footprints will be monitored until it can be demonstrated that they have recovered to levels consistent with a high LEP.

The cumulative area occupied by the MEPA (i.e. both active and recovery footprints) is less than 5% of the area within a 10 km radius of the MWADZ, which is within the acceptable limit for MEPA specified in EAG 15 (EPA 2015). The spatial arrangement and extent of the moderate and high LEP to be applied to the MWADZ is illustrated in Figures 15-1 of this PER and 4.1 of the EMMP.

7.5.3 Fishing and Aquaculture

This EV relates to ensuring environmental quality is suitable for the gathering and farming of seafood for human consumption. The intent is to ensure seafood collected or grown in waters where this EV is protected would not have levels of contaminants in the flesh that would exceed the Australian Food Standards (EPA 2000).

The EV "fishing and aquaculture" has two EQOs, "seafood safe for eating" and "marine environment suitable for aquaculture".

Fishing and aquaculture are concerned with the protection of the human population from the potential adverse effects of toxicants and microbiological contaminants (typically present in sewage and storm water) and the protection of nearby aquaculture and industry from the effects of toxicants and other contaminants (EPA 2015a).

As stated in Section 7.5.2 of this PER, the key pressures associated with aquaculture are inputs of nutrients and organic material derived from finfish metabolic processes and feeding. As such, none of the pressures identified in Figure 3.6 of the EMMP (Figure 6-3 of the PER) are expected to compromise the EQOs for this EV.

The monitoring and management arrangements embodied in the MWADZ Proposal EMMP that focus on the key EV of ecosystem health and its associated EQO of maintenance of ecosystem integrity, include strategies and contingency management responses to protect the major elements of the ecosystem; water and sediment quality (as required under the EQMF). These are supplemented with additional (but separate from the EQMF) management arrangements with emphasis on marine mammals and seabirds; as well as human-generated waste (EMMP; ZMP; MFIMP and WMP).

Collectively, the management measures required by the EMMP effectively address all likely potential sources of toxicants and microbiological contaminants that may also impact on the EV fishing and aquaculture and its EQOs. Consequently, this EV is well-protected.

7.5.4 Recreation and Aesthetics

This EV relates to human uses of the environment and includes sporting and leisure activities with frequent direct body contact with the water (e.g. swimming), or less-frequent body contact with the water (e.g. boating) and passive recreation which does not involve contact with the water (pleasant places to be near or look at) (EPA 2000).

The EV of "recreation and aesthetics" has three EQOs, "water safe for swimming", "water safe for secondary contact" and "aesthetic values protected".

In terms of the first two EQOs, the level of protection set is usually expressed in bacteria counts. For instance, the National Health and Medical Research Council (NHMRC) have set a safe limit for swimming of 150 bacteria/100ml of water. If levels of bacteria are lower than this standard, the water is considered "safe" to swim in. If levels of bacteria exceed this standard, the water is considered "unsafe" to swim in. It follows that, if the water was safe to swim in (i.e. primary contact), it would also be safe to undertake on-water activity (i.e. secondary contact) such as boating.

Microorganisms and infectious agents are naturally abundant in all seawater. However, the strains each population experience are different. General coliform bacteria (bacteria) indicate that the water has come in contact with plants or animals. At very high levels, bacteria indicate there is (what amounts to) a lot of organic material (derived from plants or animals) in the water. This could include pathogens. However, most of the bacteria in seawater are harmless to human health.

Human faeces in sea water present the greatest risk to swimmers. Faecal coliforms, particularly *Escherichia coli* (*E. coli*), are an indicator of mammal or bird faeces within the water. The genus *Enterococcus* includes more than 17 species, although only a few cause clinical infections in humans. *Enterococcus* bacteria are persistent in sea waters. They are a more general indicator of faecal contamination from warm-blooded animals and are commonly associated with swimming-related gastrointestinal illness. The risk to human health from exposure to animal faecal matter increases the more closely that animal is related to humans, (i.e. mammals and birds present a greater risk than fish). Essentially, there are no *Enterococci* or thermo-tolerant coliforms in fish faeces.

The MWADZ Proposal provides that human sewage must be either:

- treated, using a sewage disposal system approved by the Department of Health, prior to disposal at sea in accordance with the Department of Transport's Strategy for Management of Sewage Discharge from Vessels into the Marine Environment 2015 (Strategy); or
- stored in tanks on the vessel and disposed of on land at a licensed disposal site in accordance with Local Government Authority by-laws (WMP – Appendix 3 and ZMP – Appendix 6).

By regulating the discharge of human sewage within the boundaries of the proposed MWADZ and implementing management measures designed to reduce the risk of attracting other sources of faecal contamination (e.g. dolphins, sea lions and seabirds) to aquaculture operations within the proposed MWADZ, the risk to human health by bacteria of faecal origin will be effectively addressed.

Bacterial populations in any situation feed on organic material and rely on the availability of oxygen, carbon and nitrogen (Carter, 1989). The EQMF (EAG 15) presented in this PER provide risk-based evidence that organic enrichment associated with aquaculture stock (fish) faeces will not exceed concentrations that could present a risk to swimmers or divers in the waters of the proposed MWADZ.

Total suspended solids (TSS) are a proxy for organic waste generated by the aquaculture stock which (in turn) could be linked to general coliform bacteria. Future proponents (i.e. derived proposal proponents) will measure TSS in the water column six times per year as one of the environmental quality guideline (EQG) requirements for a moderate level of ecosystem protection. The median value for TSS in both the summer sampling period and the winter sampling period must be less than the 95th percentile of the values recorded at the reference sites. Given that the reference sites are isolated water bodies several kilometres away from the nearest human habitation, the EQG for TSS ensures that concentrations of organic waste, linked to concentrations of general coliform bacteria, will be maintained at comparatively low levels.

In the event that the EQG is exceeded, the future proponents must demonstrate through video surveys that no there are no bacterial mats (of the genus *Beggiatoa*) on the seafloor beneath the sea cages. *Beggiatoa* species take advantage of organically-enriched sediments at the water-sediment interface that can be found beneath fish farms that are poorly flushed and/or heavily stocked. It is reasonable to expect that bacterial mats at the water-sediment interface would correlate with general bacteria in the water. The bi-annual benthic quality video assessment provides further confidence that the water quality within the MWADZ is safe for both primary and secondary contact recreation (i.e. in-water activities such as swimming and diving; in addition to on-water activities such as boating).

With respect to the social EQO of “aesthetic values of the marine environment are protected” the measures are more subjective. The term “aesthetics” is very closely related to the EPA environmental factor of “amenity” (Section 13 of this PER and EAG 8). Consequently, by protecting the EV “ecosystem health” (EMMP - Appendix 2) and implementing the management measures outlined for the environmental factor of “amenity”, the MWADZ Proposal will protect the “aesthetics” component of the EV “recreation and aesthetics”.

7.5.5 Industrial Water Supply

The EV “industrial water supply” is specific to the industry and the industrial process used. In most cases, the industry is able to treat intake water to the quality they require (EAG 15).

As explained in the sections above, the water quality necessary for marine finfish aquaculture is of a standard well in excess of that required for industrial water supply. Therefore, by protecting the EVs of “ecosystem health”, “fishing and aquaculture” and “recreation and aesthetics”, the EV of “industrial water supply” is similarly protected.

While not a consideration for environmental impact assessment, it is also worth noting the proposed MWADZ is located approximately 65 kilometres offshore of the Mid West city of Geraldton. Consequently, it is improbable that water from the MWADZ Proposal area would be required for industrial use; at least, from the mainland. What is more possible is the potential future requirement for marine water for desalination purposes on the Abrolhos Islands Reserve. However, even should such requirement eventuate, the MWADZ Proposal area is located approximately six kilometres distant from the closest inhabited island and too remote for water extraction purposes; desalination or otherwise.

For the reasons outlined above, the MWADZ Proposal will protect this EV by protecting the EV "ecosystem health" (EMMP - Appendix 2).

7.5.6 Cultural and Spiritual

The EV "cultural and spiritual" applies to Aboriginal cultural and spiritual values. However, it is problematic to define spiritual value in terms of environmental quality requirements. In the absence of any specific environmental quality requirements for protection of this EV, it is assumed that if water quality is managed to protect ecosystem integrity, protect primary contact recreation, protect the quality seafood for eating and maintain aesthetic values, then this may go some way toward maintaining cultural values (EAG 15).

Until more definitive units of measurement of "cultural and spiritual" environmental quality can be determined, the MWADZ Proposal seeks to address this EV by adopting the approach outlined above (EMMP - Appendix 2).

7.5.7 Water Quality

The water quality monitoring program facilitates the assessment of several indicators of ecosystem health that relate to the environmental health of the water column (seawater within and surrounding the proposed MWADZ). Comparisons will be made between data collected at the proposed MWADZ boundary and background data that is measured at reference sites (at least 3,000 metres distant). The comparisons are to determine whether EQG and EQS have been met at the MWADZ boundary, within the High Ecological Protection Area (HEPA). The water quality monitoring program includes measurements for total suspended solids (TSS), chlorophyll-a, light attenuation coefficient (LAC) and dissolved oxygen (DO) (EMMP - Appendix 2).

7.5.8 Sediment Quality

The sediment monitoring program facilitates the assessment of several indicators of ecosystem health relating to the environmental health of the seafloor (benthos). Comparisons are made between data collected at impacts sites (within 300 metres of sea cages) and background data that is measured at reference sites (at least 3,000 metres distant from the sea cages).

The comparisons are to determine whether environmental quality guidelines (EQG) and environmental quality standards (EQS) have been met at the Moderate Ecological Protection Area (MEPA) boundary (i.e. 300 metres from the sea cages) and to build knowledge on the extent and intensity of organic enrichment and/or metal contamination near the sea cages (i.e. inside the MEPA boundary). The sediment monitoring program includes the following analytes: total nitrogen (TN), total phosphorus (TP), total organic carbon (TOC), metals (copper and zinc) and infauna (EMMP - Appendix 2).

7.5.9 Environmental Quality Management Framework for Moderate and High Ecological Protection

Under the MEPA framework, proponents will be required to undertake management (to reduce pressures) upon an exceedance of these criteria, all of which are expected to be exceeded well in advance of the "worst case" levels of impact predicted by the Model (which predicted isolated heavy impacts to sediments beneath the cages, but with no resulting changes in water quality). The EQMF and the criteria contained within the EMMP are a practical solution to management, particularly given the expected slow development of the industry (which will impart only small pressures prior to reaching full production) and the ability for proponents to routinely relocate sea cage infrastructure as needed. Cage clusters will be periodically relocated to allow sediments to return to the equivalent of baseline physical/chemical conditions (i.e. the practice of fallowing). Relocation of entire clusters may be undertaken to allow impacted habitats to recover and shift from conditions representing a moderate level of ecological protection to conditions representing a high level of ecological protection (EMMP - Appendix 2).

At a moderate level of environmental protection, EAG 15 allows for small changes in rates, but not types of ecosystem processes. However, it requires that biodiversity, as measured on both local and regional scales; remain at natural levels (i.e. no detectable change). The EQMF relies on the recovery of marine environmental quality. The Model has demonstrated that sediment chemistry will recover over time. However, recovery of biological components of sediment quality (i.e. restoration of infauna and associated ecosystem functions) is more complex and could not be reliably predicted by the Model. With respect to such limitations, Abelson *et al*. supports the use of existing management frameworks, such as EAG 15, to identify clear restoration targets, but recommends that benchmarks such as the re-establishment of ecosystem functions should be appraised bearing in mind that, in reality, biologically-driven ecosystem functions (having chemical, physical and biological interactions) can take decades (or longer) to return to a state equivalent to the baseline.

Nevertheless, the efforts by proponents to implement the fallowing regime (required in the EMMP - Appendix 2) will bring about recovery of ecosystem services (aspects of the ecosystem valued by people) at the operation-site level and maintain ecosystem functions at a local level. In this context, the EQMF will maintain the quality of water, sediment and biota so that the environmental values, both ecological and social, are protected.

The ability to relocate the infrastructure (either routinely or upon an exceedance of the EMMP criteria) allows the receiving environment to recover prior to recommencement of operations. The ability to fallow areas within aquaculture leases is an important advantage for aquaculture industry over other coastal industries (including harbours and outfalls) that cannot simply be relocated upon discovery of an unacceptable environmental response.

The EQMF and the EMMP are therefore critical to the development of the MWADZ, and provide the security to ensure future derived proposals are sustainable and well managed to achieve levels of environmental quality much higher than that predicted under the modelled "worst case" scenarios (EMMP - Appendix 2).

7.5.10 Response to Exceedances

The periodic relocation of sea cage clusters (i.e. fallowing) allows sediments to return to the equivalent of baseline physical/chemical conditions. Such practices have been shown to be a highly effective method for reducing the point source impacts of aquaculture. Relocation of entire cage clusters may be undertaken to allow impacted habitats to recover, and shift from conditions representing a moderate level of ecological protection, to conditions representing a high level of ecological protection.

Following exceedance of an EQC, the EMMP requires that one or more of the following contingency management measures be applied:

- relocation of cage cluster(s); or
- execution of temporary measures, such as:
  - partial harvest of the stock;
  - reduction in stock density; and/or
  - reduction in feed input.

Fallowing may be undertaken as part of routine operations, or in response to an exceedance of an EQS. In the case of an EQS exceedance, fallowing is recommended to reduce the source of the contaminants and to restore environmental quality to a level commensurate with high level of ecological protection (HEPA). The proponent must report an EQS exceedance to the Department and the OEPA within 24 hours and will commence a contingency management phase to:

- reduce the effect and/or mitigate the source of the contaminants; and
- restore environmental quality within the specified level of ecological protection.

Regardless of the management option, in the event of an EQS exceedance, proponents would be required to capture the transition from operational or impacted conditions to remediated conditions. Recovery monitoring will be undertaken at the former moderate ecological protection area (MEPA) compliance sites, which will be referred to as "recovery" sites. Sampling will be undertaken at a sub-set of the former MEPA compliance sites at distances: centre, 0 metres, 50 metres and 100 metres from the sea cage clusters. Recovery monitoring will be undertaken once during the scheduled summer sampling period and will be supplemented by qualitative video assessment. Recovery will be monitored until the sediment chemistry at the fallowed site achieves conditions commensurate with a high level of ecological protection. To assess recovery, data from the recovery (previously, "monitoring") sites will be compared against data from baseline or reference sites using appropriate statistical methods. The proponent shall report the results of recovery monitoring program to DoF and the OEPA annually (EMMP – Appendix 2).

7.6 Predicted Environmental Outcome

Results presented here indicate that the impacts of the proposal can be constrained within small areas of the seafloor within the proposed MWADZ, with no adverse effects to regional environmental quality.

7.6.1 Water Quality

Sea cage aquaculture may, in some circumstances, lead to elevated concentrations of dissolved inorganic nitrogen (DIN) and suspended particles in the water column. These factors can, in turn, lead to shading and reduced light levels at the seafloor resulting in the loss of BCH (Appendix 1).

Despite large inputs of DIN to the ecosystem, any faecal plumes or phytoplankton blooms within the proposed MWADZ will dissipate rapidly, and water quality will be maintained at levels consistent with a high level of ecological protection. The extent of light reduction (or shading) is largely associated with the extent of particles in the water, a proportion of which is phytoplankton. Phytoplankton concentrations, as indicated by chlorophyll-a concentrations, are not expected to change significantly across the proposed MWADZ. Similarly, light and dissolved oxygen levels in the water column of the proposed MWADZ are not expected to be affected. No discernible impacts on sub-surface light conditions are expected to be caused by increased phytoplankton blooms or suspended waste in the water column (Section 8.2.3.5; Appendix 1).

7.6.2 Sediment quality

The seafloor sediments beneath the sea cages will be exposed to deposition of organic material that will result in changes to concentrations of oxygen and hydrogen sulphide in the sediments (Section 7.4.1.1). Organic waste inputs will lead to some localised sediment organic enrichment and changes to sediment chemistry. Appropriate levels of standing biomass and three-year cage cluster site rotation will constrain the extent of the zone of high impact. After more than three years of finfish production at any one location, the zone of high impact is unlikely to breach the cage cluster perimeter (Appendix 1).

Given the conservative approach adopted for the development of the Model, the predicted impact to the sediment represents a "most likely worst case" outcome, as required by the ESD (EPA 2013). However, it should be noted that the expected environmental outcome sits between the modelled "most likely worst case" outcome and the aspirational "most likely best case" outcome. The precautious approach to the modelling has ensured that outputs relating to marine environmental quality were not under-predicted, but within the upper range of aquaculture related impacts reported in the scientific literature. In balancing the "most likely worst case" outcome (as predicted by the Model) with the "most likely best case" outcome (based on a breadth of relevant aquaculture literature and professional experience) the actual environmental outcome is expected, on average, to be less severe than that predicted by the Model. This provides confidence that the proponents will achieve a moderate level of protection within the operational area (i.e. within 300 metres of sea cages) and a high level of protection in at least 50% of each aquaculture lease within the MWADZ.

A key factor in modelling was that the rates of recovery (refer to Section 7.4), as predicted by the sediment diagenesis model, were assumed to proceed at a steady rate.

Although the modelling of recovery simulated some capacity to account for reoxygenation of the sediment, it did not take into account any extreme oceanic conditions associated with occasional intense low-pressure weather systems. While infrequent, major storm events could result in substantial scouring of the seafloor that could "reset" the sediments and advance their chemical recovery. Under a "most likely best case" scenario, it is expected that "resetting" events (associated with major storms) would result in less accumulation of organic material than described in Section 7 and faster chemical remediation. As such, the impacts predicted in this document are more extensive than might be expected on average. Nevertheless, they are within the upper range of impacts reported in the literature (i.e. Brooks et al. 2004). The greater propensity for flushing and sediment reoxygenation could be expected to reduce the overall impact footprint as predicted by the Model.

Large standing biomasses (up to 8 tonnes per hectare of lease) are achievable, while constraining the benthic impacts to relatively small areas. However, increasing the stocking density by reducing the total sea cage volume used to contain the same standing biomass of stocked fish will increase the intensity of impacts beneath the sea cages. Under the EQMF, proponents are expected to maintain a moderate level of ecological protection to a distance of 300 metres from the cages, beyond which a high level of ecological protection will apply.

The EQMF provides the mechanism for protecting the MWADZ and surrounding region by applying strict environmental performance criteria on proponents. These performance criteria are conservative and therefore useful as "early warning" triggers for management. If stocking densities are sustained around and beyond the upper limits of industry norms, the risk of exceeding the Ecosystem Quality Criteria (EQC) will exponentially increase (for contingency options refer to Section 7.5). Although an exceedance of the EQS will trigger a management action to reduce impacts on sediment quality, the time taken for sediments to achieve chemical remediation is approximately five years (Appendix 1).

Increases in stocking density will extend the time required for sediment (chemical) remediation during fallowing. Therefore, a limit on the stocking density (up to eight tonnes per hectare of lease) is essential for managing the proposed MWADZ. Once a site has been fallowed, impacted seafloor habitats within the operational areas are predicted to recover to a high level of ecological protection within five years. Immediately under the sea cages, the small proportion of sediments that are heavily impacted may require as long as nine years to achieve full biological recovery (Appendix 1).

In addition to contributing organic wastes to the seafloor, any antibiotics administered to stock inside the sea cages will deposit in the sediments beneath. Although its use is rare in the industry today, an incident such as a disease outbreak may require that antibiotics be administered to the stock within the sea cages. The main risk associated with the use of antibiotics in sea cages is the potential degradation of bacterial communities at the seafloor. An impact on bacterial communities could affect biochemical and broader ecological processes. Because antibiotics are administered in feeds, the spatial extent of potential impacts is likely reflected in the settlement patterns of organic wastes. Given the majority of wastes in the proposed MWADZ would be deposited within 60 metres of the sea cages, it would be constrained to relatively small areas. The more commonly used antibiotics in the industry may persist in the sediments beneath sea cages for a number of weeks. However, accumulation over multiple seasons in the MWADZ is considered unlikely and the potential effects are considered negligible (Appendix 1).

Areas outside, and at least half of the area inside, the proposed MWADZ will maintain sediment chemistry (in relation to oxygen and sulphide concentrations) equivalent to background levels, with no resulting changes in infauna diversity. Providing standing biomasses do not exceed eight tonnes per hectare of lease, it is expected that EQC for infauna diversity will not be exceeded (Appendix 1).

Although present in commercial feeds (and therefore also present in fish faeces), it is predicted that the low molar ratios of zinc and copper in the fish waste will be insufficient to result in sediment concentrations in excess of the EQC, even after five years production at the upper end of the proposed standing biomass limit of 24,000 tonnes of marine finfish for the proposed MWADZ (Appendix 1).

8 ASSESSMENT OF POTENTIAL IMPACT ON BENTHIC COMMUNITIES AND HABITATS

8.1 Assessment Framework

8.1.1 Environmental Objective

The EPA environmental objective for Benthic Communities and Habitat (BCH) is as specified in EAG 8, namely:

"*To maintain the structure, function, diversity, distribution and viability of benthic communities and habitats at local and regional scales*".

8.1.2 Relevant Legislation, Policies, Plans and Guidelines

Table 8-1: Legislation, Policies, Plans, and Guidelines Relevant to Benthic Communities and Habitat

Legislation, Polices, Plans and Guidelines	Intent
State	
Environmental Protection Act 1986	This State Act provides for an EPA, for the prevention, control and abatement of pollution and environmental harm, and for the conservation, preservation, protection, enhancement and management of the environment.
Fisheries Resources Management Act 1994	Provides a legal framework to conserve, develop, and share fish resources for the benefit of current and future populations in WA. This legislation also provides the management framework for the Abrolhos Islands reserve and for the establishment and management of the Fish Habitat Protection Areas.
The Management Plan for the Houtman Abrolhos Islands. Fisheries Management Paper 260. (Department of Fisheries 2012)	The Houtman Abrolhos Islands Management Plan outlines both the vision and strategic objectives of management of the Abrolhos for the next ten years. It aims to conserve and promote the unique environmental and cultural heritage values of the Abrolhos Islands. The Plan's management objective for marine biota is: "*To minimise impact from human activities on marine habitats, distribution and populations of marine species in the Abrolhos Fish Habitat Protection Area.*"

Environmental Assessment Guidelines (EAG)	
Environmental Assessment Guidelines No.8 (EAG 8) Environmental Assessment Guideline for Environmental Principles, Factors and Objectives (EPA 2015)	The EAG 8 provides guidance for proponents to help them understand the need to consider environmental principles, factors and objectives for the purpose of environmental impact assessment. Environmental principles, factors and objectives are critical to the environmental impact assessment process as they underpin the EPA's decision on the environmental acceptability of a proposal or scheme. In making its decisions, the EPA also takes a holistic approach to assessing environmental acceptability based on a number of broader considerations including whether the proposal aligns with broader international, national and State policies and agreements and takes account of the interconnected nature of the environment.
Environmental Assessment Guidelines No.3 (EAG 3) – Protection of Benthic Habitats in Western Australia's Marine Environment December 2009 (EPA 2009	EAG 3 recognises the fundamental importance of the Benthic Communities and Habitats (BCH) and the potential consequences of their loss for marine ecological integrity. The EAG 3 expects the following hierarchy of principles to be addressed by proponents when assessing proposals that could damage/ loss of BCH: • Consideration of options to avoid damage or loss of BCH; • Design that minimises damage or loss of BCH; • Best practice in design, construction methods, and environmental management aimed at minimising indirect impacts; • Consideration of environmental offset where substantial cumulative losses of BCH have already occurred; and • Risk to ecosystem integrity within a management unit is not substantial. The EAG 3 also provides a risk-based spatial assessment framework for evaluating cumulative irreversible loss of and/or serious damage of BCHs (EPA 2009). The EPA has termed within which to calculate cumulative losses "Local Assessment Units".
Environmental Assessment Guidelines No.7 (EAG 7) Environmental Assessment Guideline for Marine Dredging Proposals (EPA 2011)	The EAG 7 sets out guidance for predicting impacts to benthic communities and habitats due to significant dredging activities. The EPA has developed a spatially-based zonation scheme for proponents to use as a common basis to describe the predicted extent, severity and duration of impacts associated with the dredging proposals. The scheme consists of three zones that represent different levels of impact (EPA 2011) : • Zone of High Impact (ZoHI) - the area where impacts on benthic communities are predicted to be irreversible (defined as lacking capacity to return or recover to a pre-dredging state within a timeframe of five years. • Zone of Moderate Impact (ZoMI) - the area where predicted impacts on benthic communities are expected to be sub lethal and/or the impacts recoverable within a period of five years following completion of the dredging activities. • Zone of Influence (ZoI) - the area where changes in environmental quality associated with dredge plumes are predicted, but these changes are not expected to result in a detectable impact on benthic communities.

Environmental Assessment Guidelines No.15 (EAG 15) Environmental Assessment Guideline for Protecting the Quality of Western Australia's Marine Environment (EPA 2015)	The EAG 15 provides an environmental quality management framework to protect the environmental values of Western Australia's marine environment from waste discharges and contamination. The EPA has provided this environmental quality management framework in EAG 15 to assist the proponent in predicting and managing the effects of pollution, waste discharges and deposits on the quality of the marine environment (EPA 2015)

8.2 Existing Environment

8.2.1 Benthic Communities and Habitat

8.2.1.1 2014 Baseline Survey

Surveys in 2014 of the study area associated with the MWADZ Proposal indicated that much of the seafloor consisted of a flat layer of limestone reef (at a depth of ~15 centimetres) overlain with sand. The sand had sparsely-distributed biological communities, comprising filter feeders (sponges, and bryozoans), macro algae, rhodoliths and hard corals (although corals were observed infrequently; Figure 8-1). Because the spatial extent of the major habitat categories was interpolated to produce a map of the benthic habitats across an extensive area, some parts of the map could not be described with adequate certainty. These are represented in Figure 8-1 as an absence of coloured pixels.

Northern area

Habitats in the northern part of the study area consisted of mainly bare sand (59%) and mixed assemblages (34%; Figure 8-1). Small patches of reef were present near the north-east boundary but made up only 8% of the identified habitats within the area. Of the total northern study area, the mixed biological community habitats were mainly composed of macro algae (3.7%), rhodolith (3.3%) and sponges (2.3%), with the remainder consisting of bare sand. Examples of the most commonly observed habitats are presented in Figure 8-2.

Southern area

Habitats in the southern part of the study area were predominantly bare sand (95%; Figure 8-1) with sparse mixed biological communities (5%) in the shallower waters to the south. Of the total southern study area, the mixed biological community habitats were mainly composed of rhodoliths (0.3%) and unknown organisms comprised (0.1%), and the remaining habitat dominated by bare sand. There was no evidence of significant hard coral cover.

Reference sites

The habitats of the three reference sites (with the exception of the northern-most reference site) were dominated by bare sand (42.5%) followed by mixed assemblage categories on sand and reef (total 17.7%; Figure 8-1). The northern-most reference site had a more diverse distribution of habitats throughout the area with reef and mixed biological community/reef habitats present (12.4%; Figure 8-1). Of the total reference site area, the mixed biological community habitats were mostly macro algae (2.1%), sponges (1.3%) and hard coral (0.1%).

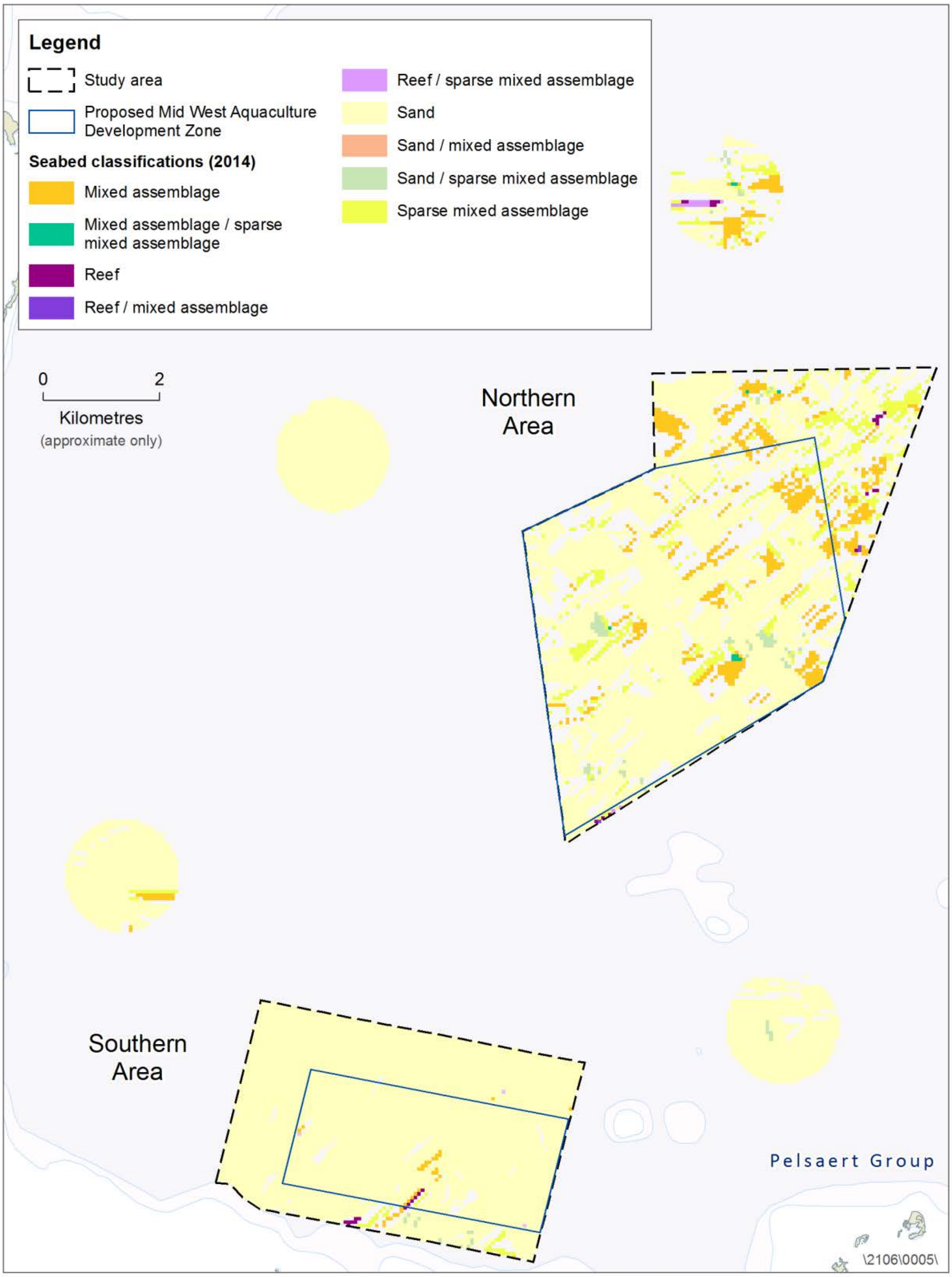
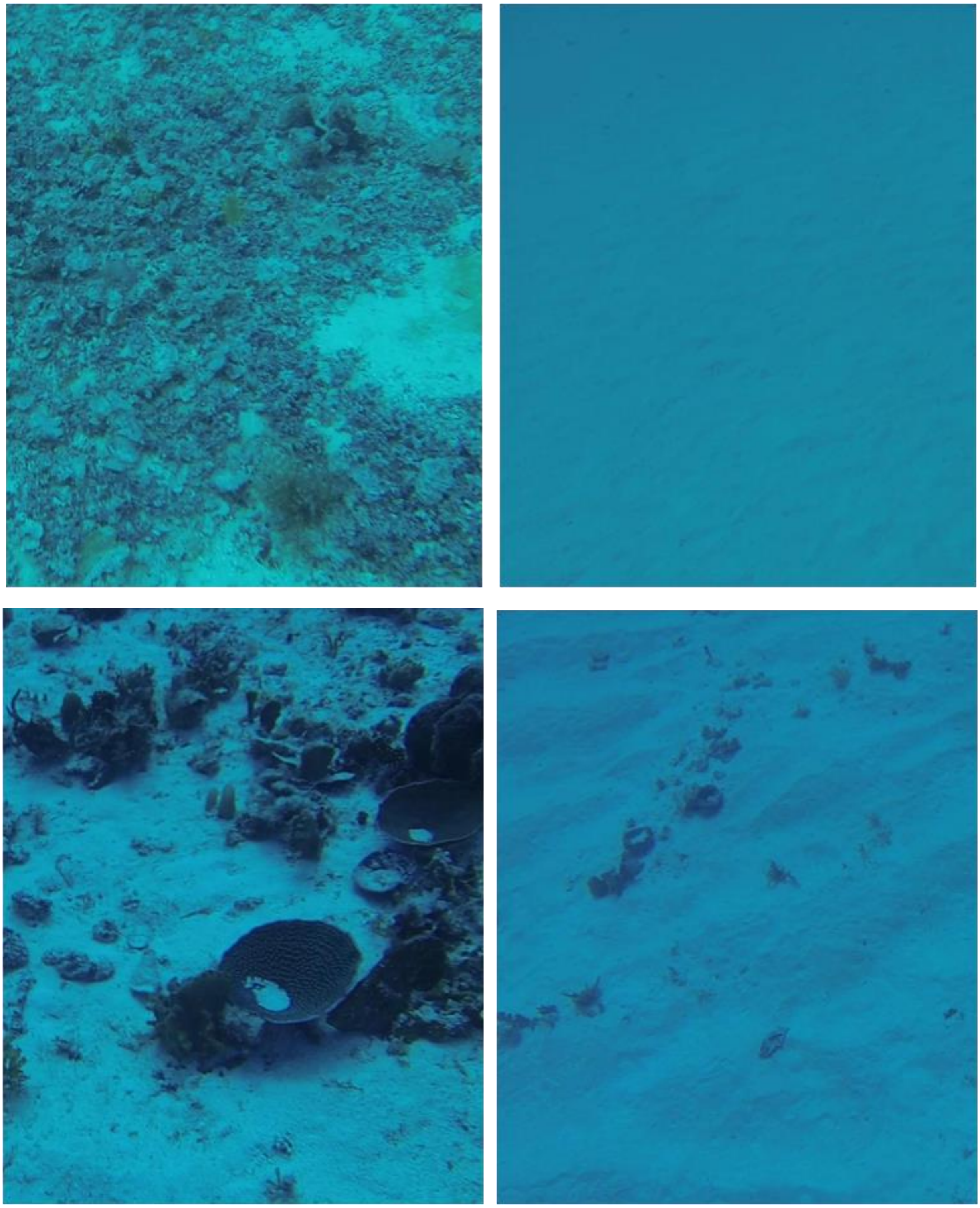


Figure 8-1: Major habitat assemblages observed in the study area in 2014



Notes:

1. Mixed assemblages with hydroids and macro algae (top left); bare sand with rhodoliths (top right); mixed assemblages with sponges and macro algae (lower left) and sparse mixed assemblages (lower right)

Figure 8-2: Examples of the common habitats observed during benthic habitat surveys

8.2.1.2 Previous Surveys

The current benthic habitat survey is provided above. Two previous relevant benthic habitat surveys are described below at a high level for contextual purposes only. Comparisons were made between the current (2014) benthic habitat survey and historical (2003, 2006/2008) benthic habitat surveys:

1. University of Western Australia - Marine Futures Project - hydro-acoustic mapping, towed video and biodiversity sampling in and around the Southern Group of Abrolhos Islands in 2006 and 2008 (hereon referred to as historical 2006 survey); and
2. University of Western Australia and Undersea Community Pty Ltd - Habitat Survey North of the Pelsaert Group of the Abrolhos Islands, by Andy Bickers in 2003. This survey (hereon referred to as historical 2003 survey) used side-scan sonar.

The historical surveys and 2014 survey differed significantly in their approaches, in terms of equipment and the classification schemes used (Appendix 1). Each of the three surveys provided discrete, low-resolution assessments. Comparisons of the surveys indicate considerable temporal variability in benthic habitats within the study area. These changes in the benthic habitat may have occurred between surveys as a result of the dynamic nature of the seabed and is consistent with the effects of sand sheet movement over time.

Although the 2006 survey only captured a portion of the northern part of the MWADZ study area, comparisons identified a recent change to a sand dominated habitat with a noticeable reduction of biological communities (predominately macro algae) observed in 2014 (Appendix 1).

Similarly, comparisons with these previous surveys identified that the southern area has recently shifted to a sand dominated habitat, with a noticeable reduction of biological communities (including rhodoliths) and reef habitats observed in the 2014 survey. Although small areas of seagrass were recorded in the southern part of the MWADZ study area by the historical surveys, no seagrass was observed during the more recent 2014 survey.

8.3 Potential Impacts

The benthic communities living in or on the calcareous sands and reefs within the proposed MWADZ include macro algae (various species of Chlorophyta, Heterokontophyta, and Rhodophyta); and other organisms that rely on symbiotic algae, zooxanthellae (i.e. most species of stoney corals, soft corals, anemones, and gorgonians). The assessment found that the cover of benthic communities and habitat (BCH) within the proposed MWADZ is less than 13 percent and the seafloor within the zone is currently a sand dominated habitat (Section 8.2.1; Appendix 1).

However, the dynamic nature of the sand-sheet movement on the seafloor means that BCH is likely to be transient in its cover and biological composition. No seagrass (e.g. *Halophila* spp.) was observed within the proposed MWADZ during the 2014 survey. *Halophila* spp. was historically present in some habitats of the shallow areas within the southern part of the MWADZ. If in future *Halophila* spp. was to colonise the parts of the MWADZ area, its distribution would be highly restricted to the shallowest patches that have adequate levels of light at the seafloor.

The establishment and physical presence of aquaculture infrastructure is not expected to impact upon BCH. The anchoring points for the sea cage cluster will be low profile, and given its sparse coverage, the installation will not require the destruction of any BCH.

The proposed aquaculture will generate organic particles that will deposit in the immediate vicinity of the sea cages. The organic loads are linked to three potential mechanisms leading to impacts on BCH, namely:

- direct smothering through burial;
- indirect smothering and, or, shading due to increased phytoplankton and epiphyte growth;
- oxygen starvation through anoxia cause by microbial activity; and/or
- toxicity due to the production of sulphides forming in the sediments.

If the settlement of organic material is sufficient to deprive photosynthesising organisms (BCH) of light or oxygen, the interruption to primary production (autotrophic) feeding mechanisms can result in degradation and mortality. The increase in dissolved inorganic nitrogen (DIN) that is associated with the deposition of stock faeces could promote growth of phytoplankton and epiphytes. This cause-effect-response also leads to smothering and/or shading of the BCH. Additionally, changes to sediment chemistry that cause the depletion of oxygen or production of sulphides in the seafloor sediments will result in mortality of BCH. Recovery of BCH after heavy exposure of organic loading will require the seafloor sediment to return to its original condition in term of chemical composition. Chemical and biological recovery may take several years (Appendix 1).

8.4 Assessment of Potential Impacts

8.4.1 Cumulative Loss of Benthic Communities and Habitat

The first consideration as part of this assessment was to determine the extent to which any previous losses of Benthic Community Habitat (BCH) had resulted from historical anthropogenic activities. It is considered that the benthic habitats in the proposed MWADZ are relatively pristine. Historic surveys (refer to Appendix 1) suggest that the composition of the benthic habitats is naturally transient due to the effects of sand sheet movement and corresponding natural variability of the benthic habitat coverage over time. There is no evidence that historical anthropogenic activities have caused lasting impacts that would contribute to cumulative loss.

Environmental Assessment Guidelines No. 3 (EAG 3) requires that the expected cumulative loss of BCH is assessed as a proportion against those in an agreed Local Assessment Unit (LAU). Relevant data was used to define two local assessment units within a one kilometre buffer around the Northern and Southern areas of the proposed zone (Figure 8-28). In relation to benthic habitat, most (71%) of the Northern LAU (44.2 km^2) and nearly all (96%) of the Southern LAU (23.2 km^2) has been surveyed. The benthic layers in Figure 8-28 are primarily based on the 2014 survey (contributing 67% of the data uses to describe the LAU); historical surveys informed some parts of the representation of the one kilometre buffer around the proposed zone.

To gain an understanding of the dynamics of the BCH in and around the strategic proposal areas, and interpolate/extrapolate the coverage of BCH to include a one kilometre strip outside the proposed MWADZ, two historical (2003, 2006/2008) benthic habitat surveys were taken into account. The data was used to estimate the most likely coverage of mixed assemblages, reef and bare sand in the LAUs. For the purposes of this assessment, mixed assemblages and reef have been conservatively assumed to correspond to BCH.

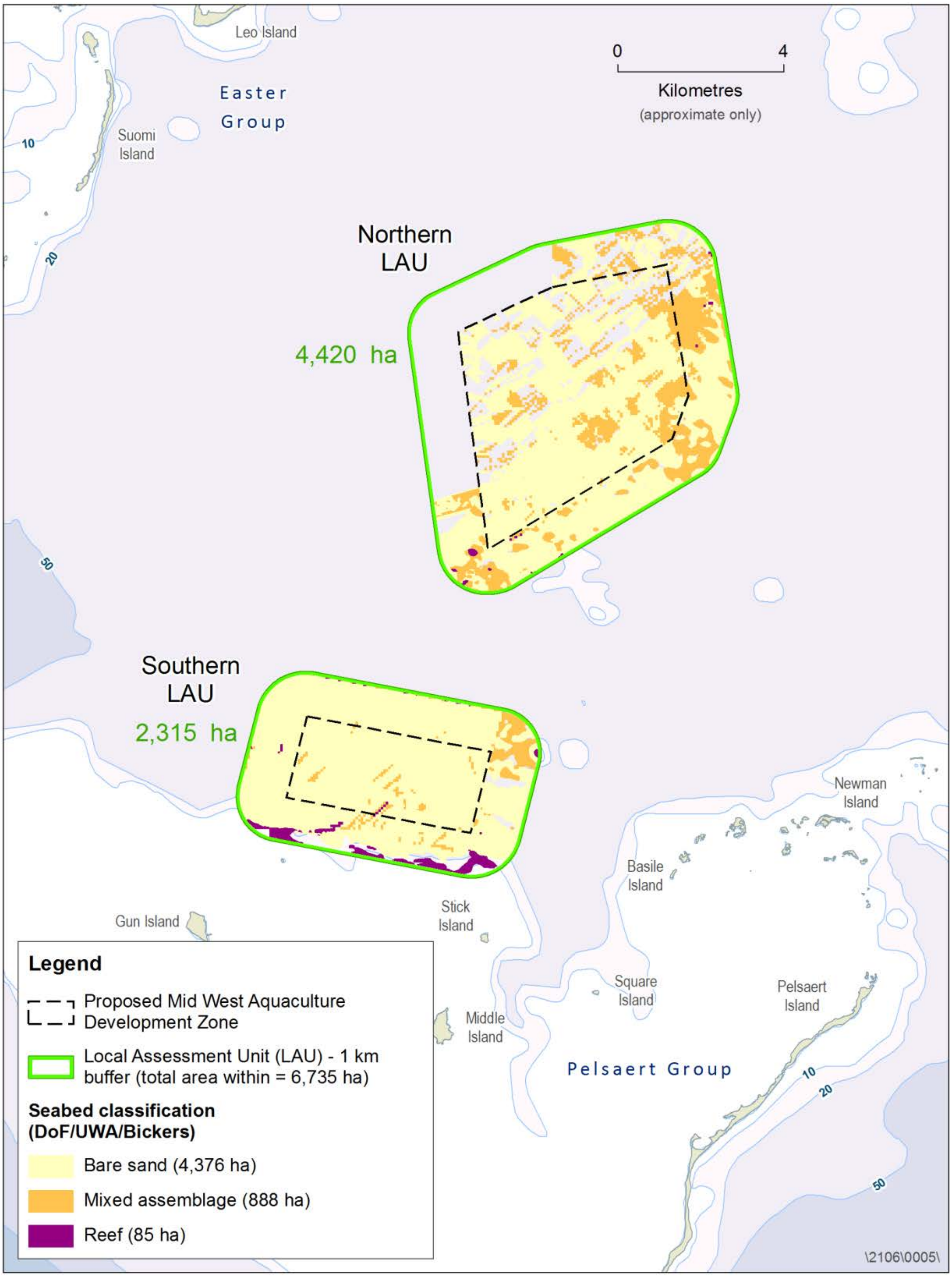


Figure 8-28: The Northern and Southern Local Assessment Units and the indicative benthic substrates in the vicinity of the MWADZ

8.4.2 Estimating the benthic cover of Benthic Communities and Habitat

8.4.2.1 Local Assessment Units

Habitat surveys in both the Northern and Southern Local Assessment Units (LAUs) captured the diversity and natural variability of the benthic environment (i.e. bathymetry and proximity to islands) within one kilometre buffers around the proposed MWADZ. At least 24% of the Northern LAU supports mixed biological communities consisting of algae and sessile invertebrates, while approximately 6% of the Southern LAU supports mixed assemblages consisting of algae, rhodolith and sessile invertebrates.

The benthic substrate classified as reef has some three-dimensional complexity and is the only substrate capable of sustaining coral reef habitat. Reef makes up less than one percent of the Northern LAU and less than four percent of the Southern LAU. The benthic substrate classified as bare sand makes up approximately 75% of the Northern LAU and 91% of the Southern LAU.

Of the 4,420 hectares in the Northern LAU, approximately 25% of this area (1,091 hectare) comprises habitats capable of supporting BCH (i.e. around 0.29% reef and 24% mixed assemblages, while approximately 75% is bare sand). Of the 2,315 hectares in the Southern LAU, approximately 9% (208 hectares) comprises habitats capable of supporting BCH (3.4% Reef and 5.6% mixed assemblages, while approximately 91% is bare sand).

8.4.2.2 Estimated Losses of Benthic Communities and Habitat

Approximately 25% of the Northern LAU (1,091 hectares) and 9% (209.9 hectares) of the Southern LAU comprise habitats capable of supporting BCH. The modelling predicted that the zone of high impact (ZoHI) would occupy 41 hectares and 21 hectares respectively in the Northern LAU and Southern LAU[41] [Section 6.2 of the Modelling and Technical Studies (Appendix 1) refers]. These figures were tripled to account for the one aquaculture impact "footprint" and two "recovering sites" that form over time as cages are relocated and the previous sites are fallowed.

Aquaculture is contained well-within the boundaries of the zone and therefore only the BCH inside the proposed zone can be impacted by aquaculture. The 2014 benthic habitat survey recorded 374 hectares (Northern Area) and 11 hectares (Southern Area) of BCH sparsely distributed throughout the proposed MWADZ.

The technical and environmental studies have predicted that the zone of high impact (ZoHI) beneath and immediately surrounding the sea cages within the proposed MWADZ will cover approximately 123 hectares (Northern Area) and 63 hectares (Southern Area) respectively of the seafloor within the zone areas inside the Northern LAU and Southern LAU. Taking into account the sparse distribution of the BCH within each LAU, we estimated the loss of BCH by calculating the probability that BCH would coincide with areas within the ZoHI. The ZoHI is predicted to coincide with approximately 20.9 hectares and 0.87 hectares of BCH within the Northern LAU and Southern LAU, respectively.

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[41] Note that the figures shown for the area occupied by the ZoHI are based on the modelling outputs for Scenario 4 (i.e. 24,000 tonnes of standing biomass after 3 years of production; Table 8-4).

While the proposed MWADZ is within the Abrolhos Islands Fish Habitat Protection Area (FHPA), the Management Plan for the FHPA does not identify any areas of high conservation value that would be Category A and there have been no historical, irreversible losses of BCH in the LAU. Based on this, the assessment against EAG 3 was undertaken using the Category C cumulative loss guidelines (EAG 3).

The Cumulative Loss Guidelines (EAG 3) recommend for LAUs located in Category C areas, that cumulative losses of BCH should not exceed 2% of the LAU area. The cumulative loss of BCH likely to result from the proposed aquaculture in the Northern LAU and Southern LAU is 1.92% and 0.42% respectively; both of which fall beneath the 2% benchmark.

8.5 Management Measures

The Environmental Monitoring and Management Plan (EMMP - Appendix 2), that has been developed to provide proponents with an appropriate EQMF for managing the potential impacts of stocking up to 24,000 tonnes of marine finfish across the MWADZ, is described in general terms in Section 13.3.1.1.

Maintenance of ecosystem integrity is concerned with maintaining the structure and functions of marine ecosystems to an appropriate level. In this context, the EMMP includes mechanisms to protect the key environmental factor "benthic communities and habitat" (BCH).

Cage clusters will be periodically relocated to allow sediments to return to the equivalent of baseline physical/chemical conditions. Relocation of entire clusters may be undertaken to allow impacted habitats to recover and shift from conditions representing a moderate level of ecological protection to conditions representing a high level of ecological protection (EMMP - Appendix 2).

Although operations within the zone will lead to small localised footprints of impact on water and sediment quality, ecosystem processes, and biodiversity, the EMMP is designed to facilitate a "feed-back-loop" between the monitoring and management processes to maintain acceptable levels of environmental protection of BCH across the proposed MWADZ. Over time, the monitoring program (Section 13.3.1.1) is designed to generate a comprehensive dataset that provides sufficient evidence that impacts on BCH are restricted to local-scale areas and are restored (over time) to a high level of environmental quality (EMMP - Appendix 2).

The monitoring allows operators to demonstrate that EQG and EQS have been met at the MEPA - HEPA boundary. Although conditions in up to 50 percent of the proposed MWADZ may reflect a moderate level of ecological protection, the monitoring and management "feed-back-loop" will ensure that (overall) the BCH within in the proposed MWADZ and the surrounding ecosystem is being maintained at a high level of ecological protection for the maintenance of environmental integrity (EMMP - Appendix 2).

8.6 Predicted Environmental Outcome

Sea cage aquaculture may, in some circumstances, lead to smothering or degradation of seafloor habitats including BCH. The modelling predicted a heavy organic deposition will be spatially-constrained to areas immediately under the sea cages.

The deposition of organic particles in the immediate vicinity of the sea cages will lead to some smothering and interruption to filter feeding processes within the operational area. However, the impact to the sediment chemistry is isolated to the vicinity of the sea cages and the overall cover of BCH within the proposed MWADZ is unlikely to be significantly affected by the aquaculture.

The associated increases in dissolved inorganic nitrogen (DIN) could promote localised algal growth, thereby shading BCH within areas near the sea cages. However, the modelling predicted no changes to water quality would result from the deposition of aquaculture-derived organic particles.

The predicted environmental outcome in relation to BCH is in keeping with the overall results of the EIA, which predicted that the most severe impacts are restricted to small areas (i.e. less than 300 hectares) when aquaculture production is at full capacity. The baseline survey found that the cover of BCH within the proposed MWADZ is less than 13 percent, and the proposal was unlikely to yield significant cumulative losses of BCH. The cumulative loss would be restricted to less than two per cent of the local assessment units that were defined for the MWADZ Proposal (Appendix 1), which complies with the Cumulative Loss Guidelines (EAG 3).

Given the conservative approach adopted for the development of the model, the predicted environmental outcome represents a "most likely worst case" outcome, as required by the ESD (EPA 2013). However, it should be noted that the expected environmental outcome sits between the modelled "most likely worst case" outcome and the aspirational "most likely best case" outcome. A precautious approach to the modelling was adopted to predict the impact on water and sediment quality. Outputs from the model were conservative, but within the upper range of impacts reported in the aquaculture literature (i.e. Brooks et al. 2004). These conservative outputs informed the assessment of potential impacts on BCH. Considering the precautious nature of the modelling, it is reasonable to expect that the actual impact on BCH will be less severe than the conservative estimates of cumulative loss (Section 8.4.2).

9 ASSESSMENT OF POTENTIAL IMPACT ON MARINE FAUNA

9.1 Assessment Framework

9.1.1 Environmental Objective

The environmental objective established in this PER for marine fauna is as specified in EAG 8, namely:

> *"To maintain the diversity, geographic distribution and viability of fauna at the species and populations levels".*

9.1.2 Relevant Legislation, Policies, Plans and Guidelines

Table 9-1: Legislation, Policies, Plans, and Guidelines Relevant to Marine Fauna

Legislation, Polices, Plans and Guidelines	Intent
State	
Environmental Protection Act 1986	This State Act provides for an EPA, for the prevention, control and abatement of pollution and environmental harm, and for the conservation, preservation, protection, enhancement and management of the environment.
Fisheries Resources Management Act 1994	Provides a legal framework to conserve, develop, and share fish resources for the benefit of current and future populations in WA. This legislation also provides the management framework for the Abrolhos Islands reserve and for the establishment and management of the Fish Habitat Protection Areas.
Wildlife Conservation Act 1950	Provide a legal framework for the conservation and protection of flora and fauna in Western Australia.
Conservation and Land Management Act 1984	An Act to make better provision for the use, protection and management of certain public lands and waters and the flora and fauna thereof, to establish authorities to be responsible therefor, and for incidental or connected purposes.
The Management Plan for the Houtman Abrolhos Islands. Fisheries Management Paper 260. (Department of Fisheries 2012)	The Houtman Abrolhos Islands Management Plan outlines both the vision and strategic objectives of management of the Abrolhos for the next ten years. It aims to conserve and promote the unique environmental and cultural heritage values of the Abrolhos Islands. Some of the main management objectives include: • *To protect and maintain marine and terrestrial environments of the Abrolhos; and* • *To facilitate and manage fishing an aquaculture activities consistent the environmental and cultural values of the Abrolhos.*
Environmental Assessment Guidelines (EAG)	
Environmental Assessment Guidelines No.8 (EAG 8) Environmental Assessment Guideline for Environmental Principles, Factors and Objectives (EPA 2015)	The EAG 8 provides guidance for proponents to help them understand the need to consider environmental principles, factors and objectives for the purpose of environmental impact assessment. Environmental principles, factors and objectives are critical to the environmental impact assessment process as they underpin the EPA's decision on the environmental acceptability of a proposal or scheme. In making its decisions, the EPA also takes a holistic approach to assessing environmental acceptability based on a number of broader considerations including whether the proposal aligns with broader international, national and State policies and agreements and takes account of the interconnected nature of the environment.

Environmental Assessment Guidelines No.7 (EAG 7) Environmental Assessment Guideline for Marine Dredging Proposals (EPA 2011)	The EAG 7 sets out guidance for predicting impacts to benthic communities and habitats due to significant dredging activities. The EPA has developed a spatially-based zonation scheme for proponents to use as a common basis to describe the predicted extent, severity and duration of impacts associated with the dredging proposals. The scheme consists of three zones that represent different levels of impact (EPA 2011): • Zone of High Impact (ZoHI) - the area where impacts on benthic communities are predicted to be irreversible (defined as lacking capacity to return or recover to a pre-dredging state within a timeframe of five years. • Zone of Moderate Impact (ZoMI) - the area where predicted impacts on benthic communities are expected to be sub lethal and/or the impacts recoverable within a period of five years following completion of the dredging activities. • Zone of Influence (ZoI) - the area where changes in environmental quality associated with dredge plumes are predicted, but these changes are not expected to result in a detectable impact on benthic communities.
Commonwealth	
Marine Bioregional Plan for the South-west Marine Region (SEWPaC 2012) and associated Conservation Value Report Cards	Sets out broad objectives for the region's biodiversity, identifies regional priorities, and outlines strategies and actions to achieve these. As part of the overall Plan, Conservation Value Report Cards present environmental baseline information and conservation values for the Commonwealth Marine Environment.
Environment Protection and Biodiversity Conservation Act 1999	It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places — defined in the EPBC Act as matters of national environmental significance.
Marine Fauna and their Habitats	
Australia's Biodiversity Conservation Strategy 2010–2030 (National Biodiversity Strategy Review Task Group 2010)	Sets a national direction for biodiversity conservation over the next decade, including a vision that "Australia's biodiversity is healthy, resilient to climate change and valued for its essential contribution to our existence".
Marine Bioregional Plan for the South-west Marine Region (SEWPaC 2012) and associated Conservation Value Report Cards	Sets out broad objectives for the region's biodiversity, identifies regional priorities and outlines strategies and actions to achieve these. As part of the overall Plan, Conservation Value Report Cards present environmental baseline information and conservation values for the Commonwealth Marine Environment and EPBC Act-listed threatened and migratory species.
Fish and their Habitats	
Memorandum of Understanding (MoU) on the Conservation of Migratory Sharks (Convention on Migratory Species [CMS] 2007)	Australia is a signatory to this MoU, which aims to achieve and maintain a favourable conservation status for seven shark species, including ensuring healthy and viable populations of these species remain in their existing habitats.
National Plan of Action for the Conservation and Management of Sharks 2012 Shark-Plan 2	Shark Plan 2 identifies how Australia will manage and conserve sharks and ensure that Australia meets international conservation and management obligations. It identifies research and management actions across Australia for the long-term sustainability of sharks, including actions to help minimise the impacts of fishing on sharks.

Recovery Plan for the White Shark (*Carcharodon carcharias*)	The overarching objective of this recovery plan is to assist the recovery of the white shark in the wild throughout its range in Australian waters with a view to: • improving the population status, leading to future removal of the white shark from the threatened species list of the EPBC Act; and • ensuring that anthropogenic activities do not hinder recovery or impact on the conservation status of the species in the future.
Conservation Advice *Rhincodon typus* Whale Shark 2015	The Whale Shark Recovery Plan 2005 - 2010 is no longer valid. However, until such time as a new recovery plan is in place (or the need for one is removed) a Conservation Advice (http://www.environment.gov.au/cgi-bin/sprat/public/conservationadvice.pl) is in place.
Recovery Plan for the Grey Nurse Shark (*Carcharias taurus*) 2014	The plan considers the conservation requirements of the species across its range, identifies the actions to be taken to ensure the species' long-term viability in nature and indicates the parties that will undertake those actions.
Sawfish and River Sharks Multispecies Recovery Plan 2015	This recovery plan considers the conservation requirements of these species across their range, identifies the actions to be taken to ensure their long-term viability in nature and the parties that will undertake those actions. The document outlines: the basic biology and ecology of these species; details the known threats; presents the key conservation objectives; and includes performance criteria to measure the achievement of these objectives.
Approved Conservation Advice for Green Sawfish (*Pristis zijsron*) (DEWHA 2008)	Provides advice as to the priority actions for recovery and conservation of this species in the wild. The overall objective is to aid the recovery of the species and abatement of threats (e.g. habitat degradation).
National Plan of Action for the Conservation and Management of Sharks 2012 Shark-Plan 2	Shark Plan 2 identifies how Australia will manage and conserve sharks and ensure that Australia meets international conservation and management obligations. It identifies research and management actions across Australia for the long-term sustainability of sharks, including actions to help minimise the impacts of fishing on sharks.
Marine Mammals and their Habitats	
The Action Plan for Australian Cetaceans (Environment Australia 1996)	The plan aims to provide more information on taxonomy, distribution, habitat preference and diet in Australian waters for cetaceans, as well as identify threatening processes and priority actions.
Conservation Management Plan for the Southern Right Whale - A Recovery Plan under the *Environment Protection and Biodiversity Conservation Act 1999* 2011–2021	The long-term recovery objective is to minimise anthropogenic threats to allow the conservation status of the southern right whale to improve so that it can be removed from the threatened species list under the EPBC Act.
The Blue, Fin and Sei Whale Recovery Plan 2005–2010 (DEH 2005a)	The objectives of this plan are to: • recover populations of blue, fin, and sei whales using Australian waters so that the species can be considered secure in the wild; and • maintain the protection of blue, fin, and sei whales from human threats.
MoU on the Conservation and Management of Dugongs (*Dugong dugon*) and their Habitats throughout their Range (CMS 2007)	Australia is a signatory to this MoU, which aims to facilitate national and transboundary actions that will lead to the conservation of dugong populations and their habitats.
Recovery Plan for the Australian Sea Lion (*Neophoca cinerea*) 2013(DSEWPaC)	Sets out strategies for ensuring the conservation and recovery of the Australian Sea Lion.

Marine Reptiles and their Habitats	
Recovery Plan for Marine Turtles in Australia (Environment Australia 2003)	Aims to reduce detrimental impacts on Australian populations of marine turtles and hence promote their recovery in the wild.

9.2 Existing Environment

9.2.1 Fish

A total of 389 species of fishes have been recorded from the Abrolhos Islands, of which 257 (66%) are tropical species, 74 (19%) warm temperate species and 50 (13%) subtropical species (Hutchins, J.B 1997). Over 70% of the tropical fish species are very low in abundance suggesting that many are not maintaining breeding populations at the Abrolhos (Hutchins, J.B. 1997). It is thought that many of the tropical species occurring in the Abrolhos, do not actually spawn in the islands, but instead are dependent for recruitment of larvae being carried southward by the Leeuwin Current from areas further north, such as Shark Bay or Ningaloo Reef (Hutchins, J.B. 1997). Given that the majority of coral habitat is located on the eastern side of the island groups away from the flow of the Leeuwin Current, it may receive only low numbers of tropical fish recruits (Hutchins, J.B 1997). Another reason for the low abundance of tropical fish species may be due to the dominance of a few types of coral such as *Acropora spp.* (branching coral) at the islands, which may limit the presence of coral specific fish species (Hutchins, J.B. 1997).

The Abrolhos Islands are home to populations of large, non-tropical, coral inhabiting species such as the baldchin groper (*Choerodon rubescens*) and bar-cheek coral trout (*Plectropomus leopardus*). The Abrolhos Islands are the only area of high abundance of coral trout on the west coast of Western Australia. Commercially-important temperate species such as pink snapper (*Chrysophrys auratus)* and Western Australian dhufish (*Glaucosoma herbraicum*) also occur on deep-water limestone reefs and the shallower coral areas in the islands (Department of Fisheries 1997).

No specific studies of marine fish fauna have been conducted at the proposed MWADZ area. However, a number of studies have examined single fish species or assemblages within the Abrolhos Islands FHPA. Biological studies have been conducted on individual target species including baldchin groper (Fairclough, D *et al.* 2011,Nardi, K *et al.* 2006, Fairclough, D *et al.* 2005, Fairclough, D *et al.* 2004) coral trout (How, J 2013, Nardi, K *et al.* 2004) and red-throat emperor (Mclean, D *et al.* 2010). Several research studies have also been conducted on the broader fish assemblages at Abrolhos Islands (Harvey, E.S *et al.* 2012, Shedrawi, G 2008).

The fish community within the strategic MWADZ Proposal area is likely to be comprised of transient species such as cobia (*Rachycentron canadum*), samson fish (*Seriola hippos*), and some demersal scalefish species which inhabit sandy bottom habitat and areas of mixed assemblage substrate. Within the proposal area there are some small areas of mixed assemblage substrate, comprising rubble, low platform reef, algae and/or sponges. These types of habitats at the Abrolhos Islands are often used by juvenile stages of species such as baldchin groper and red-throat emperor. Low platform reef is used by adult target species such as coral trout and pink snapper and may be used during spawning.

While there is some known fish habitat within the MWADZ Proposal area, a large proportion of the habitat within the proposal area does not represent a key habitat for target finfish species. The mixed assemblage fish habitat within the aquaculture zone represents a very small area of the overall habitat of these species within the Abrolhos Islands FHPA. The aquaculture activities in the proposed MWADZ are therefore, unlikely to have significant impact on the broader fish stocks in the area.

9.2.2 Sharks and Rays

In the South West bioregion, in which the Abrolhos Islands are encompassed, there is a rich variety of chondrichthyan fishes (sharks, skates and rays) with 152 species (both demersal and pelagic) believed to occur in these waters occupying a broad ranges of shallow and deep-water habitats (DEWHA 2008). Nine shark and rays species are listed as either threatened or protected/migratory fish species under the EPBC Act and have been identified as potentially occurring within the strategic MWADZ Proposal area (Table 9-2). These species also have regional distributions.

Table 9-2: Conservation Status – Shark and Ray Species Listed as Threatened and/or Migratory that may occur in the Vicinity of the Proposed MWADZ

Common Name	Scientific Name	Conservation Status		Presence in the Vicinity of the Mid West Aquaculture Development Zone
		Commonwealth (EPBC Act) Status	***Western Australian Status***	
Grey Nurse Shark	*Carcharias taurus*	Vulnerable	Specially protected fauna (WC Act)	Possible
Whale Shark	*Rhincodon typus*	Vulnerable, Migratory	Totally protected fish (FRMA) Specially protected fauna (WC Act)	Possible
White Shark	*Carcharodon carcharias*	Vulnerable, Migratory	Totally protected fish (FRMA) Specially protected fauna (WC Act)	Likely
Shortfin Mako Shark	*Isurus oxyrinchus*	Migratory	Not listed	Unlikely
Longfin Mako Shark	*Isurus paucus*	Migratory	Not listed	Unlikely
Scalloped Hammerhead	*Sphyrna lewini*	Potential Migratory listing – under review	Not listed	Possible
Smooth Hammerhead	*Sphyrna zygaena*	Potential Migratory listing – under review	Not listed	Possible

Common Name	Scientific Name	Conservation Status		Presence in the Vicinity of the Mid West Aquaculture Development Zone
		Commonwealth (EPBC Act) Status	***Western Australian Status***	
Green Sawfish	*Prisitis zijsron*	Vulnerable	Totally protected fish (FRMA) Specially protected fauna (WC Act)	Not likely
Giant Manta Ray	*Manta birostris*	Migratory	Not listed	Possible

There are a number of other shark species present at the Abrolhos Islands including the tiger shark (*Galeocerdo cuvier*), bronze whaler shark (*Carcharhinus brachyurus*), dusky whaler shark (*Carcharhinus obscurus*), and sandbar shark (*Caraharhinus plumbeus*).

9.2.2.1 Grey Nurse Shark

The grey nurse shark (*Carcharias taurus*) is listed as two separate populations under the EPBC Act. The east coast population is listed as critically endangered whilst the west coast population is listed as vulnerable (DotE 2014). This species is also protected under the *Wildlife Conservation Act 1950* (Specially Protected Fauna Notice 2006). The grey nurse shark has a broad inshore distribution around Australia (Environment Australia 2002).

Although the distribution of the western population is not well defined, records indicate it extends from the North West Shelf south to coastal waters in the Great Australian Bight (McAuley et al 2002; Cavanagh et al, 2003). Grey nurse sharks are known to occur within the Mid West region, including the Abrolhos Islands (McAuley, R Department of Fisheries, pers. comm.). No aggregation sites or other sites critical to the survival of grey nurse sharks have been identified (Chidlow, J et al 2005).

Grey nurse sharks are often observed near the sea floor in and around deep sandy-bottomed gutters and rocky caves, in the vicinity of inshore rocky reefs and islands (Pollard, 1999). The diet of the adult grey nurse shark mainly consists of a wide range of fish, but the species also consumes other sharks, squids, crabs and lobsters (Compagno, 1984).

The grey nurse shark may be present within the waters of the MWADZ Proposal area.

9.2.2.2 Whale Shark

The whale shark (*Rhincodon typus*) is currently listed as vulnerable and migratory species under the EPBC Act. This species is also protected under the *Wildlife Conservation Act 1950* (Specially Protected Fauna Notice 2006) and the *Fish Resources Management Act 1994*. The whale shark is the world's largest fish (up to 18 metres total length) and, in Western Australia, is commonly recorded at total lengths around 12 metres and weights of approximately 11 tonnes. Individuals are solitary or exist in aggregations of over 100 individuals. They are known to inhabit both deep and shallow coastal waters including lagoons of coral atolls and reefs.

This species has a broad distribution. It is found in both tropical and subtropical seas and is often seen in offshore waters as well as inside lagoons of coral atolls. In Australia, they are usually found in northern waters in latitudes between 30 degrees north and 35 degrees south. In Western Australia, the whale shark is known to aggregate in large numbers at Ningaloo Reef between March and April each year prior to travelling north east along the continental shelf.

Individual whale sharks may pass through the deeper waters outside of the Abrolhos Islands and occasional sightings have been observed inside the Fish Habitat Protection Area.

9.2.2.3 White Shark

The white shark (*Carcharodon carcharias*) is currently listed as a vulnerable and migratory species under the EPBC Act. This species is also protected under the *Wildlife Conservation Act 1950* (*Specially Protected Fauna Notice 2006*) and the *Fish Resources Management Act 1994*. White sharks are widely distributed in temperate and sub-tropical oceans worldwide and have been known to travel large distances. In Australia, its range extends primarily from Moreton Bay in southern Queensland, around the southern coastline to the North West Cape in Western Australia (Environment Australia 2002). They are primarily found in coastal and offshore areas of the continental shelf, but also occur in the open ocean, recorded from the surface down to 1,280 metres (Last & Stevens 2009).

The great white shark is one of the largest of shark species, having a total length up to 600 centimetre total length. Individuals can have wide ranges and undergo migrations in the order of hundreds of kilometres. Generally, the great white shark has a broad prey spectrum; however, an individual's diet is influenced by its size (Oceanica 2015). Juveniles and small great white sharks consume mainly teleosts (bony fish) and elasmobranchs (sharks), while larger individuals typically prey on marine mammals (DPC 2014). The species is known to follow humpback whales during their southern migration along the Western Australian coastline.

Great white sharks are usually solitary or in pairs; can often be found in feeding aggregations, but do not form schools. Although sightings are rare, they are typically more frequent around pinniped (seals and sea lions) colonies in the southern ocean (Oceanica 2015).

Great white sharks have been recorded within the Fish Habitat Protection Area at the Abrolhos Islands (DEWHA 2008). Given the presence of resident Australian sea lion populations (i.e. Easter and Pelsaert Group Islands) at the islands and the potential increase in the availability of food from the finfish aquaculture activities, this species is likely to be an occasional visitor to the MWADZ Proposal area.

9.2.2.4 Shortfin Mako Shark

The shortfin mako shark (*Isurus oxyrinchus*) is currently listed as a migratory species and is therefore protected under the EPBC Act. This species inhabits both tropical and temperate waters except for those offshore from the Northern Territory. They are rarely found in water below 16° C and are highly migratory (Last & Stevens 2009). The species is generally found in oceanic waters and unlikely to be present within the MWADZ Proposal area.

9.2.2.5 Longfin Mako Shark

The longfin mako shark (*Isurus paucus*) is currently listed as a migratory species and is protected under the EPBC Act.
This shark species is an oceanic tropical shark found predominantly in northern Australian waters. Its range includes the MWADZ Proposal area and extends from Geraldton across northern Australia to at least Port Stephens in New South Wales on the eastern coast (DoE 2014 a). Given that the Abrolhos Islands is at the southern end of the distribution for this species, it is unlikely this species will be present within the MWADZ Proposal area.

The longfin mako shark is currently listed as a migratory species and is protected under the EPBC Act. This shark species is an oceanic tropical shark found predominantly in northern Australian waters. Its range includes the MWADZ Proposal area and extends from Geraldton across northern Australia to at least Port Stephens in New South Wales on the eastern coast (DoE 2014 a). Given that the Abrolhos Islands is at the southern end of the distribution for this species, it is unlikely this species will be present within the MWADZ Proposal area.

9.2.2.6 Scalloped Hammerhead

The scalloped hammerhead (*Sphyrna lewini*) is likely the most common and well known of the hammerheads. It has a worldwide distribution through tropical and subtropical oceans (Simperdorfer, C 2014). It reaches sizes of over 4 metres in length, grows slowly and produces large litters of young (Harry *et al.* 2011a). The scalloped hammerhead is listed on the CITES Appendix II and internationally is considered threatened. However, in Australian waters the scalloped hammerhead has a non-detriment finding. This species is considered bycatch in the temperate shark fisheries and has a non-detriment finding for international trade if caught within Australian waters, indicating that fishing activities in Australian waters are not considered to be detrimental to the species status (DoF, 2014).

9.2.2.7 Smooth Hammerhead

The smooth hammerhead (*Sphyrna zygaena*) is listed in CITES Appendix II. The main reason for listing the smooth hammerhead is under “look-alike” provisions as its fins are considered very similar to the potentially threatened Scalloped Hammerhead (Simperdorfer, C 2014). The smooth hammerhead shark is a moderate sized hammerhead that occurs in all of the world’s subtropical and temperate oceans. In Australian waters, it grows to around 3.5-4.0 metres (Last & Stevens 2009). Age and growth data indicate that, like other similar-sized hammerhead species, the smooth hammerhead shark grows relatively slowly (Coelho *et al.* 2011).

Given that the Abrolhos Islands is at the southern end of the distribution for this species, it is possible that it will be present within the MWADZ Proposal area.

This species is considered bycatch in the temperate shark fisheries and has a non-detriment finding for international trade if caught within Australian waters, indicating that fishing activities in Australian waters are not considered to be detrimental to the species status (DoF, 2014).

9.2.2.8 Green Sawfish

The green sawfish (*Prisitis zijron*) is currently listed as vulnerable and is protected under the EPBC Act. In Australia, this species has been historically recorded in the coastal waters off Broome, Western Australia, around northern Australia and down the east coast as far as Jervis Bay, New South Wales (Stevens *et al.* 2005).
The green sawfish is predominantly a tropical species but is occasionally caught in temperate waters (Last, P.R., Stevens, J .D 2009).

The green sawfish occurs in near-shore coastal environments, including estuaries, river mouths, embayments and along sandy and muddy beaches (Stevens *et al.* 2005). Given the distribution and habitat of the green sawfish, the presence of this species in the MWADZ Proposal area is unlikely.

9.2.2.9 Giant Manta Ray

The giant manta ray (*Mantra bostris*) is currently listed as a migratory species and is protected under the EPBC Act. In Australia, the giant manta ray distribution ranges from as far south as Rottnest Island in Western Australia around the tropical north of Australia and south to the southern coast of New South Wales (Last, P.R., Stevens, J .D 2009). The giant manta ray is commonly sighted along coastlines with regular ocean current upwellings, oceanic island groups and particular offshore pinnacles and seamounts (DEWHA 2008a).

Manta rays may be encountered on shallow reefs while being cleaned by “cleaner” fish or feeding close to the surface inshore and offshore. They are occasionally observed in sandy bottom areas and seagrass beds. No aggregation sites or other sites critical to the survival of giant manta rays have been identified at the Abrolhos Islands. Manta rays may be occasionally present within the MWADZ Proposal area.

9.2.2.10 Tiger Shark

The tiger shark (*Galeocerdo* cuvier) is a relatively common and wide-ranging coastal-pelagic species, found globally in tropical and warm temperate oceans. In Australian waters, tiger sharks have a geographic distribution that extends from the west coast of Western Australian over the northern half of Australia to southern New South Wales. Tiger sharks are known to inhabit inshore waters, and oceanic waters around islands and seamounts; generally to depths of 150 metres. The species is known to make seasonal excursions into temperate waters with their range in Western Australia, possibly becoming more extensive in the last few decades and presumably in response to years of stronger Leeuwin Current (DPC 2014).

Tiger sharks can attain approximately 600 centimetres total length (Last & Stevens 2009).In Western Australia, tiger sharks with an inter-dorsal fin measurement greater than 70 centimetres are “totally protected fish” under the *Fish Resources Management Act 1994* (FRMA). However, the species is not considered to be an Endangered Threatened or Protected (ETP) species in Australia. Nevertheless, the ecological niche the tiger shark occupies as an apex predator and the time taken to mature (i.e. more than 6-7 years) mean it is considered similar to some of the other ETP species of sharks (e.g. the white shark). It is often used, therefore, as a representative species when considering potential impacts to ETP sharks. It is distributed globally and there are several recorded interactions between tiger sharks and aquaculture.

Tiger sharks are considered a near-threatened species due to excessive finning and fishing by humans according to International Union for Conservation of Nature. Tiger sharks are currently subjected to only minor levels of exploitation by fisheries along the Western Australian coast. Generally most of the captures of these species have occurred in the more northern and more tropical part of their Western Australian range.
However, there have been more frequent captures of this species in temperate waters recently (DPC 2014). This species is likely to be an occasional visitor to the strategic MWADZ Proposal area and could potentially interact with finfish aquaculture in the zone. For the aforementioned reasons, it has been included in this assessment.

9.2.2.11 Other whaler sharks

Bronze whaler sharks (*Carcharhinus brachyurus*) are widely distributed throughout Australia and can be found from Geraldton in Western Australia to Coffs Harbour in New South Wales. The Abrolhos Islands is at the northern end of their range. However, this species may be an occasional visitor to the MWADZ Proposal area and could potentially interact with the finfish aquaculture.

The dusky whaler shark (*Carcharhinus obscurus*) is widely distributed in Australia and is found in both tropical and temperate continental shelf and oceanic waters. Dusky whaler shark is one of the most important and economically-valuable shark species that occurs in the region. The West Australian dusky whaler shark stocks support a significant component of the temperate commercial shark fisheries in the area, most notably the West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery. In the 2012/13 fishing season, dusky whaler shark catches were approximately 204 tonnes, comprising approximately 22% of the overall catch for the fishery (Fletcher, R and Santoro, K 2014).

This species is long lived and late maturing species (i.e. > 30 years to reach sexual maturity) and is particularly vulnerable to overfishing pressures due to these biological characteristics. In Western Australia, dusky whaler sharks have historically been heavily exploited by the temperate commercial shark fisheries. Over the past decade a recovery program has been in place in Western Australia for this species to ensure the stocks are sustainable. Whaler sharks with an inter-dorsal length over 70 centimetres are protected under the FRMA. Dusky whaler sharks may be an occasional visitor to the strategic MWADZ Proposal area and could potentially interact with finfish aquaculture in the zone.

Sandbar sharks (*Carcharhinus plumbeus*) are widely distributed in Australia and are found in both tropical and temperate waters. In Western Australia, they are found as far south as Esperance and extend into Northern Australia (Last & Stevens 2009). This species is susceptible to population depletions due to their longevity and low productivity (Department of the Environment 2015). Sandbar sharks are commercially-important due to its meat and fins and (to a lesser extent) its hide and liver oil (Last & Stevens 2009). They historically provided an important component of the catch in Western Australian commercial shark fisheries. In the 2002/03 fishing season, approximately 87.7 tonnes of sandbar shark were captured in the Western Australian North Coast Shark Fishery (WANCSF). This comprised approximately 17.9% of the overall catch for the fishery that year (McCauley, R *et al.* 2005). The WANCSF is currently non-operational and is likely to remain that way until such time as a stock assessment on vulnerable species has been conducted on the status of stocks throughout northern Australia. Sandbar sharks may be present within the vicinity of the MWADZ Proposal area.

A number of shark species, including ETP species, are likely to be visitors to the proposed MWADZ area and have the potential to interact with the sea cage aquaculture. The proposal is, however, unlikely to have a significant impact on the sustainability of these species.

9.2.3 Marine Invertebrates

Marine invertebrates include a very broad range of fauna such as molluscs (shellfish), crustaceans, anemones, sponges, sea urchins and worms. There are a total of 492 mollusc species and 172 echinoderm species which have been identified at the Abrolhos Islands (MBS Environmental 2006). There is a complex assemblage of marine invertebrate species with both tropical, temperate and Western Australian endemic species occurring in all three island groups at the Abrolhos (Department of Fisheries 2000). A higher proportion of tropical species are represented in most island groups, but the majority of hydroid (members of the invertebrate order Hydroida) and sponge species are usually found in temperate, rather than tropical, waters (Department of Fisheries 2007). Some of the invertebrate species which are important for both commercial and recreational fisheries include the Western rock lobster, saucer scallops, octopus and species that produce specimen shells.

9.2.3.1 Southern Saucer Scallop

Southern saucer scallops (*Amusium balloti*) are short-lived, benthic, filter-feeding bivalve molluscs that reside on sandy bottoms areas (Department of Fisheries 2007). The species is predominantly sub-tropical and occurs along the continental shelf of Australia. However, it has been known to occur as far south as Jervis Bay on the east coast (Department of the Environment 2013). In Western Australia, the distribution of the species is from just north of Shark Bay to the Western Australian and South Australian border (Kangas, M pers. comm. Department of Fisheries 2015). The species has been reported to occur in depths from 10-75 metres in discrete beds up to 15 kilometres in length and at densities of up to one per square metre (Dredge 1988; Kailola *et al.* 1993, NFS 2015). At the Abrolhos Islands, saucer scallops generally occur in depths of 20-40 metres on the leeward side of the islands; but in some years their distribution can be extensive throughout much of the sandy habitats within and between island groups (Kangas, M pers. comm. Department of Fisheries 2015).

The saucer scallop is known to have two breeding seasons one in winter and the other in spring when the larval phase is believed to be 15-25 days in duration (Caputi, N *et al.* 2015). Saucer scallops develop rapidly, growing to a size of 90 millimetres in just six to twelve months and, characteristic of short lived species with high natural mortality, the species is susceptible to a “boom and bust” stock level (Caputi, N *et al.* 2015). They are subject to great natural fluctuations in reproductive success from year-to-year and grow to maturity within a year. Southern saucer scallops spawn at the Abrolhos between August and March. They are known to inhabit the sandy sea bottom habitats in the strategic MWADZ Proposal area.

9.2.3.2 Western Rock Lobster

The Western rock lobster (*Panulirus cygnus*) is an endemic species which inhabits the continental shelf along the lower west coast of Australia from 25^{o} South to 34^{o}South (Chubb, C 2003). The species is widespread at the Abrolhos Islands and is known to occur in all three island groups. Unlike the rest of the west coast populations, *Panulirus cygnus* mature at a smaller size at the Abrolhos Islands, before they reach minimum legal length (St John, J 2006). The Abrolhos Islands lobster population contributes a large proportion (i.e. approximately 50%) of the total reproductive output/spawning biomass for the West Coast Rock Lobster Managed Fishery (WCRLMF) (St John, J 2006).

At the Abrolhos Islands, Western rock lobsters predominantly occur over reef habitat with between 45 and 65% of fishing effort occurring in shallow waters (0 - 20 metres) near submerged platforms and exposed reefs (Webster, F *et al.* 2002). These habitats tend to occur generally on the western and central parts of the island groups where there is a high abundance of limestone reef and macro algae habitat (Webster, F *et al.* 2002).

Benthic habitat data collected in the strategic MWADZ Proposal area indicates that the predominant habitat is sand, which does not represent a key habitat area for Western rock lobster [pers. comm. De Lestang, S (DoF)]. Indeed, the majority of the benthic habitat within the MWADZ Proposal area is comprised of soft-bottom, sandy habitats. While sandy benthic habitat can sometimes provide and important transit area for migrating lobster at certain times of the year (i.e. the “whites” run), the MWADZ Proposal area is not known to be important for migrating rock lobster.

9.2.3.3 Coral Reefs

The Abrolhos Islands coral reef system is the most southerly in the Indian Ocean. The presence of coral reefs at such high latitudes is attributed to the Leeuwin Current providing a source of warm water for coral function and survival and coral planulae from equatorial regions (Hatcher, B 1991, Pearce, A 1997, Wilson and Marsh 1979). The Abrolhos reefs have most of the structural habitats of tropical reef systems (Wilson and Marsh 1979). Given the high latitudes, coral diversity is very high for the Abrolhos reefs. There are approximately 184 species of hermatypic corals in 42 genera and a further 10 species of ahermatypes in eight genera are found there (Webster, F *et al.* 2002). All but two coral species are tropical (Hatcher *et al.* 1990, Wilson and Marsh 1979). *Acropora* species dominate both shallow leeward and lagoon reef habitats. While in the deep water, or more sheltered sites, genera including *Montipora, Echinopyllia, Oxypora, Mycedium, Pachyseris* and *Leptoseris* are common (Hatcher *et al.* 1988). Even though being at the extreme southern limit of their latitudinal range, the Abrolhos Islands coral populations are considered to be reproductively active, with 60 per cent of the species spawning in late summer (Babcock *et al.* 1994). It is likely most species spawn during March/April and, given the latitude, do not participate in the second spring spawning characteristic of the warmer northern waters.

Benthic habitat data collected in the MWADZ Proposal area indicates that there are very limited areas of coral habitat (i.e. less than one percent of the proposed 3,000 hectares) within the aquaculture zone. Therefore, it is highly unlikely that the MWADZ Proposal will have a significant impact on coral reef communities within the Abrolhos Islands FHPA.

9.2.3.4 Molluscs

A total of 492 species of marine molluscs have been recorded from the Abrolhos Islands with the majority of the species found in shallow water reef areas. Sixty eight percent of the species were tropical, 20.3% temperate and 11.3% endemic to Western Australia (Webster, F *et al.* 2002). Several research studies have been conducted on the molluscs within intertidal and shallow water environments of the Abrolhos Islands (Wells, F and Bryce, C 1997, Jenson, K 1997 and Evertsen, J 2006). However, limited research has been conducted on molluscan fauna in the deeper water areas of the Abrolhos Islands.

A study was conducted by (Glover, E and Taylor, J 1997) around the Wallabi Group at the Abrolhos Islands and results from the study concluded that the molluscan community was dominated by suspension-feeding bivalves (particularly pectinilds), a suspension-feeding gastropod (*Monilea lentiginosa*) and an algal-grazing gastropod (*Calthalotia mundula*) (Glover, E and Taylor, J 1997). No data has been collected on the marine molluscs within the MWADZ Proposal area.

9.2.3.5 Echinoderms

The rich echinoderm fauna of the Abrolhos Islands are dominated by tropical species. Sixty three percent of the 172 species were tropical species, 14% Southern Australian temperate and 21% endemic to Western Australia but no species is confined to the islands (Webster, F *et al.* 2002). The richness of the echinoderms is attributed to the presence of both tropical and temperate species in the West Coast Overlap Zone, due to the warm Leeuwin Current, and the Abrolhos Islands habitat complexity which provides niches for a wide diversity of echinoderms life styles (Marsh 1994). No data is currently available on echinoderms in the proposed MWADZ area. However, there is some anecdotal evidence (from benthic habitat mapping conducted by the Department) to suggest that sea cucumbers may be present within the proposed MWADZ area.

Nevertheless, given any potential impact on benthic invertebrates would be localised (i.e. directly under the sea cages) it unlikely the MWADZ Proposal will have a significant impact on echinoderms in the area.

9.2.4 Marine Mammals

There are ten marine mammal species (Table 9-3) that are known or have the potential to occur within the vicinity of the MWADZ Proposal area. All marine mammals are currently protected under the *Wildlife Conservation Act 1950* (WA) and listed as vulnerable, endangered, marine or migratory under the EPBC Act. Marine mammals are also protected under international wildlife conventions including Appendix II of Convention on Migratory Species (CMS) and Convention on International Trade in Endangered Species (CITES).

Table 9-3: Conservation Status and Likelihood of Marine Mammals Occurring in the Proposed MWADZ

Species	Conservation Status		Likelihood of occurrence within the MWADZ Proposal area	Likely time of occurrence
	Commonwealth (EPBC Act)	***Western Australia (WC Act)***		
Humpback whale (*Megaptera novaeangliae*)	Vulnerable Cetacean Migratory	Vulnerable	Likely	July - November
Blue whale (*Balaenoptera musculus*)	Endangered Cetacean Migratory	Endangered	Unlikely	November - May

Species	Conservation Status		Likelihood of occurrence within the MWADZ Proposal area	Likely time of occurrence
	Commonwealth (EPBC Act)	***Western Australia (WC Act)***		
Pygmy blue whale (*Balaenoptera musculus brevicauda*)	Endangered Cetacean Migratory	Endangered	Occasional	June – August/ October- January
Bryde's whale (*Balaenoptera edeni*)	Cetacean Migratory	Not listed	Possible	Unknown
Southern right whale (*Eubalaena australis*)	Endangered Cetacean Migratory	Vulnerable	Possible	May - November
Killer whale (*Oricinus orca*)	Cetacean Migratory	Not listed	Unlikely	Unknown
Indo-Pacific bottlenose dolphin (*Tursiops aduncus*)	Cetacean	Not listed	Likely	All year
Bottlenose dolphin (*Tursiops truncatus*)	Cetacean	Not listed	Likely	All year
Australian sea lion (*Neophoca cinerea*)	Vulnerable Marine	Specially protected fauna	Likely	All year
Dugong (*Dugong dugon*)	Marine	Other protected	Rare	All year

9.2.4.1 Whale

Humpback Whale

Humpback whales (*Megaptera novaeangliae*) migrate along the Western Australian coastline between their summer feeding grounds (south of 55° South) and winter breeding grounds of Camden Sound in north-west Western Australia (DoE, 2014b, Jenner *et al.* 2001). As the humpback whale migration corridor centres on the 200 metre isobath, the Abrolhos Islands are recognised as a significant habitat during their migration (DoE 2014b). Additionally, the Abrolhos Islands are a well-known resting area used by female humpback whales with their calves and escort males (DoE, 2014b).

In the MWADZ Proposal area, the peak abundance in north-bound migration occurs in July, with breeding and calving taking place between mid-August and early September in Camden Sound (Jenner *et al.* 2001). After the calving period, humpback whales migrate south along the Western Australian coastline with their peak abundance during the south-bound migration near the Abrolhos Islands occurring from mid-October to November each year (Jenner *et al.* 2001). Humpback whales are therefore likely to occur within the vicinity of the MWADZ Proposal area.

Blue Whale

In Australian waters, there are two known sub-species of blue whales which include the Southern (or "true") blue whale (*Balaenoptera musculus intermedia*) and the pygmy blue whale (*B. musculus brevicauda*). As a general distributional trend, Southern blue whales are predominantly found in waters in Australia south of 60 degrees south, while pygmy blue whales are found in waters north of 55 degrees south (DEWHA 2008).

In Western Australia, blue whales are known to inhabit deeper water areas of the Perth coast and near the edge of the continental shelf in 500 to 1,000 metre water depth (McCauley and Jenner 2010, McCauley *et al.* 2001). They are known to regularly forage in upwelling areas in the Perth Canyon and have been frequently sighted on the northern or southern sides of the canyon between December and April each year (Oceanica 2015). Regular sighting of blue whales have also been observed annually in Geographe Bay between October and December each year with over 100 sightings observed in the area in 2003 (Oceanica 2015).
The majority of whales move slowly into the bay from the north and follow the shallow bathymetry around Cape Naturaliste to the west. It appears to be a transitory corridor and/or migratory resting area (Burton, pers. comm.).

Sightings of blue whales in water north of the Perth Canyon have been rare; therefore, this species is unlikely to be present within the MWADZ Proposal area.

Pygmy Blue Whale

In Western Australia, pygmy blue whales (*Balaenoptera musculus brevicauda*) are known to inhabit the waters around the Perth Canyon between January and April each year. They are known to use this area as a foraging ground (Double et al 2012). Passive acoustic monitoring data collected for this species has shown that this species migrates northwards along the Western Australian coastline, passing Exmouth Gulf between April and August and continuing further north into Indonesian waters (McCauley & Jenner 2010). The pygmy blue whale south-bound migration begins from October to late December along the 500 to 1,000 metre depth contour on the edge of the slope (McCauley & Jenner 2010).

The satellite-tagged pygmy blue whales have been recorded in the offshore areas of the Abrolhos Islands, providing evidence that their migratory pathways are in the vicinity of the strategic proposal area. Pygmy blue whales have also been observed in waters near Geraldton and the Abrolhos Islands during aerial surveys as part of the baseline investigations for the Oakajee Deepwater Port Project (Oceanica, 2015). Pygmy blue whales may, therefore, be present near the vicinity of the MWADZ Proposal area during their migratory period.

Southern Right Whale

Southern right whales (*Eubalaena australis*) have a distribution between 20°S and 60°S and have been recorded in coastal waters of all Australian states except the Northern Territory. They migrate from high-latitude feeding grounds in summer, to warm, low-latitude coastal locations in winter (May through to November) between Sydney and Perth, as well as Tasmania (Bannister *et al.*1996). The population is suggested to be growing, and rare sightings are recorded in northern waters, such as Shark Bay and the North West Cape (Bannister *et al.* 1996). Within their broader geographic range, Southern right whales in Australia concentrate in certain areas to breed. Major calving areas are located in Western Australia at Doubtful Island Bay (34°10'S, 119°40'E), east of Israelite Bay (33°15'S, 124°10'E). However, there are no critical habitats recognised in the waters around the Abrolhos Islands. Therefore, sightings of Southern right whales within the MWADZ Proposal area are likely to be rare and infrequent, given that the location of the area is beyond the species usual northern limit of distribution.

Other Cetaceans

The Bryde's whale (*Balaenoptera edeni*) is distributed throughout tropical and warm temperate waters, between 40˚North and 40˚South, in both oceanic and inshore waters (DoE, 2014b). With the exception of the Northern Territory, Bryde's whales have been recorded in all Australian states, although no feeding or breeding areas have been identified in Australia (DoE, 2014b). Observations of Bryde's whales were documented at the Abrolhos Islands and north of Shark Bay.
However, sighting frequency, habitat use and abundance of Bryde's whales at the Abrolhos Islands are not available (Bannister *et al.* 1996). Given that low numbers have been recorded elsewhere in Australia, large numbers of Bryde's whales are not expected to be encountered in the nearshore waters of the MWADZ Proposal area.

Other whale species that have been sighted in the mid-west region include the killer whale (*Orcinus orca*). The killer whale is a migratory species and generally occurs in offshore pelagic areas from the equator to the polar regions (Bannister et al 1996). In Australia, killer whales are widely distributed and have been observed in all states on the continental slope and shelf, near seal colonies and humpback whale resting areas (Oceanica 2015). Recent scientific evidence documented killer whale attacks targeting humpback whales off Ningaloo Reef, WA (Pitman *et al.* 2015), confirming their presence in coastal areas. Killer whales are capable of rapid, long distance movements (approximately 1,000 kilometres) into mid-latitudes, suggesting their capability to intercept and hunt humpback whales during their migration movements (Pitman *et al.* 2015). While the Abrolhos Islands are a known resting area for migrating humpback whales there is only a low likelihood that killer whales may occur within the MWADZ Proposal area.

9.2.4.2 Dolphin

The dolphin (*Tursiops spp.*) most likely to be present throughout the year in the MWADZ Proposal area is the common bottlenose dolphin (*Tursiops truncatus*) and the Indo Pacific bottlenose dolphin (*Tursiops aduncus*) (DSEWPaC 2012). The common bottlenose dolphin distribution is not well documented in Australia, although sightings have been recorded for this species in Queensland, New South Wales, Tasmania, South Australia and south-west Western Australia (DoE 2014 b). Bottlenose dolphins can be found in both offshore waters (more than 30 kilometres offshore) and coastal waters, and inhabit a variety of habitats, such as mud, sand, seagrasses, mangroves and reefs (DoE 2014 b). During the Oakajee Deepwater Port baseline surveys, common bottlenose dolphins formed about 26% of the observations in the mid-west region, the majority of which were located greater than 15 kilometres from shore (Oceanica 2010). Therefore, common bottlenose dolphins are likely to be encountered within the MWADZ Proposal area.

Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) are generally found between the continental shelf and the coastline in reef, sandy and seagrass habitats (DEWSPaC 2012). The distribution and habitat usage for this species varies seasonally, and these patterns are likely to reflect changes in the abundance and distribution of fish in the locations (Oceanic 2015). This species can often be found in estuarine and coastal habitats in the south west region of Australia. Indo-Pacific dolphins are known to occur at the Abrolhos Islands and may be present within the MWADZ Proposal area.

Although other dolphin species, including the common dolphin, Risso's dolphin and the spotted dolphin, are listed in the EPBC Act Protected Matters Report, they have not previously been observed in the Mid West region (Oceanica 2010). It is therefore unlikely that these species will be present within the MWADZ Proposal area.

9.2.4.3 Dugong

In Australia, dugongs (*Dugong dugon*) are distributed throughout coastal and island waters from Shark Bay in Western Australia (25° South) across the northern coastline to Moreton Bay in Queensland (27° South) (Marsh *et al.* 2002, 2011a). Most of their time is spent in the neritic zone, especially near tidal and subtidal seagrass meadows (DoTE, SPRAT). Areas known to support dugongs in Western Australia include: Shark Bay; Ningaloo Marine Park; Exmouth Gulf; Pilbara coastal and offshore regions (Exmouth Gulf to De Grey River); Eighty Mile Beach and the Kimberley coast (Marsh *et al.* 2002).

Although not commonly sighted south of Shark Bay, dugong are highly migratory and undertake long distance movements (greater than 100 kilometres) over several days, possibly in search of seagrass beds or warmer water (DoE 2014b). During baseline investigations for the Oakajee Deepwater Port Project, aerial surveys of the Mid West region were undertaken. The results included observations of individual dugong at Horrocks, approximately 45 kilometres north of Geraldton (Oceanica 2010).

Benthic habitat data collected as part of this project have shown there are no known areas of *Halophila spp.* seagrass habitat within the MWADZ Proposal area. Given the limited suitable foraging habitat and the rarity of sightings of this species at the Abrolhos, it is unlikely that dugong will be present in the MWADZ Proposal area.

9.2.4.4 Australian Sea Lion

The Australian sea lion (*Neophoca cinerea*) is an endemic species in Australia, with a known distribution extending approximately 3,500 kilometres from the Abrolhos Islands along southern Australia to the Pages in South Australia (Campbell 2005; DSEWPaC 2013a). The Australian sea lion is one of the rarest sea lion species in the world and is currently listed as vulnerable under the EPBC Act. This assessment is based on both primary threats such as fishery bycatch and marine debris entanglement, and secondary threats that include interactions with aquaculture operations (DSEWPAC 2013a). There currently is an Australian National Recovery Plan for the Australian sea lion. The overarching objective of the recovery plan is to halt the decline and assist the recovery of the species throughout its range in Australian waters by increasing the total population size, while maintaining the number and distribution of breeding colonies (DSEWPAC 2013 b).

The Australian sea lion is currently listed as “specially protected fauna” under the *Wildlife Conservation Act 1950* - Wildlife Conservation (Specially Protected) Fauna Notice. The Western Australian Government has implemented several initiatives to support the recovery of the Australian sea lion, including the use of sea lion exclusion devices (SLEDs) in rock lobster pots to mitigate this incidental mortality within the area of known interactions in the West Coast Rock Lobster Managed Fishery (Campbell, *et al.* 2008). The Department of Fisheries is currently in the process of implementing a number of management measures (i.e. exclusion zones around Australian sea lion colonies) within Western Australian demersal gillnetting fisheries to reduce potential adverse interactions (DSEWPAC 2013 b).

In Western Australia, there are currently 28 known breeding sites for Australian sea lions (including the Abrolhos Islands) and 48 sites in South Australia (Shaughnessy *et al.* 2011), most of which are characterised by fewer than 30 pups per breeding season.
The Abrolhos Islands population is small and at the northern limit of the species range. Small, closed populations (such as that at the Abrolhos Islands) are highly vulnerable, especially to increased mortality from anthropogenic causes (Campbell 2008) and the removal of only a few individuals annually may increase the likelihood of decline and potentially lead to the extinction of smaller colonies (DSEWPaC 2013b).

There are only a few Australian sea lion colonies in Western Australia that have accurate, long-term trend data in pup production (AMMC 2014). Of the colonies that have sufficient long term data, it appears that pup production at the Houtman Abrolhos is stable (AMMC 2014). Australian sea lions have extensive historical accounts and sightings from the Abrolhos Islands, which are documented as both breeding and haul-out sites (DSEWPaC 2013a). Historical population abundances at the Abrolhos Islands ranged from 300 to 580 sea lions. In contrast, recent surveys described severely reduced population estimates (76 to 96 sea lions), most likely resulting from historical harvesting (Campbell 2005, DSEWPaC 2013a). In 2004, 17 sea lion pups were counted from breeding areas within the Easter Group islands, and two pups were recorded on the Pelsaert Group islands. The latter are predominantly used as haul-out sites with occasional pupping events (DSEWPaC 2013a).

Recent telemetry data from tagged Australian sea lions recorded foraging ranges with a broad use of coastal shelf waters to the shelf edge (Campbell 2008). Foraging behaviour varied among different Australian sea lion populations and different cohorts within each population. From all Western Australian populations studied, sea lions generally displayed strong foraging site fidelity, and the Abrolhos Islands population had the smallest foraging range observed (Campbell 2008). Females and juveniles had small foraging ranges (less than ten kilometres) and foraging trips comprised travel within the Abrolhos Islands.

As benthic foragers, Australian sea lions may dive up to 90 metres to target prey species, such as cephalopods, crustaceans and fish (Campbell 2005). Among all age groups from Western Australia's populations, similar diving patterns included shallow depths (average depth less than 20 metres) with a maximum of 50 metres. The shallowest range of dive depths was recorded from the Australian sea lions tagged at the Abrolhos Islands, where the mean dive depth was approximately 10 metres for adult females, juveniles and pups, and the maximum dive depth (37 metres) was recorded from a juvenile sea lion (Campbell 2008).

Although the telemetry data were recorded from a low number of sea lions, the documented foraging range, dive depths and significant breeding and haul-out sites confirm that the Australian sea lion population at the Abrolhos Islands are likely to occur within the MWADZ Proposal area (Figure 9-1).

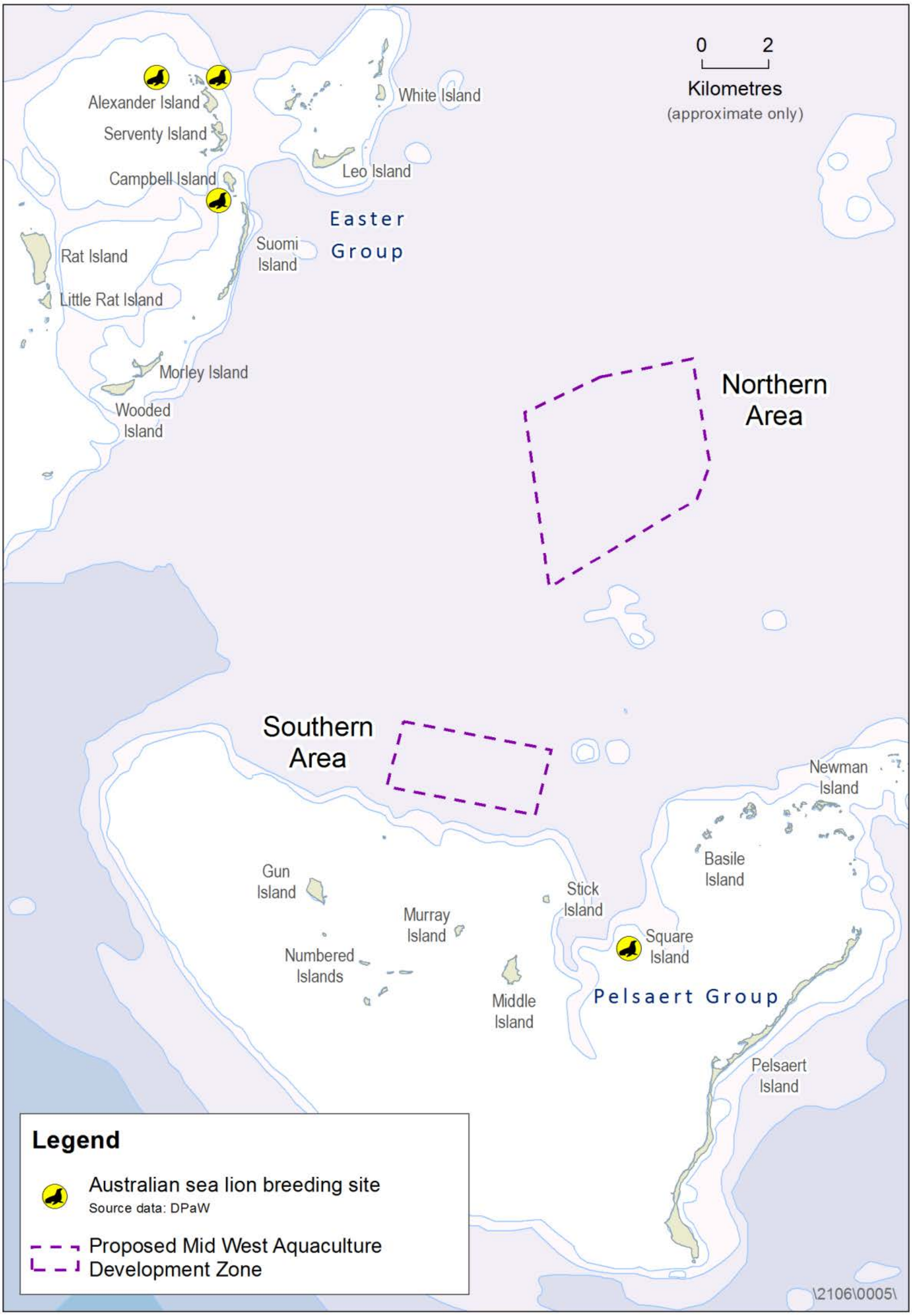


Figure 9-1: Australian Sea Lion Breeding Sites in the Abrolhos Islands

9.2.5 Marine Reptiles

9.2.5.1 Turtle

There are six species of marine turtle that occur in the waters of Western Australia these include green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricatal*), loggerhead turtle (*Caretta caretta*), flatback turtle (*Natator depressus*), leatherback turtle (*Dermochelys coriacea*) and olive Ridley (*Leidochelys olivacea*). All of these species are listed as Threatened and Migratory under the Western Australian *Wildlife Conservation Act 1950* and the EPBC Act. Under the EPBC Act, loggerhead, leatherback and olive Ridely turtle are listed as "endangered"; while the green, flatback and hawksbill turtles are listed as "vulnerable".

The turtle species most likely to be present within the vicinity of the strategic MWADZ Proposal area are the green, leatherback, loggerhead and flatback turtle (refer to Table 9-4).

Green Turtle

Green turtle (*Chelonia mydas*) are found in tropical and subtropical waters globally. Western Australia supports one of the largest green turtle populations in the world, with three genetically distinct stocks comprising approximately 20,000 turtles (DoE 2014b). Important breeding areas for this species include Barrow Island and the Muiron Islands and the nesting period is between November and March (DoE 2014b).

Resident green turtles primarily feed on seagrass and algae in shallow benthic environments. They regularly feed around the Abrolhos Islands, which is recognised as an important foraging area (DEWHA 2008). In Western Australia, telemetry data documented green turtles feeding 200 to 1,000 kilometres away from nesting beaches (DoE 2014b).

Considering all these factors, green turtles are likely to occur within the MWADZ Proposal area.

Loggerhead Turtle

Loggerhead turtle (*Caretta caretta*) are widely distributed throughout tropical, subtropical and temperate waters, preferring the waters of coral and rocky reefs, seagrass beds and muddy bays (DoE 2014b). This species feeds primarily on benthic invertebrates, foraging from the nearshore zone to water depths of approximately 50 to 60 metres (DoE 2014b). In Western Australia, this species is known to forage and nest primarily in the north-west of the state, from Shark Bay to the Pilbara region (DoE 2014b). In south west Western Australia, resident loggerhead turtles are commonly observed foraging in waters from Rottnest Island to Geographe Bay (DEWHA 2008).

The Abrolhos Islands do not represent an important breeding/nesting area for this species, with most loggerhead turtles breeding in areas north of Dirk Hartog Island. Based on their foraging habitats and prey species preferences, adult loggerhead turtles may be present within the Abrolhos Islands/Geraldton region. However, this species is unlikely to occur frequently within the MWADZ Proposal area.

Leatherback Turtle

The leatherback turtle (*Dermochelys coriacea*) is found in tropical, subtropical and temperate waters throughout the world, and has been observed foraging in all Australian waters (DoE 2014b). Primarily in pelagic and coastal waters of all Australian states, leatherback turtles feed on marine invertebrates (such as jellyfish and tunicates). Usually, this occurs in areas of upwelling or convergence where primary productivity is high (DoE 2014b).

Leatherback turtles are most commonly observed foraging in the mid to south-west WA regions (DEWHA 2008). Therefore, it is likely that leatherback turtles may be encountered within the MWADZ Proposal area.

Flatback Turtle

Flatback turtle (*Natator depressus*) are endemic to subtropical and tropical waters of Australia, Papua New Guinea and Irian Jaya, with nesting activity confined to Australia (Limpus 2007, DoE 2014b). They are commonly found in turbid water over soft-bottom habitats in shallow, nearshore waters (DoE 2014b). Without a pelagic phase or global distribution, flatback turtles will mature and remain in shallow coastal waters that are close to their natal beaches (DSEWPaC 2012b). In northwest Western Australia, the mating season for the flatback turtle usually occurs from November to March, with a peak in January (DSEWPaC 2012b). However, flatback turtles are not expected to occur in the mid-west region or south of Exmouth WA (Limpus 2007).

Therefore, this species is unlikely to occur in the MWADZ Proposal area.

Table 9-4: Likelihood of Marine Turtle Species Presence within the Proposed MWADZ

Common name	Scientific name	EPBC Act status	Wildlife Conservation Act status	Presence in the vicinity of the MWADZ
Loggerhead turtle	*Caretta caretta*	Endangered, Marine, Migratory	Endangered	Low likelihood
Leatherback turtle	*Dermochelys coriacea*	Endangered, Marine, Migratory	Vulnerable	Likely
Green turtle	*Chelonia mydas*	Vulnerable, Marine, Migratory	Vulnerable	Likely
Flatback turtle	*Natator depressus*	Vulnerable, Marine, Migratory	Vulnerable	Unlikely

9.2.5.2 Sea Snake

Two sea snake species, namely the spectacled sea snake (*Disteira kingii*) and yellow-bellied sea snake (*Pelamis platura*) are recorded by the EPBC Protected Matters database as species that may occur or whose habitat may occur in the area (DoE 2015). These sea snake species are not resident at the Abrolhos Islands, but during winter storms they may be transported south to the Abrolhos from Shark Bay and further north (Department of Fisheries 1998).

9.2.6 Marine Avifauna

Marine avifauna at the Abrolhos Islands are currently protected under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) Act, the *Wildlife Conservation Act 1950* (WA) and the Western Australian Wildlife Conservation (Specially Protected Fauna) Notice 2014. Many of the marine avifauna species are also protected under international treaties (e.g. Japan-Australia Migratory Bird Agreement (JAMBA), China-Australia Migratory Bird Agreement (CAMBA) and the Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA) (Surman, C 2015). Seabirds at the Abrolhos Islands that are currently protected under these agreements include the Eastern reef egret, bridled tern, Caspian tern, crested tern, osprey and white-breasted sea eagle (Surman, C 2015).

The Abrolhos Islands represents one of the most significant seabird breeding locations in the eastern Indian Ocean. Eighty percent (80%) of brown (common) noddy (*Anous stolidus*), 40% of sooty tern (*Onychoprion fuscata*) and all the lesser noddy (*Anous tenuirostris melanops*) found in Australia nest at the Houtman Abrolhos (Ross *et al.* 1995). It also contains the largest breeding colonies in Western Australia of wedge-tailed shearwater (*Ardenna pacific)*, little shearwater (*Puffinus assimilis*), white-faced storm petrel (*Pelagodroma marina*), white-bellied sea eagle (*Haliaeetus leucogaster*), osprey (*Pandion haliaetus*), Caspian tern (*Hydroprogne caspia*), crested tern (*Thalasseus bergii*), roseate tern (*Sterna dougalli*) and fairy tern (*Sterna nereis*) (Storr *et al.* 1986, Surman and Nicholson 2009). The Abrolhos Islands also represents the northernmost breeding islands for both the little shearwater and white-faced storm petrel (Surman, C 2015).

Within the Pelsaert and Easter Groups at the Abrolhos, 17 species have been confirmed as breeding regularly. These are the white-bellied sea eagle, osprey, wedge-tailed shearwater, little shearwater and white-faced storm petrel, Pacific gull, silver gull, Caspian tern, crested tern, bridled tern (*Onychoprion anaethetus*), roseate tern, fairy tern, brown noddy, lesser noddy, Eastern reef egret (*Egreta sacra*), pied oystercatcher (*Haematopus longirostris*) and pied cormorant (Surman and Nicholson 2009).

Sooty tern, brown noddy and lesser noddy form a large community of breeding seabirds at the southern end of Pelsaert Island. There are 264,000 brown noddy (100% of total Abrolhos population) and 45,000 lesser noddy (65% of total) breeding over summer at the Pelsaert Group (Surman, C 2015). These seabirds feed in association with predatory fishes (i.e. tunas) as well as over large schools of larval fishes and squids across both shelf and oceanic waters at least 150 kilometres west of the Houtman Abrolhos (Surman pers. obs.).

Other significant marine avifauna likely to be present within the MWADZ Proposal area includes the crested tern (*Thalasseus bergii*), Caspian tern (*Hydroprogne caspia*) and fairy tern (*Sternula nereis)* (Surman, C 2015). Crested tern nest in colonies of up to 1,000 pairs at the Abrolhos Islands. Half of this population nests within the Pelsaert Group (Surman, C 2015).

Crested tern feed predominately on schools of small to medium-sized schooling fishes over shelf waters. At the Abrolhos, this species predominantly preys on scaly mackerel *Sardinella lemura* (Surman and Wooller 2003). Fairy tern also nest in colonies of a few to several hundred pairs. They feed predominately upon small fishes, particularly slender sprat (*Spratelloides gracillis*), juvenile black-spotted goatfish (*Parupeneus signatus*) and hardyheads (Atherinidae) (Surman, C 2015). The large Caspian tern feeds almost exclusively over shallow reef flats on wrasse, blenny, mullet, whiting and goby (Surman, C 2015).

The wedge-tailed shearwater (*Ardenna pacifica*) is one of the most populous seabird species that currently nests at the Abrolhos Islands (Surman,C 2015). Current population estimates at the islands are approximately 2.2 million, with most occurring on Pelsaert Island (approx. 1,600) and West Wallabi Island (2 million) (Surman, C 2015). This species breeds at the Abrolhos Islands over the summer months before their young fledge in May each year (Surman, C 2015).

Table 9-5 provides a list of the protected marine avifauna that may occur in the vicinity of the MWADZ Proposal area.

Table 9-5: Protected Marine Avifauna that May Occur in the Vicinity of the Proposed MWADZ

Common name	**Scientific name**	***EPBC Act status***	***Wildlife Conservation Act status****	**Presence in the vicinity of the MMADZ**
Common Noddy	*Anous stolidus*	Marine, Migratory	Schedule 3	Likely
Lesser Noddy	*Anous tenuirostris melanops*	Vulnerable, Marine, Migratory	Schedule 1	Likely
Brown noddy	*Anous stolidus*	Marine Migratory	Not listed	Likely
Bridled Tern	*Onychoprion anaethetus*	Marine, Migratory	Schedule 3	Likely
Sooty Tern	*Onychoprion fuscata*	Marine	Not listed	Likely
Roseate Tern	*Sterna dougallii*	Marine, Migratory	Schedule 3	Likely
Fairy Tern	*Sternula nereis*	Vulnerable, Marine, Migratory	Schedule 1	Likely
Crested Tern	*Thalasseus bergii*	Marine	Not listed	Likely
Caspian Tern	*Hydroprogne caspia*	Marine, Migratory	Schedule 3	Likely
Eastern Reef Egret	*Egreta sacra*	Marine Migratory	Schedule 3	Likely
Pacific Gull	*Larus pacificus*	Marine	Not listed	Likely
Red-tailed Tropicbird	*Phaethon rubricauda*	Marine, Migratory	Not listed	Unlikely
Silver Gull	*Chroicocephalus novaehollandiae*	Marine	Not listed	Likely
South Polar Skua	*Stercorarius maccormicki*	Marine, Migratory	Schedule 3	Likely
Southern Giant Petrel	*Macronectes giganteus*	Endangered, Marine, Migratory	Not listed	Likely
Black-browed Albatross	*Thalassarche melanophris*	Marine, Migratory	Schedule 1	Likely
Indian Yellow-nosed Albatross	*Thalassarche carteri*	Marine, Migratory	Schedule 1	Likely
Wedge-tailed Shearwater	*Ardenna pacifica*	Marine, Migratory	Schedule 3	Likely
Fleshy-footed Shearwater	*Ardenna carneipes*	Marine, Migratory	Schedule 3	Likely
Hutton's Shearwater	*Puffinus huttoni*	Marine, Migratory	Schedule 1	Likely
Little Shearwater	*Puffinus assimilis*	Marine	Not listed	Likely

Common name	Scientific name	*EPBC Act status*	*Wildlife Conservation Act status**	Presence in the vicinity of the MMADZ
Wilson's Storm-Petrel	*Oceanites oceanicus*	Marine, Migratory	Schedule 3	Likely
White-faced Storm-Petrel	*Pelagodroma marina*	Marine	Not listed	Likely
White-bellied Sea Eagle	*Haliaeetus leucogaster*	Marine	Schedule 3	Likely
Eastern Osprey	*Pandion cristatus*	Marine, Migratory	Not listed	Likely

In order to determine the potential impacts of the MWADZ Proposal on seabird communities at the Abrolhos Islands an impact assessment was conducted by Surman (2015) (Appendix 1d). During the assessment three increaser seabird species were identified that had the potential to be moderately impacted by the MWADZ Proposal. These include:

- pied cormorant (*Phalacrocorax varius*)
- silver gull (*Chroicocephalus novaehollandiae*)
- Pacific gull *(Larus pacificus)*

9.2.6.1 Pied Cormorants

The pied cormorant is widely distributed throughout mainland Australia. This species is more common on the south coast and along the coast of south-western Australia (Surman, C 2015). The pied cormorant is found in marine habitats (almost exclusively so in Western Australia), including estuaries, harbours and bays. It is also found in mangroves and on large inland wetlands in eastern Australia (Surman, C 2015).

Approximately 1,861 pairs of pied cormorant nest throughout the Abrolhos Islands, most on Wooded Island, however significant numbers (>500) are observed foraging regularly throughout the Pelsaert Group (Surman, C 2015). Pied cormorants have been observed foraging in the region of the Southern (Pelsaert Group) aquaculture site, and may continue to do so in relatively low numbers (Surman, C 2015).

9.2.6.2 Silver Gull

The silver gull is widely distributed throughout Australia and commonly found along coastlines, islands, ports and near any watered habitat. It is rarely seen far from land. The current silver gull summer populations at the Abrolhos Islands are relatively small (~50 pairs), reflecting food availability (nitre bush berries, seabird eggs and chicks, marine invertebrates) during the summer months (Surman, C 2015). A larger breeding population (~ 150+ nests) once nested in the Pelsaert Group during the autumn, taking advantage of bait discards from "A Zone" rock lobster boats and food scraps from fishing camps. The current breeding silver gull population at the Houtman Abrolhos is very small.

Like other gull species, the silver gull has become a successful scavenger, readily pestering humans for handouts of scraps, pilfering from unattended food containers or searching for human refuse at tips. This species has been successfully able to increase in numbers and abundance by exploiting food and rubbish discarded by humans (DEC 2007). Silver gulls have a high fecundity rate and can often produce two broods in one year. The breeding season for this species is usually between August and December each year (DEC 2007).

Due to the foraging behaviour and the ability of this species to exploit food sources associated with marine finfish aquaculture it was identified as a species that could benefit from the MWADZ Proposal through the potential to secure additional sources of food that could (in turn) translate to improved breeding success and an expanded population. However, a potential negative impact of such an effect is the risk that any increase in the silver gull population may be accompanied by increased competition for nesting sites with other species utilising the Abrolhos Islands.

9.2.6.3 Pacific Gull

The Pacific gull *Larus pacificus* is moderately common from Carnarvon in Western Australia through southern Australia and up to Sydney in New South Wales. The Abrolhos Islands represents the largest population of Pacific gulls along the Western Australian coast. Currently, there are 74 active pairs of Pacific gulls across the Easter and Pelsaert Groups at the Abrolhos. Previously research studies have indicated Pacific gull numbers were as high as 127 pairs at these island groups (Surman and Nicholson 2009a). Elsewhere this species is threatened by displacement by the successful scavenging kelp gull *Larus dominicanus*. Almost half of all Pacific gulls found at the Houtman Abrolhos nest within the Pelsaert Group (Fuller *et al.* 1994).

Pacific gulls are predominately predatory, foraging on reef flats at low tide on whelks, trochus shells, turbo shells, baler shells, mantis shrimps, cuttlefish, octopus and crabs. However, during the previous “Zone A” rock lobster fishing season they scavenged for bait scraps from fishing boats and upon fish frames from wet line boats and other areas where fish are cleaned. Due to this foraging behaviour, this species was identified as one of the key species likely to be impacted by the MWADZ Proposal.

9.3 Potential Impacts

Information is based on a literature review of the best available scientific data, documented information on the adverse interactions between marine fauna and aquaculture equipment, impact assessments and “threat identification hazard pathway analysis” and risk identification and assessment methodology (Fletcher, W.J. 2014).

The primary risks identified in the risk assessments that could have a potential impact on invertebrate and fish (including shark and ray) species from the MWADZ Proposal were the following:

- Nutrient enrichment of the water column and increased turbidity
- Organic deposition and nutrient enrichment of the sediments
- Release of trace metals, therapeutants and other contaminants into the marine environment
- Introduction of marine pests and pathogens
- Additional food from aquaculture activities
- Physical presence of aquaculture infrastructure
- Artificial lighting

9.4 Assessment of Potential Impacts

9.4.1 Nutrient Enrichment of the Water Column and Increased Turbidity

Fish feed, fish faeces and metabolic waste including ammonia and urea from aquaculture stock within the MWADZ Proposal area has the potential to increase the level of nutrients (i.e. nitrogen and phosphorous) in the water column (Hargrave, B 2005). Nitrogen and phosphorous are often limiting nutrients for primary production in coastal marine environments (de Jong & Tanner, 2004). The level of nutrient enrichment is however generally highly dependent on the species being cultured, feed sources, farm practices and the density of proximal farm sites (Hargrave, B 2005). An increase in the level of nutrients in the water column can potentially result in elevated levels of primary (i.e. phytoplankton) and macro algal production (Nash *et al.* 2005), which can then lead to eutrophication of the water column. Any potential eutrophication is likely to have a negative impact on both fish and invertebrate species within the localised area.

Research studies on the potential impacts of finfish aquaculture have shown however that any changes to nutrient levels in the water column are generally localised and within close proximity to sea cage infrastructure (Price and Morris 2013). Given the hydrodynamics of the MWADZ Proposal area (i.e. strong current flow, well flushed with high levels of water circulation and dispersion) it is unlikely that an increase in nutrients levels in the area will result in eutrophication events.

Particulates from feed and fish faeces from aquaculture stock would have the potential to cause an increase in the turbidity in the water column in close proximity to the proposed sea cage infrastructure in the MWADZ. These particulates would likely settle beneath the sea cages, resulting in an increase in sedimentation beneath the sea cages. An increase in turbidity can lead to a decrease in light penetration within the water column, which can have negative impacts on photosynthetic organisms (i.e. corals) and cause potential changes to the benthic/fish habitat directly underneath and in close proximity to the sea cages (Price and Morris 2013). Given the hydrodynamics of the MWADZ Proposal area, (i.e. strong current flow, well flushed with high levels of water circulation and dispersion) it is unlikely that an increase in turbidity will have a significant impact on invertebrate and fish species.

9.4.2 Organic Deposition and Nutrient Enrichment of the Sediments

Discharges from uneaten food, faeces and metabolic waste from aquaculture stock in the MWADZ Proposal area, have the potential to cause organic deposition and nutrient enrichment of the sediments beneath the sea cages. An increase in organic deposition through nutrient enrichment of the sediment beneath the sea cages would have the potential to result in potential loss or reduction in diversity of benthic invertebrates through smothering of benthic habitats. Bacterial decomposition of the organic matter can result in an increase in the biological oxygen demand of the sediment, leading to depletion of oxygen at the benthos (Hargrave, B 2005). This could result in anoxic conditions at the sediment-water interface resulting in a sharp decline in populations of invertebrates (i.e. saucer scallops) and other demersal finfish in the area. These anoxic conditions can also result in a significant increase in the small opportunistic benthic invertebrates such as scavengers and deposit feeding species [e.g. capetellid worms (Price and Morris 2013)].

Anoxic conditions could also lead to elevated levels of nitrites and hydrogen sulphide, which are toxic to invertebrate and fish species (Hargrave, B 2005). These conditions could also result in potential changes in biological and chemical processes in the sediment and the ecology of benthic organisms.

Any potential changes to the biochemical properties of the benthic environment within the MWADZ are likely to result in the avoidance of the area by invertebrate species such as saucer scallops. The survival and recruitment of fish species confined to habitats beneath the sea cages and within close proximity are likely to be impacted.

Many studies that have been conducted on the impacts of marine finfish aquaculture on the benthic environment in Australian waters have shown that in most cases impacts have been highly localised and restricted to areas beneath or in the immediate vicinity of the sea cages (McGhie *et al.* 2000; Hoskin & Underwood, 2001; DPIWE, 2004; Woods *et al.* 2004; Felsing *et al.* 2005; McKinnon *et al.* 2008; Edgar *et al.* 2010; Tanner & Fernandes, 2010).
Generally, the level of impact has been found to decrease with increasing distance away from sea cages (Macleod *et al.* 2002).

9.4.3 Release of Trace Metals, Therapeutants and other Contaminants

Worldwide a range of chemicals are used in aquaculture for the purpose of transporting live organisms, in feed formulation, health management, manipulation and enhancement of reproduction and for processing and adding value to the final product (Douet *et al.* 2009). Chemicals and therapeutants include anti-foulants, fertilisers, disinfectants, antibacterial agents, parasticides, feed additives, anaesthetics and breeding hormones (Burridge *et al.* 2010).

Operational activities conducted in the MWADZ are likely to require the use of some chemicals and therapeutants (i.e. veterinary pharmaceuticals) to treat cultured stock with disease, control pests, fish handling and euthanizing fish (i.e. anaesthetics). These chemicals have the potential to be released into the surrounding marine environment; through fish feed, fish faeces and directly into the water column (e.g. leaching from anti-foulants or heavy metals released from feeds). The amount of chemicals released into the environment can vary depending on the specific chemicals used, the characteristics of the aquaculture farm site (e.g. flushing rate and sediment type) and farm management practices (e.g. feeding rates, husbandry techniques etc.).

Chemicals used in the MWADZ Proposal area have the potential to have an impact on both fish and invertebrate species through direct toxicity and bioaccumulation in the food chain (Burridge *et al.* 2010). Heavy metals originating from anti-foulants used in farming practices could also have potential impacts on invertebrate species (i.e. saucer scallops) due to accumulation of contaminants in the sediments below the sea cages (reduces benthic colonisation) and direct toxic effect through bioaccumulation in the food chain (Pittenger et.al 2007).

9.4.4 Introduction of Marine Pests or Pathogens

There are a number of significant pathogens of the marine fish proposed for aquaculture in the MWADZ, including for yellowtail kingfish. Diseases may potentially be introduced into sea cage farms directly from the environment (e.g. as a result of transmission from wild fish), or via infected stocked fish, movement of personnel and infrastructure, the use of untreated aquaculture feeds or other vectors. Once introduced into an aquaculture facility, pathogens may persist, be transmitted between generations and potentially adapt to a state of virulence higher that that seen in the wild (where there may be no evolutionary advantage to kill a host) as a result of the selection pressures associated with intensive aquaculture. Spread of pathogens from aquaculture facilities could then occur via effluent, escapes, and/or predation. The spread of a significant pathogen could ultimately impact a wide range of species and the fisheries and ecosystems which they support.

Marine pests are known to be present in the region and thought to have been introduced into the state mostly as a result of anthropogenic activity involving international shipping. The MWADZ Proposal has the potential to assist with the further spreading of marine pests in the region. Marine pests can be transported in ballast water and as biofouling on vessel hulls. Vessel movements in the region have the potential to spread marine pests that can then establish themselves within the ecosystem. Commercial aquaculture activities also have the potential to be directly responsible for introduction of marine pests e.g. through introduction via feed sources or brood stock or via the use of imported equipment that is not sufficiently cleaned.

9.4.5 Additional Food

The presence of aquaculture stock (including dead or moribund stock), harvesting activities and effluent (i.e. blood, lipids, scales), biological residue (e.g. fish faces) and excess feed has the potential to attract or deter marine fauna from the proposal area. These factors could lead to changes in the behaviour of marine fauna within the MWADZ. These include:

- Increase/decrease in the visitation rates of finfish, shark and ray species
- Increase in the duration of visits for these marine fauna species
- Altered feeding behaviours for fish, sharks and rays and invertebrate species
- Increase/ decrease in the abundance of fish, sharks and rays and invertebrate species within the aquaculture zone.

Aquaculture stock feed which consists of fish meal and fish oil is known to attract fish species (Machias *et al.* 2005). The provision of food and habitat has the potential to lead to changed behaviour in fish species. An increase in food availability within the aquaculture zone has the potential to cause an increase in the abundance of prey species and could influence the behaviour of predatory fish species (e.g. pelagic fish species such as Spanish mackerel and yellow fin tuna) in the MWADZ. An increase in the abundance of prey species could, in turn, influence shark and ray behaviour.

If these fish species are able to regularly gain provision (e.g. food) from the fish farms it is likely to result in an increase in the visitation rates and duration of visits from these species. There are also likely to be a localised increase in the abundance of shark and ray species which could lead to increased rates of predation on aquaculture stock and the risk of interactions and potential entanglement and entrapment in the sea cages.

Aquaculture activities conducted within the MWADZ Proposal area are likely to provide an additional food source from the presence of cultured stock, dead or moribund stock, biological residues and excess feed for increaser marine avifauna species such as pied cormorant, silver gull and Pacific gull. These species are currently reliant upon natural food sources only at the Abrolhos Islands. The current silver gull summer population at the islands is relatively small (approximately 50 pairs) reflecting food availability (nitre bush berries, seabird eggs and chicks, marine invertebrates) during the summer months (Surman, C 2015). Previously large breeding populations (over 150 nests) of silver gull populations once nested in Pelsaert Group of the Abrolhos Islands (Surman, C 2015) during the autumn months, taking advantage of bait discards from rock lobster fisherman from the West Coast Rock Lobster Managed Fishery who operated in that area. Silver gulls have the ability to adjust their behaviour in line with fishery activities and have demonstrated in previous studies to be able to increase populations very quickly when additional food is available in the marine environment (Surman, C 2015). Increased availability of food for silver gulls across the North-west Shelf from gas flares over water has led to massive increases in gull populations with consequential displacement of other nesting seabirds and the predation of their young and eggs and hatchling turtles (Surman, C 2015).

Pied cormorants are known to actively pursue fish prey underwater regularly attaining depths of 20 metres or more (Surman, C 2015). This species is known to chase whole fishes from commercial wetline fishing vessels, and to enter rock lobster pots in pursuit of small fishes attracted to the pots by bait (Surman, C 2015). Pied cormorants are known to actively predate on aquaculture finfish stock in aquaculture farms in Scotland (Beveridge, M.C.M 2001). This species is likely to receive an advantage (provision) if able to feed upon any cultured fish within the MWADZ Proposal area. If these species are able to gain a provision from fish farming it is likely to increase the visitation rates, duration of visits and abundance of this species in the area. An increase in the abundance of pied cormorants may result in an increase in the number of entanglements with sea cage infrastructure. Any potential increase in pied cormorant populations may also result in more habitat loss for the threatened lesser noddy (*Anous tenuirostris melanops*) and hamper the recovery of this species at the Abrolhos Islands (Surman, C 2015).

Pacific gulls are predominantly predatory, foraging reef flats at low tide for whelks, trochus shells, turbo shells, baler shells, mantis shells, mantis shrimps, cuttlefish, octopus and crabs (Surman, C 2015). An increase in the availability of the food through aquaculture activities has the potential to replace the feeding behaviour of this species from predatory to scavenger. Given that current populations of this species are relatively low at the Abrolhos Islands any increase in the abundance of this species may initially be of a positive effect. However, over the longer term a population increase in such a large species may not be sustainable and may have negative impacts during certain times of the year (Surman, C 2015). Any increases in the abundance of this species may also result in an increase in predation rates on other seabird species eggs and chicks; in particular, adult storm petrels (Surman, C 2015).

9.4.6 Physical Presence of Aquaculture Infrastructure

The physical presence of aquaculture infrastructure including sea cages, anchoring and mooring systems and feeding systems could have potential adverse impacts on finfish and invertebrate species within localised areas in the MWADZ Proposal area.

Sea cages could potentially provide an additional three dimensional structure to the marine environment and provide an artificial habitat for fish species. Artificial marine structures are known to provide shelter, habitat complexity and a food source for small fish species (Forrest *et al.* 2007). Mooring lines and anchors used to secure the sea cage infrastructure can also be of advantage to particular fish species or their prey by providing an artificial habitat. These artificial structures commonly become encrusted with ascidians, mussels and encrusting organisms which provide a food source for some fish species.

The presence of infrastructure can modify the behaviour of mobile fish species and can congregate fish species around the area causing Fish Aggregation Device (FAD) effects. The presence of barge accommodation, feeding barges and moored operational vessels are also likely to create FAD effects. The aggregation of fish species to these structures has the potential to increase both recreational and commercial fishing activity within the MWADZ Proposal area. Wild fish species that aggregate around the sea cages may be more vulnerable to any potential diseases or pathogens that aquaculture stock may develop.

The presence of aquaculture farms has the potential to create barriers to movement if it restricts migratory routes or transit routes of marine mammals, reptiles and seabirds between their habitats. The presence of aquaculture infrastructure may also attract larger marine predators including sea lions and dolphins due to FAD effects. Sea-based infrastructures that may have an impact on marine fauna include:

- sea cages;
- mooring and anchoring lines and systems;
- feeding barges; and
- vessels (service and accommodation).

Potential impacts to marine fauna related to the physical presence of aquaculture infrastructure during the installation process and operational activities include:

- changes in natural feeding behaviour of marine fauna as a result of higher fish density from FAD effects;
- serious injury or mortality of marine fauna due to entanglement or entrapment in aquaculture infrastructure;
- habitat changes due to placement of infrastructure and degradation of marine water and sediment quality; and
- changes to marine fauna distribution and migration patterns due to avoidance or attraction cues.

The physical presence of aquaculture infrastructure such as sea cages, accommodation barges and feeding barges has the potential to have adverse impacts on marine avifauna increaser species. These increaser species may become entangled in sea cage netting, bird netting or anti predator netting during foraging or roosting causing drowning. The roosting of these species on the infrastructure has the potential to result in a reduction in water quality from faecal matter, increase the risk of collision with operational vessels and increase the amount of fouling on the infrastructure (Surman, C 2015). Increaser species may also use barges as a potential area for shelter and roosting areas. The increased presence of silver gull and cormorant species on accommodation barges and the sea cage infrastructure is likely to increase the likelihood of human interactions between these species and aquaculture farm staff.

The presence of sea cage infrastructure in the MWADZ Proposal area could also provide an attraction for baitfish, crustaceans and predatory fish due to fish aggregation (FAD) effects. These FAD effects may result in changes to seabird natural foraging behaviour and also result in an increase in populations of increaser species (i.e. gulls and cormorants) which have significant ecological effects. Changes to populations of these increaser species has the potential to lead to changes in ecosystem structure in area and can also lead to increases in kleptoparasitism (i.e. one animal takes prey or other food from another) on other more vulnerable sea bird species (Surman, C 2015). Increases in the pied cormorant colonies could also enhance the mechanical and guano stress on the mangrove habitats on the Abrolhos (Surman, C and Dunlop, N 2015).

9.4.7 Artificial lighting

Artificial light spill and glow generated during the installation and operation of aquaculture farms within the MWADZ area may have potential impacts on marine fauna. Sources of light emissions from activities within the area that may affect marine fauna include:

- routine lighting on aquaculture infrastructure;
- navigation marker lighting; and
- vessel lighting.

Light spill can have the following potential impacts to marine fauna:

- attraction of marine turtle hatchlings and disorientation;
- injury or death of juvenile seabirds attracted to lighting and flying into aquaculture infrastructure; and
- modification of fauna foraging behaviour around infrastructure due to light spill on the water.

Artificial lighting used on sea barge accommodation and on sea cage infrastructure has the potential to have a number of impacts on seabirds in the area. An increase in lighting has the potential to cause disorientation, collision for seabirds with the infrastructure and lead to potential death of seabirds that transit the area at night. Light emissions on aquaculture infrastructure have the potential to attract and extend seabird foraging times within the MWADZ Proposal area. Silver gulls are often attracted to offshore marine lighting as it increases the availability of prey (i.e. insects, fish attracted to light spilling onto the sea surface) (Chevron Australia 2010). The increased availability of prey and the ability of this species to be able to extend their foraging time through the night could potentially result in increased numbers of silver gulls, which may have flow on effects for other seabirds and for marine turtles, through direct competition for breeding habitat and predation of turtle eggs and hatchlings, respectively (Chevron Australia 2010). Light emissions from aquaculture infrastructure may alter the foraging behaviour of other gull species such as the Pacific gull and provide a competitive advantage to this species which may result in population increases in these species (Surman, C 2015).

9.4.8 Vessel Movements

Vessels will operate throughout the MWADZ area during the installation of the aquaculture infrastructure and during operational activities.

A range of vessel types, including service vessels, supply vessels and feeding barges, may be active within the area. The potential impacts to marine fauna related to the physical presence of vessels during the installation process and operational activities include:

- injury or death of marine fauna from vessel strikes;
- disturbance to marine fauna behaviour from vessel movements; and
- habitat degradation (e.g. through anchoring and mooring).

Higher vessel activity is likely during the construction of the aquaculture farms (i.e. installation of sea cages, anchoring and mooring systems) as opposed to during the operational period.

9.4.9 Noise and vibration

Noise and vibrations generated during the installation of aquaculture infrastructure and during operational activities within the MWADZ area may have potential impacts on marine fauna. The primary sources of potential noise and vibration include:

- vessel movements in the area;
- machinery used to install the sea cages, moorings and anchoring systems; and
- machinery used in operations (e.g. hand-held welders, mobile cranes, hand tools, small power tools, blowers and winches).

Anthropogenic marine noise has the potential to impact marine fauna that rely on acoustic cues for feeding, communications, orientation and navigation. The extent of the impacts will vary depending on a number of variables, including the frequency range of the emitting noise and its intensity, the receiving environment (e.g. salinity, water depth, and sea bed type), met-ocean conditions, characteristics and sensitivity of the animal, and its distance from the source. Underwater noise and vibration can have the following impacts on marine fauna:

- behavioural changes;
- temporary or permanent injury and (in extreme cases) mortality;
- stress response;
- complete avoidance of the immediate area (habitat displacement);
- attraction to the noise source; and
- disruption to underwater acoustic cues for navigation, foraging and communication.

However, the assessment provided in the PER concluded that noise and vibration from construction and operational activities within the MWADZ did not pose a significant risk to marine fauna in the area. The majority of noise and vibration is likely to be generated by machinery potentially used to anchor sea cage infrastructure to the seabed and such activity is unlikely to occur on a frequent basis. Noise resulting from vessel movements within the proposed MWADZ is also expected not to exceed that historically generated by the fishing industry in the Abrolhos Islands FHPA.

9.5 Management Measures

Proposed management and mitigation measures that are intended to be implemented to minimise the potential impacts of the risks to marine fish and invertebrate species and marine fauna (including avifauna) are provided in Table 9-6.

Although the degree of risk to the groups (e.g. fish, mammals and avifauna) is different, the management measures applied to address the risk are largely consistent. To avoid repetition, the table below does not address each group separately.

Table 9-6: Proposed Management and Mitigation Measures

Risk	Management Measures
Nutrient enrichment of the water column and increased turbidity	Management measures that can be implemented to reduce the potential impacts of nutrient enrichment of the water column and increased turbidity include: • Adopt good husbandry practices including the monitoring of nutrient levels under farm management practices such as direct measurement of the level of Chlorophyll-a at the farm reference sites. (Chlorophyll-a is a proxy for phytoplankton levels.) • Locate sea cages in well flushed locations with good water circulation and dispersion. • Set densities of aquaculture stock at conservative levels to help minimise the likelihood of water column enrichment. • Use species and system-specific feeds in order to maximise feed conversion ratios (FCR) and minimise waste. • Monitor fish feeding behaviour and particulate matter deposition to inform adapting the feeding strategy to maximise feeding efficiency and minimise particulate matter fallout. • Develop and comply with an EMMP and best-practices in aquaculture, including the requirement to monitor the levels of dissolved nutrients and chlorophyll-a in the water column.
Organic deposition and nutrient enrichment of the sediments	Key management and mitigation strategies that can be used to reduce the potential impacts of organic deposition and nutrient enrichment to sediments include: • Locate the sea cages in well-flushed areas where there is an increased water depth below the sea cages. • Control feed by minimizing feed wastage. This can significantly reduce sediment enrichment effects and help improve sediment conditions underneath the sea cages. • Use high-quality feeding systems which minimise waste. • Use high-quality feed and seek improved feed conversion ratios. • Fallow sites to allow seabed recovery. The rotation of sea cages is likely to allow the recovery of nutrient enrichment in the sediments. • Consider cumulative impacts under the zone management policy. • Monitor sea floor chemistry and infauna. • Encourage integrated multi-trophic aquaculture. • Regulate the density of sea cage operations, in addition to limiting the stocking density per hectare of lease. • Develop and comply with an EMMP and best-practices in aquaculture, including the requirement to monitor the levels of dissolved nutrients and chlorophyll-a.
Release of trace metals, therapeutants and other contaminants into the marine environment	Key management and mitigation measures designed to minimise the impacts of the potential release of chemicals include the following: • Apply good husbandry and farming practices (e.g. removal of sick or dead fish, reducing feed waste, conservative stocking densities etc.) to reduce the need for chemical use associated with marine finfish aquaculture. • Regular monitoring of contaminant levels at the lease sites. • Use high-quality feed. • Regular cleaning and maintenance of sea cage infrastructure to avoid

Risk	Management Measures
	accumulation of biofouling organisms and reduce the need for anti-foulants. • Locate sea cages in well-flushed areas. • Treat any infected aquaculture stock promptly. • Consult the relevant Material Safety Data Sheets (MSDS) before applying chemicals to aquaculture stock, promoting the safety of staff, stock and the environment. • Ensure all chemicals including antibiotics, therapeutants and anti-foulants are secured in storage containers with tightly fitted lids to minimise the risk of spills into the environment. • Ensure all residual or out-of-date chemicals are transferred to land-based facilities and disposed of in an appropriate manner. • Monitor, on an annual basis and as part of the requirements of the EMMP, three of the more common trace metals found in fish feeds. Should levels trigger the guidelines set in the EMMP, differently-formulated feeds may need to be utilised.
Introduction of marine pests or pathogens	The management measures which have been proposed to address the risk of the introduction of marine pests and pathogens have been covered in more detail in the biosecurity assessment in Section 10 of this document.
Additional food and artificial habitat	In order to reduce the potential impacts associated with additional food sources, operators within the MWADZ Proposal area must comply with the relevant requirements in the EMMP. Management arrangements within the EMMP will include requirements to: • Minimise opportunities for provisioning (i.e. by removing dead and moribund stock on a daily basis); • Use appropriate stocking densities [i.e. keep stocking densities at levels below or equal to industry-best-practice bench marks (e.g. 10-25 kg m^2)]; • Minimise feed wastage (e.g. through setting a benchmark of less than two percent wastage). This can be achieved by using efficient delivery systems and real-time monitoring of environmental conditions and stock feeding responses; • Use a high-quality pellet feed, noting: ➢ increasing knowledge on nutritional needs of particular finfish species in aquaculture is leading to improved quality of feed and is responsible for significant improvements in feed conversion ratios; ➢ modern feed for culturing fin-fish contains less fish meal and fish oil that traditional aquaculture feeds; and ➢ modern, high-quality feed can be designed to sink at rates which optimise consumption by stock; • Apply best-practice pelletised feed dispersion approaches to prevent seabirds from gaining access to waste feed and stock mortalities, take care to clean up feed spilled during loading and fully enclosing the feed system under the bird nets. • Prevent access to pellet food stored on site in bulk feed hoppers and store loose bags of feed in the below-deck compartment of the supply boat or on deck covered by heavy-duty PVC tarpaulin. • Use other deterrents (visual and audio) as appropriate. • Cover the above-sea component of sea cages with bird-netting material made of high-visibility, two millimetre polyethylene with a maximum bar-length of 60 millimetres to allow no points of entry for seabirds. • Regulate the quantity of aquaculture feed delivered to farm fish based on fish body weight measurements (to establish biomasses) and

Risk	Management Measures
	observations of fish feeding behaviour to ensure minimal feed remains uneaten by farm fish. • Use contemporary feeding technologies and best-practice farming techniques to reduce feed wastage and optimise food conversion ratios (FCR) as highlighted in the zone Management Policy and the Industry's Code of Practice. • Prevent the feeding of increaser marine avifauna by aquaculture farm staff. • Contain all post-harvest blood water and effluent; and • Monitor (real-time) environmental conditions and stock responses during feeding. • In order to prevent predation of juvenile aquaculture stock by pied cormorants, the following management and mitigation measures will be implemented: • Sub-surface exclusion or "anti-predator" netting with mesh sizes 60 millimetre bar-length or less will be mandatory on sea cages. Operators within the MWADZ will use durable fish nets (heavy-duty single barrier) and (where needed) external anti-predator nets (double barrier) to avoid predation on farmed stock. • Tension on anti-predator netting must be as tight as is practicable to provide a buffer between the grow-out net and the anti-predator net that will prevent any potential access to stocked fish by pied cormorants.
Physical presence of aquaculture infrastructure	Management measures that will be implemented to mitigate and or manage any potential impacts posed by the aquaculture infrastructure include: • Manage sea cage infrastructure to minimise entanglement hazards, roosting opportunities and potential collisions with seabirds. • Design railings, floats, net rings, etc. to reduce the opportunity for roosting sites that could be used by increaser seabird species. • Maintain nets, ropes and sea cages in proper working order, being clean (i.e. free of excessive fouling), taught and without damage (e.g. holes) that may cause entanglement of wildlife. • Inspect nets, ropes and sea cages daily for any marine fauna that may have become entangled. • Prevent sea birds such as pied cormorants, silver gulls and Pacific gulls from entering sea cages to gain provision (i.e. food) in the form of uneaten fish feed and biological residue and implement feeding protocols that reduce the likelihood of increaser marine avifauna species gaining access to feed outside of the sea cages. • Cover the above-sea component of sea cages with bird-netting material made of high-visibility, two millimetre polyethylene with a maximum bar-length of 60 millimetres to allow no points of entry for seabirds. • Monitor interactions between seabirds and sea cage infrastructure daily using semi-quantitative approaches. Record the numbers and types of seabirds and compare with the baseline assessment published in Halfmoon Biosciences (2015). • Engage an independent seabird consultant on site during the initial establishment of the sea cages and at intervals thereafter (for the purposes of establishing baseline data and validating monitoring undertaken by fish farm staff) and incorporate a training program for farm staff to continue ongoing observations, paying particular attention to surface-feeding silver gulls and Pacific gulls, as well as sub-surface feeders such as pied cormorants and wedge-tailed shearwaters (Oceanica 2015). • Monitor seabird activity by farm crew (after training), using identification guides provided by the consultant and require the farm

Risk	Management Measures
	crew to report daily the: ➢ numbers and species of seabird in the vicinity (i.e. within 100 metres) of the sea cages; ➢ types of seabird behaviour (i.e. roosting on floats, feeding on fish food, etc.); ➢ location and cause of any entanglement/entrapment incident and the seabird species involved; and ➢ incidents of any seabirds colliding with any service vessel. • Consolidate and share data in a common database where multiple fish farms are operating within the MWADZ and report results of the individual monitoring programs in the Annual Compliance Report submitted by each operator. • Assess the need to conduct ongoing broad-scale surveys of silver gull populations (based on the success of silver gull exclusion measures) after six and twelve months of operation in consultation with the Office of the Environmental Protection Authority (OEPA).
Artificial lighting	The key management and mitigation measures that will be used to reduce any potential impacts associated with artificial lighting include: • Minimise the light intensity used on vessels to as low as practicable when conducting activities at night and conduct the majority of work on the aquaculture farms during day light hours. • Reduce light spill by shielding lights and pointing lights directly at the work area (directional alignment), thereby reducing the amount of lights shining directly onto water. • Cover windows on accommodation barges with tinting or drapes at night to reduce the light emission. • Avoid (where possible) the use of bright lights (e.g. mercury vapour, metal halide, halogen and fluorescent light) on aquaculture infrastructure and consider the option of using use of low-wattage lights (i.e. Low Pressure Sodium Vapour lighting or orange and red lights). • Keep lighting on moored vessels at night to the minimum consistent with safe operations. • Monitor (periodically) the waters around moored vessels and accommodation barges to determine the level of night-foraging behaviour of silver gulls.
Noise and vibration	The key management and mitigation measures that will be used to reduce any potential impacts associated with noise and vibration include: • maintain and inspect noise generating equipment (e.g. vessel engines, drilling equipment) to reduce unnecessary increase in noise levels from the equipment (i.e. all vessels shall operate in accordance with the appropriate industry noise codes); • avoid the practice of leaving engines, thrusters and auxiliary motors on standby or running mode (where practicable); • the Master of any aquaculture vessel taking note if marine fauna is sighted in the vicinity of the aquaculture infrastructure and reducing speed to minimise noise disturbance (other staff are also responsible for bringing the situation to the attention of the Master of the vessel); and • install sound suppression devices (e.g. mufflers) on noise-emitting equipment (if applicable).

9.6 Predicted Environmental Outcome

The key risks to marine fauna presented by sea cage aquaculture include:

- collision/entrapment associated with the sea cage infrastructure;
- attraction/increased abundance associated with provisioning, due to the availability of stock feed and dead or moribund stock or increased prey availability;
- reward, behavioural changes or population growth due to provision of artificial habitat and supplementary feeding;
- disturbance/collision associated with service vessels;
- habitat exclusion due to the physical presence of sea cage infrastructure;
- disturbance by aquaculture practices with implications to foraging success (e.g. the use of artificial lighting); and
- pressures associated with disease and genetic pollution.

These risks (above) will be eliminated or minimised through best practice management and world-class infrastructure, as required by the EMMP and Draft Management Policy for future derived proposals (i.e. aquaculture operations within the MWADZ). The above risks not eliminated (i.e. residual risks) will be reduced to an acceptable level commensurate with a high level of protection for the maintenance of ecosystem integrity (EMMP - Appendix 2).

Indirect impacts on marine fauna related to organic deposition are not considered significant, as these would be restricted to localised areas in close proximity to the sea cage infrastructure. Aquaculture activities conducted within the MWADZ Proposal area are likely to result in some degree of nutrient enrichment in the water column based on discharge from uneaten feed, faeces and metabolic wastes (such as urea) from aquaculture stock. Organic deposition associated with finfish aquaculture has potential to impact upon benthic communities and habitats which, in turn, can affect some species of marine fauna. Any risks related to the potential use of treatment chemicals or accumulation of trace metals is low due to restricted use, limited spatial distribution, rapid dilution and decomposition in the environment.

Proponents within the MWADZ will be required to work within the EQMF (refer to EMMP - Appendix 2), which requires operators to conduct regular monitoring of the marine environmental quality (EAG 15), through the ecological value of "ecosystem health" and its associated environmental quality objective of "maintain ecosystem integrity". If proponents fail to achieve the appropriate level of environmental quality required by the EQMF, additional management measures will be applied to reduce the potential impacts. The EQMF and the EMMP are therefore critical to the development of the MWADZ and provide the security to ensure future derived proposals are sustainable and well managed to achieve levels of environmental quality higher than that predicted under the modelled "worst case" scenarios (EMMP - Appendix 2).

The EMMP provides the EQMF to protect marine environmental quality and benthic communities and habitat within the appropriate levels of ecological protection. However, it also includes proactive management strategies to protect the important biological and ecological values of the Abrolhos Islands region, including its significant marine mammal, seabird, wild fin-fish and invertebrate populations (Sections 4.4, 4.5, 4.6 and 4.7 of the EMMP - Appendix 2).

The key pressures associated with aquaculture are inputs of nutrients and organic material derived from fin-fish metabolic processes and feeding. None of the pressures on marine environmental quality and benthic communities and habitat are expected to impact on significant marine fauna (i.e. marine mammal, marine reptile, seabird, wild finfish and invertebrate populations).

The implementation of appropriate management and mitigation measures ensures the potential risks associated with provisioning of food and artificial habitats are low. Ongoing monitoring of the activity and populations of these species will ensure any impacts to populations of vulnerable species are further reduced. Compliance with the EMMP and the adoption of best-management practices will also ensure any impacts to marine mammals are minimised.

To reduce the risk to marine fauna [including endangered, threatened and protected (ETP) species] from the MWADZ Proposal, operators within the MWADZ will be required to develop and implement an individual Management and Environmental Monitoring Plan (MEMP) that corresponds to an overarching zone Environmental Monitoring and Management Plan (EMMP). The Department will support or endorse best-management practices for aquaculture and manage compliance around the MEMPs of individual operators, including mandatory reporting of interactions with ETP species. Failure to comply with the MEMP may result in suspension or cancellation of the aquaculture licence.

Several risk factors were identified in relation to seabirds, including: entanglement, habitat exclusion, disturbance from aquaculture activities, increased prey availability, creation of roosting sites, implications for foraging success; and spread of pathogens (Sagar 2008, 2013, Lloyd 2003, Comeau et al. 2009). Other than the risks associated with artificial light and stock feeds, all other risks to seabirds can be eliminated or significantly reduced through a range of management measures (Halfmoon Biosciences 2015).

The monitoring and management component of the EMMP is aimed at maintaining the integrity of Abrolhos seabird populations, with a focus on limiting potential interactions between increaser species and sea cage aquaculture (EMMP - Appendix 2).

A number of risk factors were identified for marine mammals and turtles relating to sea cage infrastructure, stock feeds, service vessels and the use of artificial lighting. The availability of supplementary feeds was identified as a significant risk factor, with potential to alter the natural feeding regimes of marine mammals and turtles. Other risk factors included physical presence of sea cages, anchor lines and the use of service vessels, all of which create potential for injury (or mortality) via collision and/or entanglement.

The monitoring and management component of the EMMP is aimed at protecting marine mammals and turtles by limiting potential interactions between vulnerable species and sea cage infrastructure (EMMP - Appendix 2). In the context of preventing interactions with marine mammals, particular consideration has been given to managing the risks associated with the physical presence of sea cage infrastructure, vessel movements and artificial light. Mitigation of risks will be undertaken using proactive and reactive management strategies.

The objective of wild finfish management is to minimise environmental and ecological risks to wild finfish populations, including sharks, rays and other finfish. ETP finfish species have been given special consideration. The primary residual risk was the presence of excess feed pellets and dead or moribund stock attracting wild finfish to sea cage infrastructure to feed. The intent is to manage these attractants by reducing or preventing the:

- strength of signals that may attract wild finfish;
- opportunity for interactions between ETP species wild finfish and aquaculture;
- breaching of sea cage netting by sharks; and
- ecological impacts of such interactions.

The biosecurity management component of the EMMP is aimed at protecting wildlife, particularly wild finfish, from risks associated with pathogens, parasites, genetic pollution, and marine pests.

Compliance with the identified management and mitigation measures through MEMPs and the zone EMMP, that include best-practice management, should result in:

- significant reductions in levels of attractant signals to minimise the likelihood of marine fauna making contact with sea cages;
- significant reductions in opportunities for provisioning from aquaculture by marine fauna to prevent behavioural changes;
- use of anti-predator nets to deny marine fauna access to sea cages (a potential food source);
- use of mesh or netting of an appropriate mesh size (e.g. less than 60 millimetres in bar length), tear-resistant and tangle-resistant to minimise the probability of marine fauna becoming entangled in, or entrapped within, the sea cages; and
- tensioning of aquaculture infrastructure to eliminate the possibility of entanglement of marine fauna.

The potential contribution of aquaculture to mortality rates of marine fauna in the absence of management and mitigation measures could be significant when added to the other various pressures on individual species (particularly ETPs). However, while it is not possible to eliminate signals that could attract marine fauna to the sea cages, the likelihood of entanglement, and potential death, can be substantially reduced.

In summary, the proponent considers that the potential risks to marine fauna will be adequately managed such that proponents of future derived proposals will achieve the EPA's environmental objective by providing a high level of protection for marine fauna (EMMP - Appendix 2).

10 ASSESSMENT OF POTENTIAL IMPACT ON BIOSECURITY

10.1 Assessment Framework

While "biosecurity" is not, of itself, an environmental factor identified in the EPA's EAG 8 for the purpose of organising environmental information for environmental impact assessment, it has the potential to contribute in a significant way to factors other than simply the marine fauna factor specified in Section 2.3 of the ESD.

In relation to the MWADZ Proposal, biosecurity was recognised as the most significant potential risk associated with the proposal (refer to Appendix 4 - *Threat Identification,* *Hazard Pathway Analysis and Assessment of the Key Biosecurity Risks presented by the establishment of the Mid West Aquaculture Development Zone in Western Australia*).

Consequently, biosecurity has been included as a separate section in this PER.

10.1.1 Environmental Objective

The environmental objective established in this for biosecurity is essentially that for marine fauna (as specified in EAG 8), namely:

> *"To maintain the diversity, geographic distribution and viability of fauna at the species and populations levels".*

However, noting the potential impacts on biosecurity may extend beyond fauna, the environmental objective for benthic communities and habitats (Section 8 of this PER) may also apply, namely:

> *"To maintain the structure, function, diversity, distribution and viability of benthic communities and habitats at local and regional scales".*

To give effect to these objectives, it is necessary to describe translocation, biosecurity and management arrangements addressing:

- fish disease/pathogen (including parasite) and marine pest management and incident response;
- strategies for preventing disease and pest outbreaks and/or preventative treatment chemicals to escape into the surrounding environment;
- brood stock and translocation issues; and
- prevention and management of escaped fish.

10.1.2 Relevant Legislation, Policies, Plans and Guidelines

10.1.2.1 State Protection

The Department is responsible for managing the State's finfish and invertebrate stocks and to ensure the long-term sustainability of these resources under the FRMA and the *Fish Resources Management Regulations 1995* (FRMR). The Department will transition to a new Act to replace the FRMA subject to its passage through Parliament and proclamation. The *Aquatic Resources Management Bill 2015* (ARMB) builds on key elements of the FRMA, but extends the provisions of the FRMA in a number of areas, including biosecurity. The timing of this transition is currently uncertain.

Part 6 of the proposed ARMB provides powers for the declaration of organisms, the establishment of biosecurity management plans and emergency powers to deal with biological threats. This will require the drafting of regulations to give legislative effect to the Department's existing biosecurity policy.[42] For this reason, some of the documents referred to in the biosecurity assessment section (and associated risk assessment at Appendix 4.) are

[42] Refer to http://www.fish.wa.gov.au/Documents/biosecurity/aquatic_biosecurity_policy.pdf

listed as biosecurity management arrangements. This is because the drafting of regulations to give effect to the ARMB's Part 6 powers are (at the time of writing) not yet finalised.

Table 10-1 outlines the policies, plans and guidelines that currently govern biosecurity management in Western Australia.

Table 10-1: Legislation, Policies, Plans, and Guidelines Relevant to Biosecurity - State

Legislation, Polices, Plans and Guidelines	Intent
State	
Environmental Protection Act 1986	This State Act provides for an EPA, for the prevention, control and abatement of pollution and environmental harm, and for the conservation, preservation, protection, enhancement and management of the environment.
Fisheries Resources Management Act 1994	Provides a legal framework to conserve, develop, and share fish resources for the benefit of current and future populations in WA. This legislation also provides the management framework for the Abrolhos Islands reserve and for the establishment and management of the Fish Habitat Protection Areas.
Department of Fisheries: *Biofouling Biosecurity Policy*	Focus on prevention of introducing marine pests via vessel and equipment biofouling through the key principles of: • prevention • least-restrictive measures • risk-based resource allocation • shared responsibility
Department of Fisheries Guidance Statement: *In-water treatment of vessels in Western Australian waters*	The Western Australia, the in-water cleaning guidelines are a tool to assist in managing vessel hygiene while also meeting the minimum endorsed standard for any prospective in-water treatment systems and specific vessel cleans. (Note: these guidelines dovetail with the Commonwealth *Anti-fouling and In-water Cleaning Guidelines* mentioned below).
ACWA: *Environmental Code of Practice*	Seven species-specific codes designed to assist the continued improvement of industry profitability, environmental performance and community relations through the adoption of environmental management systems and environmental Codes of Practice.
Department of Fisheries Guidance Statement: *Management and Environment Monitoring Plans (MEMP)*	Biosecurity to be addressed as a component of the MEMP.
Conditions associated with the Aquaculture Licence	1. Regulation 69 of the Fish Resources Management Regulations 1995 prescribes *inter alia* certain obligations relating to disease biosecurity that will apply to the holder of the Aquaculture Licence. 2. Section 95 of the FRMA provides for conditions relating to biosecurity to be placed on the Aquaculture Licence.
Department of Fisheries: *Houtman Abrolhos Islands Management Plan*	The Abrolhos Islands Reserve and the associated Fish Habitat Protection Area (FHPA) to be managed in accordance with the Department of Fisheries' vision for these reserves, namely: *To conserve and promote the unique cultural and environmental heritage values of the Abrolhos for the benefit of present and future generations.*
Department of Fisheries: *Western Australian Prevention List for Introduced Marine Pests*	Listing of Introduced Marine Pests (IMP) that either are: • present on national pest lists; or

	• of concern to the protection of Western Australian waters.
Department of Fisheries: *Noxious Fish List*	Lists those species banned from being brought into, or have possession of within, Western Australian under Schedule 5 of the FRMA.
Department of Fisheries: *Policy for managing translocations of live fish into and out of Western Australia*	To protect and conserve fish populations, fish habitats and natural aquatic biodiversity in Western Australia by minimising the risks associated with the translocation of live fish.
Department of Fisheries: *Guidelines for Streamlined Translocation Approval for Commercial Aquaculture*	Guidelines for applying for translocation approval for moving live fish (finfish, crustaceans, algae, shellfish or any other aquatic organism), including a streamlined process for "white list" species.
Environmental Assessment Guidelines (EAG)	
Environmental Assessment Guidelines No.8 (EAG 8) Environmental Assessment Guideline for Environmental Principles, Factors and Objectives (EPA 2015)	The EAG 8 provides guidance for proponents to help them understand the need to consider environmental principles, factors and objectives for the purpose of environmental impact assessment. Environmental principles, factors and objectives are critical to the environmental impact assessment process as they underpin the EPA's decision on the environmental acceptability of a proposal or scheme. In making its decisions, the EPA also takes a holistic approach to assessing environmental acceptability based on a number of broader considerations including whether the proposal aligns with broader international, national and State policies and agreements and takes account of the interconnected nature of the environment.

10.1.2.2 Commonwealth Protection

The Commonwealth legislation that protects the threatened, endangered and protected species is the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The EPBC Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places defined in the Act as matters of national environmental significance (Department of the Environment, 2013).

A new Commonwealth *Biosecurity Act 2015*, which will commence in June 2016, replaces the existing *Quarantine Act 1908*. This will become the primary biosecurity legislation for Australia at the national level. (Note that regulation of biofouling is currently only at the State level).

Table 10-2: Legislation, Policies, Plans, and Guidelines Relevant to Biosecurity - Commonwealth

Legislation, Polices, Plans and Guidelines	Intent
Commonwealth	
National Biofouling Management Guidelines for the Aquaculture Industry	Provide recommended approaches for control of biofouling to minimise the spread of exotic species associated with moving aquaculture stock and equipment. These guidelines provide practical management options that can: • reduce the risk of marine pest infestations; • reduce the costs associated with managing an incursion or with quarantine measures if a marine pest is discovered; and • reduce the possible translocation of a marine pest.
National Biofouling Management	These guidelines provide commercial fishing vessel operators with

Guidelines for Commercial Fishing Vessels	tools to minimise the amount of biofouling accumulating on their vessels and thereby to minimise the risk of spreading marine pests around the Australian coastline.
Anti-fouling and In-water Cleaning Guidelines	The guidelines are divided into two parts and address: • the application, maintenance, removal and disposal of anti-fouling coatings at shore-based maintenance facilities; and • in-water cleaning.
AQUAVETPLAN and AQUAVETPLAN Manuals	The Australian Aquatic Veterinary Emergency Plan and associated manuals is a series of working documents that are designed to provide guidance in the event of a disease outbreak for specific pathogens and situations. These are updated as required.[43]

10.2 Existing Environment

A broad overview of the existing environment is described in Section 3 of this PER document.

10.2.1 Introduced Marine Pests

The introduction of marine pests can create significant economic, social, environmental and biological costs to Western Australia (Bridgwood and McDonald, 2014). Invasive species tend to have characteristics that allow them to quickly adapt to their environment and reproduce at a rate that can out-compete native species. The typical management goal is to prevent invasive marine pests from incurring, as once established they are extremely difficult and expensive to eradicate (Bridgwood and McDonald, 2014).

There have been at least four Introduced Marine Pest (IMP) surveys conducted in the Port of Geraldton (Bridgwood and McDonald, 2014). The Geraldton Port is notable because it is the closest commercial port to the Houtman Abrolhos Islands and is at high risk of IMP introduction due to the high number of vessel movements in this area (Bridgwood and McDonald, 2014).

The Commercial Boat Harbour supplies vessels to support trade for the resources industry, with biofouling from slow-moving barges noted as being the major vector for the transfer of IMPs (Commonwealth of Australia, 2010). The Port of Geraldton is also at risk from domestic infection, for example from Fremantle and Kwinana Ports, based on both the number of vessels that transit between these three ports (Bridgwood and McDonald, 2014).

In 2013, the Department of Fisheries conducted IMP monitoring in all three parts of the Port of Geraldton - the Fishing Boat Harbour, the Batavia Coast Boat Harbour and the Commercial Boat Harbour (Hourston, M 2013). This monitoring recorded one IMP species, *Didemnum perlucidum*, which is listed on the National System target list and has a detectable population size in the Batavia Coast Boat Harbour. Repeat monitoring in 2015 again detected *D. perlucidum* but no other IMP species (C. Astbury pers. comm.).

Biofouling and ballast water are the two main vectors for IMPs, both in Australia and internationally (Commonwealth of Australia, 2010). Indeed, in aquaculture and fisheries, it is predominantly biofouling that has resulted in inadvertent transfer of species (Commonwealth

[43] Refer to http://www.agriculture.gov.au/animal/aquatic/aquavetplan.

of Australia, 2010). Aquaculture involves deployment of artificial structures into the water, and movement of those structures and stock between locations.
These novel surfaces can then be rapidly colonised by biofouling species, thus creating opportunities for IMPs to establish in the area. This is how aquaculture and fisheries industries remain a risk of inadvertent transfer of IMPs. However, adopting best-practice to manage biosecurity risks will restrict the likelihood of transfer of IMPs (Commonwealth of Australia, 2010).

In Western Australia, the Aquaculture Council of Western Australia (ACWA) has developed a number of codes of practice including the *Environmental Code of Practice for the Sustainable Management of Western Australia's Marine Finfish Aquaculture Industry 2013*. Although voluntary, the adoption of these codes is strongly encouraged by both ACWA and the Department. Further information on the Environmental Codes of Practice (ECOPs) can be accessed from http://www.aquaculturecouncilwa.com.au.

10.2.2 Aquatic Diseases

Aquaculture production has substantially increased on both an international and national scale. In South Australia, marine finfish aquaculture production has increased from $87 million in 1997/98 to $261 million in 2001/02 (de Jong and Tanner, 2004). With this increase in value and the associated increase in international trade (translating to increased movement of live aquatic animals) has come a heightened risk of introducing pathogens and pests into the environment (Oidtmann et al, 2011).

One of the key concerns associated with sea cage-cultured fish is controlling the spread of native or exotic pathogens from cultured fish to wild populations (Terlezzi et al, 2012). As yet, there have been no documented cases of exotic pathogens in Australia (de Jong and Tanner, 2004). However, on an international scale, there are cases where exotic diseases are thought to have passed from cultured stock to wild fish, with potentially significant repercussions for those wild stocks (Heggberget et al, 1993).

Internationally, documented cases where aquaculture has been implicated in infecting wild populations include *Gyrodactylus salaris* in wild salmon stocks in Norway (Heggberget et al, 1993) and infectious hematopoietic necrosis introduction in Japan via infected sockeye salmon eggs causing significant mortalities in three species of salmon (McDaniel et al, 1994; Waknitz et al, 2003).

In Australia, a number of native nodaviruses have the potential to cause major problems in finfish aquaculture. Nodaviruses have been reported in both wild and cultured finfish indicating that there is the potential to spread any outbreaks between stocks (Barke et al, 2002). Marine white spot is another potential disease. Being an obligatory parasite, it requires a host to survive. The best way to address white spot is to prevent it entering stock in the first place. Therefore, in high-density stocking arrangements, it has the potential to transfer quickly from fish to fish. Maintaining stringent biosecurity and husbandry practices are vital to prevent the spread of such pathogens.

In addition, aquaculture feeds have been implicated in the introduction of disease in turbot (Munro, 1996) and the disease epidemic in wild pilchards off the coast of Western Australia (Jones et al, 1997); although there is no definitive proof in the case of the latter.

10.3 Potential Impacts

Under its Ecosystem-Based Management Framework, the Department applies a qualitative risk assessment methodology to filter the different types of ecological issues (Fletcher, R.J., 2014).[44] The Department's risk assessment methodology is based on a consequence/likelihood matrix that is applied during the risk evaluation step. This step identifies the threats and hazard pathways and identifies management controls that can be implemented to affect the risk rating. Such risk assessments aim to make decisions about which risks need treatment, the degree required and the priority level (Fletcher, R.J., 2014)

The Department prepared a "*Threat Identification, Hazard Pathway Analysis and Assessment of the Key Biosecurity Risks presented by the establishment of the Mid West Aquaculture Development Zone in Western Australia*" (Biosecurity Risk Assessment or BRA) document (refer to Appendix 4). This assessment drew on a number of previously conducted generic aquaculture risk assessments including:

- Marine Finfish Environmental Risk Assessment (de Jong and Tanner, FRDC Project 2003/223)
- National ESD Reporting Framework: The "How to" Guide for Aquaculture. Version 1.1 FRDC, Canberra, Australia (Fletcher et al, 2004)
- Finfish Aquaculture in Western Australia: Final ESD Risk Assessment Report for Sea-Cage and Land-Based Finfish Aquaculture (Vom Berg, 2008; Fisheries Management Paper No 229, Department of Fisheries, Western Australia)
- Finfish Aquaculture in Western Australia: Final ESD management Report for Marine Finfish Aquaculture (Vom Berg 2009; 2008; Fisheries Management Paper No 233, Department of Fisheries, Western Australia).

The BRA used these previous reports as a basis to identify the three primary biosecurity risks that the proposed MWADZ could pose on the surrounding environment. These risks were that:

1. A significant pathogen or disease is spread from an infected aquaculture facility leading to a significant impact on wild target fisheries based around the same or alternate species.

2. Escaped fish lead to a significant impact on the future sustainability of wild stocks through either competitive interaction or genetic mixing.

3. The introduction and/or spread of marine pests in association with aquaculture activity have a significant impact on the sustainability of local ecosystems.

This risk assessment focussed only on the ecological risk and did not consider economic concerns. Each risk was associated with a number of Hazards or Hazard Pathways (see Section 2 of the BRA for a description of the methodology used).

[44] Refer to http://www.fisheries-esd.com/a/pdf/Fletcher%20et%20al%20EBFM%20framework.pdf

10.4 Assessment of Potential Impacts

10.4.1 Risk 1

RISK 1: *Significant pathogen or disease is spread from an infected aquaculture facility leading to a significant impact on wild targeted fisheries based around the same or alternate species*

Hazard Pathways

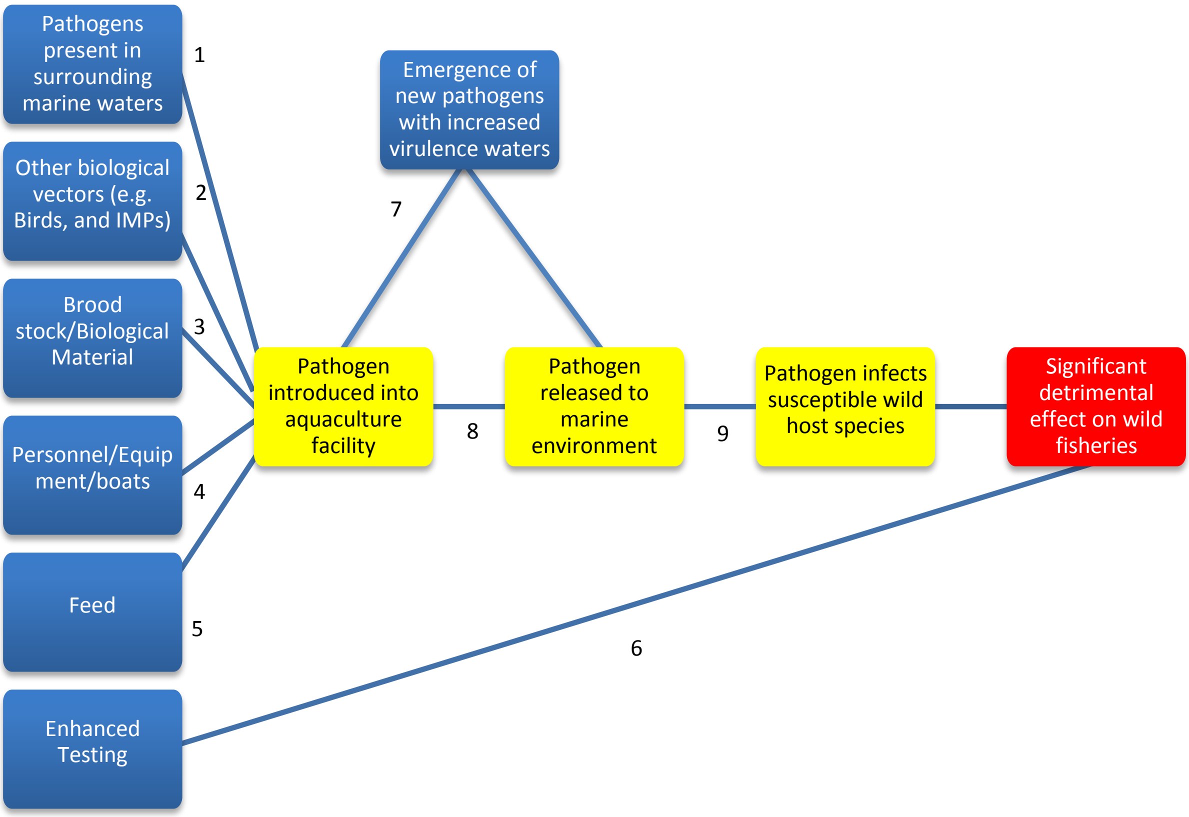


Figure 10-1: Compendium Map of Potential Pathways Leading to a Pathogen Introduction and Potential Disease Outbreak in an MWADZ Aquaculture Facility that may lead to Potential Spread of Disease to Wild Fisheries and Subsequent Significant Impact. Numbers refer to hazard pathways.

10.4.1.1 Pathogens Present in Surrounding Marine Waters

Open sea cage aquaculture (such as that proposed in the MWADZ) exposes cultured species during grow-out to a variety of potential pathogens that are present in the marine environment (reviewed by Lafferty *et al.* 2015). While every effort, using good husbandry techniques and ensuring high health status in hatcheries, can be made to ensure fish are disease free when entering cages, studies have shown that sea water can contain viral particles in the order of 10^7 per mL (Suttle *et al.* 2005). Additionally, wild stock and cultured fish of the same species are likely to share similar profiles of potential susceptibility to pathogens.

Little is known about the transmission of pathogens and disease between cultured and wild stock fish, or between fish and non-fish (de Jong and Tanner, 2004). However, it is recognised that while pathogens and disease naturally occurring in wild stocks may be quite benign, they may cause significant issues for cultured fish (Department of Fisheries, 2015). This is because wild fish have often co-evolved with the pathogen/disease in such a way as to co-exist.

When such a pathogen/disease is introduced into an aquaculture facility, it is presented with a different opportunity (i.e. a different set of selection pressures) that favour rapid evolution combined with lack of wild population constraints on host abundance and can result in strains that cause significant mortality in cultured fish (Einer-Jensen *et al.* 2004). (Refer to the BRA.) Potentially, such new pathogen/disease strains could then be re-introduced into the environment.

Biofouling on aquaculture infrastructure also has the potential to act as a reservoir for pathogens. For example, there is evidence that amoebic gill disease was harboured on sea cages in the Tasmanian Atlantic salmon fisheries (Tan *et al.* 2002 SA risk assessment). However, this particular disease is found free-living within the aquatic environment and there is a need for further research on the transmissions of disease between culture and wild populations (de Jong and Tanner, 2004).

10.4.1.2 Other Biological Vectors

Many pathogens have several vectors, or hosts, with birds in particular having been implicated in the spread of some pathogens (McAllister and Owens, 1992). It is known that bird parasite lifecycle often has an intermediate parasitic phase within fish (Barber, 2003 SA risk assessment). Transfer to the ultimate host is usually via ingestion and possible through the stocking of fingerlings (rather than large adults) in sea cages.

10.4.1.3 Brood Stock/Biological Material

The accidental introduction of disease to Western Australia via translocation of live fish for aquaculture from brood stock facilities is a concern for industry and the environment, particularly given the State's relatively disease free status (Thorne, 2002). Two main risks have been identified for translocation; namely the introduction of:

- exotic disease/pathogens; and
- exotic organisms (i.e. IMPs) (de Jong and Tanner, 2004).

Importation of aquarium fish species has previously been responsible for introducing diseases such as the goldfish ulcer disease (*Aeromonas salmonicidai*) which has the potential to spread to salmonids (including Atlantic salmon) (Carson and Handlinger, 1988; Whittington and Cullis, 1988 and de Jong and Tanner, 2004). Although these aquarium species are not cultured in sea cages, this demonstrates the risks associated with translocation (de Jong and Tanner, 2004). There is also some evidence to suggest that there is a greater risk of translocating native fish within their natural distribution, as any pathogen would be capable of surviving in wild populations that may not have had previous exposure (Langdon, 1989).

Although less well understood, there is evidence that IMPs can be imported with brood stock and/or biological material. For example, the implied origin of invasive *Codium fragile fragile* in Australia is importation with Pacific oysters as, along with *Grateloupia turuturu*, first records are from around Bicheno in eastern Tasmania [pers. comm. Lewis, J (July 2015)]. Organisms such as *Codium* are particularly difficult to eradicate once present as, being essentially a single-celled plant, they are capable of re-growing from a single filament.

10.4.1.4 Personnel/Equipment/Boats

A pathogen may spread through personnel, equipment and boats if it is present:

- in the immediate environment; or
- on the equipment itself (Snow, BRA).

This is considered most likely if equipment or infrastructure is shared between facilities (such as boats moving between farms) or imported/re-used equipment. Through comprehensive epidemiological studies, divers, boats and equipment have all been implicated in the spread of infections such as salmon anaemia virus between marine aquaculture sites (Jarp and Karlsen, 1997).

Biofouling is not only the leading way in which marine species (including IMPs) are transported by humans, but also one of the oldest mechanisms (DAFF, vectors paper). This biofouling can occur on vessels and infrastructure associated with marine operations such as barges, ropes, cages, floats and nets (Fitridge, *et al.* 2012).

Given the presence of *D. perlucidum* in the Batavia Boat Harbour at the Geraldton Port, and at pearling aquaculture leases within the Houtman Abrolhos Islands, movement of vessels between aquaculture facilities and in and out the Geraldton Port have the potential to spread IMPs.

10.4.1.5 Feed

Pellets tend to be the main source of feed for sea cage facilities, consisting predominantly of fishmeal and fish oil from international baitfish wild catch fisheries (de Jong and Tanner, 2004). These imported feeds have been identified as one of the more likely sources for introducing pathogens (Baldock, 1999).

Marine finfish aquaculture is dependent on high-quality brood stock conditioning feeds, especially in the early development stages of new aquaculture species. Beyond the sustainability and general environmental concerns, such feeds have been implicated in the introduction of disease into aquaculture facilities and surrounding wild catch populations (Munro, 1996; Jones *et al.* 1997).

10.4.1.6 Enhanced Testing

The expanding aquaculture industry and focus on good husbandry and management practices, have resulted in enhanced testing regimes that provide increased knowledge about the presence of disease in a geographic range. Largely, such an increase in the testing regimes is a positive outcome of the aquaculture industry, particularly given the greater understanding of how health conditions potentially affect wild fish in the wider ecosystem.

Australia is fortunate to the extent that it has a high biosecurity status and reputation. However, increased testing has the potential to highlight health issues and diseases not previously considered of concern. This may lead to a negative perception in the global trade context both for aquaculture and more broadly for wild catch fisheries.

10.4.2 Risk 2

RISK 2: *Escaped fish lead to a significant impact on the sustainability of wild stocks through either competitive interaction or genetic mixing*

Hazard Pathways

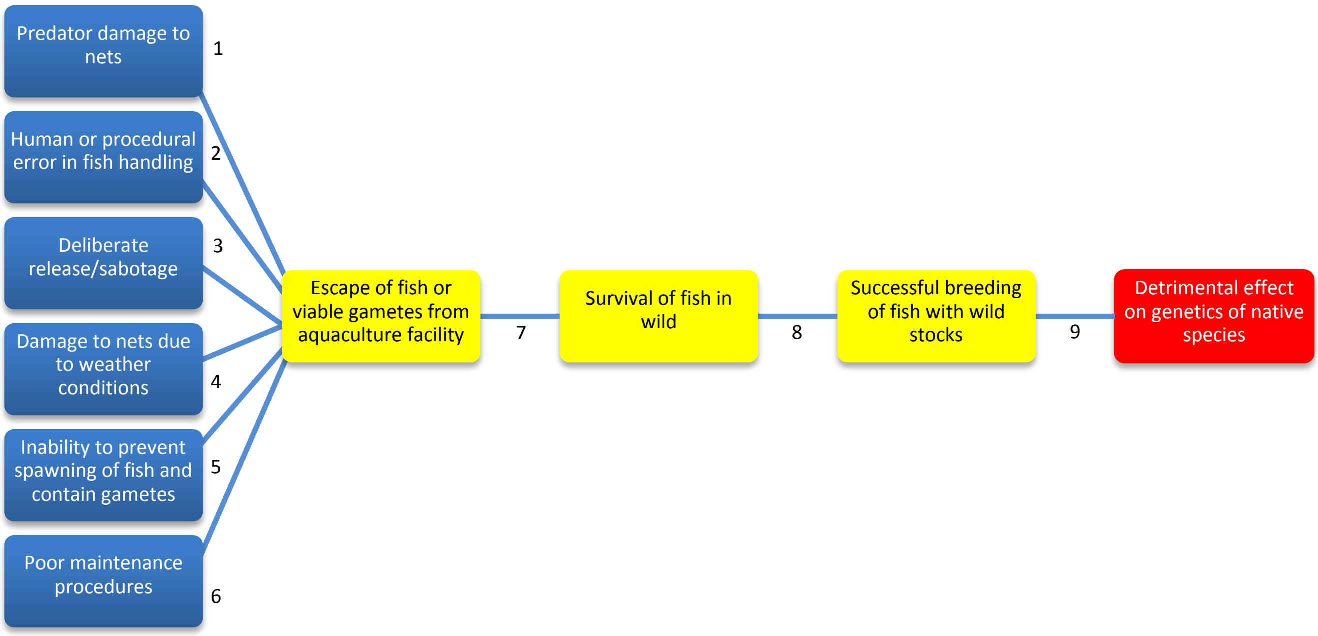


Figure 10-2: Compendium Map of Potential Pathways leading to Potential Negative Genetic Effects on Wild Fisheries arising from a Potential MWADZ Aquaculture Facility that May Lead to Subsequent Significant Impact. Numbers refer to hazard pathways.

10.4.2.1 Stock Escapes

Escape of cultured fish species from marine sea cages is probably unavoidable (Waples *et al.* 2012). However, the consequence (and frequency) of such escapes can be reduced through the implementation of a number management measures (discussed in "Management Measures" below).

There are numerous mechanisms by which escapes from sea cages occur (e.g. net failure caused by predator attack, storms, vandalism and wear). The environmental risks associated with escapees include:

- competition with wild stocks for food and space;
- genetic alteration or degradation of wild stocks;
- spread of pathogens/disease; and

- establishment of feral populations. (PIRSA, 2003d).

The consequence of these escapes is ultimately determined by the volume of escaped fish, coupled with their ability to compete in the wild.

The ecological and genetic impacts of escapees and the mechanisms by which the level of impacts are determined are poorly understood. However, even at the current levels of global aquaculture production such escapes present a problem for the long term sustainability of the aquaculture industry (Naylor *et al.* 2005).

The risk of escape through spawning is increased where a species matures relatively quickly. This risk is further highlighted where the cultured fish are in the known range of native fish of the same species. This would mean that a significant release of viable eggs could put the development of those cultured fish eggs on par with native fish eggs. It also follows that survival of larval fish from aquaculture would be on the same scale as the native individuals.

Successful spawning of escaped fish from both within and external to their native range has been documented in farmed salmon (reviewed by Weir and Grant, 2005). However, spawning success was reduced possibly due to the high level of domestication in farmed salmon. Given that the aquaculture industry in Western Australia is still in its infancy, it is likely that the level of spawning success of species such as the early-maturing yellowtail kingfish could be higher.

10.4.3 Risk 3

RISK 3: *The introduction and/or spread of marine pests associated with aquaculture activity have a significant impact on the sustainability of local and/or regional ecosystems.*

Hazard Pathways

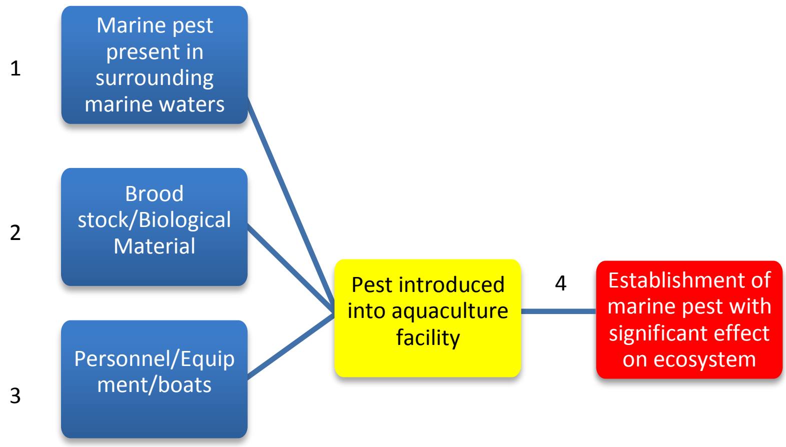


Figure 10-3: Compendium Map of Potential Pathways leading to Marine Pest-Associated Impacts arising from a Potential MWADZ Aquaculture Facility that May Lead to Subsequent Significant Loss. Numbers refer to hazard pathways.

10.4.3.1 Marine Pest Present in Surrounding Waters

The Houtman Abrolhos Islands are already known to have *Didemnum perlucidum* on aquaculture infrastructure associated with pearl farms. The original source of the pest is unknown; however, it is likely that it was introduced via infested vessels visiting the area. *D. perlucidum* is widely distributed around the State and could have been moved to the island via vessels and or equipment from a number of locations (V. Aitken pers. comm.).

The impact of IMPs can be difficult to predict. For example, *D. perlucidum* has largely been restricted to fouling artificial surfaces such as aquaculture or port infrastructure. While mostly restricted in its distribution to disturbed or artificial habitat, it has been recorded in the Swan River, where negative impacts such as overgrowing seagrass has been observed (Simpson, C pers. comm.). *D. perlucidum* has also been observed on coral reefs in the Northern Territory (M Barton, pers. comm.).

10.4.3.2 Brood Stock/Biological Material

This hazard is addressed in sub-section 10.4.1.3.

10.4.3.3 Personnel/Equipment/Boats

This hazard is addressed in sub-section 10.4.1.4.

10.4.3.4 Effect of Introduced Marine Pests on Habitat and Ecosystem

IMPs can have significant impacts on ecosystems and the commercial viability of dependent fisheries. By their nature, IMPs establish readily in appropriate receiving environments, although the risk of establishment and impact is species-dependent. Once established, IMPs are often difficult or impossible to eradicate.

Internationally, examples exist of the detrimental impacts following introductions of seemingly innocuous species. Such an example is the introduction of North American comb jelly into the Black Sea. This resulted in the collapse of pelagic commercial fisheries.

In Australia, the introduction of the Pacific sea star (*Asterias amurensis*) into Tasmania and subsequently into Port Philip Bay poses a very real threat to the viability of mariculture operations as well as wild capture shellfish fisheries in the area. This is due to its rapid population growth and diet of mussels, scallops and clams.

Biofouling species are also known to cause significant problems, particularly when they occupy the same ecological niche. For example, the Asian paddle crab is a very aggressive swimming crab that not only has the potential to outcompete native species but is also known to pose a threat to aquaculture species (New Zealand Government, 2013). Asian paddle crabs are known to travel extensive distances as larvae and are capable swimmers as adults. Human activities, including marine farming, are considered a potential vector for the spread of species. While not currently established in Australia, recent records have found several of these crabs within the Swan River.

10.5 Management Measures

A summary of the proposed management measures associated with the MWADZ Proposal is detailed below.

RISK 1: *Significant pathogen or disease is spread from an infected aquaculture facility leading to a significant impact on wild targeted fisheries based around the same or alternate species*

In order to realise this risk, one or more of the hazard pathways identified in Figure 10-1 must result in the introduction of a potentially significant pathogen into the proposed MWADZ. The pathogen present on the farm must then be exported from the facility at sufficient levels, and come into contact with susceptible wild stocks and successfully infect these susceptible stocks, resulting in disease occurrence. The resulting disease must have a significant impact on wild stocks of fisheries which they support.

There is a number of management measures in place that reduce the likelihood of one or more of the hazard pathways identified leading to the introduction and spread of a significant pathogen or disease from an infected aquaculture facility subsequently impacting on wild fisheries (Table 10-3).

It is in the interest of the State to support development of a sustainable aquaculture industry in the MWADZ through implementation of biosecurity control measures aimed at:

- preventing introduction and emergence of disease onto a farm;
- ensuring effective early detection and containment of significant pathogens; and
- preventing their release into the environment.

Table 10-3: Management Measures to Address Risk 1

Risk	Inherent Risk (no management measures)	Management measures	Residual Risk (based on implementation of identified management measures)
1. Significant pathogen or disease is spread from an infected aquaculture facility leading to a significant impact on wild targeted fisheries based around the same or alternate species.	Moderate (8)	Existing Policy/Plans & Guidelines: • s.92 FRMA/MEMP; • Licence Condition; • EMMP; • Aquatic Biosecurity Policy; • Biofouling Policy; • Translocation Policy; and • ACWA Environmental Codes of Practice. Key Management strategies that could be or (as part of the above) are applied: a. Measures to promote high level of fish welfare and husbandry both through education and regulatory measures ;	Low (4)

Risk	Inherent Risk (no management measures)	Management measures	Residual Risk (based on implementation of identified management measures)
		b. Use of pathogen free brood stock and exclusion of known significant pathogens through a program of sensitive brood stock screening; c. Health testing of stock prior to translocation to sea cages; d. Exclusion devices for predators including birds, appropriate sea cage design; e. Only commercial pelleted food to be used; f. Feed approved by AQIS or complies with ISO 900 1:2008; g. Controlled communication plans and research to extend knowledge around pathogens/disease vectors; h. Limit pressure from pathogens through regular cleaning and exchange of nets i. Implementation (as required in the MEMP) of appropriate and timely disease treatment regime for endemic diseases; and j. Consideration of vaccine treatments to reduce effects of opportunistic or ubiquitous pathogens.	

RISK 2: *Escaped fish lead to a significant impact on the sustainability of wild stocks through either competitive interaction or genetic mixing.*

While escapes associated with sea-case based aquaculture are considered almost inevitable, significant advances have been made in understanding the cause of these escapes and thus developing improved management strategies aimed at limiting their occurrence.

Given weather patterns in Western Australia, the relative exposure of offshore aquaculture operations in the MWADZ and the biology of the species under consideration, the likelihood of escaped fish having an impact to sustainability of wild stocks is linked to the magnitude and frequency of escape events in addition to the size of fish escaping. Evidence does exist to indicate that escaped yellowtail kingfish can survive in the wild (Fowler *et al.* 2003) and where such species are cultured within their natural range, the potential for interaction between wild and cultured fish may also be high as has been demonstrated in Spencer Gulf, South Australia (Fowler *et al.* 2003).

Fish escaping at larger sizes would generally have become adapted to aquaculture conditions and may remain near cages subsequent to escape events, or exhibit modified behaviours which may limit the likelihood of direct interaction with wild stocks. In support of this, Fowler *et al.* (2003) demonstrated that a population of fish in the northern Spencer Gulf region, identified as being of cultured origin, had apparently different opportunistic and reduced foraging behaviours compared to wild fish.

The likelihood of escapes leading to an impact on sustainability of wild stocks is also influenced by the degree of domestication of the aquaculture stock in question.

Higher degrees of domestication and genetic selection in favour of properties considered conducive to aquaculture production (e.g. high growth rates) can lead to a stock which has significantly different genetic and phenotypic characteristics from its parent population. The likelihood of escapee fish impacting sustainability of local wild fish populations can be reduced by limiting the degree of genetic differentiation of the cultured stock from its wild fish siblings. This could be managed by maintaining a strategy of hatchery production of F1 generation stock based on locally sourced brood stock. If marine finfish proposed for culture are all F1 generation, significant genetic selection is unlikely to have occurred and thus the potential for their escape and interaction with wild fish to lead to detrimental effects would be low.

The likelihood that escaped fish lead to a significant impact on the future sustainability of wild stocks through either competitive interaction or genetic mixing may be reduced through the introduction of measures aimed at reducing the frequency and magnitude of escape events.

Table 10-4 below shows the inherent risk level (i.e. with no management measures), summarises the existing policy/plans and guidelines and key management strategies that could be applied to that risk, and finally the residual risk of the threat based on implementation of management measures.

Table 10-4: Management Measures to Address Risk 2

Risk	Inherent Risk (no management measures)	Management measures	Residual Risk (based on implementation of identified management measures)
2. Escaped fish lead to a significant impact on the sustainability of wild stocks through either competitive interaction or genetic mixing.	Moderate (6)	Existing Policy/Plans and Guidelines: • FRMA s.92A/MEMP; • Licence conditions; • Translocation Policy; • Reporting and compliance inspections; and • ACWA Environmental Codes of Practice. Key Management strategies that could be or (as part of the above) are applied: a. Mandatory reporting of all escape events; b. Conduct mandatory technical assessments to determine causes of serious escapes; c. Establishment of a mechanism to analyse and learn from mandatory reporting; d. Technical standards for sea cage aquaculture equipment – with an independent mechanism to enforce the standard; e. Mandatory training of staff in escape-critical operations and techniques; f. Locating sea cages within appropriately sheltered area; g. Maintenance of good husbandry practices; and h. Installation of anti-predator devices and site	Low (4)

		security.	

RISK 3: The introduction and/or spread of marine pests associated with aquaculture activity have a significant impact on the sustainability of local and/or regional ecosystems.

It is more likely that the MWADZ Proposal might play a role in spreading pests already present in the State than be directly responsible for the import of new pest species. In particular, *Didemnum pelucidum* is known to be present on aquaculture infrastructure in existing facilities within the Houtman Abrolhos Islands Fish Habitat Protection Area.

The infrastructure associated with the MWADZ Proposal may represent a new opportunity for the establishment of marine biofouling organisms. Associated vessel movements may also present a vector for subsequent dispersal.
The prevention and control of IMPs in the proposed MWADZ is, therefore, of great importance given that the risk assessment shows that habitat dynamics and ecosystem function have the potential to be fundamentally altered by high levels of IMP abundance.

The likelihood of significant impact from marine pest species is dependent on the degree of biosecurity management associated with facilities within the proposed MWADZ. Table 10-5 below shows the inherent risk level (i.e. with no management measures), summarises the existing policy/plans and guidelines and key management strategies that could be applied to that risk, and finally the residual risk of the threat based on implementation of management measures.

Table 10-5: Management Measures to Address Risk 3

Risk	Inherent Risk (no management measures)	Management measures	Residual Risk (based on implementation of identified management measures)
3. The introduction and/or spread of marine pests associated with aquaculture activity have a significant impact on the sustainability of local and/or regional ecosystems.	High (9)	Existing Policy/Plans and Guidelines: • FRMA s.92A/MEMP; • FRMA Part 9 – Noxious fish • FRMR Reg. 176 • Licence Conditions; • Biosecurity Policy; • EMMP; • Translocation Policy; • Biofouling Policy; • Anti-fouling and In-water Cleaning Guidelines; and • ACWA Environmental Codes of Practice. Key Management strategies that could be or (as part of the above) are applied: a. State-wide monitoring program for the early detection of marine pests at high risk ports in Western Australia (in this case particularly Geraldton);	Moderate (6)

Risk	Inherent Risk (no management measures)	Management measures	Residual Risk (based on implementation of identified management measures)
		b. Development of a monitoring regime based on a recognised and agreed national surveillance system supported by a research program (potentially incorporated into the monitoring section of the MEMP); c. Freezing of non-commercial pellet feed to kill any marine pests; d. Consideration given to an industry based biosecurity specific Code of Practice; e. Development of protocols for farm management practices (e.g. pest monitoring); and f. Compulsory reporting of marine pests.	

10.6 Predicted Environmental Outcome

Overall, the MWADZ Proposal is likely to pose a low to moderate biosecurity risk. The potential impacts posed by MWADZ Proposal can be effectively managed through implementation and compliance with the range of biosecurity legislative, policy and guidelines; either currently in existence or that will be enacted as a result of biosecurity powers conferred by the ARMA.

RISK 1: Significant pathogen or disease is spread from an infected aquaculture facility leading to a significant impact on wild targeted fisheries based around the same or alternate species

There is a threat to wild catch fisheries and aquatic ecosystems from pathogens and/or disease. For this reason the inherent risk associated with the potential spread is likely for any marine aquaculture development to be at least moderate to high. However, perhaps in part due to the seriousness of the threat (and the lack of certainty around the transmission of pathogen/disease between cultured and wild stock fish); a suite of effective management measures is in place.

The level of risk associated with pathogens/disease causing significant impact to wild stocks in the MWADZ can be reduced from moderate to low by applying appropriate management measures. This is largely due to the ability to establish controls over the major known pathways for the introduction of pathogens into farms and the development of protocols to rapidly detect and control emerging disease issues.

In line with the risk assessment, the low risk rating suggests current or planned management/control measures are adequate in reducing levels of identified risk to an acceptable level.

RISK 2: Escaped fish lead to a significant impact on the sustainability of wild stocks through either competitive interaction or genetic mixing

Escapes are almost an inevitable occurrence of sea cage aquaculture associated with equipment failure, extreme weather or predator damage (Jensen *et al.* 2010). The magnitude, frequency and fish size all change the relative consequences of such escapes, particularly in the context of fish that are cultured in their natural range (Snow, BRA).

The level of risk associated with fish escape in the proposed MWADZ causing significant impact to wild stocks can be reduced from moderate to low by applying appropriate management measures that reduce frequency and magnitude of escapes.
Under current proposed aquaculture scenarios, a significant impact on the future sustainability of wild stocks through either competitive interaction or genetic mixing is considered unlikely.

In line with the risk assessment, the low risk rating suggests current or planned management/control measures are adequate in reducing levels of identified risk to an acceptable level.

RISK 3: The introduction and/or spread of marine pests associated with aquaculture activity have a significant impact on the sustainability of local and/or regional ecosystems.

In some cases the presence of a marine pest causes little to no impact. However, given appropriate conditions and a pest with the appropriate biological characteristics, the outcomes can be catastrophic for the environment. This means the consequence remains high even though the risk is low, giving rise to a moderate rather than low risk. Despite this, under current proposed aquaculture scenarios a significant impact to regional habitats and ecosystems as a result of introduction or spread of high-risk marine pests remains unlikely.

The level of risk associated with marine pests causing significant impact to regional habitats and ecosystems can be reduced from high to moderate by applying appropriate management measures. The reason the risk level remains moderate is due to the unpredictable nature of marine pest incursions. In line with the risk assessment the moderate risk rating suggests current or planned management/control measures are adequate in reducing levels of identified risk to an acceptable level.

The Department, as Zone Manager for the proposed MWADZ, understands that a multi-tiered approach to address current and future vulnerabilities for aquaculture biosecurity, as well as the sustainable development of the aquaculture industry, is in the best interest of the State. Biosecurity is of concern not only to regulators and environmental organisations but also to farm operators. The spread of an IMP and/or pathogen/disease through aquaculture operations has the potential to affect not only the environment but also the reputation of individual lease holders and the industry as a whole (Fitridge, *et al.* 2112).

The current aquaculture specific management measures, including MEMPs and licence conditions, have mandatory biosecurity arrangements. However, as part of the Department's overall regulatory changes associated with the ARMB, a number of potential measures for increasing the strength of biosecurity arrangements are being considered. At the time of writing these arrangements have not been finalised, but potentially include:

- a single repository that is publicly available for all biosecurity documents;
- a review of the MEMP/licence arrangements that references key biosecurity documents to assist in consistency and transparency;
- standard protocols and arrangements for biosecurity management, emergency response and disease mitigation in areas where facilities have the potential to interact with one another; and
- biosecurity regulations under Part 6 of the ARMA, including vessel cleaning and bio-fouling practices.

It is also important to acknowledge the contribution of industry in the development of best-practice codes and guidelines and, where possible, strongly encourage the adoption of these. This can be done in conjunction with, or perhaps as a requirement of, more formal legislative arrangements.

Given both the current and proposed biosecurity management measures, the MWADZ Proposal presents a low-moderate risk to the surrounding aquatic environment.

11 ASSESSMENT OF POTENTIAL IMPACT ON FISHERIES

11.1 Assessment Framework

Section 2.3 of the Environmental Scoping Document (ESD) specified that the potential for the MWADZ Proposal to impact upon fisheries be addressed as a component of the scope of works outlined under the marine fauna environmental factor as described in the EPA's EAG 8.

Rather than incorporate this component under the "Assessment of Potential Impact on Marine Fauna" section (Section 9) of this PER, it has (like biosecurity) been included as a separate section.

11.1.1 Environmental Objective

The environmental objective established in this PER for fisheries is essentially that for marine fauna (as specified in EAG 8), namely:

> *"To maintain the diversity, geographic distribution and viability of fauna at the species and populations levels"*.

To give effect to this objective, it is necessary to describe the fisheries operating in the region of the MWADZ Proposal and assess the potential direct and indirect environmental impacts on recreationally and commercially important marine species, including impacts to migratory patterns, spawning and nursery areas.

It is important to understand that this environmental objective is different and separate from any potential issues relating to resource (including habitat) sharing between aquaculture and wild-capture fisheries, or indeed other anthropogenic uses of the MWADZ Proposal area. Those issues of a significant resource-sharing nature that have been identified through the consultation process have and will continue to be addressed in parallel, but separate, to this PER process.

11.1.2 Relevant Legislation, Policies, Plans and Guidelines

Table 11-1: Legislation, Policies, Plans, and Guidelines Relevant to Fisheries

Legislation, Polices, Plans and Guidelines	Intent
State	
Environmental Protection Act 1986	This State Act provides for an EPA, for the prevention, control and abatement of pollution and environmental harm, and for the conservation, preservation, protection, enhancement and management of the environment.
Fisheries Resources Management Act 1994	Provides a legal framework to conserve, develop, and share fish resources for the benefit of current and future populations in WA. This legislation also provides the management framework for the Abrolhos Islands reserve and for the establishment and management of the Fish Habitat Protection Areas.
The Management Plan for the Houtman Abrolhos Islands. Fisheries Management Paper 260. (Department of Fisheries 2012)	The Houtman Abrolhos Islands Management Plan outlines both the vision and strategic objectives of management of the Abrolhos for the next ten years. It aims to conserve and promote the unique environmental and cultural heritage values of the Abrolhos Islands. Some of the main management objectives include: • *To protect and maintain marine and terrestrial environments of the Abrolhos; and* • *To facilitate and manage fishing an aquaculture activities consistent the environmental and cultural values of the Abrolhos.*
Environmental Assessment Guidelines (EAG)	
Environmental Assessment Guidelines No.8 (EAG 8) Environmental Assessment Guideline for Environmental Principles, Factors and Objectives (EPA 2015)	The EAG 8 provides guidance for proponents to help them understand the need to consider environmental principles, factors and objectives for the purpose of environmental impact assessment. Environmental principles, factors and objectives are critical to the environmental impact assessment process as they underpin the EPA's decision on the environmental acceptability of a proposal or scheme. In making its decisions, the EPA also takes a holistic approach to assessing environmental acceptability based on a number of broader considerations including whether the proposal aligns with broader international, national and State policies and agreements and takes account of the interconnected nature of the environment.

11.2 Existing Environment

11.2.1 Commercial Fishing

There are a number of commercially managed fisheries that are currently permitted to operate within the broader region of Geraldton and the Abrolhos Islands. These include:

- West Coast Demersal Scalefish (Interim) Managed Fishery
- Temperate Demersal Gillnet and Demersal Longline Fishery
- Abrolhos Islands and Mid-West Trawl Managed Fishery
- Mackerel Managed Fishery

- Marine Aquarium Managed Fishery
- Specimen Shell Managed Fishery
- Octopus Interim Managed Fishery
- West Coast Rock Lobster Managed Fishery
- West Coast Deep Sea Crustacean Managed Fishery
- West Coast Purse Seine Managed Fishery

The fisheries listed above, which are permitted to fish inside the Abrolhos Islands Fish Habitat Protection Area (FHPA) where the strategic MWADZ Proposal area is located, include: West Coast Demersal Scalefish (Interim) Managed Fishery, Abrolhos Islands and Mid West Trawl Managed Fishery, Mackerel Managed Fishery, Marine Aquarium Managed Fishery, Specimen Shell Managed Fishery, Octopus Interim Managed Fishery and the West Coast Rock Lobster Managed Fishery.

11.2.1.1 Invertebrate Fisheries

The two main commercial invertebrate fisheries most likely to be impacted by the MWADZ Proposal are the West Coast Rock Lobster Managed Fishery (Figure 11-1) and the Abrolhos Islands and Mid-West Trawl Managed Fishery (Figure 11-2).

West Coast Rock Lobster Managed Fishery

The West Coast Rock Lobster Managed Fishery (WCRLMF) is one of the most important commercial fisheries at the Abrolhos Islands. The rock lobster fishery targets the western rock lobster (*Panulirus cygnus*) through the use of baited traps (pots) (Fletcher and Santoro 2014). The WCRLMF operates in the waters of the west coast of Western Australia between North West Cape (Exmouth Gulf) and Cape Leeuwin (from 34°24'S to 21°44'S). The fishery is managed in three management zones of which the Abrolhos Islands is classified as Zone A of the fishery.

In 2013, the WCRLMF was transitioned from an input based total allowable effort system to an output based individual transferable quota management model. Under this new system, each individual fisher is now allocated a discrete share of a total allowable commercial catch. The fishery is now managed in accordance with the *West Coast Rock Lobster Managed Fishery Management Plan 2012*, the *Fish Resources Management Act 1994* and other relevant subsidiary legislation. Previously under the input based management system commercial fishers were only permitted to fish at the Abrolhos Islands from 15 March to 30 June each year (St John, J 2006). Under the new management arrangements all commercial fishers authorised to operate in the fishery, including those permitted to operate at the Abrolhos Islands, are permitted to fish all year round (Fletcher and Santoro 2014).

Catch across the whole fishery has historically been close to 11,000 tonnes annually; however, in 2009-10 the total annual catch for the commercial fishery was significantly reduced to less than 6,000 tonnes with the introduction of catch limits and catch targets for each zone.

Commercial rock lobster fishing activity at the Abrolhos Islands predominantly occurs over limestone reef habitat with between 45 and 65% of fishing effort occurring in shallow waters (0 to 20 metres) near submerged platforms and exposed reefs (Webster, F *et al.* 2002). These habitats tend to occur generally on the western and central parts of the islands groups where there is a high abundance of limestone reef, macro algae and coral habitat (Webster, F *et al.* 2002). Coral reef habitats do also provide an important habitat area for Western rock lobster at the islands (St John, J 2006). Previous research surveys conducted at the Abrolhos have shown that the highest average number of fishing effort for the fishery occurs in the Wallabi/North Island area (273,000) pot lifts compared to the Easter Group (196,000) and the southern Pelsaert Group (98,300) (Webster, F *et al.* 2002).

Benthic habitat data collected in the strategic MWADZ Proposal area indicate that the predominant habitat is sand, which does not represent a key habitat area for Western rock lobster (pers. comm. De Lestang DoF). While sandy benthic habitat can sometimes provide an important area for migrating lobster during the "whites run" at certain times of the year, the MWADZ Proposal is not known to be an important area for migrating rock lobster. Given this information, it is unlikely that the MWADZ project will have a significant impact on the WCRLMF and (as a result) no further assessment was conducted on this fishery.

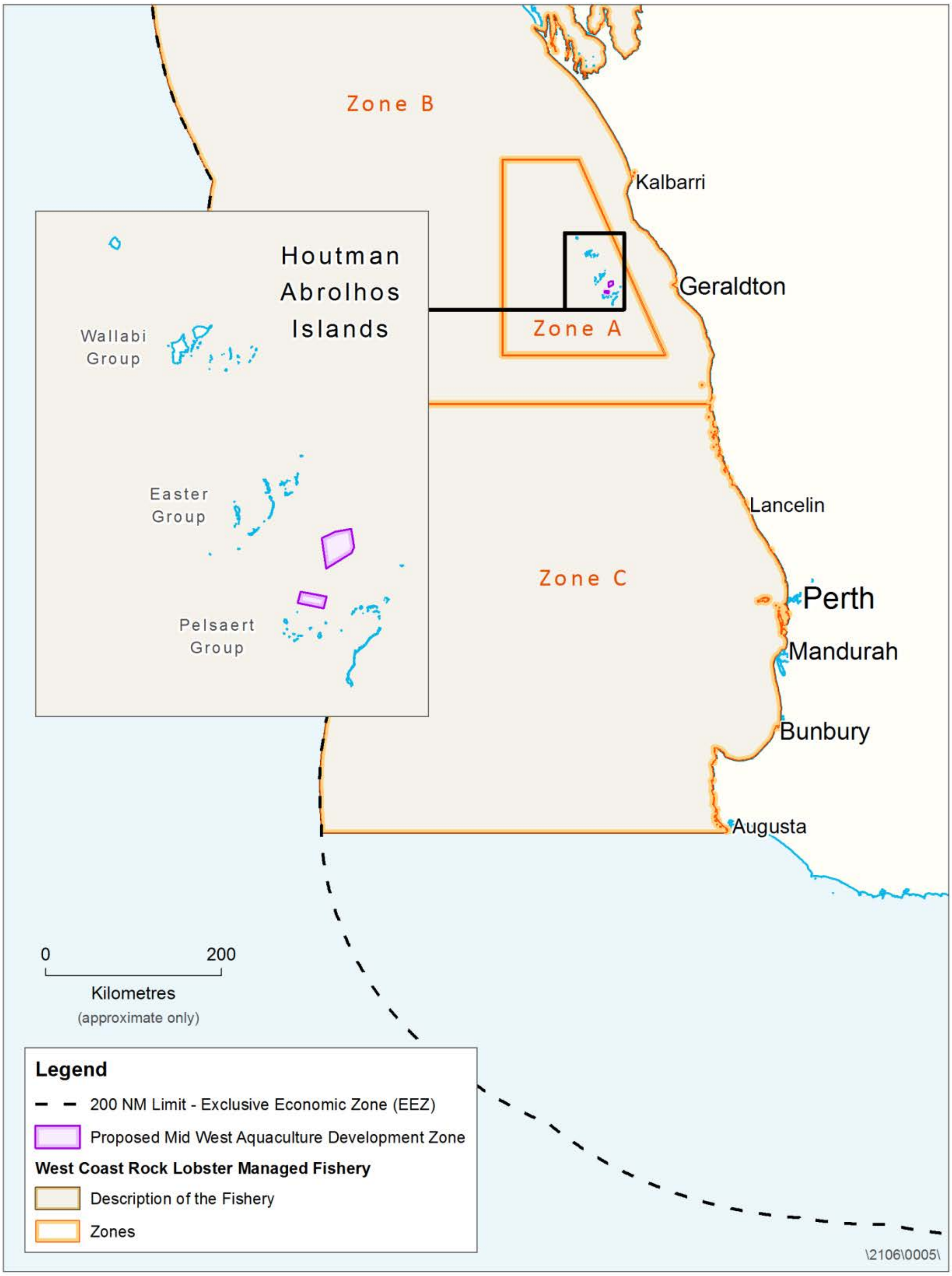


Figure 11-1: The Proposed MWADZ Area within Zone A of the West Coast Rock Lobster Managed Fishery

Abrolhos Islands and Mid-West Trawl Managed Fishery

The Abrolhos Islands and Mid-West Trawl Managed Fishery (AIMWTMF) is the second most important commercial fishery at the Abrolhos Islands in terms of its economic value. This fishery is managed under the *Abrolhos Islands and Mid-West Trawl Limited Entry Fishery Notice 1993*. The fishery mainly targets the saucer scallop (*Amusium balloti*), with a small component targeting the Western king prawn (*Penaeus latisulcatus*) in the Port Gregory area (Fletcher and Santoro 2013). The fishery encompasses the waters of the Indian Ocean between 27^{o} 51' south latitude and 29^{o} 03' south latitude on the landward side of the 200 metre isobath (Fletcher and Santoro 2014). There are currently a total of 16 licences in the fishery (Fletcher and Santoro 2014).

Scallops are a short-lived, benthic, filter feeding bivalve molluscs, which live on sandy bottoms and are subject to great natural fluctuations in reproductive success from year to-year. This variability is apparently related to the strength of the Leeuwin Current, as strong current is correlated with low scallop recruitment (Department of Fisheries 2012 a). The AIMTWMF fishing season normally runs between the months of April to July each year, depending on the results of pre-season recruitment research surveys (Department of Fisheries 2012 a). The major area fished for scallops in the Abrolhos Islands is the sandy sea bottom between the various island groups in waters deeper than 30 metres (Department of Fisheries 2007). Catches can vary greatly from year to year; from 2001 to 2003, for example, the total annual catch totalled 1,182 tonnes, 195 tonnes and 5,840 tonnes (whole weight) respectively (Department of Fisheries 2007).

Since 2012, there has been no scallop fishing at the Abrolhos Islands, due to low scallop abundance which was triggered by unfavourable environmental conditions during that period (Fletcher and Santoro 2014). Some areas of the strategic MWADZ Proposal area (i.e. the southern area) are within historical scallop fishing grounds of the AIMWTMF. The MWADZ Proposal is therefore likely to restrict the extent and availability of fishing ground and have a potential impact on the AIMWTMF.

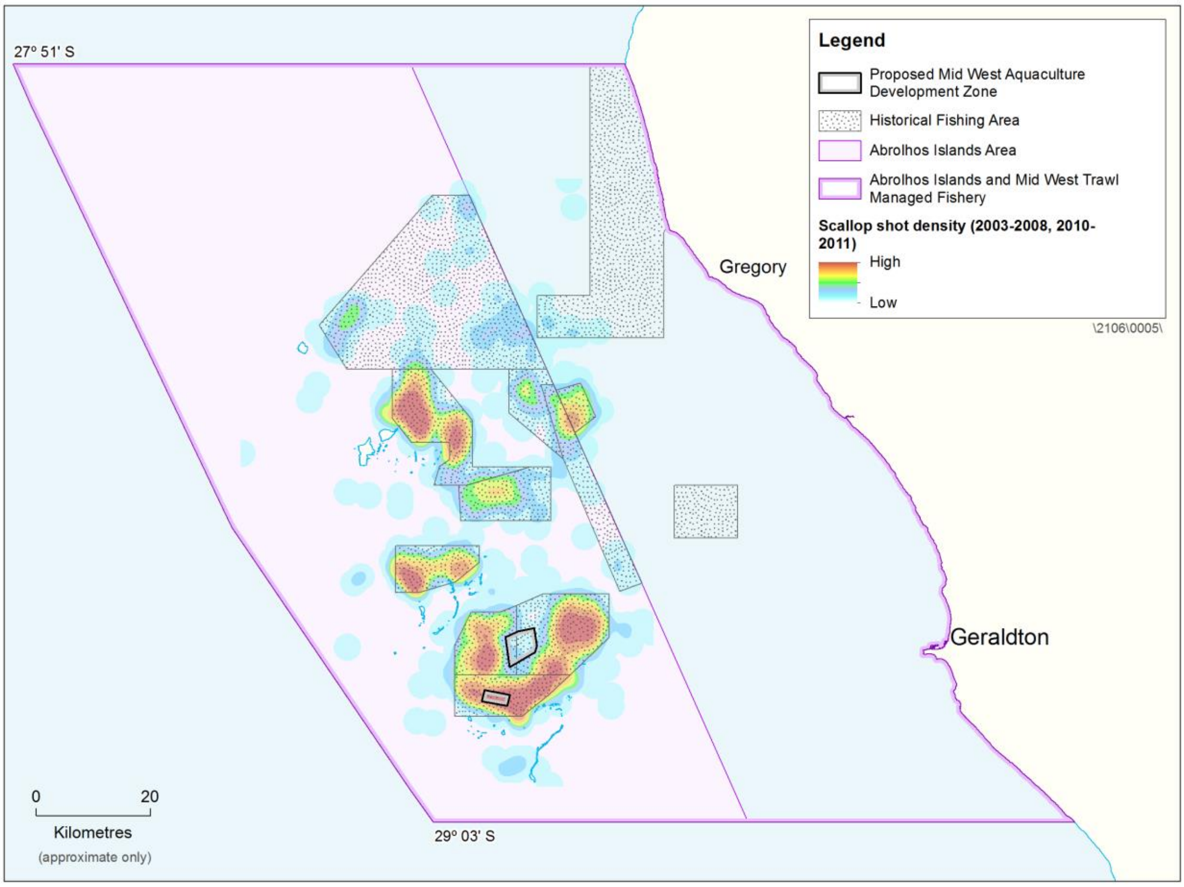


Figure 11-2: Historical Fishing Effort in the AIMWTMF from 2003-2011 and the Location of the Proposed MWADZ in the Fishery

11.2.1.2 Finfish Fisheries

There are two managed commercial finfish fisheries which are permitted to fish in the waters of the Abrolhos Islands FHPA which encompasses the strategic MWADZ Proposal area. These are the West Coast Demersal Scalefish (Interim) Managed Fishery and the Mackerel Managed Fishery.

The West Coast Demersal Scalefish (Interim) Managed Fishery (WCDSIMF) uses hooks and line to target a variety of demersal finfish species such as pink snapper (*Pagrus auratus*), baldchin groper (*Choerodon rubescens*), West Australian dhufish (*Glaucosoma hebraicum*), red throat emperor (*Lethrinus miniatus*) and coral trout (*Plectropomus leopardus*). The fishery currently operates under the *West Coast Demersal Scalefish (Interim) Management Plan 2007*. Under the current management arrangements licence holders in the fishery are only permitted to fish inside the Abrolhos Islands FHPA by means of a dropline by no more than three hooks (Clause 18c *West Coast Demersal Scalefish (Interim) Management Plan 2007*).

The majority of fishing effort from the WCDSIMF within the Abrolhos Islands FHPA is generally concentrated in areas near limestone and coral reef systems on the western and central areas of the islands (Webster, F *et al.* 2002). These areas provide a key habitat area for target species such as baldchin groper and coral trout.

Baseline habitat surveys conducted in the MWADZ Proposal area indicates that majority of the habitat is comprised of sandy bottom, which is not a key habitat for targeted species from the WCDSIMF. In the proposal area there is small areas of mixed assemblage substrate which comprises of rubble, low platform reef, algae and/or sponges. These types of habitat are often used by juvenile stages of species such as baldchin groper and red-throat emperor (Fairclough, D pers. comm. 2015). However, the size of cage clusters within the proposed zone will represent a very small proportion of the overall fish habitat for these species within the Abrolhos Islands FHPA. The proposed finfish aquaculture activities are therefore unlikely to have significant impact on the WCDSIMF.

The Mackerel Managed Fishery uses near-surface trolling gear from vessels in coastal areas, around reefs, shoals and headlands to target Spanish mackerel (*Scomberomorus commerson*) (Fletcher and Santoro 2014). Jig fishing is also used to capture grey mackerel (*Scomberomorus semifasciatus*) with other species from the genera *Scomberomorus*, *Grammatorcynus* and *Acanthocybium* also contributing to commercial catches (Fletcher and Santoro 2014). The fishery extends from the West Coast bioregion to Western Australian/Northern Territory border with most of the effort recorded north of Geraldton. The majority of the catch from the fishery is taken from either Area 1 (Kimberley area) or Area 2 (Pilbara area), which reflects the tropical distribution of the mackerel species. Commercial fishing activity from the fishery is limited at the Abrolhos Islands and is concentrated in areas outside the proposed MWADZ.

11.2.1.3 Other Fisheries

The Specimen Shell Managed Fishery, Octopus Interim Managed Fishery and the Marine Aquarium Managed Fishery are all permitted to fish in waters of the Abrolhos Islands FHPA, but concentrate their fishing activities in areas outside of the proposed MWADZ. These fisheries are therefore unlikely to be impacted by the MWADZ project.

Other commercial fisheries that operate in the Abrolhos region such as the West Coast Deep Sea Crustacean Managed Fishery and Temperate Demersal Gillnet and Demersal Longline Fishery are not permitted to fish within the strategic MWADZ Proposal area. Licence holders are only permitted to fish in waters outside of the Abrolhos Islands FHPA (Fletcher and Santoro 2014). As such no further assessment was conducted on these commercial fisheries.

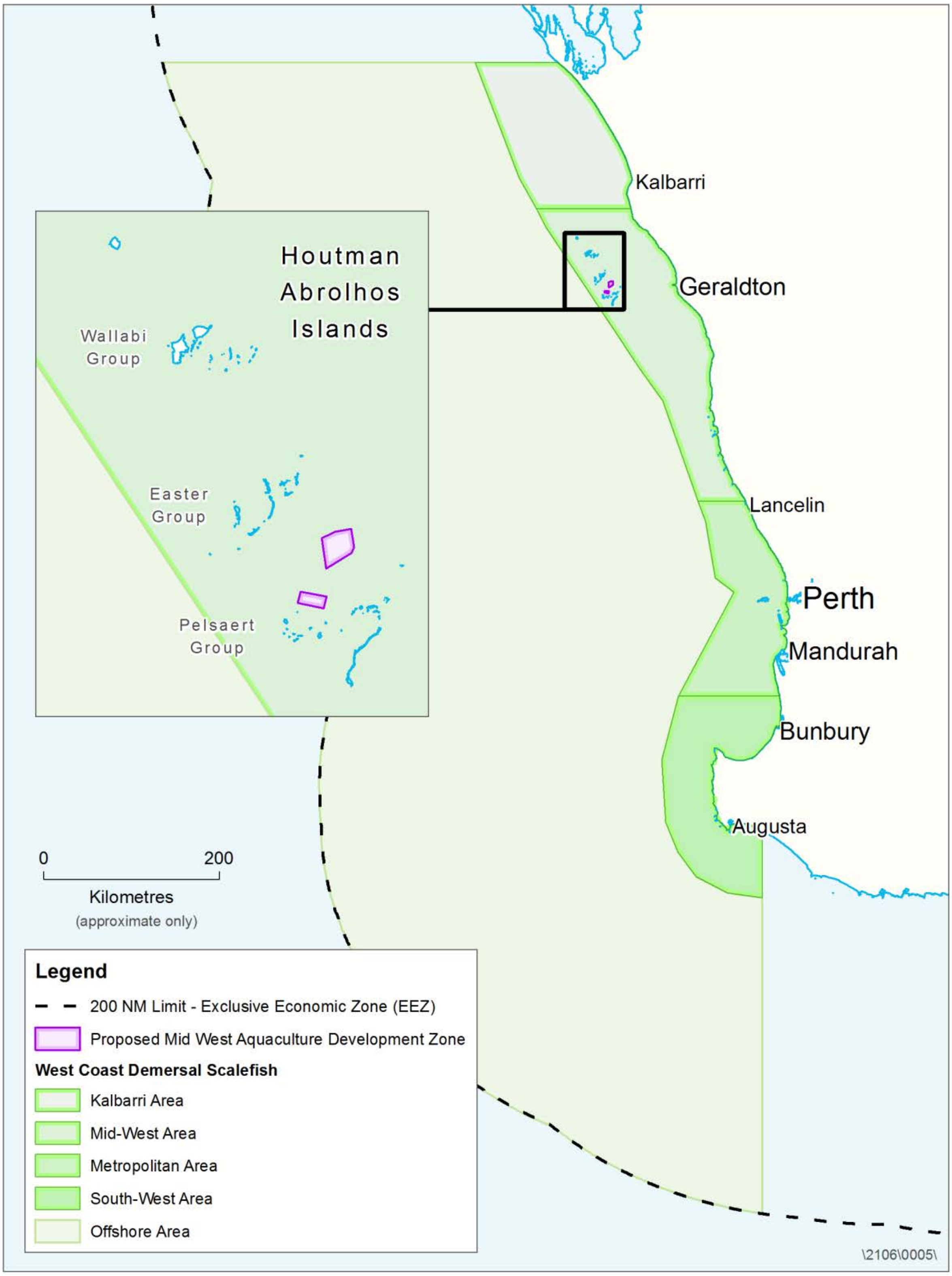


Figure 11-3: The Proposed MWADZ Area within the Mid West Area of the West Coast Demersal Scalefish (Interim) Managed Fishery

11.2.2 Recreational and Charter Fishing

11.2.2.1 Recreational Fisheries

Recreational fishers at the Abrolhos Islands and the surrounding areas target a large number of fish and invertebrate species. The vast majority of recreational fishing is boat based and concentrated within a few kilometres of the islands (Sumner 2006). The most commonly targeted demersal finfish species include, pink snapper (*Pagrus auratus*), baldchin groper (*Choerodon rubescens*), coral trout (*Plectropomus leopardus*), Western Australian dhufish (*Glaucosoma hebraicum*) and emperors (*Lethrinus species*). Recreational fishers also target pelagic species such as narrow-barred Spanish mackerel (*Scomberomorus commerson*) and yellowfin tuna (*Thunnus albacares),* mahi mahi (dolphinfish) (*Coryphaena hippurus*) and yellowtail kingfish (*Seriola lalandi)* (Sumner, N 2006).

Western rock lobster is also caught recreationally around Geraldton and the Abrolhos Islands during the recreational rock lobster season which runs from the 15 October to 30 June each year. Recreational rock lobster fishers have historically only been permitted to take Western rock lobster via pots at the Abrolhos Islands, however recent changes to the fishing regulations now enables fishers to take lobsters via diving methods.

Spear fishing is another popular recreational fishing activity at the Abrolhos Islands with most fishers targeting shallow water finfish species such as baldchin groper (*Choerodon rubescens*) and coral trout (*Plectropomus leopardus*) near shallow water reef habitats (Sumner, N 2006).

Recreational fishers mainly visit the Abrolhos Islands between the months of February to June each year when the weather is favourable for boating. Recreational fishing activity can be placed into four main groups:

- Recreational fishers that stay for one or more nights on private power boats and yachts;
- Commercial rock lobster fishers and their friends and families that stay on the islands in camps;
- Recreational fishers that conduct day trips to the Islands from the mainland; and
- Recreational fishers on vessels owned by tour or charter operators. (Sumner, N 2006).

There is a number of specific fishing regulations which apply to recreational fishers at the Abrolhos Islands. These include:

- The maximum quantity of finfish that a person may be in possession of at the Abrolhos Islands is 10 kilogram of finfish fillets, or one day's bag limit of whole fish or fish trunks.
- Baldchin groper (*Choerodon rubescens*): A fishing closure from 1 November to 31 January each year.
- Western rock lobster (*Panulirus cygnus*) can only be taken during the recreational rock lobster fishing season which is between the 15 October to 30 June each year.
- Samson fish (*Seriola hippos*) and yellowtail kingfish (*Seriola lalandi*) are not permitted to be taken by recreational fishers in the anchorage areas of the inhabited islands at the Abrolhos Islands.

Recreational fishers are required to notify the Department of Fisheries prior to entering the waters of the Abrolhos Islands FHPA. This notification can be made by completing the notification form, available from the Geraldton Regional Office and at: www.fish.wa.gov.au. The form must be lodged with the Geraldton Office either by email, fax and post or in person.

11.2.2.2 Charter Fisheries

There are a number of charter boat operators which operate within the Abrolhos Islands FHPA. Activities that are conducted on these operations include SCUBA diving, recreational fishing, sightseeing as well as other non-extractive activities such as surfing and birdwatching. The majority of charter fishing activity is conducted between the months of March to May when the prevailing winds tend to be lighter (Sumner, N 2006). Data which has been collected from recreational charter fishing surveys has indicated that charter boat operators preferred the Easter Group for extractive fishing activities whilst the Wallabi Group for non-extractive activities (i.e. diving and snorkelling). The majority of charter fishing activity conducted at the islands is outside of the strategic MWADZ Proposal area. Figure 11-4 indicates the level of charter fishing effort over the last five years in the Abrolhos Islands FHPA.

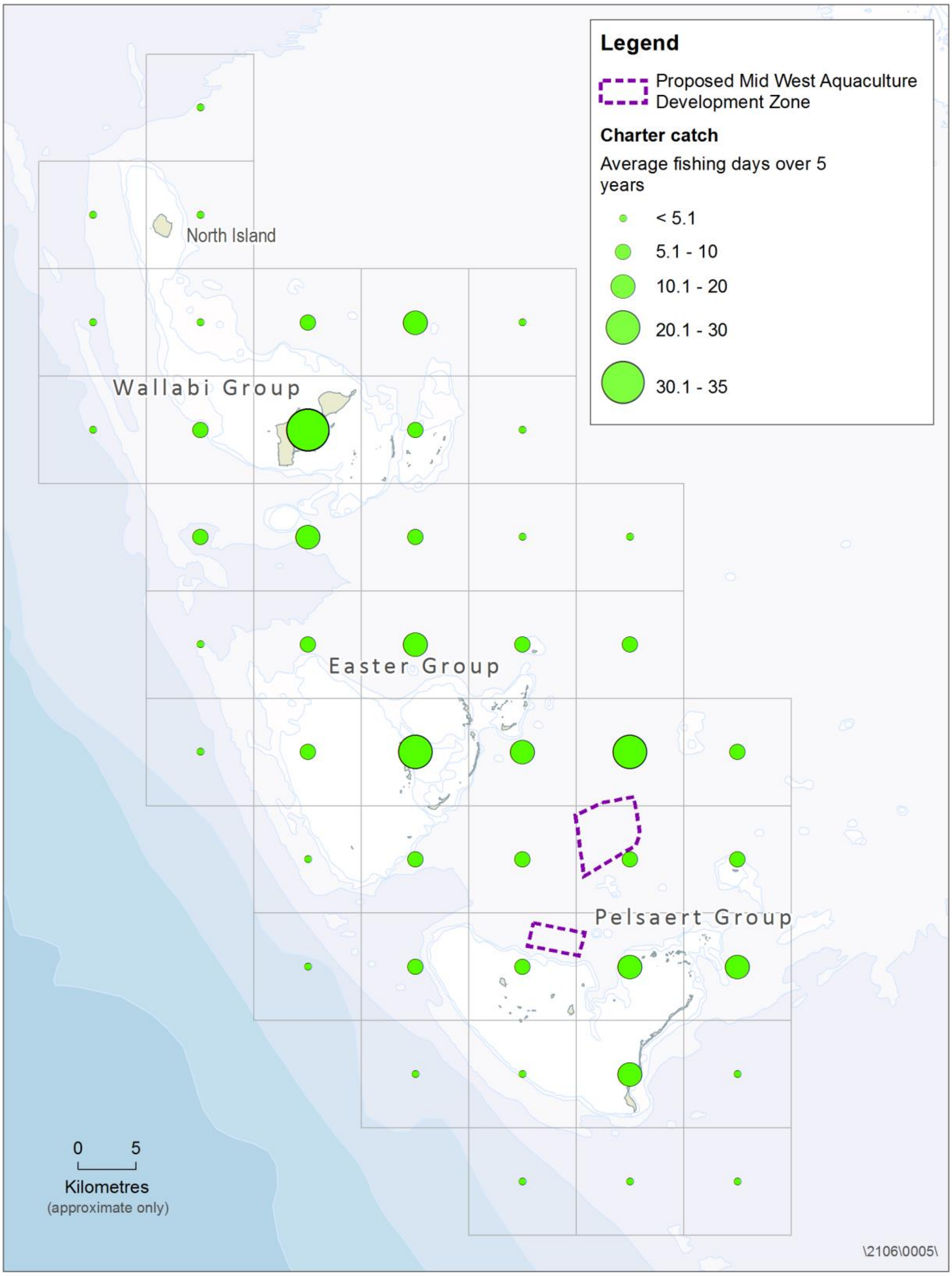


Figure 11-4: Average Number of Charter Fishing Days at the Abrolhos Islands over the Last Five Years

11.2.3 Aquaculture

There is currently a total of 17 aquaculture licences at the Abrolhos Islands covering 21 separate sites (Figure 11-5). Four licences (seven sites) are in the Wallabi Group, three licences (three sites) in the Easter Group and ten licences (11 sites) in the Pelsaert Group of islands. Not all of these are currently in production.

The dominant aquaculture sector at the Abrolhos Islands is based on the production of the black pearl oyster species (*Pinctada margaritifera*), with eight licences currently issued for production of this species. A number of licence holders have recently diversified into the production of sea sponges, other pearl oysters, including akoya pearl oyster (*Pinctada fucata*) and bat wing pearl oyster (*Pteria spp.*), and edible rock oysters, such as Western rock oyster (*Saccostrea glomerata*). In addition, a number of licences have been issued for the culture of live rock, live sand and coral at the Abrolhos Islands, using natural substrates such as limestone.

There is also currently an existing 800 hectare aquaculture licence for the sea cage production of marine finfish species, including those species envisaged for the MWADZ, within the southern area of the MWADZ Proposal.

This licence was originally granted in 2004 and has been in place continuously since that time. The licence holder has indicated a desire for the licensed site to be incorporated in the proposed MWADZ.

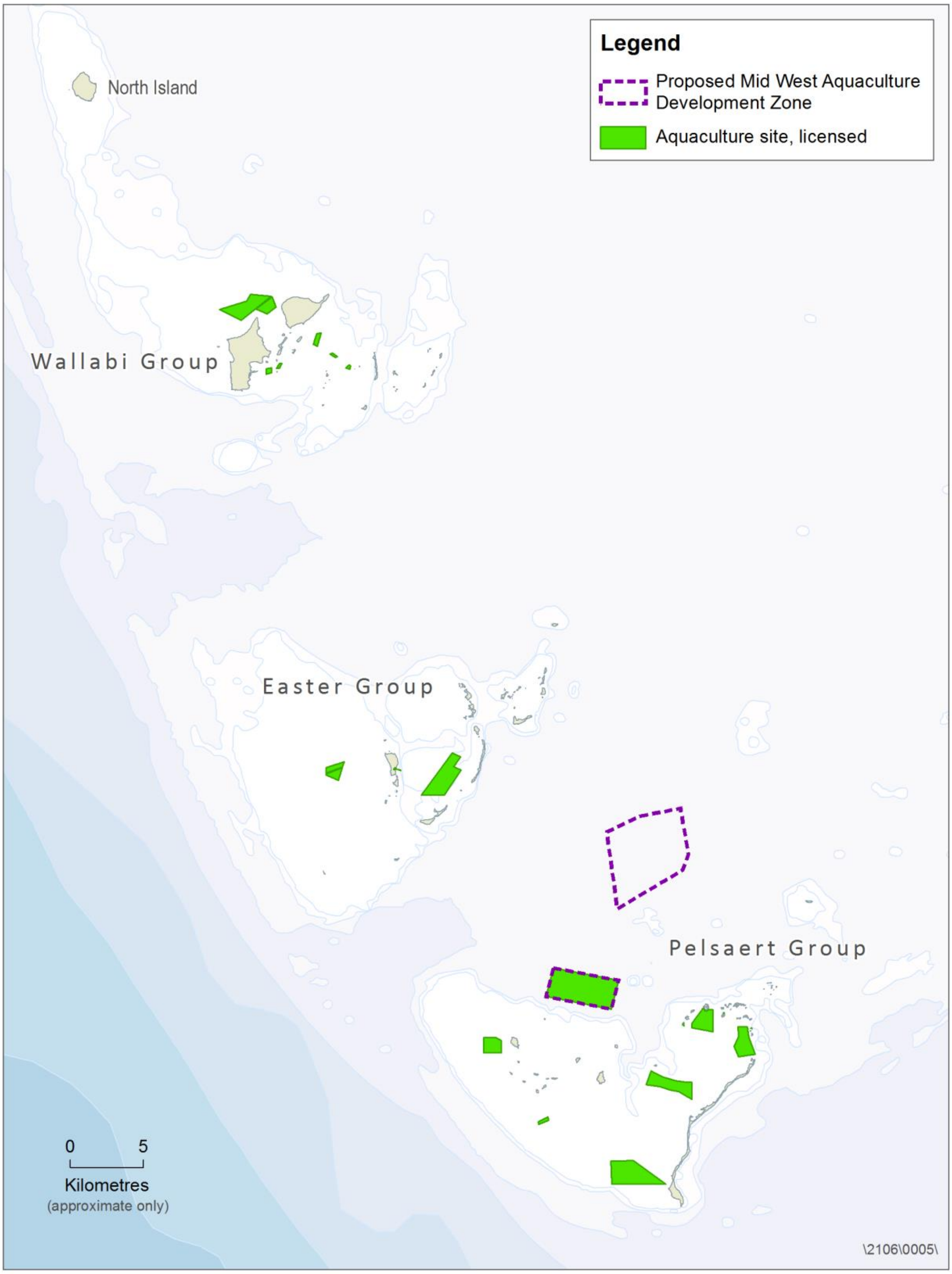


Figure 11-5: Existing Aquaculture Licenced Sites at the Abrolhos Islands

11.3 Potential Impacts

Identification of the potential impacts of the MWADZ Proposal on fisheries is based on a combination of literature review of the best-available scientific data, documented information on the adverse interactions between marine fauna and aquaculture equipment, impact assessments and "threat identification hazard pathway analysis" and risk identification and assessment methodology (Fletcher, W.J. 2014).

Essentially, the primary potential impacts determined through this process were:

- potential changes in the habitat of the fishery target species;
- potential changes in the recruitment patterns and spawning stock of the fishery target species;
- introduction of marine pests or pathogens;
- physical presence of aquaculture infrastructure; and
- potential changes in the abundance and distribution of the fishery target species.

11.4 Assessment of Potential Impacts

11.4.1 Commercial Fisheries

In order to determine and assess the potential impacts of the aquaculture zone on the key commercial fisheries, the Department of Fisheries prepared a "*Threat Identification, Hazard Pathway Analysis and Assessment of the Key Risks to Invertebrate and Finfish Species and Fisheries at the Abrolhos Islands presented by the establishment of the Mid West Aquaculture Development Zone in Western Australia*" (Fish and Invertebrate Risk Assessment) (Appendix 1c). The risk assessment methodology used for this risk assessment is covered in more detail in Section 2 of the risk assessment document.

The assessment was based on the current knowledge/literature of the potential impacts of sea cage finfish aquaculture on commercially-caught fish and invertebrate species and fisheries production. Information that was used as part of the risk assessment included:

- proposed location within the Abrolhos Islands FHPA;
- description of the proposal as provided in this document;
- previous high-level, generic, risk assessment conducted for marine finfish;
- Aquaculture in Australia (FRDC project 2003/223);
- relevant scientific studies and publications and knowledge of fish and invertebrate species within the vicinity of the proposed MWADZ area;
- knowledge of key fisheries within the vicinity of the proposed MWADZ area; and
- commercial catch and effort information for those fisheries.

During the risk assessment process the invertebrate fishery which was identified to be most likely to be impacted by the proposal was the Abrolhos Islands and Mid West Trawl Managed Fishery (AIMWTMF). Some areas of the strategic MWADZ Proposal area (i.e. the Southern area) are within historical scallop fishing grounds of the AIMWTMF, and therefore the proposal is likely to limit the extent of available fishing ground in this fishery. Given these impacts a specific risk assessment was conducted on the AIMWTMF.

The two commercial finfish fisheries were identified to be potentially impacted by the MWADZ Proposal these included the West Coast Demersal Scalefish (Interim) Managed Fishery and the Mackerel Managed Fishery. Catch and effort information which has been reported for these fisheries indicates that the MWADZ Proposal area does not represent a key fishing area for these fisheries at the Abrolhos Islands. The majority of the commercial fishing effort for these fisheries is conducted outside of the MWADZ Proposal area (pers. comm. Fairclough, D DoF). As a result, a more generic risk assessment was conducted for the key finfish fisheries.

11.4.1.1 Abrolhos Islands and Mid West Trawl Managed Fishery

The potential impacts of the MWADZ Proposal on the AIMWTMF that were identified as part of the risk assessment were:

- potential changes in benthic habitat of target invertebrate species;
- potential changes in the recruitment patterns and spawning stock of invertebrate species;
- introduction of marine pests or pathogens;
- physical presence of aquaculture infrastructure; and
- potential changes in the abundance and distribution of target invertebrate species.

Potential changes in benthic habitat

The installation of sea cages and aquaculture infrastructure from the MWADZ Proposal has the potential to result in shading of the marine benthic environment or changes to the benthic habitat underneath the sea cages through modification, isolation, disturbance or fragmentation. Aquaculture activities within the MWADZ are also likely to result in a potential increase in sedimentation, nutrient enrichment of the water column and increased turbidity which can have adverse effects on the benthic habitat. An increase in sedimentation on the seabed can result in a potential loss or reduction in diversity of benthic invertebrates through the smothering of benthic habitats and through oxygen depletion and hydrogen sulphide production during bacterial de-composition of organic matter. This could in turn lead to a dominance of small opportunistic benthic invertebrate species including capetellid worms and other scavengers and deposit feeding species (Hargrave, B 2005).

Particulates from aquaculture feed and fish faeces, is likely to increase the turbidity within close proximity of the sea cages. An increase in turbidity can lead to a decrease in light penetration within the water column, which can have negative impacts on photosynthetic organisms (like corals) directly underneath and in close proximity to the sea cages used in the aquaculture (Price, C and Morris, J 2013).

The installation of the sea cages and associated infrastructure will impact on a relatively small area of soft sediment habitat beneath the sea cages or within close proximity to the aquaculture infrastructure. Anchoring and mooring systems used as part of aquaculture infrastructure is also likely to impact the benthic habitat via smothering and/or exclusion.

Potential changes in the recruitment patterns and spawning stock of invertebrate species

The MWADZ Proposal may have an impact on the survival of settled juveniles and/or adult scallops within the vicinity of the sea cage infrastructure due to localised changes in environmental conditions. The benthic habitat is likely to be modified directly underneath the sea cages and within close proximity to these areas due to increase sedimentation/ smothering of the benthos from fish feed, faeces and other impacts from aquaculture activities. Any alteration to the benthic habitat underneath the sea cages has the potential to cause localised impacts on the settlement /recruitment patterns and spawning stock of invertebrate species. Saucer scallops are filter feeding organisms, which live on sandy bottom habitat any changes to the benthic habitat are likely to directly impact saucer scallops directly underneath the sea cages.

Physical presence of aquaculture infrastructure

The physical presence of aquaculture infrastructure which includes sea cages, anchoring and feeding barges in the proposed MWADZ is likely to limit the extent of available fishing ground within the AIMWTMF. The southern area in the proposed zone area has historically been a key scallop settlement area in the Abrolhos Islands. The physical presence of aquaculture infrastructure will directly exclude commercial scallop fishing vessels from fishing certain areas of the aquaculture zone. Under the proposed management arrangements, commercial fishers will still be permitted to operate within the zone provided they do not interfere with the aquaculture infrastructure.

Introduction of marine pests or pathogens

There is a number of significant pathogens of the marine fish proposed for aquaculture in the MWADZ, including for yellowtail kingfish. Diseases may potentially be introduced into sea cage farms directly from the environment (e.g. as a result of transmission from wild fish), via sub-clinically infected stocked fish, movement of personnel and infrastructure, the use of untreated aquaculture feeds or other vectors. Once introduced into an aquaculture facility, pathogens may persist, be transmitted between generations and potentially adapt to a state of virulence higher that that seen in the wild (where there may be no evolutionary advantage to kill a host) as a result of the selection pressures associated with intensive aquaculture. Spread of pathogens from aquaculture facilities could then occur via effluent, escapes, and/or predation. The spread of a significant pathogen could ultimately impact a wide range of species and the fisheries and ecosystems which they support.

Marine pests are known to be present in the region and the MWADZ Proposal has the potential to assist with the further spreading of these pests. Marine pests can be transported in ballast water and as biofouling on vessel hulls. Commercial aquaculture activities also have the potential to be directly responsible for introduction of marine pests by introduction via feed sources or brood stock or via the use of imported equipment that is not sufficiently cleaned.

Potential changes in the abundance and distribution of saucer scallops

The MWADZ Proposal has the potential to cause changes in the abundance and distribution of saucer scallops which is the targeted species for the AIMWTMF at the Abrolhos Islands.

The southern zone of the MWADZ Proposal has historically been a key scallop settlement area in the AIMWTMF. The distribution of scallops is dependent on larval settlement patterns associated with hydrodynamic processes and spawning stock distribution.

Due to the variable settlement patterns and abundance of scallops in any one year, the quantification of impacts is relatively complex and difficult to assess. It is, however, anticipated that small scale changes in the abundance and distribution of scallops may occur within the vicinity of sea cages if unfavourable environmental conditions (i.e. nutrient enrichment, sedimentation, organic deposition) prevail. Scallops have a limited capacity to move away from settlement areas (i.e. 10 to 100 metres) and therefore, if conditions are unfavourable, there may be some localised changes in the abundance and distribution of saucer scallops in the MWADZ Proposal area.

11.4.1.2 Finfish Fisheries

The primary potential impacts of the MWADZ Proposal on finfish fisheries such as the West Coast Demersal Scalefish (Interim) Managed Fishery (WCDSIMF) within the Abrolhos Islands FHPA were assessed as part of the risk assessment process. The potential impacts that were identified were:

- potential changes in fish habitat;
- potential changes in the settlement/recruitment patterns and spawning stock of fish species;
- introduction of marine pests or pathogens;
- physical presence of aquaculture infrastructure; and
- potential changes in the abundance and distribution of finfish species.

In essence, these are the same as those applicable to invertebrate fisheries.

Potential changes in fish habitat

The habitat of the strategic MWADZ Proposal area is mainly comprised of sandy bottom with some areas of mixed assemblages. Baseline habitat surveys conducted in the MWADZ area indicate that majority of the habitat is comprised of sandy bottom with some areas of mixed assemblages and isolated patches of reef. In the Northern area of the MWADZ 47.1% of the habitat comprised of bare sand, 34.9% of mixed assemblages and 8.5% of reef habitat. While in the Southern area, 91.6% of the habitat comprised bare sand and 5.2% of mixed assemblage (BMT Oceanica 2015).

Mixed assemblage habitat which is comprised of rubble, low platform reef, algae and/or sponges can often be used by juvenile species such as baldchin groper (*Choerodon rubescens*), coral trout (*Plectropomus leopardus*) and red-throat emperor (*Lethrinus miniatus*). These fish species are commonly targeted by commercial fisheries such as the WCDSIMF and recreational fishers. The majority of the habitat within the MWADZ does not represent a key fish habitat area for these target species. While there might be some areas within the aquaculture zone where these species may inhabit (i.e. mixed assemblage habitat) the area where habitat may be potentially affected represents a very small proportion of the overall fish habitat for these species within the Abrolhos Islands FHPA.

The MWADZ Proposal may have an impact on the fish habitat for non-target species which may inhabit sandy areas directly underneath the sea cages and within close proximity to these areas. The proposed development of finfish aquaculture infrastructure including sea cages, anchoring systems as well as potential localised changes in environmental conditions has the potential to result in some localised changes to the fish habitat within the MWADZ area.

Potential changes in the recruitment patterns of spawning stock of finfish species

Finfish aquaculture activities within the MWADZ Proposal has the potential to cause localised changes in environmental conditions near the sea cages due to increased nutrient enrichment and turbidity of the water column, increased sedimentation and smothering of the fish habitat and potential release of trace metals and therapeutants. These impacts have the potential to cause changes in the recruitment patterns of the spawning stock of finfish species within the area.

Introduction of marine pests or pathogens

The potential impacts of the introductions of marine pest or pathogens are discussed in Section 10 of this PER.

Physical presence of aquaculture infrastructure

The physical presence of aquaculture infrastructure including sea cages, anchors and feeding systems from the MWADZ Proposal is likely to directly exclude commercial and recreational fishers from fishing within certain areas of the aquaculture zone. Under the proposed management arrangements both commercial and recreational fishers will be permitted to fish within the strategic MWADZ Proposal area, on the condition they do not interfere with the aquaculture infrastructure.

Sea cage infrastructure used in the proposal is also likely to provide a fish aggregating (FAD) effect and may potentially attract some finfish species to the area. Some species of fish that may be attracted to the infrastructure include baitfish and predatory fish (large and small) such as Spanish mackerel (*Scomberomorus commerson*), yellowfin tuna (*Thunnus albacares*) and mahi mahi (*Coryphaena hippurus*). Potential increases in the visitation rates and the abundance of these species near the infrastructure may potentially lead to an increase in both recreational and commercial fishing activity within the area, and may result in increased fishing pressure on these fish stocks.

Potential changes in the abundance and distribution of finfish species

The MWADZ Proposal has the potential to cause changes in the abundance and distribution of finfish species which are targeted by commercial (and recreational) fishers within the Abrolhos Islands FHPA. Finfish aquaculture in the area has the potential to increase the abundance of some baitfish and predatory fish species through the FAD effect. Aquaculture infrastructure such as sea cages has the potential to provide an additional habitat area for some finfish species and may cause localised changes in their abundance.

Fish farming activities in the proposal area also has the potential to cause localised changes in the abundance and distribution of finfish species.

Harvesting activities and biological residues such as blood, the presence of cultured stock and plumes created from feeding practices are likely to attract more finfish species to the area. The presence of additional food in the MWADZ area could potentially lead to an increase or decrease in the abundance of certain fish species within the zone. Potential changes in the fish habitat due to smothering of the benthic habitat, nutrient enrichment of the water column, increased turbidity and sedimentation also have the potential to cause localised changes in the abundance and distribution of finfish species.

11.4.2 Recreational and Charter Fisheries

As the potential impacts of the MWADZ Proposal on recreational and charter fisheries are essentially the same as those applicable to the commercial fisheries, the assessment of the potential commercial fisheries impacts is also transferable to the recreational and charter fishing context. This is especially so in relation the commercial finfish-related assessments.

11.5 Management Measures

The likelihood that the proposed activities in the MWADZ will have a significant impact on commercial and recreational fisheries may be further reduced through the implementation of management measures. Management measures that can mitigate potential effects from the proposal include those detailed in Table 11-3.

Table 11-3: Proposed Management and Mitigation Measures – Fisheries Issues

Potential Impacts	Management Measures
Potential changes in benthic/fish habitat	Information from preliminary baseline studies and past experiences with marine finfish aquaculture suggest that it is likely that the MWADZ Proposal may have some minor impacts on the benthic/ fish habitat directly underneath the sea cages and within close proximity to these areas. Any impacts on habitat are however likely to be on a relatively small scale and unlikely to have a significant impact on the AIMWTMF and finfish fisheries in the area. The primary sources of impact in terms of changes to benthic and fish habitat are primarily related to aquaculture feed and faeces from aquaculture fish. Possible management measures that could be undertaken to reduce these impacts include the following: • locate the sea cages in well flushed areas where there is an increased water depth below the sea cage; • fallow sea cages, including the rotation and movement of cages to enable fish habitat to recover; • control feed - minimizing feed wastage can significantly reduce sediment enrichment effects which can help improve sediment conditions underneath the sea cages; • reduce stock densities and feed input rates; and • use high quality feed, contemporary feeding techniques and best-practice farming techniques to reduce feed wastage and feed conversion ratios (FCR) are highlighted in the Management Policy and Industry Code of Practice. Each licence holder operating in the MWADZ is required to comply with an Environmental Management and Monitoring Plan (EMMP). Under the EMMP all operators are required to monitor parameters such as Total Organic Carbon (TOC) and Total Phosphorous (TP) in the sediment against Environmental Quality Guidelines (EQG). If any of the EQGs are triggered benthic infauna monitoring is required.

Changes in recruitment patterns and spawning stock of invertebrate and fish species	Any potential changes to the settlement /recruitment patterns and spawning stock of invertebrate and finfish species can be reduced through the implementation of management measures designed to reduce localised changes to environmental conditions. Management measures which can be used to improve environmental conditions include: • feed control – minimising feed wastage can reduce any potential impacts on the benthic habitat and therefore minimise impacts; • locate sea cages in well-flushed areas where there is an increased water depth below the sea cages; and • set the stocking density of fish farms at conservative levels.
Introduction of marine pests and pathogens	The management measures proposed to address the risk of the introduction of marine pests and pathogens have been covered in more detail in the Biosecurity assessment in Section 10 of this PER.
Physical presence of aquaculture infrastructure	The physical presence of aquaculture infrastructure including fish cages anchors and feeding systems is likely to directly exclude commercial trawl fishers from the AIMWTMF from fishing within certain areas of the aquaculture zone. The southern site of the MWADZ has historically been a key fishing area for the AIMWTMF. The proposal has the potential to limit the amount of available fishing ground in this fishery. The MWADZ Proposal area however, represents a very small proportion (0.2%) of the overall available AIMWTMF fishing ground and 1.3% of the historical fishing ground in the fishery. Historical fishing effort for the AIMWTMF from 2003 to 2011 has indicated that the southern site in the MWADZ represents an important area for scallop fishing (refer to PER document AIMWTMF effort map). The northern site of the MWADZ Proposal area however, does not represent a key fishing area for the fishery. Commercial fishing effort in this area has been very limited over the last ten years (Kangas, M pers. comm.). The presence of aquaculture infrastructure in the aquaculture zone is also likely to limit the availability of fishing ground for finfish fisheries including the WCDSIMF. However, the MWADZ Proposal area represents a very small proportion (i.e. less than 1%) of the overall available fishing ground in this fishery and the proposal is therefore unlikely to have a significant impact. Under the proposed management arrangements for the MWADZ Proposal area, commercial and recreational fishers will be permitted to operate within the aquaculture zone provided they do not interfere with the aquaculture infrastructure. Management measures that could be implemented to further reduce the potential impacts of the infrastructure on commercial and recreational fisheries include: • place sea cages in parts of the MWADZ Proposal area that are not significant fishing grounds for commercial and recreational fisheries; and • provide information to commercial and recreational fishers on the lighting and marking locations of aquaculture infrastructure. Under the licencing conditions for the MWADZ Proposal, licence holders will be required to complete a guidance statement for evaluation and determining categories for marking and lighting for aquaculture leases/ licences. This guidance statement will be used by the Department of Transport to determine the marking and navigational lighting requirements for the aquaculture lease/licence. Licence holders will be required to abide by the marking and lighting requirements as part of the conditions on their licence. A copy of a link to this form is available on the Department of Fisheries website http://www.fish.wa.gov.au/Documents/aquaculture_licencing/marking_and_lighting_guidance_statement.pdf

Potential changes in the abundance and distribution of fish and invertebrate species	Possible management measures that could be implemented to minimise any potential changes in the abundance and distribution of fish and invertebrate species include: • develop and comply with a Management and Environmental Monitoring Plan (MEMP) and best-practices in aquaculture, including the requirement for operators to monitor environmental conditions such as water quality and sediment quality; and • adopt best-practice management arrangements, including good husbandry and farming practices. The management measures described above ensure that the likelihood of the proposed aquaculture having a significant impact on the abundance and distribution of fish and invertebrate species is reduced to remote.

11.6 Predicted Environmental Outcome

11.6.1.1 Abrolhos Islands and Mid West Trawl Managed Fishery

The MWADZ Proposal is likely to pose a low risk to the AIMWMTF. Some parts of the aquaculture zone (i.e. the Southern area) of the MWADZ Proposal have historically been a key fishing area for scallop fishing in the AIMWTMF. The physical presence of aquaculture infrastructure is likely to exclude scallop trawl fishing vessels from fishing in the vicinity of the sea cage infrastructure within the aquaculture zone. This has the potential to limit the amount of available fishing ground in the fishery. The proposed MWADZ, however, represents only a very small proportion (less than 0.2%) of the overall available AIMWTMF fishing ground and 1.3% of the historical scallop fishing ground in the fishery.

Historical fishing effort information collected by the Department of the Fisheries for the AIMWTMF from 2003 to 2011 has indicated that the Southern area in the MWADZ represents an important area for scallop fishing (refer to PER document AIMWTMF effort map). The Northern area of the MWADZ Proposal, however, does not represent a key fishing area for the fishery. Commercial fishing effort in this area has been very limited over the last ten years (pers. comm. Kangas, M).

The actual level of impact on the AIMWMTF that the MWADZ Proposal presents into the future cannot be determined with any degree of certainty and the Department will continue to work with the AIMWMTF and the aquaculture industry to explore ways of minimising any such impact.

11.6.1.2 Finfish Fisheries

The MWADZ Proposal is likely to pose a negligible and acceptable risk to finfish fisheries within the Abrolhos Islands Fish Habitat Protection Area (FHPA). Baseline benthic habitat surveys conducted in the MWADZ have indicated that the area does not represent a key habitat area for target finfish species such as coral trout, baldchin groper, red-throat emperor and other demersal fish species which are commonly targeted by finfish fisheries. These species tend to prefer limestone reef, macro algae and coral habitats which are generally located on the western and central parts of the Abrolhos Island groups. While there may be some localised changes to the fish habitat within the aquaculture zone it is unlikely to result in any significant changes in the abundance, distribution, recruitment patterns and spawning stock of these finfish species within the Abrolhos FHPA.

Catch and effort information which has been reported for the finfish fisheries permitted to fish within Abrolhos FHPA indicates that the MWADZ Proposal area does not represent a key fishing area for these fisheries. The majority of the commercial fishing effort for these fisheries is conducted outside of the MWADZ Proposal area. While commercial fishers may be physically excluded from fishing certain areas of the MWADZ due to the presence of aquaculture infrastructure the overall area of the proposed aquaculture zone represents a very small proportion (i.e. less than 1%) of the overall fishing area for these finfish fisheries. It is unlikely that the MWADZ Proposal will have a significant impact on finfish fisheries within the Abrolhos Islands FHPA.

Any potential environmental impacts from the MWADZ Proposal can be managed effectively through the adoption of good husbandry and farming practices including, maximising feeding efficiency and reducing feed waste and the adoption of conservative stocking densities. The potential impacts posed by MWADZ Proposal can also be effectively managed through the implementation of, and compliance with, the zone EMMP (EP Act) and the MEMP (FRMA) for individual operators, both of which include mandatory environmental monitoring.

Consequently, it is expected that the MWADZ Proposal will have negligible environmental (or economic) impacts on commercial finfish fisheries within Abrolhos FHPA.

11.6.1.3 Recreational and Charter Fisheries

Recreational and charter fisheries operating within the MWADZ Proposal area are unlikely to target invertebrate species due to the relative remoteness of the area, the depth of water involved and legislated restrictions on the types of fishing gear permitted to be used.
Instead, the principal focus of these fisheries is a similar suite of marine finfish species to that targeted by the commercial finfish fisheries operating within this area.

The available charter fishing catch and effort data (Figure 11-4) suggests the MWADZ Proposal area is not a key area for recreational charter fishing activity and consultation with recreational fishing stakeholders (including RecFishWest) throughout the PER process to date has reinforced that this is also the case for other forms of recreational fishing (i.e. non-charter recreational fishing).

With regard to the predicted environmental outcome for recreational and charter fisheries, it is expected that this will be the same as for commercial finfish fisheries due to the similarity in potential environmental impacts, management and mitigation measures to be implemented and anticipated environmental responses to such measures.

Consequently, it is expected that the MWADZ Proposal will have negligible environmental impacts on recreational and charter fisheries within Abrolhos FHPA.

12 ASSESSMENT OF POTENTIAL IMPACT ON HERITAGE

12.1 Assessment Framework

As part of the requirements in Section 2.4 of the Environmental Scoping Document (ESD) the proponent is to ensure all other relevant environmental factors and impacts that may be of interest to the public, including heritage, are considered in the environmental review.

12.1.1 Heritage Objectives

The objective established in this PER for heritage values associated with the MWADZ Proposal is as specified in EAG 8, namely:

"To ensure that historical and cultural associations, and natural heritage, are not adversely affected."

12.1.2 Relevant Legislation, Policies, Plans and Guidelines

Table 12-1 lists the policies, plans and guidelines that are relevant to heritage considerations within the MWADZ Proposal area.

Table 12-1: Legislation, Policies, Plans and Guidelines Relevant to Heritage Issues

Legislation, Polices, Plans and Guidelines	Intent
State	
Environmental Protection Act 1986	This State Act provides for an EPA, for the prevention, control and abatement of pollution and environmental harm, and for the conservation, preservation, protection, enhancement and management of the environment.
Heritage of Western Australia Act 1990 (WA)	Provides a legal framework that conserves cultural heritage places of significance and facilities development in harmony with cultural and heritage values.
Maritime Archaeology Act 1973	An Act to make provision for the preservation on behalf of the community of the remains of ships lost before the year 1900, and of relics associated with those wrecks.
Fisheries Resources Management Act 1994	Provides a legal framework to conserve, develop, and share fish resources for the benefit of current and future populations in WA. This legislation also provides the management framework for the Abrolhos Islands reserve and for the establishment and management of the Fish Habitat Protection Areas.
Wildlife Conservation Act 1950	An Act to provide for the conservation and protection of wildlife in Western Australia.
Conservation and Land Management Act 1984	An Act to make better provision for the use, protection and management of certain public lands and waters and the flora and fauna thereof, to establish authorities to be responsible therefor, and for incidental or connected purposes.
The Houtman Abrolhos Islands Management Plan	Provides a management framework to conserve and promote the unique environmental and cultural heritage values of the Abrolhos for the benefit of present and future generations.
Environmental Assessment Guideline (EAG)	

Environmental Assessment Guidelines No.8 (EAG 8) Environmental Assessment Guideline for Environmental Principles, Factors and Objectives (EPA 2015)	The EAG 8 provides guidance for proponents to help them understand the need to consider environmental principles, factors and objectives for the purpose of environmental impact assessment. Environmental principles, factors and objectives are critical to the environmental impact assessment process as they underpin the EPA's decision on the environmental acceptability of a proposal or scheme. In making its decisions, the EPA also takes a holistic approach to assessing environmental acceptability based on a number of broader considerations including whether the proposal aligns with broader international, national and State policies and agreements and takes account of the interconnected nature of the environment.
EPA Guidance Statement No. 33: Environmental Guidance for Planning and Development (EPA 2008)	Specifies that changes to the biophysical environment do not adversely affect historic and cultural associations and that such change complies with heritage legislation.
Commonwealth	
Environment Protection and Biodiversity Conservation Act 1999	It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places — defined in the EPBC Act as matters of national environmental significance.
Commonwealth Historic Shipwrecks Act 1976	Provides for the protection of historic shipwrecks and all associated artefacts from those wrecks.

12.2 Existing Environment

12.2.1 Cultural Heritage

12.2.1.1 Aboriginal Heritage

A search of the Register of Aboriginal Sites maintained by the Western Australian Department of Indigenous Affairs was undertaken on 17 August 2015. The search returned no results from the register. In addition, a search of the available literature on the Abrolhos Islands did not indicate there were any indigenous heritage and cultural issues that may be impacted by the MWADZ Proposal.

Native Title

The National Native Title Register and Register of Native Title Claims (http://www.nntt.gov.au/applications/imdex.html) was searched in June 2015. There is currently no native title or native title claim over the Abrolhos Islands and the strategic MWADZ Proposal area.

12.2.1.2 European Heritage

Shipwrecks

There are a number of shipwrecks scattered throughout the Abrolhos Islands. One of the most historical shipwreck sites is the *Batavia* which is located near the Wallabi Island Group. The wreck of the Batavia and the associated land sites on Beacon Island, Long Island and West Wallabi Islands together comprise one of the most important maritime archaeological sites in Australia.

In 2006, the Batavia wreck and the Survivors Camp Area were gazetted under the Commonwealths *Environment Protection and Biodiversity Conservation Act 1999*, as an area to be put on the National Heritage List. These sites are of international significance and provide a major attraction for visitors to the Islands.

Shipwrecks and associated land sites are protected under Western Australia's *Maritime Archaeology Act 1973* and the *Commonwealth Historic Shipwrecks Act 1976*. Several shipwrecks in the Abrolhos Islands are gazetted under the Commonwealth *Historic Shipwrecks Act 1976.* These are: *Batavia* (1629), *Zeewijk* (1727), *Hadda* (1877), *Marten* (1878), *Ben Ledi* (1879), *Ocean Queen* (1842) and the *Windsor* (1908). Figure 12-1 illustrates all listed historic shipwrecks and identified dive trails within the vicinity of the MWADZ Proposal.

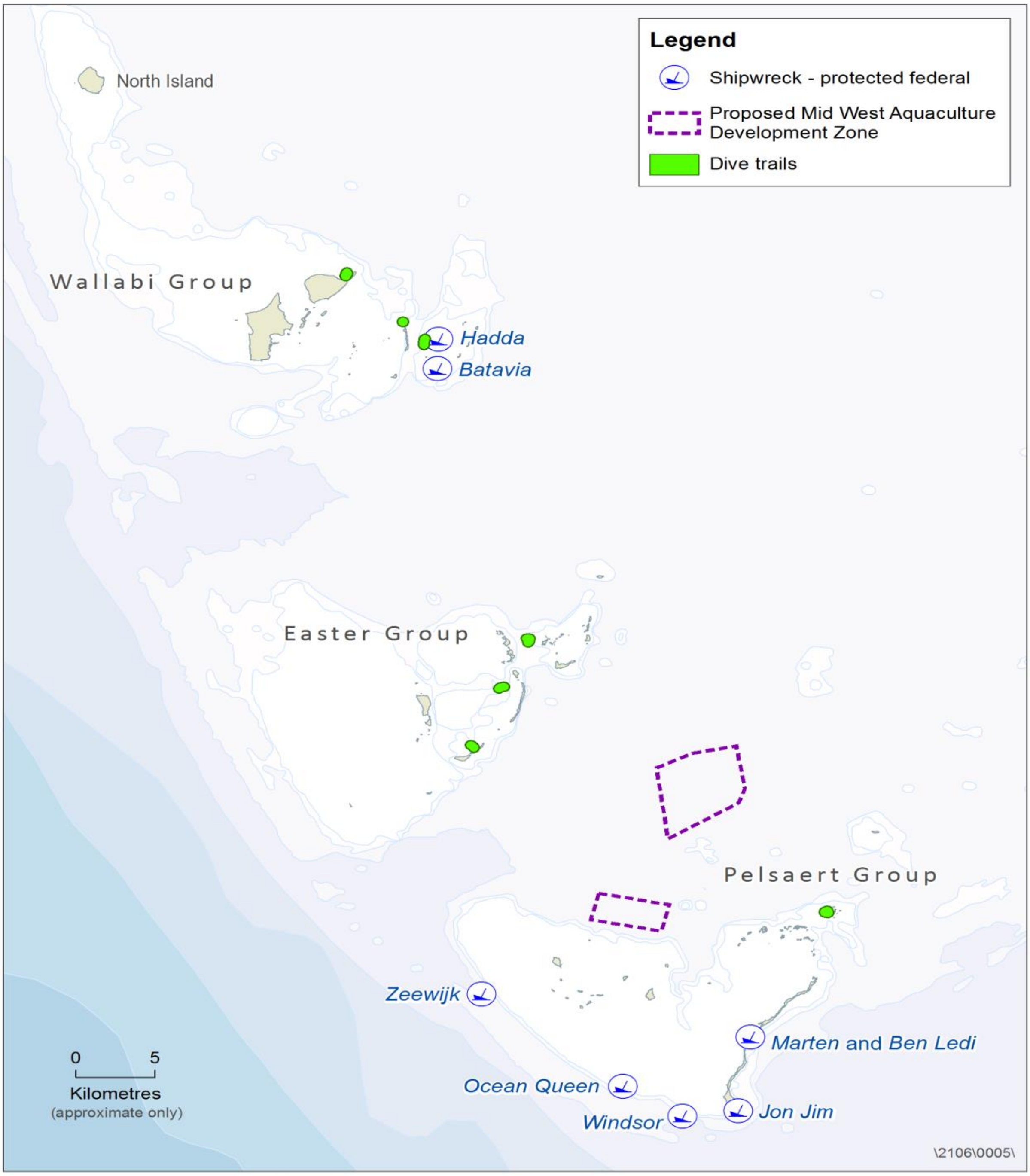


Figure 12-1: Shipwrecks Protected under State and Commonwealth Legislation

As indicated above, there are no National Heritage Places in the vicinity of the MWADZ Proposal.

12.3 Potential Impacts

The physical presence of marine finfish sea cage aquaculture infrastructure within the MWADZ Proposal area is the only possible potential impact on environmental heritage values. However, there do not appear to be any such values applicable to that particular area.

12.4 Assessment of Potential Impacts

In the context of the MWADZ Proposal, heritage encompasses Aboriginal cultural heritage and European (maritime) heritage.

Given the absence of any evidence of indigenous heritage and cultural issues relating to the Abrolhos Islands; and considering the remoteness of the wrecks and associated dive trails from the MWADZ Proposal area, it is unlikely that the proposed zone will have any impact on their values.

12.5 Management Measures

The MWADZ Proposal does not present any known potential impacts to either of these heritage values. Nevertheless, if any cultural heritage material is uncovered within the proposed MWADZ at any time in the future, the appropriate authorities (e.g. Department of Aboriginal Affairs and the Western Australian Museum) will be immediately contacted for advice.

12.6 Predicted Environmental Outcome

There is unlikely to be any adverse impacts to historical and cultural associations, and natural heritage, as a result of the MWADZ Proposal.

13 ASSESSMENT OF POTENTIAL IMPACT ON AMENITY

13.1 Assessment Framework

As part of the requirements in Section 2.4 of the Environmental Scoping Document (ESD) the proponent is to ensure all other relevant environmental factors and impacts that may be of interest to the public are considered in the environmental review.

Consultation thus far with stakeholders has identified the potential for the EPA environmental factor of amenity to also be relevant to the MWADZ Proposal.

13.1.1 Amenity Objectives

The objective established in this PER for amenity values associated with the MWADZ Proposal is as specified in EAG 8, namely:

"To ensure that impacts to amenity are reduced as low as reasonably practicable."

13.1.2 Relevant Legislation, Policies, Plans and Guidelines

The term "amenity" can have a range of meanings and does not appear to be clearly defined in the various statutes applicable to the MWADZ Proposal. For the purposes of this PER, it has been interpreted as relating to *"... a pleasant, attractive or agreeable feature of a geographic location."*

In the context of the MWADZ Proposal and the EPA's EAG 8, this has been taken to mean features associated with the key senses (e.g. sight, hearing and smell), and human perceptions of beauty (i.e. aesthetics). In other words, the assessment of potential environmental impacts relating to amenity is the assessment of impacts that could affect the perceived level of agreeableness in terms of indicators like colour, noise and odour.

This is an important consideration when seeking to differentiate between factors associated with environmental amenity and those associated with non-environmental amenity, such as resource sharing or other socio-economic matters.

Table 13-1 lists the policies, plans and guidelines that are relevant to amenity considerations within the MWADZ Proposal area.

Table 13-1: Legislation, Policies, Plans and Guidelines Relevant to Amenity Issues

Legislation, Polices, Plans and Guidelines	Intent
State	
Environmental Protection Act 1986	This State Act provides for an EPA, for the prevention, control and abatement of pollution and environmental harm, and for the conservation, preservation, protection, enhancement and management of the environment.
Fisheries Resources Management Act 1994	Provides a legal framework to conserve, develop, and share fish resources for the benefit of current and future populations in WA. This legislation also provides the management framework for the Abrolhos Islands reserve and for the establishment and management of the Fish Habitat Protection Areas.
The Houtman Abrolhos Islands Management Plan	Provides a management framework to conserve and promote the unique environmental and cultural heritage values of the Abrolhos for the benefit of present and future generations.
Environmental Assessment Guideline (EAG)	
Environmental Assessment Guidelines No.8 (EAG 8) Environmental Assessment Guideline for Environmental Principles, Factors and Objectives (EPA 2015)	The EAG 8 provides guidance for proponents to help them understand the need to consider environmental principles, factors and objectives for the purpose of environmental impact assessment. Environmental principles, factors and objectives are critical to the environmental impact assessment process as they underpin the EPA's decision on the environmental acceptability of a proposal or scheme. In making its decisions, the EPA also takes a holistic approach to assessing environmental acceptability based on a number of broader considerations including whether the proposal aligns with broader international, national and State policies and agreements and takes account of the interconnected nature of the environment.
Environmental Assessment Guidelines No.15 (EAG 15) Environmental Assessment Guideline for Protecting the Quality of Western Australia's Marine Environment (EPA 2015)	The EAG 15 provides an environmental quality management framework to protect the environmental values of Western Australia's marine environment from waste discharges and contamination. The EPA has provided this environmental quality management framework in EAG 15 to assist the proponent in predicting and managing the effects of pollution, waste discharges and deposits on the quality of the marine environment (EPA 2015)
Commonwealth	
Not applicable	

13.2 Existing Environment

13.2.1 Abrolhos Islands FHPA

13.2.1.1 Context

The State Territorial Waters (i.e. high water mark out to three nautical miles seaward of the Territorial Sea Baseline) of the Abrolhos Islands are a gazetted Fish Habitat Protection Area (FHPA). This FHPA was gazetted in 1999.

The MWADZ Proposal area is located within this FHPA and the Abrolhos Islands FHPA surrounds the Abrolhos Islands Reserve.

The FHPA is designated for the following purposes:

- *the conservation and protection of fish, fish breeding areas, fish fossils or the aquatic ecosystem;*
- *the culture and propagation of fish and experimental purposes related to that culture and propagation; and*
- *the management of fish and activities relating to the appreciation or observation of fish.*

Under the FRMA, the Department of Fisheries has the power to regulate fishing operations in the FHPA (Department of Fisheries 2001). Regulation of fishing and aquaculture operations may be undertaken for a number of purposes including conservation, fisheries management and for the preservation of areas for observation and eco-tourism pursuits.

The scope of other existing uses of the FHPA is covered in Sections 3, 5, 11, 12 and 14 of this PER.

For a more detailed description of the biophysical characteristics of the area, refer to Sections 3 and 9 of this PER.

13.3 Potential Impacts

Potential environmental amenity impacts associated with the MWADZ Proposal were identified in the scoping phase of the PER, when establishing the assessment context (Section 6.3). Essentially, this involved:

- determining which MWADZ Proposal activities could potentially result in environmental impacts (but also noting any potential social and economic impacts that may be of public interest); and
- identifying MWADZ Proposal stressors, environmental factors and potential impacts that would require examination in the PER.

Through this process, the following potential environmental amenity impacts resulted:

- excessive presence of macroalgae, phytoplankton and encrusting invertebrates on and around the sea cages;
- reductions in the natural visual clarity of the water;

- visible film the water from petrochemical origins;
- floating debris, dust or other objectionable matter; and
- presence of objectionable odours.

13.4 Assessment of Potential Impacts

13.4.1 Nuisance Organisms

The presence of macrophytes, phytoplankton scums, filamentous algal mats or blue-green algae may result if nutrient inputs from marine finfish aquaculture activities increase to levels in excess of that able to be assimilated by the surrounding environment. Aquaculture-related activities associated with the MWADZ Proposal include inputs such as fish feed and fish faeces, both of which have the potential to increase nutrient levels.

Should nuisance organisms be present in numbers or frequency above naturally-occurring levels, they may be considered to be impacting negatively on the aesthetic values of the MWADZ Proposal area. They also could contribute towards changes in some of the other environmental quality indicators outlined below.

13.4.2 Water Clarity

Water clarity is often considered an aesthetic indicator of environmental quality, particularly in naturally oligotrophic (i.e. low nutrient) marine environments such as the Abrolhos Islands. It has relevance to a number of recreational activities, including diving.

If aquaculture-related activities associated with the MWADZ Proposal, such as the inputs of fish feed and fish faeces, either directly or indirectly cause the visual clarity of the water to be reduced to levels significantly lower than natural levels, then they may be considered to be having a negative impact on the recreational and aesthetic values of the area.

13.4.3 Surface Films

Visible film on the water from oil or petrochemical origins is not only in conflict with what is considered to be a relatively pristine natural environment, but also likely to have a negative impact on the recreational and aesthetic values of the area. Aquaculture-related activity associated with the MWADZ Proposal that has the potential to result in oil or petrochemical spills or discharges include the operation of surface vessels and other fish farm machinery or equipment.

While the MWADZ Proposal would not be the only potential sources of this type of contaminant, it is important to demonstrate that these aquaculture-related activities do not significantly contribute to the problem.

13.4.4 Surface Debris

Like the oil or petrochemical surface films described above, water surfaces should be free of floating debris, dust or other objectionable matter. Again, these contaminants are inconsistent with an area valued for the relatively pristine status of its natural environment and are likely to be perceived as having a negative impact on these aesthetic values.

Consequently, it is important that aquaculture-related activities associated with the MWADZ Proposal do not contribute negatively to this issue.

13.4.5 Odours

Odours different to that naturally occurring, and particularly those perceived as objectionable, have the potential to have a negative impact on the recreational and aesthetic values of an area.

Therefore, aquaculture-related activities within the MWADZ Proposal area must be managed to avoid generating such odour emissions. The likelihood of this environmental quality indicator being an issue in the proposed MWADZ is the lowest of all the indicators outlined above.

13.5 Management Measures

The management measures to protect the environmental factor of amenity and maintain aesthetic values of the area within and surrounding the proposed MWADZ have been incorporated in the environmental quality management framework (EQMF) for the MWADZ Proposal in accordance with the guidance described in the EPA's EAG 15.

The objective of the aesthetic management program is to assess whether the Environmental Quality Guideline (EQG) and Environmental Quality Standard (EQS) have been met and to provide contextual information about the extent of aesthetic changes in the vicinity of the sea cages. The results of semi-quantitative and qualitative measurements will be compared against the EQG and EQS in Table 13-2, following those recommended in EPA (2015b).

Monitoring will be undertaken twice each year, in summer and winter. Monitoring will coincide with the seasonal water quality and sediment monitoring.

Table 13-2: Environmental quality criteria for the environmental quality objective of maintenance of recreation and aesthetics

<table>
<tr><th rowspan="2">Environmental Quality Indicators</th><th colspan="2">Environmental Quality Criteria</th></tr>
<tr><th>Environmental Quality Guideline (EQG)</th><th>Environmental Quality Standard (EQS)</th></tr>
<tr><td>Nuisance organisms</td><td>Macroalgae, phytoplankton and encrusting invertebrates should not be present in excessive amounts on or around the sea cages.</td><td rowspan="5">There should be no overall decrease in the aesthetic water quality values of the Zeewijk Channel, Abrolhos Islands that are attributable to aquaculture using direct measures of community perception of aesthetic value.</td></tr>
<tr><td>Water clarity</td><td>The natural visual clarity of the water should not be reduced by more than 20%</td></tr>
<tr><td>Surface films</td><td>Petrochemicals, such as engine oil, should not be noticeable as a visible film on the water or detectable by odour.</td></tr>
<tr><td>Surface debris</td><td>Water surfaces should be free of aquaculture-derived floating debris, feed dust and other objectionable matter.</td></tr>
<tr><td>Odours</td><td>There should be no objectionable odours.</td></tr>
</table>

Note:
1. Derived from EPA (2015b)
2. Many of the environmental quality guidelines for aesthetic quality are subjective and relate to the general appreciation and enjoyment of the Abrolhos by the community as a whole. Consequently, when using these criteria, consideration should be given to whether the observed change is in a location, or of intensity, likely to trigger community concern and to whether the changes are transient, persistent or regular events.
3. Further investigation (environmental quality standards) involves direct measures of aesthetic value to determine whether there has been a perceived loss of value. For example, regular community surveys can be used to show trends in community perception of aesthetic value over time.

Assessment against the EQG will be supplemented via a questionnaire supplied to field personnel (Table 13-3). The questionnaire will be completed during the annual water quality monitoring survey and will be based on observations made adjacent to sea-cage clusters.

Assessment against the EQS will be based upon credible community observations of the aesthetics within the proposed MWADZ. Proponents will provide community users of the Abrolhos Islands FHPA and other relevant stakeholders with an open invitation to comment on any depreciation of the aesthetic values of the Zeewijk Channel that may be attributable to the aquaculture within the proposed MWADZ. The Department's website at www.fish.wa.gov.au will provide a mechanism by which the community and stakeholders can submit comments. Any decreases in aesthetic water quality values of the Zeewijk Channel will be measured as an increase in the number of complaints or a distinct change in the perception of the community (refer to EQS in Table 13.2). Instances of complaints will be recorded and documented in the Annual Report. All records associated with the monitoring, need to be included in the Annual Compliance Report.

Table 13-3: Field sheet for demonstrating compliance with environmental quality guidelines for aesthetics

Site: Date:	**Recorder:**	**Comments**
Environmental Quality Guideline		
Algal/plant material visible on surface?	Yes/No	
Water clarity (light attenuation)	Metres	
Petrochemical or other pollutants visible on surface?	Yes/No	
Floating debris visible on the surface?	Yes/No	
Noticeable odour associated with water?	Yes/No	

The decision scheme for assessing EQG and EQS related to aesthetics, including management responses following an exceedance of the EQC is summarised in Table 13-4.

Table 13-4: Management response following an exceedance of the environmental quality criteria for maintenance of aesthetic values

Environmental Quality Indicators	Management following trigger level exceedance	
	Environmental Quality Guideline (EQG)	**Environmental Quality Standard (EQS)**
All instances	Upon an exceedance of the EQG, the proponent will investigate the cause and the source of the exceedance. An exceedance of the EQG will result in further assessment against the EQS. Any instances of an exceedance of the EQG will be reported by the proponent in the Annual Compliance Report (a condition of the Ministerial Statement).	If there is a decrease in the aesthetic values of the Abrolhos Islands marine environment, as determined using direct measures of the community perception of aesthetic values, the proponent will consult with DoF and OEPA to determine an appropriate management response.

13.6 Predicted Environmental Outcome

The Abrolhos Islands are multi-use with an array of stakeholders, all of which have vested interest in preserving the unique features of the Reserve and the surrounding marine environment within the Fish Habitat Protection Area. These features include those relating to the EPA's environmental factor of amenity (EAG 8).

Amenity values are fundamentally reliant on the maintenance of the key environmental value of ecosystem health. Without ecosystem health, amenity values are inevitably diminished. By protecting this key environmental value through the establishment and implementation of an effective EQMF (EAG 15) specific to the MWADZ Proposal (refer to EMMP – Appendix 2), the environmental quality objectives of both ecosystem health and aesthetics will be protected and the impacts to amenity (EAG 8) reduced as low as is reasonably practicable.

14 ASSESSMENT OF POTENTIAL IMPACT ON NON-ENVIRONMENTAL MATTERS

14.1 Assessment Framework

While not within the scope of this PER, there have been several matters identified in the consultation process associated with the MWADZ Proposal that are not of an environmental nature but rather relate to social or economic issues. As some of these may be of interest to the public, they have been mentioned in this section as additional information.

It is important to understand that such matters are not an integral part of the PER and not matters to be considered by the EPA in its assessment of the MWADZ Proposal. However, including them in this document may assist stakeholders and the wider public to distinguish them from the environmental principles, factors and objectives that are the subject of this PER. Such a separation may be helpful when respondents frame their formal submissions during the public comment phase of the MWADZ Proposal PER process.

14.1.1 Socio-Economic Objectives

The MWADZ Proposal objective the Department has established for socio-economic values (i.e. values other than the environmental values addressed elsewhere in this PER) is:

"To take into account other uses of the MWADZ Proposal area while providing the opportunity for the development of ecologically-sustainable, large-scale, commercial aquaculture and associated economic benefits to the community."

14.1.2 Relevant Legislation, Policies, Plans and Guidelines

Table 14-1 lists the legislation, policies, plans and guidelines that are relevant to non-environmental considerations within the MWADZ Proposal area.

Table 14-1: Legislation, Policies, Plans and Guidelines Relevant to Non-Environmental Matters

Legislation, Polices, Plans and Guidelines	Intent
State	
Land Administration Act 1997	An Act to consolidate and reform the law about Crown land and the compulsory acquisition of land generally, to repeal the Land Act 1933 and to provide for related matters.
Fisheries Resources Management Act 1994	Provides a legal framework to conserve, develop, and share fish resources for the benefit of current and future populations in WA. This legislation also provides the management framework for the Abrolhos Islands reserve and for the establishment and management of the Fish Habitat Protection Areas.
The Houtman Abrolhos Islands Management Plan	Provides a management framework to conserve and promote the unique environmental and cultural heritage values of the Abrolhos for the benefit of present and future generations.
Environmental Assessment Guideline (EAG)	
Not applicable	
Commonwealth	
Not applicable	

14.2 Non-environmental Matters

14.2.1 Compatibility with Other Uses

14.2.1.1 Sea Use

While the physical presence of aquaculture infrastructure within the proposed MWADZ has the potential to impact on some components of the commercial sector of the community that have previously had an unrestricted level of access to all parts of this area (e.g. the AIMWMTF) access to the MWADZ will be non-exclusive. The use of State waters for aquaculture does not confer an exclusive access right and persons other than aquaculture licence holders may enter the zone and lease areas, although they are not permitted to interfere in any way with aquaculture gear.

14.2.1.2 Navigation

The lease area must be marked with approved buoys, markers, lights and signage in accordance with the "*Guidance Statement for Evaluating and Determining Categories of Marking and Lighting for Aquaculture and Pearling Leases/Licences (2010)*". This Statement can be accessed at the Department's website (www.fish.wa.gov.au/Documents/aquaculture_licencing/marking_and_lighting_guidance_statement.pdf). These requirements will be a condition on the aquaculture licence.

14.2.1.3 Conservation

The MWADZ Proposal area is located within the Abrolhos Islands FHPA and the strategic and management objectives of the Abrolhos Islands FHPA Strategic Plan and Management Plan have been considered in the development of this proposal. The aquaculture activities associated with the MWADZ Proposal are consistent with the purposes [prescribed in s.115 (2) of the FRMA and reflected in the Abrolhos Islands Fish Habitat Protection Area Order 1999] for which the Abrolhos Islands FHPA was created.

The MWADZ Proposal area is not in the vicinity of any of the FHPA Reef Observation Areas and is most unlikely to have any impacts upon them.

14.2.1.4 Mining and Oil Exploration

The provisions of mining and petroleum-related statutes (Acts) permit petroleum and gas exploration activities in the Abrolhos Islands. Four petroleum exploration wells were drilled in waters surrounding the Abrolhos Island in the late 1960s and 1970s. These wells have been capped and abandoned (Webster, F *et al.* 2002). Currently, there are no active exploration permits in the strategic MWADZ Proposal area. The proposal is therefore likely to have no impact on mining and oil and gas exploration within the area. Figure 14-1 highlights the current oil and gas exploration permits that are within the vicinity of the MWADZ Proposal.

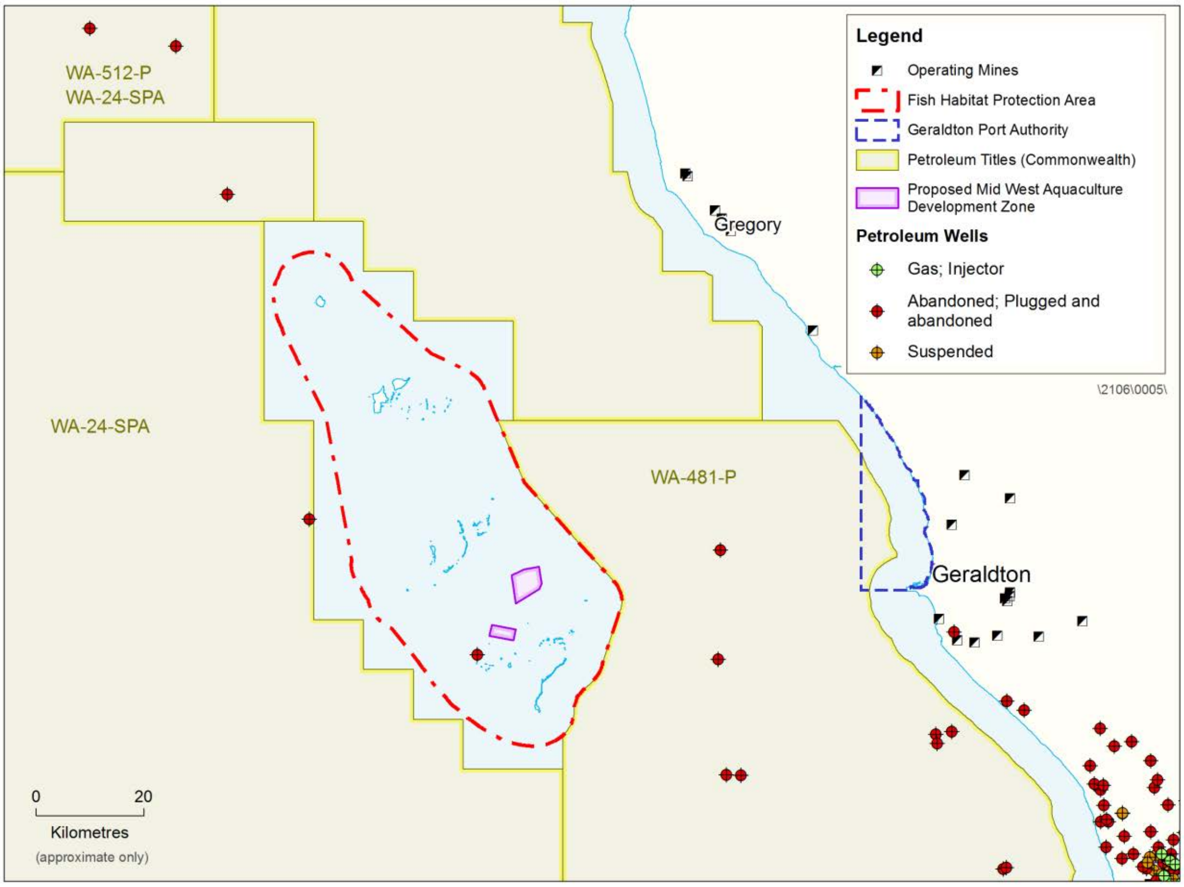


Figure 14-1: Oil and Gas Exploration Permits within the vicinity of the MWADZ

14.2.2 Workforce Health and Safety

The Abrolhos Islands is situated in a remote location which is only accessible by sea-going vessels or appropriate aircraft. The reefs, shoals and currents around the area make it a very difficult area to navigate and considerable caution must be taken when transiting the area.

The MWADZ Proposal area is approximately 65 kilometres offshore of Geraldton and will only be accessible by boat. The closest airstrip to the proposed zone is at Rat Island in the Easter Group of the Abrolhos Islands and is only suitable for light aircraft.

Mobile telephone coverage of the proposed MWADZ area is variable (depending on the prevailing conditions) and cannot be relied upon for matters relating to human safety.

Under Regulation 113AA of the FRMR, the master of a boat must not use the boat to travel to the Abrolhos Islands Fish Habitat Protection Area unless the master gives notice to the Department of the period of stay of the boat in the Abrolhos Islands Fish Habitat Protection Area. This requirement provides the opportunity to obtain information about who is in the FHPA at any one time and how they may be contacted should the need arise (e.g. approaching cyclone). This will facilitate evacuation operations should the need arise. A web-based notification facility will soon be available for these purposes.

14.2.2.1 Cyclone Protection

Tropical cyclones are known to occur periodically at the Abrolhos Islands during the summer months, with one occurring on average every five years (Webster, F *et al.* 2002). During these cyclone events winds can reach up to 165 kilometres per hour, once every 50 years, with 176 kilometre per hour winds possible once every 100 years (Webster, F *et al.* 2002).

14.2.2.2 Emergency Evacuation

All emergency management arrangements at the Abrolhos Islands are currently managed by the Batavia Emergency Management Committee (BEMC) and coordinated by City of Greater Geraldton (pers. comm. Natalie Moore 2015). Under Section 38 of the *Emergency Management Act 2005*, a local government is required to establish one or more Local Emergency Management Committees (LEMCs) for the local government district. The BEMC is the LEMC responsible for the coordination of emergency evacuations at the Abrolhos Islands. The functions of a LEMC, in relation to its district or the area for which it is established, are:

- to advise and assist the local government in ensuring that Local Emergency Management Arrangements (LEMAs) are established for its district;
- to liaise with public authorities and other persons in the development, review and testing of the LEMA; and
- to carry out other emergency management activities as directed by the SEMC or prescribed by the regulations.

Any aquaculture licence holders who operate within the MWADZ will be required to abide by the management arrangements within the LEMA emergency evacuation plan for the Abrolhos Islands. Emergency evacuation will be via helicopter and/or aeroplane, utilising the local airstrips at Rat Island or East Wallabi Island. It is intended that non-critical evacuations be transported via boat to the airstrip, while critical evacuations will be via helicopter direct from the island.

The Department of Fisheries is proposing to develop and implement an Emergency Management and Evacuation Plan in consultation with relevant stakeholders and management agencies. The plan is intended to address all high risk emergency events for the Abrolhos and incorporate requirements for training exercises and regular review (Department of Fisheries 2012c).

14.2.3 Commonwealth, State and Regional Economy

The City of Greater Geraldton local catchment area spans an area of approximately 12,625 square kilometres, of which a large proportion is farming land and rural areas along with areas of residential, industrial, commercial, mining and conservation reserves. In January 2015, the Abrolhos Islands was moved from the Northampton local government catchment area to the City of Greater Geraldton catchment area.

In the City of Greater Geraldton[45] the current population is approximately 41,087 people. The area has experienced considerable growth over the last ten years with a grow rate of approximately 17.2% since 2001. This trend is expected to continue.

The local economy is made up of retail trade, construction, agriculture, mining, fishing, health care, public administration and safety, accommodation and food services and education and training. In 2014, the City of Greater Geraldton's Gross Regional Product (GRP) was estimated at $2.853 billion. Greater Geraldton represents 49.74% of Mid West region's GRP of $5.735 billion, 1.08% of Western Australia's Gross State Product (GSP) of $264.545 billion and 0.18% of Australia's GRP of $1.584 trillion.

The largest industry sectors are mining (15.2%), manufacturing (14.5%), construction (12.1%) and rental, hiring and real estate (9.2%). The three most popular occupations are technicians and trade workers, professionals and administrative workers.

The Abrolhos Islands attracts significant economic and tourist activity, providing substantial benefits to the Western Australian community. The main activities conducted in the area include commercial fishing for rock lobster, scallops and finfish, as well as aquaculture for pearls and coral, recreational fishing, diving and bird watching and tourism. The West Coast Rock Lobster Managed Fishery is the most economically valuable industry at the Abrolhos Islands. Over the past ten years the total value of rock lobster landed in the fishery has ranged between $30 and $50 million a year (Webster, F *et al.* 2002).

The West Coast Rock Lobster Managed Fishery supports a number of local businesses in the Geraldton area, in particular the Geraldton Fisherman's Co-operative (GFC). GFC is one of the largest rock lobster processors in the world, exporting 3,572 tonnes in 2013-14 with a turnover of approximately $237 million. Around 90% of rock lobster captured from the Abrolhos Islands is exported via air to China as "live" animals. Small quantities of frozen product are also exported to countries such as Japan, Taiwan, Hong Kong, Dubai and USA.

Implementation of the MWADZ Proposal should have no significant negative economic impacts on these existing industries but rather provide significant additional rural business opportunities close to the diverse and well-established urban infrastructure of Geraldton. It builds upon the City's traditional strengths in the areas of fishing and maritime servicing vessels, harbour and maintenance facilities and seafood processing establishments. These supporting factors will increase the region's marketability in terms of attracting aquaculture developments. Broader industry growth stimulated by the establishment of an aquaculture zone will generate direct employment as well as substantial flow-on effects for local business and service industries.

These benefits will flow on through State and Commonwealth economies.

14.2.3.1 Employment

The MWADZ Proposal is expected to deliver employment and skill development opportunities that benefit the local and regional population.

[45] Note that most of the information in this section was obtained from the City of Greater Geraldton Website 2015.

The implementation of the MWADZ Proposal will stimulate the local and regional economy and create new business opportunities (or expand existing ones). It builds on the traditional strengths of the City of Greater Geraldton, particularly in respect to the fishing, maritime and agricultural industries (aquaculture is another form of farming) and will use local goods and services.

It will also provide the tourism industry with an opportunity to diversify experiences available to visitors.

14.3 Conclusion

In summary, the potential non-environmental impacts of the MWADZ Proposal are not predicted to adversely interfere with, or compromise, other social or economic uses of the proposed area. The potential impacts are considered to be able to be managed to acceptable levels by the implementation of the EMMP, the zone Management Policy, the MEMP, and the other plans, protocols and management measures outlined in this PER.

15 ENVIRONMENTAL MANAGEMENT FRAMEWORK

15.1 Overview

The Environmental Management Framework is an overarching strategy that is built not only upon the fundamental environmental requirements of the EP Act, but also draws on the Department's own statutory requirements and associated policies and guidelines to translate the commitments and management measures identified into the development of the MWADZ Proposal. These existing documents, as well as those developed specifically for the MWADZ Proposal, will be used as an integrated mechanism through which the environmental management, mitigation measures, monitoring and reporting requirements associated with the MWADZ Proposal will be implemented (refer to Section 15.3.1).

This section outlines the three tiers of the management framework, from the Department's statutory responsibilities under the *Fish Resources Management Act 1994* (FRMA)*,* the implementation through policy and other documentation of the objects of the FRMA and the reflection of these objectives and requirements in the MWADZ Proposal documentation.

15.2 Tier 1 – Ecologically Sustainable Development Obligations under the *Fish Resources Management Act 1994*

15.2.1 Statutory Requirements

The objects of the *Fish Resources Management Act 1994* (FRMA) provide as follows:

"Objects

(1) The objects of this Act are —

*(a) to **develop and manage** fisheries and **aquaculture in a sustainable way**; and*

*(b) to **share and conserve** the State's **fish** and other aquatic resources **and their habitats** for the **benefit of present and future generations**.*

(2) *Those objects will be achieved by these means in particular —*
   (a) *conserving fish and* ***protecting their environment****;*
   (b) *ensuring that the* ***impact of*** *fishing and* ***aquaculture on aquatic fauna and their habitats is ecologically sustainable*** *and that the* ***use*** *of all aquatic resources* ***is carried out in a sustainable manner****;*
   (c) *enabling the* ***management of*** *fishing,* ***aquaculture****, tourism that is reliant on fishing, aquatic eco-tourism and associated non-extractive activities that are reliant on fish and the aquatic environment;*
   (d) *fostering the* ***sustainable development of*** *commercial and recreational fishing and* ***aquaculture****,* ***including the establishment and management of aquaculture facilities for community or commercial purposes****;*
   (e) *achieving the* ***optimum economic, social and other benefits from the use of fish resources****;*
   (f) *enabling the* ***allocation of fish resources between users*** *of those resources, their reallocation between users from time to time and the management of users in relation to their respective allocations;*
   (g) *providing for the* ***control of foreign interests in*** *fishing,* ***aquaculture*** *and associated industries;*
   (h) *enabling the* ***management of fish habitat protection areas and the Abrolhos Islands reserve****."*

Note: Text in bold for emphasis only.

As the State Government agency responsible for the administration of the FRMA, these objects direct the business of the Department of Fisheries WA and guide the development, implementation and on-going maintenance of the MWADZ Proposal.

These objects embody the principles of ecologically sustainable development [i.e. same as the environmental principles (s. 4A) of the EP Act].

15.2.2 Department of Fisheries Western Australia - Policy

The objects of the FRMA are encapsulated in the Department's Ecosystem Based Fisheries Management (EBFM) approach, which views the management of the State's aquatic resources under a holistic EBFM Framework[46]. This comprehensive, risk-based framework takes into account all ecological resources, including assets such as marine mammals that fall outside the remit of the FRMA, as well as social and economic factors in deciding how to manage aquatic resources.

The Western Australian Fisheries Policy Statement 2012 outlines the Western Australian Government's position on, and vision for, the use of the State's fish and aquatic resources by the commercial (including pearling and aquaculture), recreational and Aboriginal customary fishing sectors.

The following broad-scale policies also provide guidance by which the objects of the FRMA will be implemented through the MWADZ Proposal:

- *Aquatic Biosecurity Policy*

[46] Refer to http://www.fisheries-esd.com/a/pdf/Fletcher%20et%20al%20EBFM%20framework.pdf

- ➢ Promotes the conservation and protection of fish, fisheries and fish habitat by minimising the negative impacts of aquatic pests and diseases in Western Australia's marine and fresh waters. The focus is on prevention of aquatic pest and disease establishment and continuous improvement of biosecurity practices.

- *Integrated Fisheries Management Policy 2009*

  - ➢ Allows for the allocation of fish resources between users.

- *The Houtman Abrolhos Islands Management Plan Fisheries Management Paper No. 260*

  - ➢ Provides strategic and management objectives and strategies for the Abrolhos Islands Reserve and the Abrolhos Islands Fish Habitat Protection Area.

15.3 Tier 2 – Environmental Assessment and Monitoring Program

15.3.1 Environmental Impact Assessment Documentation

15.3.1.1 Environmental Monitoring and Management Plan

A condition for environmental approval of the MWADZ Proposal is the implementation of an Environmental Monitoring and Management Plan (EMMP - Appendix 2). The EMMP has been developed to provide proponents with an appropriate environmental quality management framework (EQMF) for managing the potential impacts of stocking up to 24,000 tonnes of marine finfish across the MWADZ (EMMP - Appendix 2).

Maintenance of ecosystem integrity is concerned with maintaining the structure and functions of marine ecosystems to an appropriate level. In this context, the EQMF (refer to the EMMP - Appendix 2) includes mechanisms to protect the key environmental factor, "marine environmental quality" and the associated environmental objective, "*To maintain the quality of water, sediment and biota so that the environmental values, both ecological and social, are protected*". By protecting "marine environmental quality", all associated environmental values of Western Australian coastal waters under the EQMF are protected from impacts related to the degradation of that marine environmental quality (Section 7.5.1). The relevant EQMF environmental values of Western Australian coastal waters that are protected include:

- ecosystem health;
- fishing and aquaculture;
- recreation and aesthetics;
- industrial water supply; and
- cultural and spiritual.

As aquaculture production in the MWADZ increases towards the maximum capacity standing fish stock biomass, the EMMP will ensure future derived proposals are managing all key environmental factors identified in the strategic proposal (in the context of EAG 8). The EMMP includes proactive management strategies and mechanisms by which proponents will protect the environmental factors of:

- marine environmental quality;

- benthic communities and habitat;
- marine fauna;
- amenity; and
- heritage,

in addition to providing evidence of this through multiples lines of evidence across a range of environmental quality indicators.

Implementation of the EMMP by proponents will achieve the environmental objectives by maintaining the:

- structure, function, diversity, distribution and viability of benthic communities and habitats at local and regional scales;
- quality of water, sediment and biota so that the environmental values, both ecological and social, are protected; and
- diversity, geographic distribution and viability of fauna at the species and population levels.

By protecting important biological and ecological values of the Abrolhos region, including its significant marine mammal, turtle, seabird, wild finfish and invertebrate populations, its biosecurity and fisheries (refer to Sections 7, 8, 9, 10 and 11) other environmental factors and values (e.g. heritage and amenity – Sections 12 and 13) are also protected (EMMP - Appendix 2).

The EMMP provides important strategies to manage the anticipated pressures associated with the MWADZ Proposal on the key environmental factors, while maintaining broader regional environmental quality. Small localised effects, at a moderate level of ecological protection, will be managed beneath and immediately adjacent to the MWADZ sea cages, while maintaining overall environmental integrity of the surrounding area of the Zeewijk Channel at the Abrolhos Islands (EPA 2015).

The small localised effects of aquaculture will be confined to "floating" (i.e. moveable but linked to the location of the sea cage clusters) moderate ecological protection areas (MEPAs) within the MWADZ Proposal footprint. The area surrounding the MEPAs will be protected at a high level of ecological protection (HEPA), commensurate with the high ecological protection area status of the waters surrounding the MWADZ Proposal area (Figure 15-1).

Following commencement of aquaculture operations, operators will be required to demonstrate compliance with the environmental quality objectives (EQOs). The extent to which the EQOs have been achieved will be assessed against a suite of environmental quality criteria (EQC). The EQC, comprising guidelines and standards, provide the benchmarks against which environmental quality is measured. Unlike the EQOs, which are qualitative and described as a narrative, the EQC are quantitative and described numerically (EPA 2015; EMMP - Appendix 2).

Specifically, this EMMP will facilitate the maintenance of ecosystem integrity during the operation of the zone by providing the following set of mechanisms:

- indicators to be measured and monitoring protocols;
- areas of ecological protection and their corresponding thresholds (EQC);

- mitigation and management measures to be employed in the event of an EQC being exceeded;
- an adaptive monitoring and management approach (including a feedback loop); and
- a reporting structure.

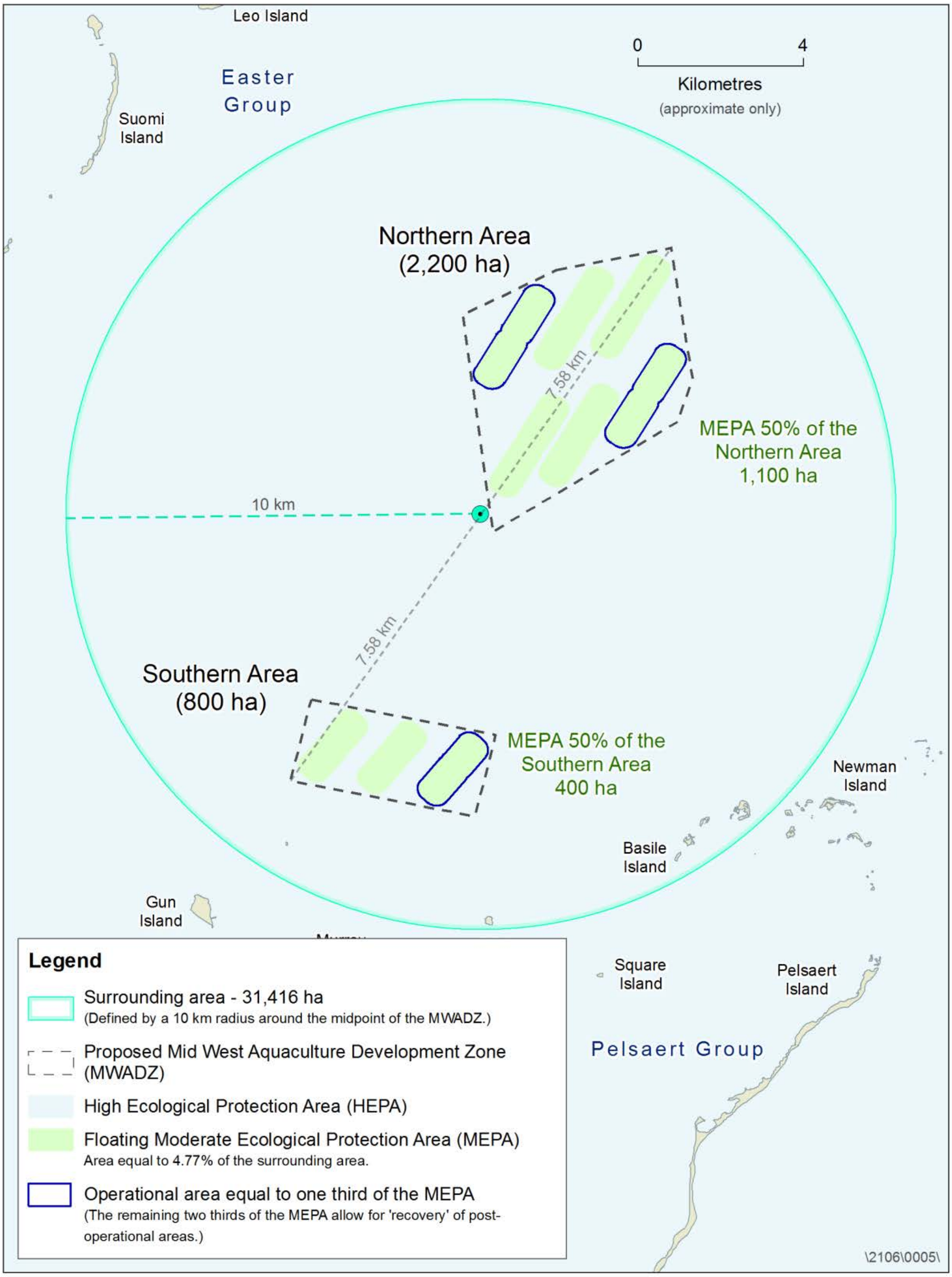


Figure 15-1: Conceptual overview of the EQO "maintenance of ecosystem integrity" for the proposed MWADZ – Location of MEPAs and HEPAs

15.3.1.2 Aquaculture Development Zone Management Framework

The Department will manage the zone within an integrated management framework that incorporates the statutory requirements of both the EP Act and the FRMA. Figure 15-2 provides details of this overarching management framework, its main elements and their inter-relationships.

The management framework comprises the zone Management Policy (Management Policy) and several associated instruments and documents.

In relation to the zone, the purpose of the management framework is to:

- establish an overarching, integrated structure for managing the aquaculture activities;
- provide clear, efficient and effective processes for monitoring, evaluating and reporting;
- continuously improve the approach being used to manage the zone;
- guide the development of marine finfish aquaculture; and
- ensure adaptive management occurs as part of a process of continuous improvement.

15.3.1.3 Aquaculture Development Zone Management Policy

The Management Policy comprises the core of the overarching management framework for the zone. It recognises the statutory requirements of both EP Act and FRMA as they relate to the MWADZ Proposal and position them in a structure such that they integrate with and support each other to ensure environmental values are protected and ecologically sustainable development of aquaculture can occur.

The Management Policy may include or define:

- the zone area, location and co-ordinates;
- spatial separation distances between leases;
- operational requirements including method, gear and feed inputs;
- waste management;
- zone biosecurity, including disease testing and fish health; and
- compliance, including reporting (i.e. triggers reached) and audit mechanisms (such as agreement by all parties on monitoring of reference sites).

15.3.1.4 Ministerial Statement and Conditions

The Department (as the proponent of the strategic assessment approved by the EPA) is required to ensure any conditions defined in the Ministerial Statement (issued under sections 40B and 45 of the EP Act) are reflected in the management framework.

The Ministerial Statement identifies:

- future proposals, which may be implemented if declared to be derived proposals; and
- conditions, which may control the implementation of the derived proposals.

These conditions relates to matters such as:

- compliance planning and reporting;
- public availability of data; and
- implementing the requirements of the EMMP.

15.3.1.5 Section 45A Notice

A Section 45A Notice (under the EP Act) issued to a future proponent provides for:

- implementation of derived proposals; and
- sets the conditions of the Ministerial Statement that apply to the derived proposal.

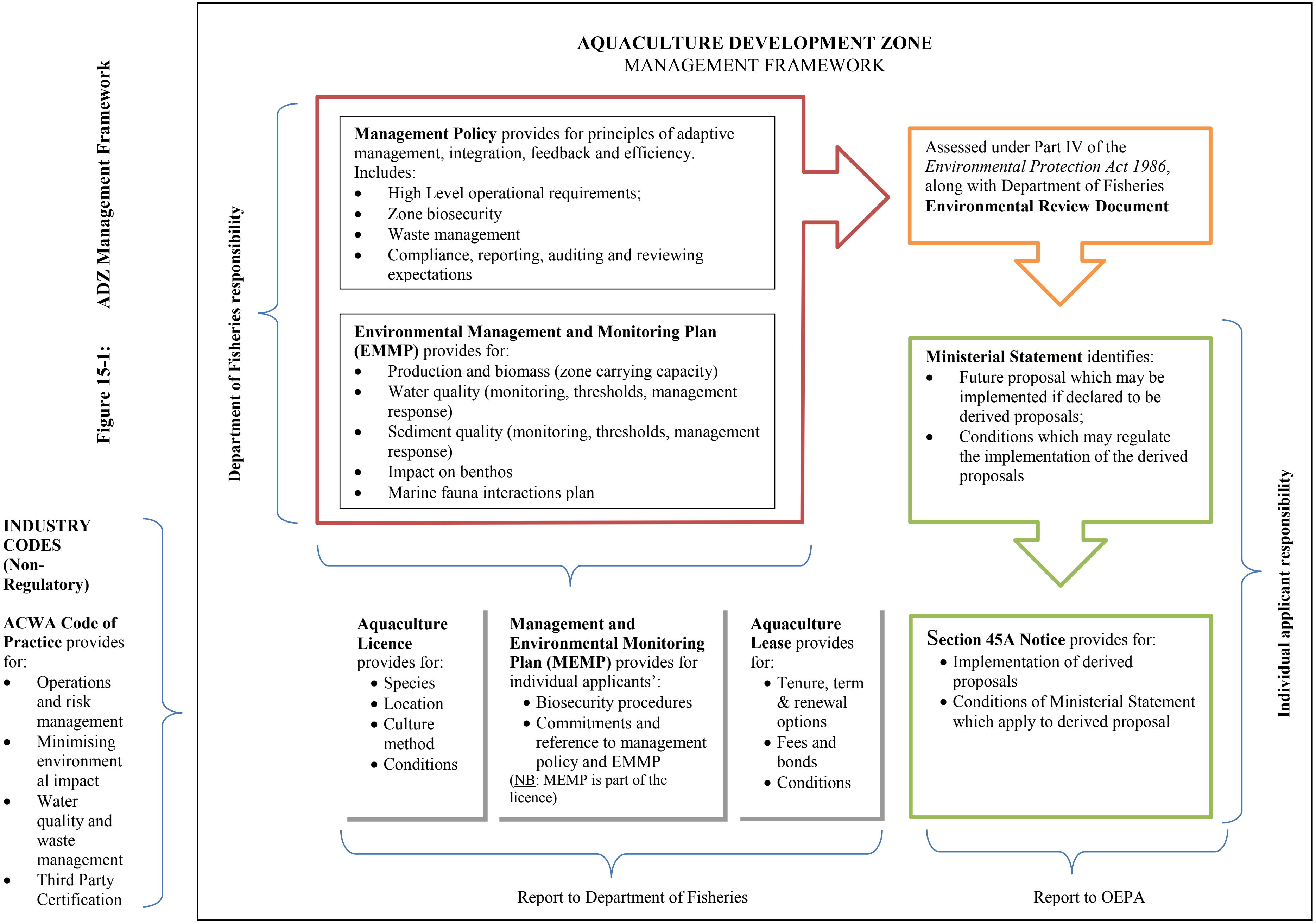
15.3.1.6 Management and Environmental Monitoring Plan (MEMP)

The Management and Environmental Monitoring Plan (MEMP) describe management and environmental monitoring parameters that are similar to those found in the EMMP. Consequently, in order to avoid duplication in structure and reporting, many elements of each operator's MEMP will likely make reference to the corresponding element of the EMMP.

Under the Department's internal MEMP Policy, the MEMP of each license holder operating within an Aquaculture Development Zone must comprise (and refer to) the relevant Management Policy and EMMP for the zone.

The annual report is a major requirement of MEMPs. This requirement is consistent with enhancing self-management by aquaculture licence holders through targeted audits and regular reporting. It will also help them ensure greater compliance with licence and lease conditions.

Figure 15-1: ADZ Management Framework



15.4 Tier 3 – Subsidiary Documents

15.4.1 Marine Fauna Interaction

To support the management of potential impacts associated with the EPA's key environmental factor of marine fauna, a separate Marine Fauna Interaction Management Plan (MFIMP) has been developed specifically for the MWADZ Proposal (refer to Appendix 5). This MFIMP focuses primarily on managing potential impacts to marine mammals, marine reptiles and marine avifauna. Specifically, this MFIMP:

- provides an overview of the potential impacts that may occur to marine fauna during the installation process and operational activities;
- outlines management measures and actions adopted to mitigate potential impacts to marine fauna during the sea cage installation process and during operational activities;
- outlines the monitoring requirements/programs required to be serviced by operators within the MWADZ; and
- outlines the marine fauna incident reporting and response strategies required of operators within the MWADZ.

The primary aim of this MFIMP is to ensure that activities conducted within the proposed MWADZ do not cause any significant disturbance to marine fauna within the Abrolhos Islands Fish Habitat Protection Area (FHPA).

The objectives of this plan include minimising:

- human interactions with marine fauna;
- any potential injuries or fatalities to marine fauna that may result from collision with vessels or entanglement;
- noise and vibration disturbance to marine fauna;
- potential impacts to marine fauna from artificial light;
- potential impacts posed to marine fauna by aquaculture infrastructure; and
- adverse effects of fish farming activities within the proposed MWADZ on marine fauna.

This MFIMP considers the EPA Scoping Document's work requirements for the MWADZ by assisting to address the EPA environmental factor "marine fauna" and its associated objective "*To maintain the diversity, geographic distribution and viability of fauna at the species and population levels*". More detailed information is available at Appendix 5.

15.4.2 Waste Management

A stand-alone Waste Management Plan (WMP) has been developed for the MWADZ Proposal (refer to Appendix 6). This WMP:

- identifies, describes and provides guidance on the various waste products that are common to aquaculture facilities including, general rubbish and sewage treatment;
- identifies potential fuel and oil spills and provides guidance for appropriate action and reporting; and

- identifies, describes and provides guidance on the disposal of biological waste common to aquaculture facilities including fish processing waste and mortalities/culls including appropriate biosecurity considerations.

The WMP encourages the use of the Waste Hierarchy detailed in the EPA's Guidance for the Assessment of Environmental Factors No. 55 (2003). Specifically:

1. avoidance of waste production;
2. reuse of wastes;
3. recycling wastes to create useful products;
4. recovery of energy from wastes;
5. treatment of wastes to render them benign;
6. containment of wastes in secure, properly managed structures; and
7. disposal of waste safely in the long term.

Note: any reuse or re-cycling of aquaculture facility products must be done in accordance with biosecurity procedures.

More detailed information is available in the WMP at Appendix 6.

15.4.3 Decommissioning

While not in the form of a separate document, should the MWADZ Proposal ever require decommissioning, the proponent (i.e. the Department of Fisheries on behalf of the Minister for Fisheries) will ensure all operators within the MWADZ clear their lease sites in accordance with the provisions of the *Fish Resources Management Act 1994* and subsidiary legislation as outlined at Section 2.6 of this PER document.

15.4.4 Aquaculture Industry Code of Conduct

Recently revised by ACWA, the *ACWA Environmental Code of Practice for the Sustainable Management of Western Australia's Marine Finfish Aquaculture Industry* (CoP) allows industry members to demonstrate their commitment to operating within the principles of ESD. It focuses on best practice through a documented environmental management system (EMS) and recommends a continuous improvement requirement where the business periodically reviews and evaluates its EMS to identify and implement opportunities for improvement.

The CoP provides recommendations licence holders should follow to remain compliant with the Code, and makes references to the requirements they are obliged to comply with under the legislative framework. Recommendations cover matters associated with:

- facility operations and risk management;
- minimising environmental impacts from production; and
- water quality and waste management.

The CoP emphasises that licence holders must collect and retain specified information on their operations and to formally declare that they have been acting in accordance with licence conditions and the intent of the CoP.

16 CONCLUSION

16.1 Cumulative Impacts

A cumulative impact assessment was considered of the potential incremental impacts, in terms of the environmental and social factors outlined in this PER, of the MWADZ Proposal. The cumulative impact assessment evaluated the potential incremental impacts of the MWADZ Proposal when combined with other present and reasonably foreseeable future actions in the vicinity of the proposed MWADZ area.

The cumulative impact assessment was based on a mostly qualitative, high-level analysis of potential impacts using professional judgement of subject matter experts, supported by baseline information (current and historic) and a range of quantitative assessments, including an Integrated Ecosystem Model (Model). The Model was able to predict the cumulative environmental effects of the proposed aquaculture, operating across a range of potential production scenarios. The ecosystem Model was capable of simulating regional oceanographic water movements, the deposition and dispersal of wastes from sea cages, the effects of these wastes on the marine environment, and the rate of environmental recovery. (EMMP – Appendix 2).

The location of the proposed MWADZ area is relatively remote (i.e. ~65 kilometres offshore of Geraldton) and its marine environment has only been subject to light and occasional anthropogenic use, principally by the Abrolhos Islands and Mid West Trawl Managed Fishery. With a benthos that is composed mostly of sand, it has not been used and is unlikely to be used in the future for other purposes.

At the maximum 24,000 tonne stocked fish standing biomass limit recommended, no unacceptable cumulative impacts to the marine, terrestrial, social and cultural environment are predicted to occur as a result of the MWADZ Proposal. With the mitigation and management controls in place, as outlined in this PER, the potential cumulative impacts are managed to meet the objectives established for the MWADZ Proposal.

16.2 Proposed Management

The Environmental Scoping Document (ESD) associated with the Mid West Aquaculture Development Zone (MWADZ) strategic proposal (Assessment No. 1972) was determined by the Environmental Protection Authority (EPA) in July 2013. This document defined the requirements of the PER document that were to be met by the Department of Fisheries (Department) on behalf of the Minister for Fisheries (the proponent for the MWADZ strategic proposal).

The preliminary key environmental factors, scope of works and policy documents relevant to the MWADZ Proposal and required to be addressed in the PER document included the EPA's Environmental Assessment Guidelines (EAG) No.3 Protection of Benthic Communities Habitats in Western Australia's Marine Environment (2009) and the EPA's EAG No.7 Marine Dredging Proposals (2011). Although the MWADZ Proposal didn't involve dredging, the principles and approaches for describing the potential impacts and addressing predictive uncertainty outlined in the latter EAG could be applied when assessing impacts to primary producing and non-primary producing communities and habitat.

These documents played a significant role in shaping the Department's approach towards developing the Environmental Monitoring and Management Plan (EMMP) for the MWADZ Proposal. The EMMP consists of a series of sub-management plans, monitoring programs and protocols that address the potential environmental impacts identified in the PER.

Given there is a level of uncertainty in predicting the long-term consequences of conducting sea cage aquaculture in the Mid West, the Department, with the assistance of its environmental consultant (BMT Oceanica), chose to adopt a conservative approach to developing the EMMP. This conservative approach was taken to ensure that the potential scale and intensity of the potential cumulative impact of the proposed aquaculture operations in the MWADZ on the local marine environment was not understated. In other words, it consistently focused on what could be termed the "most likely worst case" scenario when considering the inputs of aquaculture activity (e.g. fish faeces and uneaten fish feed) and their potential impacts on the receiving environment.

Such an approach was reinforced by the available published literature (albeit mostly relating to marine finfish aquaculture in the Northern Hemisphere) pertaining to the potential environmental impacts that may be associated with large-scale marine finfish sea cage aquaculture, supplemented by the outcomes of the environmental modelling undertaken for the MWADZ Proposal.

While this approach can be effective in reducing the likelihood of any unforeseen negative environmental impacts associated with the MWADZ Proposal, it can also result in an overly negative perception of the magnitude of the likely "actual" environmental impacts of the proposal, and (in this instance) the resultant levels of ecological protection considered appropriate when designing the proposal Environmental Quality Plan (EQP).

The combined effects of these factors led to the Department (through its environmental consultants) exploring the possibility of incorporating the principles described in Environmental Assessment Guidelines No.7 Marine Dredging Proposals (2011) in the design of the MWADZ EQP. This idea was supported in that both the published literature and the environmental modelling undertaken indicated the primary environmental impact of the proposed aquaculture was to the sediments immediately beneath the sea cages; but that such impacts did not extend significantly beyond this deposition area. At the same time, the impact of the aquaculture activity on water quality was likely to be negligible. In this respect, the anticipated behaviour of the organic inputs and the resulting environmental impacts of the MWADZ Proposal more closely reflected those expected of (say) a wastewater outfall rather than that previously thought to represent sea cage aquaculture (such as in some other locations within the State).

As a consequence, based on the available information and outputs of the 'conservative' environmental impact modelling undertaken, an EQP based on a small total area of Low Ecological Protection Area (LEPA), (occupying less than one per cent of the area encompassed within a ten kilometre radius of the zone), surrounded by larger areas of High Ecological Protection Area (HEPA) was contemplated. This was considered to reflect the 'likely worse case' scenario.

However, while the Department was confident that such a level of impact and effect is at the upper end of what might be expected and would not be exceeded by the aquaculture activity, it was of the view that, through good farm management, a better environmental outcome could be achieved. It was also conscious that the resultant 'low' level of ecological protection is not consistent with the recently-published EPA EAG No. 15 Protecting the Quality of Western Australia's Marine Environment (2015) (EAG 15). This document, among other things, sets out the EPA's views on the level of ecological protection it would normally expect to be applied, and the environmental values expected to be protected, in relation to certain types of marine areas, including those areas subject to sea cage aquaculture. For this sea cage aquaculture, EAG 15 suggests the most appropriate level of ecological protection is a Moderate Ecological Protection Area (MEPA).

As set out above, the level of uncertainty and the conservative approach to predicting the potential impacts of the proposed MWADZ in the PER resulted in a level of protection that would likely equate to 'Low'. However, the EAG 7 approach, which is designed for dealing with dredging proposals that typically have similar "levels of uncertainty" involved in predicting impacts to that of large-scale aquaculture, suggests that proponents of derived proposals should not only consider the 'most likely worst case' but should also consider the 'most likely best case'. The latter would indicate the level of impact that would occur if realistic, but less conservative (i.e. more optimistic), assumptions were considered and optimum levels of management were achieved.

Due to the lack of published literature relating to marine finfish sea cage aquaculture in sub-tropical waters where the sea bed predominately comprises calcareous sediments (i.e. like the proposed MWADZ), the design of the EQP for the MWADZ Proposal was based on studies conducted in temperate waters in the Northern Hemisphere and on locations that have sediments markedly different (and arguably more vulnerable to environmental impacts from aquaculture) to those present in the proposed MWADZ. In addition, the relatively 'shallow' depth of sediment in the proposed MWADZ and the likely periodic influence of storms, which could rework and mobilise sediments, provides a plausible mechanism to reduce organic matter accumulation rates and consequential sediment anoxia.

Combined, the overstating of potential sediment impacts due to the design basis for the EQP (i.e. Northern Hemisphere examples) and the understating of the potential ameliorating effects of shallow sediment depth and periodic storm activity have probably contributed to a far more pessimistic (i.e. worst case) assessment of the likely environmental impacts of the proposed aquaculture activity being incorporated in the modelling than should have been the case.

Considered from this viewpoint, a likely 'best case scenario' would be that organic enrichment and associated levels of oxygen depletion/hydrogen sulphide production would probably **not** occur to the same extent as that generated through the conservative modelling. Under this scenario, it is possible that the resultant environmental quality would more closely resemble that characterised as a 'moderate' level of ecological protection (i.e. MEPA).

The combined effect of the factors set out above creates some uncertainty as to whether the most appropriate EQP approach for the MWADZ Proposal should be based on a LEPA or MEPA. While not dismissing the potential applicability of the LEPA approach to the proposed MWADZ, the Department acknowledges this approach is built upon the worst case scenario and may not be the only viable approach. It recognises the uncertainty surrounding this matter and acknowledges the need to monitor and collect the relevant information necessary to remove this uncertainty.

Consequently, the Department now proposes a different approach in the EMMP for the MWADZ. This approach is iterative, informed by the results of the monitoring and other information gathered over time and aims to ascertain the most appropriate environmental management arrangements for the MWADZ Proposal. The approach includes the following key elements:

- Apply a MEPA approach to the EQP;
- Apply a 24,000 tonne standing biomass limit;
- Implement a specially-designed environmental monitoring program with the aim to acquire the scientific data necessary to clarify what EQP approach is the most appropriate for the MWADZ (noting this monitoring program is not intended to create an additional operational or financial burden to industry);
- Review all information collected over the first ten years[47] of commercial operations in the zone to clarify the continuing:
  - ✓ appropriateness of the current (MEPA) EQP approach;
  - ✓ environmental compatibility of the 24,000 tonne standing biomass limit for the MWADZ; and
- Subject to the outcomes of the review, thereafter, continue the iterative MWADZ management processes of monitoring, evaluation, review, planning and implementation conducted in consultation with industry and other relevant stakeholders.

It is important to note that, no matter what the outcome, the environmental monitoring program implemented for the MWADZ Proposal and the adaptive management tools available to the aquaculture operators (i.e. derived proponents) and the Department will ensure a rapid and effective response to the information gathered as aquaculture development in the zone progresses. Collectively, these arrangements will ensure both the environmental integrity of the Abrolhos Islands Fish Habitat Protection Area is preserved; and (within this imperative) the sustainable commercial aquaculture opportunities are maximised.

The EMMP (Appendix 2) for the MWADZ Proposal enables the MWADZ to be developed with greater certainty for the Government, the industry and the community.

The EMMP, coupled with the Management and Environmental Monitoring Plan (MEMP), will ensure the commitments in this PER, subsequent assessment reports and any approval or licence conditions are fully implemented.

The key objective of the EMMP is to ensure the MWADZ Proposal is sustainably managed and that its operation does not have a significant impact on the marine environment. The EMMP will provide an appropriate environmental quality management framework (EQMF) to manage the potential impacts of stocking up to 24,000 tonnes of marine finfish across the proposed MWADZ, using pelletised feeds. The aim is to make sure the MWADZ Proposal is managed to achieve the relevant Environmental Values (EVs) and Environmental Quality Objectives (EQOs), as outlined in EAG 15 and the State Water Quality Management Strategy (Government of Western Australia).

[47] By the tenth year of commercial operations in the MWADZ operators should have achieved a complete rotation of their sea cage cluster locations throughout their lease and be back at the (year 1) commencement site. They are also likely to be operating close to their maximum allocated standing biomass limits.

While all the EVs and associated EQOs for the marine waters of Western Australia have been addressed in this PER (Section 7.5), the key EQOs most relevant to this EMMP are:

- maintenance of ecosystem integrity; and
- maintenance of aesthetic values.

Maintenance of ecosystem integrity is concerned with maintaining the structure (e.g. the variety and quantity of life forms) and functions (e.g. the food chains and nutrient cycles) of marine ecosystems to an appropriate level. In this context, the EMMP includes strategies and contingency management responses to protect the key ecosystem elements (EPA 2015), taking into account their occurrence and sensitivity to aquaculture pressures. These key ecosystem elements include:

- water quality
- sediment quality
- seabirds
- marine mammals and turtles
- finfish (including sharks and rays)

Maintenance of aesthetic values is concerned with maintaining the visual qualities of the marine environment, including water clarity, odours and incidences of debris (EPA 2015). The monitoring and management frameworks for the ecosystem and aesthetic elements are outlined in the EMMP (Appendix 2).

16.3 Predicted Outcome

The EPA identified three key environmental factors for this proposal. The key environmental objectives for these factors are:

- *To maintain the quality of water, sediment and biota so that the environmental values, both ecological and social, are protected;*
- *To maintain the structure, function, diversity, distribution and viability of benthic communities and habitats at local and regional scales; and*
- *To maintain the diversity, geographic distribution and viability of fauna at the species and population levels.*

Within this PER and associated documents, the Department has addressed these objectives through considering the potential direct, indirect and cumulative environmental impacts of the MWADZ Proposal and comprehensively conducting the scope of work specified within the ESD. It has also addressed (EAG 8) environmental values and objectives (identified through public consultation) that are additional to those specified in the ESD; and conducted a similar assessment of their potential impacts, mitigation and management measures, and predicted outcomes. Although published over two years after the ESD was approved by the EPA, the provisions of the *Environmental Assessment Guideline for Protecting the Quality of Western Australia's Marine Environment* (EAG 15) has also been addressed in this PER. A summary of the EPA's policy and guidance documents, along with an outline of how and where they have been applied in this process, is listed in Table 1-1 of the PER.

Having completed the work outlined above, the Department concludes that all the EPA objectives have been adequately met. Further, that establishment of commercial marine finfish aquaculture projects within the proposed MWADZ is not expected to cause a significant environmental impact and will not result in a net environmental loss to the conservation values of the Abrolhos Islands Fish Habitat Protection Area or the associated Abrolhos Islands Reserve.

This assessment of the likely environmental impacts is due to several key factors, including:

- the zone's physical characteristics, in particular the high rates of flushing or water exchange in the Zeewijk Channel that is sufficient to dilute nutrients before they are assimilated by the ecosystem;
- the adaptive management controls and environmental monitoring framework the Department has developed for the zone, and the individual (derived) proposals within it, through the strategic assessment process for the MWADZ Proposal; and
- confidence in the effectiveness of these management controls and the environmental monitoring framework built upon the experience gained thus far through implementing similar arrangements in the Kimberley Aquaculture Development Zone.

The objectives described in this PER that have been established to determine the predicted environmental outcomes reflect the EP Act principle of conserving biodiversity and ecological integrity. This principle, in addition to the "precautionary" principle that is embodied in both the EP Act and the current FRMA is further reinforced in the *Aquatic Resources Management Bill 2015*.[48] The Department is the Western Australian Government agency responsible for the administration and implementation of the FRMA and is committed to adopting a conservative approach to managing uncertainties over environmental impacts. This will be achieved through the early consideration of the identified potential environmental impacts and additional cumulative impacts associated with the project proposals, and of the relevant management measures designed to control these.

Collectively, these factors underpin the Department's confidence that the MWADZ Proposal will be environmentally acceptable, subject to the effective implementation of the mitigation and management measures outlined in this PER and its associated documents.

The results from the environmental monitoring program and reviews of the effectiveness of the management plans, protocols and other mitigation measures will also provide valuable information to support evidence-based policy development for future sustainable marine finfish aquaculture production in Western Australia.

While not a consideration for the purposes of this environmental impact assessment, it should also be noted that there are other benefits to be gained by the Mid West region, the State of Western Australia and the nation through the implementation of the MWADZ Proposal.
The proposal will act as a catalyst for economic development as it will provide increased employment opportunities and use local goods and services, as well as provide the tourism industry with an opportunity to diversify experiences available to visitors.

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[48] The 'precautionary' principle, as specified in s.4A of the FRMA requires that: "*In the performance or exercise of a function or power under this Act, lack of full scientific certainty must not be used as a reason for postponing cost-effective measures to ensure the sustainability of fish stocks or the aquatic environment.*"

Ultimately, the MWADZ Proposal will become an increasingly valuable contributor to the future food security needs of Western Australia.

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18 APPENDICES

1. Modelling and Technical Studies in Support of the Mid West Aquaculture Development Zone (with the following accompanying appendices :)
    A. Marine Mammals;
    B. Endangered, Threatened and Protected Species;
    C. Fish and Fisheries;
    D. Seabirds;
    E. Peer Review;
    F. Hydro Model Calibration; and
    G. Diagenesis Calibration.

2. Mid West Aquaculture Development Zone Environmental Monitoring and Management Plan (EMMP) (with the following accompanying appendices :)

    A. Map of Sampling Site Co-ordinates; and
    B. Control Charting

3. Mid West Aquaculture Development Zone Management Policy (Draft) (ZMP)

4. Threat Identification, Hazard Pathway Analysis and Assessment of the Key Biosecurity Risks presented by the establishment of the Mid West Aquaculture Development Zone in Western Australia

5. Mid West Aquaculture Development Zone Marine Fauna Interaction Management Plan (MFIMP)

6. Mid West Aquaculture Development Zone Waste Management Plan (WMP)

7. Mid West Aquaculture Development Zone Environmental Scoping Document (ESD)

8. Environmental Protection Authority Checklist (for documents submitted for environmental impact assessment)