ATTACHMENT 5 – MWADZ EMMP

Government of **Western Australia**
Department of **Fisheries**

Mid West Aquaculture Development Zone Environmental Monitoring and Management Plan

Version 1

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Environmental Monitoring and Management Plan

Department of Fisheries Prepared by BMT Oceanica

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Quality Assurance

BMT Oceanica Pty Ltd has prepared this report in accordance with our Health Safety Environment Quality Management System, certified to OHSAS 18001, AS/NZS 4801, ISO 14004 and ISO 9001: 2008.

Approved for final release:

Author
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1. Purpose of this Plan

This document, the Environmental Monitoring and Management Plan (EMMP) (hereafter 'the Plan'), provides the Environmental Quality Management Framework (EQMF) for the Mid West Aquaculture Development Zone (MWADZ), situated in the Houtman Abrolhos Islands. The MWADZ is comprised of two areas: a northern area (2 200 ha), located roughly halfway between the Easter and Pelsaert groups and a southern area (800 ha), immediately north of the Pelsaert group (Figure 1.1).

The Plan is an interim plan designed to monitor the effects of aquaculture in the first five years of operation. The Plan will be reviewed and revised at the end of the five year period, or when production reaches 30% of the allocated standing biomass[1]. The overarching intent of the Plan is to protect sediment and water quality within the broader MWADZ to a level commensurate with the agreed levels of ecological protection (see Section 3) and to improve understanding of aquaculture / environmental interactions, particularly at the water / sediment interface.

The EPA's objective to maintain the diversity, geographic distribution and viability of marine fauna is addressed separately in the Marine Fauna Interaction and Management Plan (MFIMP) (DoF 2016). In addition, Appendix C of the EMMP details the overarching biosecurity requirements for the MWADZ. Any requirement to implement the EMMP is also considered to require derived proposals by proponents to implement the biosecurity measures. Noting that the Department of Fisheries is the agency responsible for aquatic biosecurity in Western Australia, proponents will be required under fisheries legislation to adhere to any additional biosecurity requirements placed on licence conditions or as a result of the tightening of biosecurity legislation under the recently passed Aquatic Resources Management Act 2016.

[1] *Whichever occurs first.*

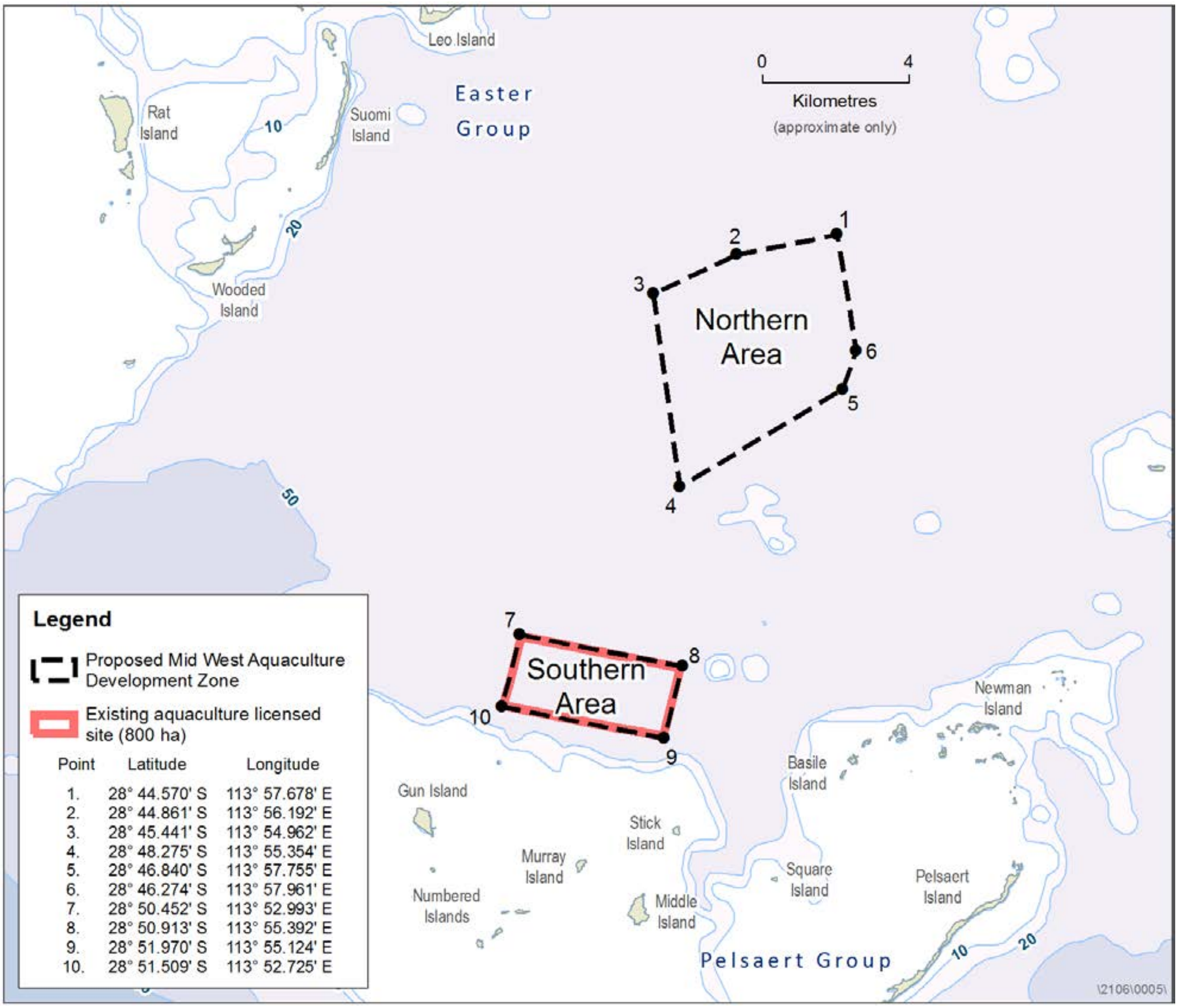


Figure 1.1 Location of the proposed Mid West Aquaculture Development Zone

2. Existing Marine Environment

The Houtman Abrolhos Islands (hereafter the 'Abrolhos Islands') are a group of islands located approximately 60 km west of Geraldton, Western Australia (WA). The islands are clustered into three main groups – Wallabi, Easter and Pelsaert, and collectively are approximately 100 km in length from the northern to the southern tip. Both the MWADZ and the broader Abrolhos region have high conservation status owing to their near-pristine marine environmental qualities and the high socio-economic importance of the area.

Sections 2.1 to 2.3 of this plan describe the existing marine environment, focusing specifically on the key environmental factors identified in the Environmental Scoping Document (Table 2.1).

Table 2.1 Key environmental factors and impacts identified in the Environmental Scoping Document

Key environmental factors	Key environmental impacts
• Hydrodynamics	• Alterations to hydrodynamics
• Marine water and sediment quality (including accumulation of trace contaminants)	• Degradation of marine water and sediment quality
• Marine flora and benthic primary producer habitat • Significant marine fauna • Marine benthic infauna and invertebrates	• Direct and indirect disturbance or loss of benthic communities and habitat • Direct and indirect impacts to key sensitive receptors • Impacts to marine environment and biota quality through release of pharmaceuticals, metals/metalloids and, or petroleum hydrocarbon • Direct and indirect impacts on significant marine fauna

2.1 Hydrodynamics

The MWADZ is located on the edge of the WA continental shelf between 28°S and 29°S, in the pathway of the warm poleward-flowing Leeuwin Current (Pearce 1997). It is also situated in the Zeewijk Channel, one of three breaks in the Houtman Abrolhos archipelago (Maslin 2005). The region surrounding the Abrolhos Islands is influenced by large-scale regional currents (e.g. Leeuwin Current, Capes Current), wind stresses, upwelling and wave dynamics (Pearce & Pattiaratchi 1999, Feng et al. 2007, Waite et al. 2007, Woo & Pattiaratchi 2008, Rossi et al. 2013). The Leeuwin Current is an oceanic flow of warm, low salinity tropical water (originating in the Timor Sea) that travels southwards along the Western Australian coast. It is driven by a southwards pressure gradient, and under the influence of Coriolis deflections, hugs the coastline as it travels from near North West Cape to Cape Leeuwin (south of Perth) and then onwards to the Great Australian Bight (Cresswell 1991).

The Leeuwin Current flow is strongest in autumn, winter and early spring. The flow is greatest and most consistently south along the shelf break, a relatively short distance to the west of the Abrolhos Islands (Webster et al. 2002). The currents 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 et al. 1999). During the winter months, strong westerlies and north-westerlies can generate southward setting currents through and inshore of the Abrolhos Islands (Pearce et al. 1999).

The waters of the MWADZ are well flushed. Their position within the Zeewijk Channel means that the area is exposed to significant westerly currents, which expel large volumes of water out of the zone toward the continental shelf slope (Maslin 2005). Differences in the hydrodynamics between the surface and bottom of the Zeewijk channel have been shown to affect particle transport times (Maslin 2005). Particles in the surface waters are expected to be expelled out of the system rapidly (within 24 hrs), while particles at the bottom of the water column may be retained in the system for longer periods, due to the recirculation of bottom currents (Maslin 2005).

2.2 Water and sediment

Waters inside the MWADZ are clean and well mixed (BMT Oceanica 2015). 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 oxygenated, achieving surface oxygen saturation levels between 96% and 99% and bottom oxygen saturation levels between 95% and 98% (BMT Oceanica 2015).

MWADZ water currents are variable, ranging between 5.8 and 14.4 cm/s. Concentrations of ammonium (2.7 µg/L) and chlorophyll-a (0.43 µg/L) are comparable to those recorded in Perth's coastal waters, pointing to an overall oligotrophic (nutrient poor) environment. Nitrite + Nitrate levels (12.9 µg/L) were higher than those recorded in Perth's coastal waters (6.5 µg/L) and in the KADZ (8.7 µg/L). Concentrations of inorganic nutrients and chlorophyll-a are seasonally variable, but are higher in the cooler months (BMT Oceanica 2015).

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 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, with generally higher values in the warmer months. Infaunal assemblages are diverse (10 phyla; 129 families) and dominated by polychaetes. Higher levels of infauna diversity and abundance are observed in the warmer months (BMT Oceanica 2015).

2.3 Benthic primary producing habitats

Surveys undertaken in 2014 indicate that the seafloor is a mosaic of habitats consisting of open sandy meadows and mixed biological assemblages (BMT Oceanica 2015), comprising 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 considered itinerant given their propensity to change significantly between surveys and over time (BMT Oceanica 2015).

Habitats in the northern MWADZ are more diverse and comprise 83% bare sand and 17% mixed assemblages. Small patches of reef were observed outside the north-east boundary of the MWADZ but make up only 8.5% of the total habitat within the study area. By contrast, the habitats in the southern area comprise 99% bare sand and 1% mixed assemblages. Although ephemeral seagrass communities have historically been observed in the MWADZ, no seagrasses were observed in the 2014/2015 assessment (BMT Oceanica 2015).

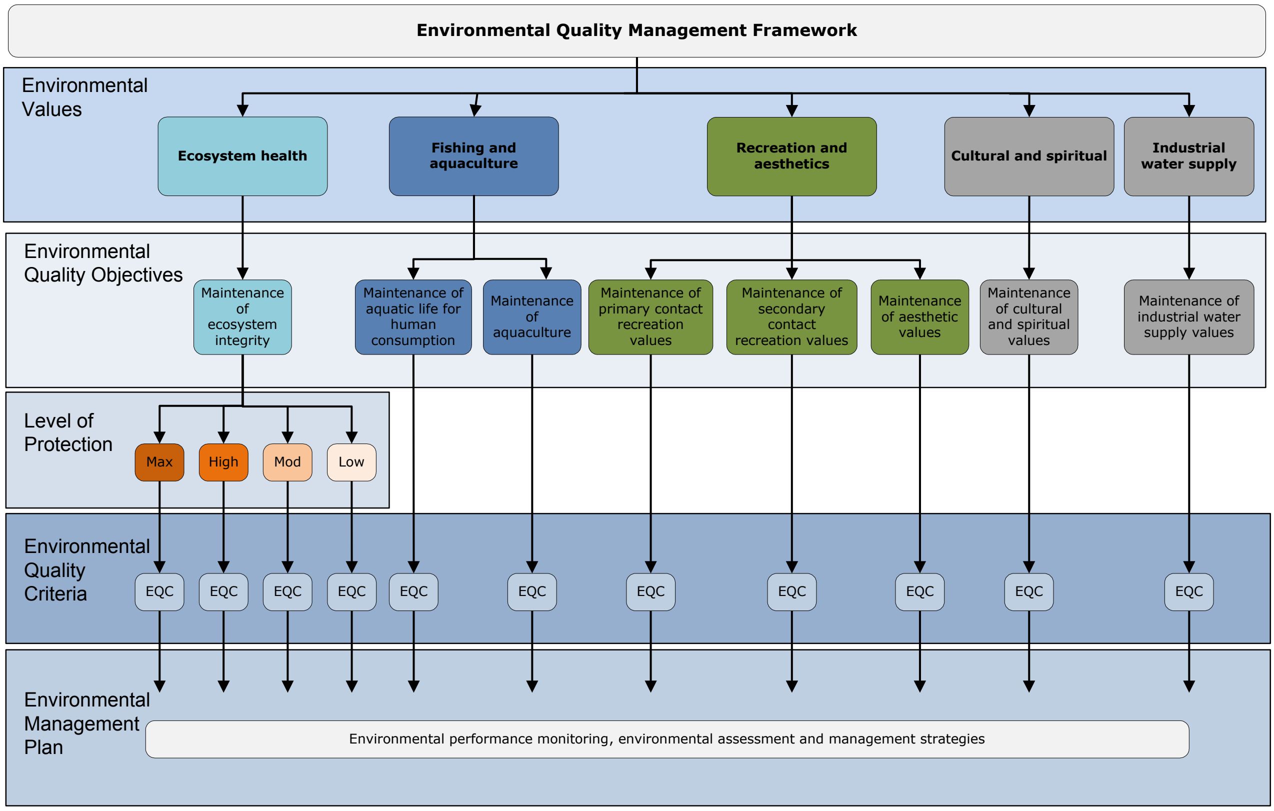
3. Environmental Management Framework

3.1 Values and objectives

Marine environmental management in WA is undertaken according to the EQMF described in EAG 15 (EPA 2015). The intent of the EQMF is that for each significant water body in WA a series of EVs with associated EQOs will be selected and applied in consultation with the community and stakeholders.

EVs refer to a particular value or use of the marine environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health, and which requires protection from the effects of pollution, environmental harm, waste discharges and deposits. The EQOs are high-level management objectives required to protect the EVs (EPA 2015) (Figure 3.1).

The objective of the EQMF is to ensure the marine environment is managed to achieve the relevant EVs and EQOs as outlined in Environmental Assessment Guideline (EAG) No. 15 (EPA 2015) and the State Water Quality Management Strategy (Government of Western Australia 2004) (Table 3.1).



Notes:

1. Modified from Figure 1 (page 7) of EPA (2015a)
2. EQC are environmental quality criteria (see Section 3.3)

Figure 3.1 Conceptual overview of the environmental quality management framework applied to Western Australia's marine environment

Table 3.1 Environmental values and environmental quality objectives

Environmental Values	Environmental Quality Objectives
Ecosystem health	1. Maintain ecosystem integrity at a maximum level of ecological protection 2. Maintain ecosystem integrity at a high level of ecological protection 3. Maintain ecosystem integrity at a moderate level of ecological protection 4. Maintain ecosystem integrity at a low level of ecological protection This means 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
Recreation and aesthetics	Water quality is safe for primary contact recreation (e.g. swimming and diving). Water quality is safe for secondary contact recreation (e.g. fishing and boating). Aesthetic values of the marine environment are protected.
Cultural and spiritual	Cultural and spiritual values of the marine environment are protected.
Fishing and aquaculture	Seafood (caught or grown) is of a quality safe for eating. Water quality is suitable for aquaculture purposes.
Industrial water supply	Water quality is suitable for industrial use.

Notes:

1. Modified from Table 1 of EPA (2015a)

3.2 Levels of ecological protection

Each of the EVs has a corresponding suite of EQOs. With the exception of the EV for Ecosystem Health, the EQOs are applied equally irrespective of the way the marine environment is utilised. The EV for ecosystem health is unique because it recognises 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 the competing environmental, societal and industrial uses of the marine environment, and allows for small localised effects (Table 3.2), while aiming to maintain overall environmental integrity (EPA 2015). This is important in the context of this Plan, 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.

Table 3.2 Levels of ecological protection linked to the environmental quality objective for maintenance of ecosystem integrity

Level of ecological protection	Environmental quality conditions (limit of acceptable change)	
	Contaminant concentration indicators	Biological indicators
Maximum	No contamination – pristine	No detectable change from natural variation
High	Very low levels of contaminants	No detectable change from natural variation
Moderate	Elevated levels of contaminants	Moderate changes from natural variation
Low	High levels of contaminants	Large changes from natural variation

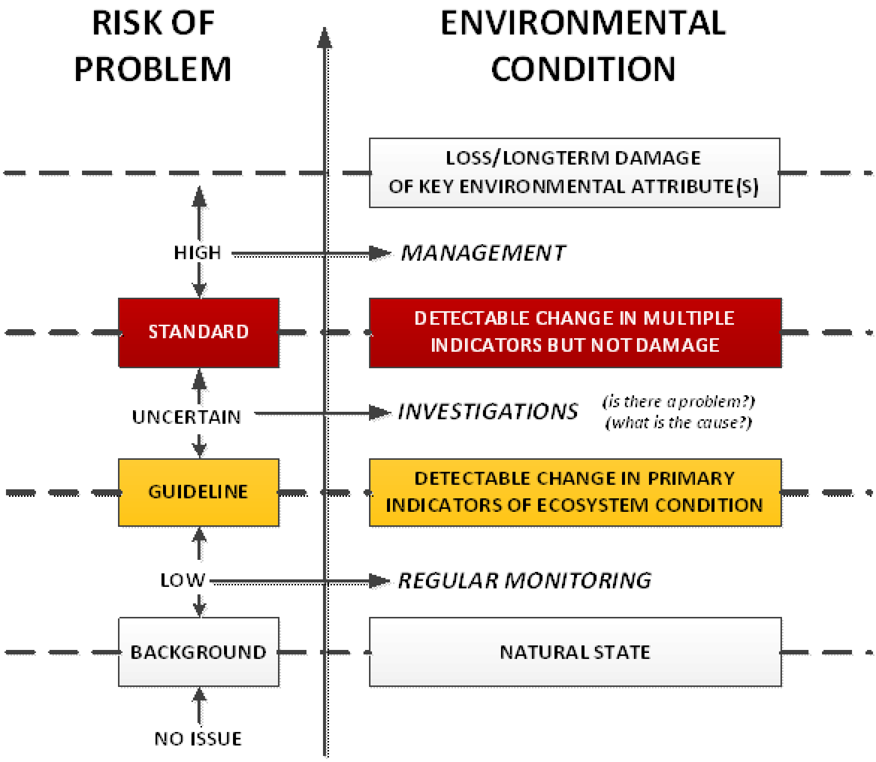
3.3 Environmental quality criteria

As per the EQMF, the extent to which the EQOs have been achieved will be assessed against agreed environmental quality criteria (EQC). The EQC provide the benchmarks against which environmental quality is measured (EPA 2015). The EQC are based on cause-effect-response relationships relating to the potential impacts (pressures) of the proposed activity, and to the specific environmental systems (response) where the activity will occur (EPA 2015).

The EQC define the limits of acceptable change in environmental quality. If the EQC are met, then it is assumed that the EQOs have been achieved. There are two levels of EQC:

- Environmental Quality Guidelines (EQGs) are threshold numerical values or narrative statements which if met indicate there is a high degree of certainty that the associated environmental quality objective has been achieved. If the guideline is not met then there is uncertainty as to whether the associated environmental quality objective has been achieved and a more detailed assessment against an environmental quality standard is triggered. This assessment is risk-based and investigative in nature; and
- Environmental Quality Standards (EQSs) are threshold numerical values or narrative statements that indicate a level which if not met indicates there is a significant risk that the associated environmental quality objective has not been achieved and a management response is triggered. The response would normally focus on identifying the cause (or source) of the exceedance and then reducing loads of the contaminant of concern (i.e. source control) and may also require in situ remedial work to be undertaken.

The conceptual framework for applying the EQC is illustrated in Figure 3.2.



Notes:

1. Adapted from Figure 3 (page 14) of EPA (2015a)

Figure 3.2 Conceptual framework for applying the environmental quality guidelines and standards

3.4 Applying the environmental management framework

3.4.1 Environmental pressures of aquaculture

The potential for adverse effects in the first five years of operation has been considered in the context of the key environmental factors and impacts outlined in the ESD (Table 2.1). Strategies for monitoring and managing the potential effects of aquaculture operations are outlined in Section 4.

Sea-cage infrastructure and feeding

In the first five years of operation, it is expected that the MWADZ will house a series of floating sea cages, all securely anchored to the seafloor. Of the potential physical pressures imparted by the sea cages (i.e. changes to hydrodynamics and benthic scouring) none present residual risks with ongoing needs for environmental monitoring (BMT Oceanica 2015).

Sediments

Finfish 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), resulting in smothering, increased nutrient loads and changes to infauna communities (Baden et al. 1990, Hargraves et al. 2008, Schaffner et al. 1992). Modelling predicted that smothering would result in localised impacts immediately beneath and adjacent to sea-cages.

Heavy metals form a small constituent of aquaculture feeds which are consumed and excreted in the faeces. A review of the metal content of trout faeces by Moccia et al. (2007) found that copper, iron and zinc were present in the highest proportions, although overall concentrations were low. Despite the low concentrations in commercial feeds, monitoring in Tasmanian waters has recorded copper and zinc values at concentrations higher than the ANZECC & ARMCANZ (2000) ISQG-low and ISQG-high guideline values at some sea-cage sites (DPIPWE 2011). The EIA for this proposal found that metal in feeds posed a very low risk to the marine environment.

In addition to contributing organic wastes, aquaculture may contribute pharmaceuticals to the marine environment. Antibiotics are used to treat bacterial disease occurring in farmed fish and are generally administered in feed. Antibiotics may impart pressure on the environment by reducing or changing numbers of sediment bacteria, which in turn may affect biochemical and/or broader ecological processes. The persistent use of antibiotics has also been shown to lead to bacterial resistance (Anderson and Levin 1999).

In the treatment of farmed salmon in Tasmania, oxytetracycline is the most common antibiotic used, accounting for more than 70% of total antibiotic use during 2006–2008 (Parsons 2012). A strong seasonal component to the use of antibiotics has been noted in Tasmania, with the greatest requirement in the summer months when water temperatures are elevated and pathogens most virulent. Oxytetracycline has been found to persist in marine sediments beneath sea cages for up to twelve weeks, with a half-life of ten weeks (Jacobsen and Berglind 1988). However, traces of the drug may be present for up to two years after treatment (Lalumera et al. 2004). It is also relatively persistent to anoxic conditions which are common under sea-cages (Jacobsen and Berglind 1988). Because antibiotics are administered in feeds, the spatial extent of potential impacts is likely to be reflected in the settlement patterns of organic wastes. Modelling predicted that the majority of wastes[2] in the MWADZ would be deposited to the seafloor within 60 m of the sea-cages[3]. If antibiotics are required, it would be administered for short periods of time. The strongest effects of antibiotics could last for up to 10 weeks but are likely to be constrained to relatively small areas.

Water Column

Sea-cage aquaculture contributes inorganic nutrients to the water column either directly through secretion of ammonia by fish, or indirectly through organic matter deposition and remineralisation and the sea-floor level. Inorganic nutrients (ammonia, nitrite + nitrate and orthophosphate) may lead to adverse environmental effects via a number of cause-effect-response pathways (Figure 3.3). For example, nutrients may be assimilated directly by phytoplankton and/or other photosynthetic organisms, leading to shading effects, phytoplankton blooms or the proliferation of ‘nuisance’ epiphytes.

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[2] *As represented by the Zone of High Impact*

[3] *After 3 years production*

Sea-cage aquaculture may also lead to an increase in the concentration of suspended organic particles (volatile suspended solids (VSS)) in the water column (Figure 3.4). Once deposited to the seafloor, a proportion of these wastes may be resuspended, creating scope for mechanical interference to filter feeding processes, disease, or reduction of photosynthetic pathways particularly at depth (via shading) (Erftemeijer et al. 2012). The deposition of organic material may also lead to dissolved oxygen drawdown in the water column as biological respiration increases in response to increased sediment nutrient loads (Gray 1992). Episodes of hypoxia or anoxia can subsequently cause loss of benthic populations, changes in benthic communities, or reduced growth rates (Forbes & Lopez 1990, De Zwann et al. 1992, Josefson & Jensen 1992, Stachowitsch 1992, Gaston & Edds 1994, Forbes et al. 1994).

The potential for the MWADZ to adversely affect the local and regional marine environment was evaluated using an integrated environmental model (BMT Oceanica et al. 2015). Deposition of organic material was predicted to lead to changes in sediment oxygen and sulphide concentrations beneath the sea-cages. Results indicated that the size of the impact was related to stocking density and the duration of operations (BMT Oceanica 2015).

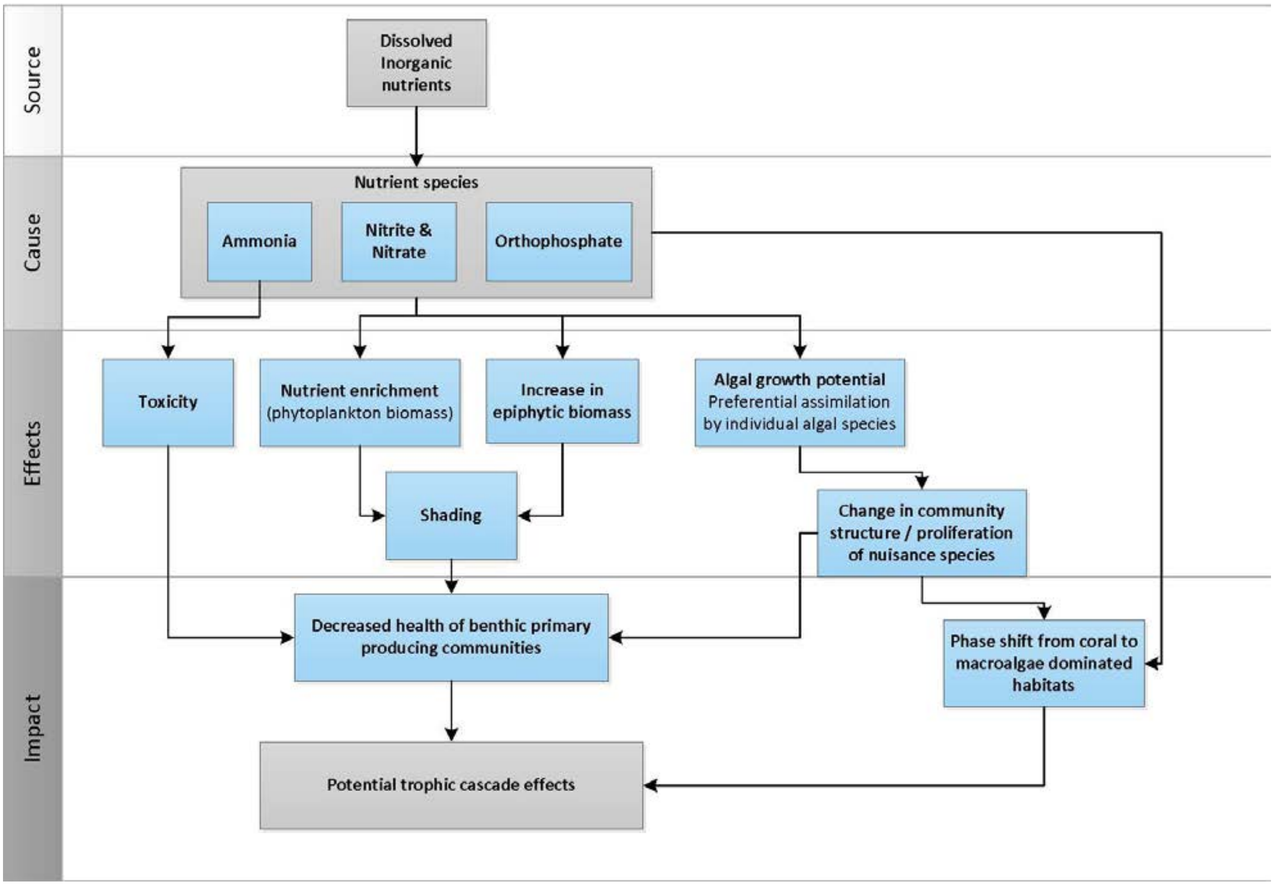
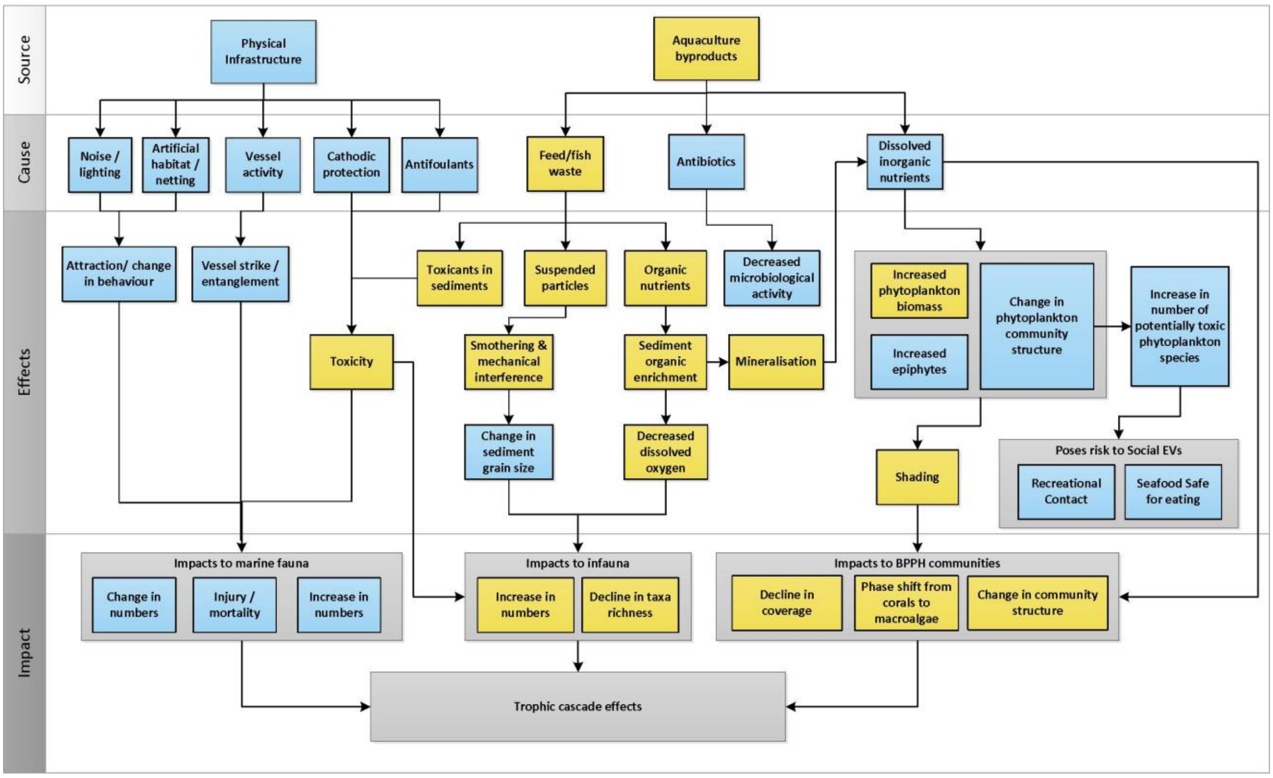


Figure 3.3 Cause-effect-response pathways relevant to inorganic nutrients

Concentrations of dissolved inorganic nitrogen (DIN) down-current of the sea-cages were predicted to increase with increasing finfish biomass (BMT Oceanica 2015). However, concentrations diluted rapidly and were generally commensurate with a high level of ecological protection by the time they reached the MWADZ boundary (BMT Oceanica 2015). Because of the lag-effect, any increase in chlorophyll-a attributable to aquaculture activities could be expected to occur down-current and away from the sea cages. Although aquaculture operations present conditions under which phytoplankton may flourish, none of the modelled scenarios predicted increases in chlorophyll-a concentrations within the modelled domain (BMT Oceanica 2015).

3.4.2 Cause-effect-response relationships

An important consideration in the building of this Plan was to understand and document the key environmental cause-effect-response pathways i.e. the key aquaculture / environmental interactions (Figure 3.4). The objective was to identify the key stressors and their effects, based on the risks identified in Section 3.4.1. The understanding gained by this process was used to identify the indicators and receptors that form the EQC in this Plan.



Notes:

1. Key cause-effect-response pathways. Pathways shown in yellow represent those for which EQC were developed.

Figure 3.4 Hierarchical stressor model showing the cause-effect pathways of most concern and the receptors potentially impacted by aquaculture

3.4.3 Environmental quality criteria (EQC) for aquaculture

EQC were derived based on the key environmental pressures identified in Section 3.4.1 and the cause-effect pathways shown in Figure 3.4. All EQC in this Plan relate to the EQOs for Maintenance of Ecosystem Integrity and Maintenance of Aesthetic values. The EQC for ecosystem integrity are highly conservative, and by meeting these triggers it is expected that the EQOs for the other EVs, Fishing and Aquaculture, Recreation and Aesthetics, Cultural and Spiritual and Industrial Water Supply, will also be met.

Table 3.3 Measurable indicators used to derive the environmental quality criteria

Source / Cause	Monitoring	EQG	EQS
• Aquaculture feeds • Finfish wastes • Inorganic nutrients • Organic nutrients	Water quality	Light attenuation coefficient	BPPH community health Infauna community diversity Video assessment
		Volatile suspended solids	
		Chlorophyll-a	BPPH community health
		Dissolved oxygen	Surface-bottom dissolved oxygen BPPH community health Infauna community diversity Video assessment
	Sediment	Total nitrogen	Surface-bottom dissolved oxygen BPPH community health Infauna community diversity Video assessment
		Total phosphorus	
		Total organic carbon	
		Copper	Infauna community diversity
		Zinc	
• Physical infrastructure • General operations • Finfish and other wastes • Litter and spills	Aesthetics	Nuisance organisms	Community perception
		Faunal deaths	
		Water clarity (qualitative)	
		Colour	
		Surface films / debris	
		Reflectance	
		Odours	

Notes:

1. BPPH = benthic primary producing habitats

3.4.4 LEP applied in this Plan

The EQO for maintenance of ecosystem integrity requires the spatial definition of up to four levels of ecological protection (LEP) – maximum, high, moderate and low (Section 3.2). The rationale for the 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 or adjacent to sea cages.

Guidance provided by the EPA suggests that sea cage aquaculture in Western Australia should be managed to achieve a 'moderate' LEP (LEP) (Table 3, EAG 15). For this LEP, EPA specifies the following limits of acceptable change:

- small changes in rates but not the type of ecosystem processes
- biodiversity as measured on both local and regional scales remains at natural levels
- small changes in abundances and/or biomasses of marine life; and
- moderate changes beyond limits of natural variation

Environmental modelling undertaken for this project (BMT Oceanica 2015) predicted that organic enrichment resulting from aquaculture would be locally constrained, with no resulting regional scale adverse effects (BMT Oceanica 2015). Based on this, it is proposed to establish moderate ecological protection areas (MEPAs), each of 300 m radii, 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 the MEPA, including sensitive BPPHs. The spatial arrangement of the LEPs to be applied in the MWADZ is illustrated in Figure 3.5.

A key strategy for mitigating the potential for organic enrichment is for operators to implement a program of routine (or reactive) fallowing (see Section 7.1.1), which may involve relocation of infrastructure to another site. Relocation of infrastructure for the purposes of fallowing will inevitably result in duplication of MEPAs, while the original site(s) recover.

The PER for the MWADZ assessment determined that the zone of high impact (ZoHI), under 24 000 tonnes standing biomass, would occupy a maximum area of 62 ha, or roughly 12% of the cumulative MEPAs. When tripled to account for a maximum 2:1 ratio of 'fallowed' to 'operational' areas, the total area occupied by the ZoHI increases to 186 ha.

DoF will manage the ZoHI to levels <186 ha by restricting the total area occupied by operational and fallowed MEPAs to <1500 ha. For auditing purposes, derived proponents will be required to demonstrate the total area occupied by MEPAs, encompassing both recovering and existing cage clusters sites, is less than the 1500 ha threshold at all times.

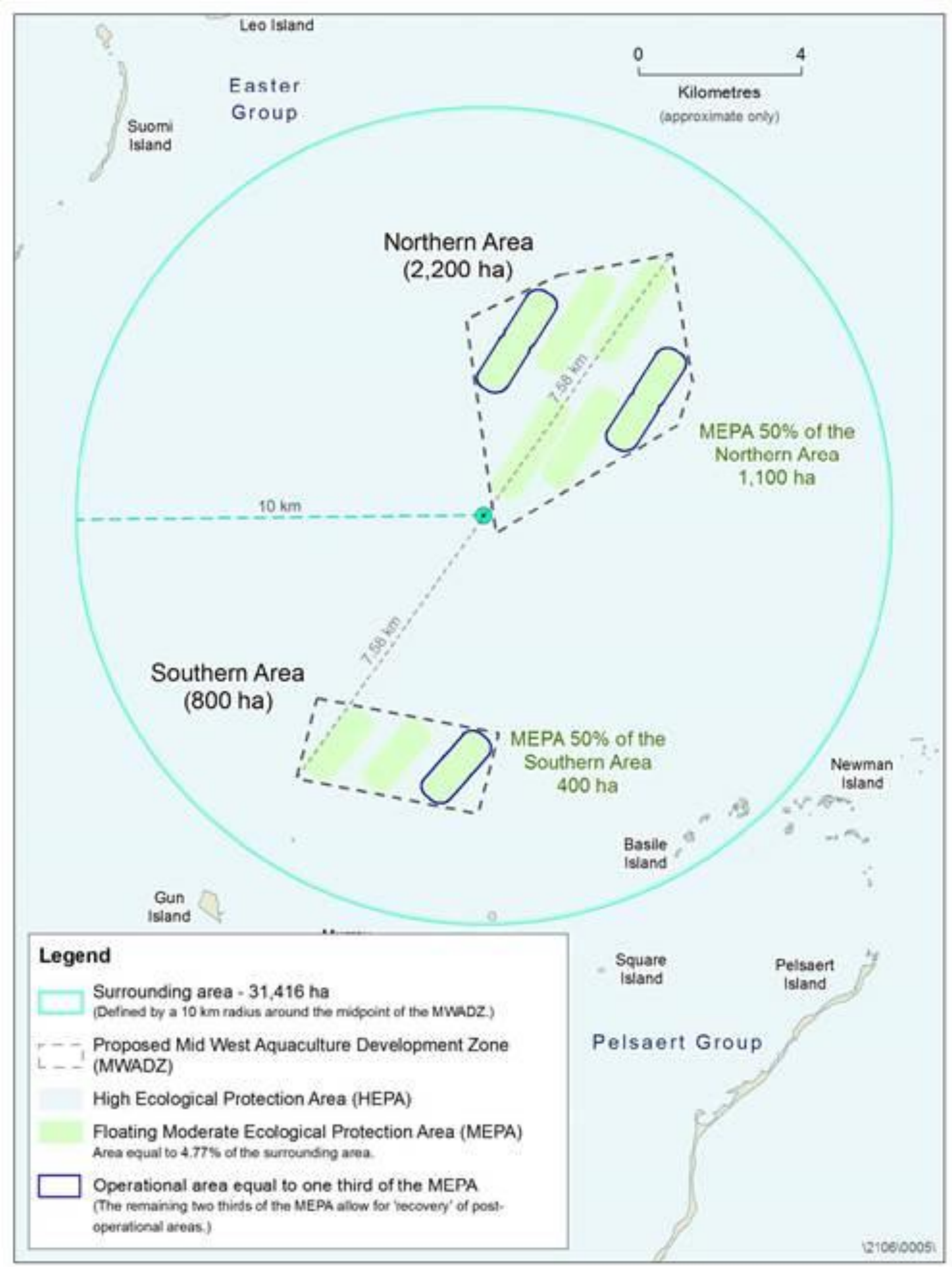


Figure 3.5 Environmental Quality Plan (EQP) for the MWADZ and surrounds.

The locations of the MEPs are conceptual, but will be contained within the northern and southern areas of the MWADZ and not exceed 50% of the area in each. Note: the MEPAs and HEPA shown in the EQP relate to the EV of 'Ecosystem Health'. All social use EVs ('Fishing and Aquaculture', 'Recreation and Aesthetics', 'Cultural nand Spititual' and 'Industrial Water Supply') apply throughout the MWADZ and surrounds.

4. Environmental Monitoring

4.1 Water quality

4.1.1 Objectives

The objective of the water quality monitoring program is to provide data for the assessment of the EQG and EQS in the moderate and high ecological protection areas, and to determine the gradient of effect down-current from the sea cages. Sampling is to be conducted at a series of sites, including seven 'information gathering' sites and up to twelve 'compliance' sites.

Compliance sites are the responsibility of the Proponent, whereas information gathering sites will be the responsibility of the Department of Fisheries. The program's design allows for scaling of effort such that sites are added to the program as production increases, or at the completion of the five year interim period (whichever occurs first). All monitoring sites and all relevant information collected from monitoring sites will be used to assess trends, and compared against relevant criteria to trigger management and demonstrate/evaluate compliance within prescribed limits.

4.1.2 Timing

Water quality sampling will be conducted at monthly intervals between February and April (three times in total), capturing the autumn season, and at monthly intervals between July and September (three times in total), capturing the late winter season.

4.1.3 Program design

Dissolved oxygen and VSS

DO and VSS samples for compliance and information gathering purposes will be undertaken at fixed distances either side of the sea-cages (centre of cluster, then 25, 50 and 100 m from the edge of the sea cages). Sampling will be undertaken parallel with the prevailing current as predicted by modelling, and verified using situ measurements (Figure 4.1). Sampling is restricted to a maximum distance of 100 m in the first 5 years, but will be expanded in the event an exceedance is detected at this distance (see Figure 6.1). To enable comparisons with background levels, sampling for DO and VSS will be undertaken at the nearest four reference sites (Figure 4.1). Reference site coordinates are provided in Appendix A.

Chlorophyll-a and light attenuation coefficient sampling design

The program for chlorophyll-a and LAC was developed based on the assumption that any signature attributable to aquaculture will not be immediately detectable, and will unlikely be detectable in close proximity to the sea cages. Sampling will be undertaken at six compliance sites around the northern zone boundary and four compliance sites around the southern zone boundary[4] (Figure 4.1) all of which are required to achieve a high LEP. To enable comparison with background levels, sampling for chlorophyll-a and LAC will also be undertaken at the four reference sites nearest to the Area occupied (Figure 4.1). Zone and Reference site coordinates are provided in Appendix A.

Chlorophyll-a samples are to be collected in duplicate. While both chlorophyll-a samples will be frozen prior to analysis, only one of the samples will be analysed immediately. The other will be stored as a back-up sample.

[4] *If only one zone is occupied, then Zone boundary compliance sampling will be restricted to the boundary of that zone. Once both zones (northern and southern areas) are operational, then monitoring will be undertaken at the boundaries of both zones. Proponents will be responsible for monitoring the boundaries of the zones in which they hold leases.*

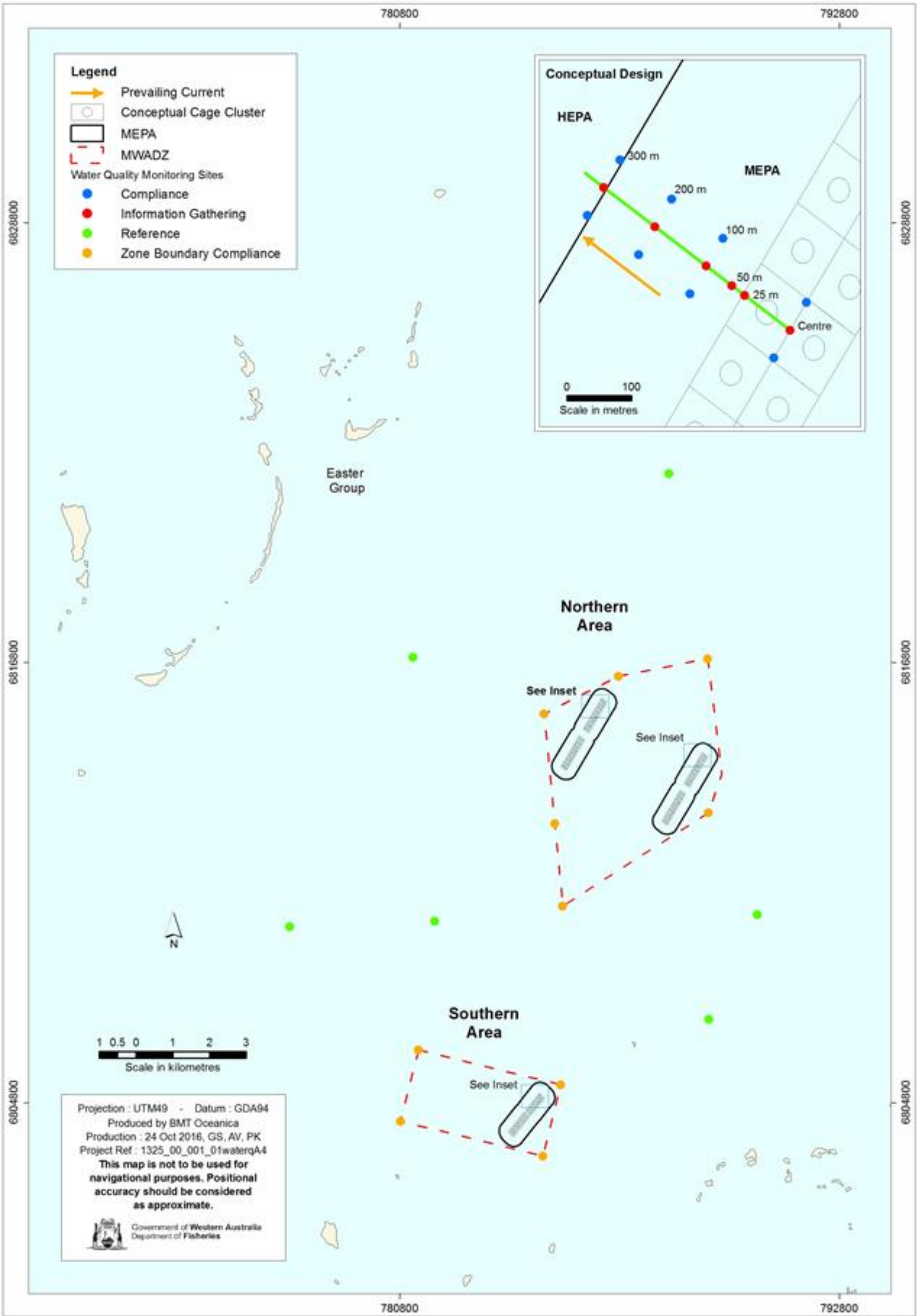


Figure 4.1 Water quality monitoring sites

4.1.4 Approach to sampling

The suite of parameters to be sampled on each occasion is detailed in Table 4.1.

Table 4.1 Water quality parameters to be sampled on each occasion

Protection zone	Parameters			
	VSS	DO	LAC	Chlorophyll-a
MEPA	✓	✓	-	-
Zone boundary (HEPA)	-	-	✓	✓
Reference	✓	✓	✓	✓

Notes:

1. VSS = volatile suspended solids; LAC = light attenuation coefficient; DO = dissolved oxygen

Dissolved oxygen and light attenuation coefficient sampling methods

DO measurements will be taken approximately 50 cm from the bottom using a calibrated water quality sensor. LAC measurements will be conducted using one light sensor positioned ~1 m below the surface and the second ~1 m from the bottom. The light attenuation coefficient (LAC) should be calculated as the difference between the logarithim$_{10}$ of irradiance values at each depth according to the equation:

$$\textit{Light Attenuation Coefficient}\ (\text{LAC}) = (\log_{10} I_1 - \log_{10} I_7)/(z-1)$$

Volatile suspended solids and chlorophyll-a sampling methods

Measurements of VSS and chlorophyll-a will be taken ~50 cm beneath the surface of the water column and ~50 cm from the bottom of the water column, being careful not to disturb the seabed during sampling. Standard laboratory analytical procedures will be employed throughout and all sampling and analyses undertaken according to NATA-accredited methods.

4.1.5 EQC

The EQG and EQS for water quality are provided in Table 4.2 and Table 4.3, respectively. The EQG provide early warning of environmental change and focus on primary (VSS and LAC) and secondary effects (DO and chlorophyll-a) along the cause-effect-response pathways.

As the ammonia fraction of DIN is rapidly assimilated by phytoplankton[5], the potential for adverse effects resulting from inorganic nutrients will be assessed against the EQG for nutrient enrichment, following EPA (2015b). In some instances, the EQS have multiple criteria. The EQS will be exceeded if one or more of the criteria is exceeded. Details on how to apply the EQG and the EQS are provided in Section 5.

[5] *Microscopic algae in the water column*

Table 4.2 Environmental quality guidelines for water quality

Effect	EQG[1]	High Protection	Moderate Protection
Shading & smothering	VSS	Median VSS at any MEPA site located 100m from sea cages, over a three month period, must be less than the 80th %ile of reference site data[3]	Median VSS at any MEPA compliance site, over a three month period, must be less than the 95%ile of reference site data.
	LAC	(i) Median LAC at any MEPA site located 100m from sea cages, over a three month period, must be less than the 80th %ile of reference site data[3]. (ii) Median LAC over a three month period, at any Area (HEPA) compliance site, must be less than the 80th %ile of reference site data.	N/A[1]
Nutrient enrichment	Chl-a	(i) Median chlorophyll-a at any MEPA site located 100m from sea cages, over a three month period, must be less than the 80th %ile of reference site data[3]. (ii) Median chlorophyll-a at any Area (HEPA) compliance site, over a three month period, must be less than the 80th percentile of reference site data.	N/A[1]
Physical & chemical stressors	DO	The median DO concentration in bottom waters at any MEPA compliance site located 100m from sea cages, calculated over a one week period, must be greater than 90% saturation[2].	The median DO concentration in bottom waters at a MEPA compliance site, calculated over a one week period, must be greater than 80% saturation.

Notes:

EGQ = environmental quality guideline; VSS = volatile suspended solids; LAC = light attenuation coefficient; DO= dissolved oxygen

1. Assessed at Zone boundary (HEPA) compliance sites
2. Assessed at the MEPA site 100m from sea cages as a surrogate assessment against the high protection criteria.

Table 4.3 Environmental quality standards for water quality

Effect	EQS[2]	High Protection	Moderate Protection
Shading & smothering	VSS	(i) No detectable change in the % abundance and/or species richness of BPPH at the MEPA/HEPA boundary relative to reference sites, or the earlier baseline assessments, as determined via (video based) quantitative methods. (ii) Video surveys undertaken at the MEPA/HEPA boundary shall not record the presence of bacterial mats (*Beggiatoa* spp.) or spontaneous outgassing of hydrogen sulphide, relative to earlier baseline assessments.	(i) The median DO concentration in bottom waters at a MEPA compliance site, calculated over a one week period, must be greater than 60% saturation, and not the result of a regional event as indicated by similar reductions in DO at the reference sites. (ii) The number of infauna families recorded (across pooled MEPA sites) is not to be different from the number of families recorded during baseline surveys, or relative to the reference sites in two consecutive sampling events. (iii) Video surveys undertaken under or at any distance from the sea-cages shall not record the presence of bacterial mats (*Beggiatoa* spp.) or spontaneous outgassing of hydrogen sulphide, relative to earlier baseline assessments.
	LAC	(i) No detectable change in the % abundance and/or species richness of BPPH at the MEPA/HEPA boundary relative to reference sites, as determined via (video based) quantitative methods.	N/A[1]

Nutrient enrichment	Chl-a	(i) No detectable change in the % abundance and/or species richness of BPPH at the MEPA/HEPA boundary relative to reference sites, or the earlier baseline assessments, as determined via (video based) quantitative methods.	N/A[1]
Physical & chemical stressors	DO	(i) No detectable change in the % abundance and/or species richness of BPPH at the MEPA/HEPA boundary relative to reference sites, or the earlier baseline assessments, as determined via (video based) quantitative methods. (ii) Video surveys undertaken at the MEPA/HEPA boundary shall not record the presence of bacterial mats (*Beggiatoa* spp.) or spontaneous outgassing of hydrogen sulphide, relative to earlier baseline assessments.	(i) The median DO concentration in bottom waters at a MEPA compliance site, calculated over a one week period, must be greater than 60% saturation, and not the result of a regional event as indicated by similar reductions in DO at the reference sites. (ii) The number of infauna families recorded (across pooled MEPA sites) is not to be different from the number of families recorded during baseline surveys, or relative to the reference sites in two consecutive sampling events. (iii) Video surveys undertaken under or at any distance from the sea-cages shall not record the presence of bacterial mats (*Beggiatoa* spp.) or spontaneous outgassing of hydrogen sulphide, relative to earlier baseline assessments.

Notes:

EQS = environmental quality standard; VSS = volatile suspended solids; LAC = light attenuation coefficient; DO = dissolved oxygen.

1. Assessed at Zone boundary (HEPA) compliance sites

4.1.6 Reporting

All records associated with the water quality monitoring program, including the results of statistical analyses and assessments against the EQC, will be included in the Annual Compliance Report (see Section 8.1). Any exceedances of the EQS shall be reported to the OEPA and the DoF within 7 days of first detecting the exceedance.

4.2 Sediment quality

4.2.1 Objectives

The objective of the sediment quality monitoring program is to provide data for the assessment of the EQG and EQS in the moderate ecological protection area, and to determine the gradient of effect down current from the sea-cages. Sampling is to be conducted at a series of sites, including up to seven 'information gathering' sites and six 'compliance' sites within the MEPA.

Compliance sites are the responsibility of the Proponent, where as information gathering sites will be the responsibility of the Department of Fisheries. The program's design allows for scaling of effort such that sites are added to the program as production increases, or at the completion of the five year interim period (whichever occurs first). All monitoring sites and all relevant information collected from monitoring sites will be used to assess trends, and compared against relevant criteria to trigger management and demonstrate/evaluate compliance within prescribed limits.

4.2.2 Timing

Consistent with the water quality sampling, sampling for nutrients and metals will be undertaken at monthly intervals (three times) in autumn (February to April) and again at monthly intervals in late winter (July to September). Sampling for infauna will be undertaken once at the beginning of the autumn season and again at the end of the autumn season.

4.2.3 Program design

Sampling will be undertaken at fixed distances either side of the sea-cages (centre of cluster, then 25, 50 and 100 m from the edge of the sea cage). Sampling will be undertaken parallel with the prevailing current as predicted by modelling, and verified using in situ measurements (Figure 4.2). Sampling is restricted to a maximum distance of 100 m in the first 5 years, but will be expanded in the event an exceedance is detected at this distance (see Figure 6.1). To enable comparisons with background levels, sampling will also be undertaken at the nearest four reference sites (Figure 4.2). Reference site coordinates are provided in Appendix A.

Cage cluster design is likely to vary between operators within the Zone. To allow the overarching EMMP program design to address this potential inconsistency, monitoring sites will be located to ensure monitoring is undertaken where environmental pressures are greatest.

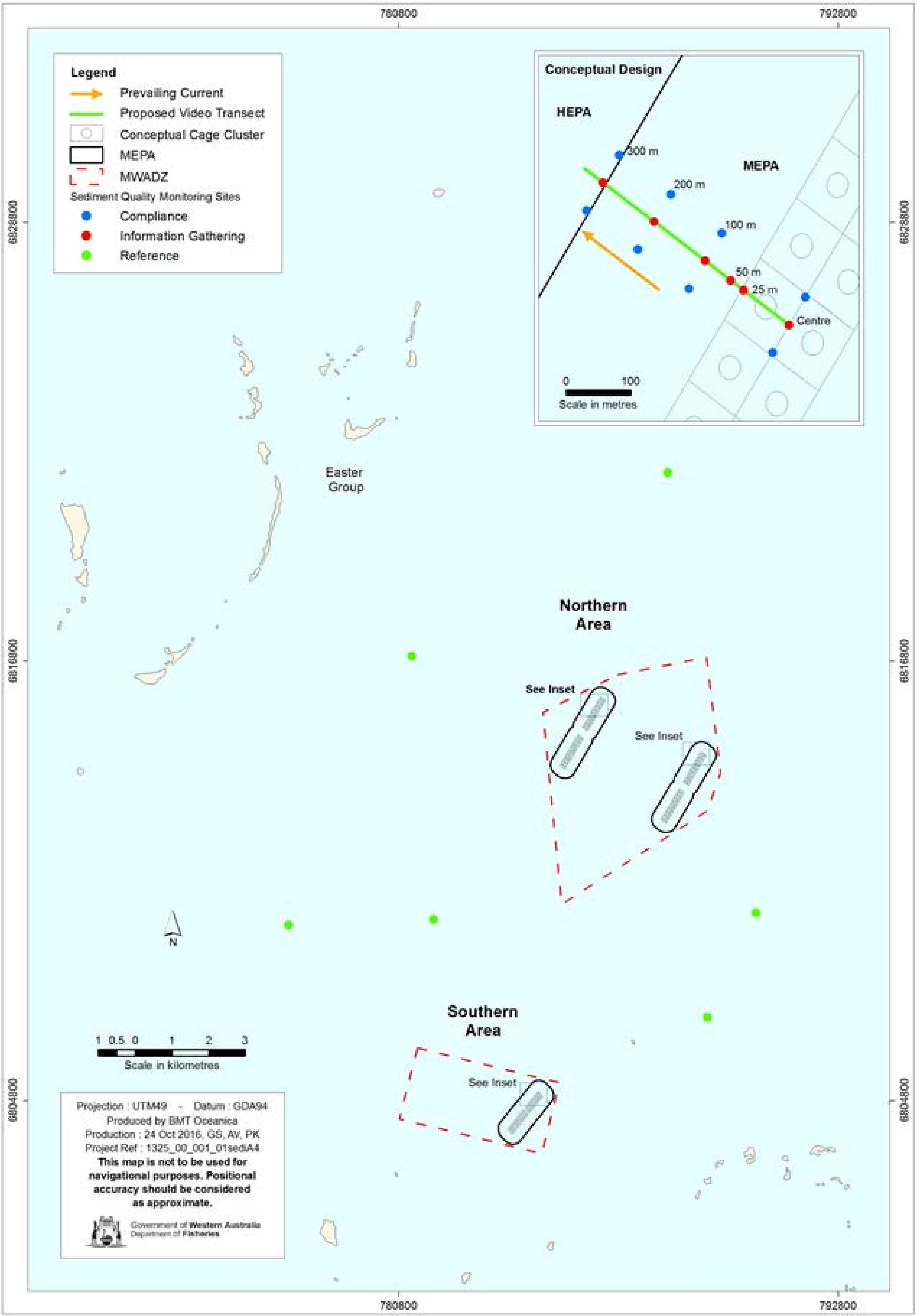


Figure 4.2 Sediment quality and infauna monitoring sites

4.2.4 Approach to sampling

The suite of parameters to be measured on each sampling occasion is detailed in Table 4.4.

Table 4.4 Sediment quality parameters to be measured on each sampling occasion

Protection zone	Parameters					
	TN	TP	TOC	Copper	Zinc	Infauna
MEPA	✓	✓	✓	✓	✓	✓
Reference	✓	✓	✓	-	-	✓

Notes:

1. TN = total nitrogen; TP = total phosphorus; TOC = total organic carbon
2. Infauna to be sampled once at beginning of autumn and once at the end of autumn

Sediment samples will be collected using protocols modified from EPA (2005) . Sample analysis will be undertaken by NATA-accredited laboratories and will achieve limits of reporting (LOR) equal to or less than the ANZECC/ARMCANZ (2000) sediment quality guidelines. Where concentrations are less than the LOR, the LOR will be used in the calculations.

Nutrients and metals

Sediment samples for nutrients and metals will be collected using a Van Veen or equivalent grab sampler. Grab sampling devices are necessary given the depth of MWADZ waters and the coarseness of sediments, both of which prevent the use of EPA (2005) recommended coring devices. While grab devices are practical tools, they are often let down by an inability to capture the 'fines' component of sediments. To prevent the escape of 'fines', OEPA has recommended the grab is initially immersed in a water filled container, before being brought aboard the vessel. Using this approach, the grab and the water filled contained would be pulled onto the vessel, keeping the fines in suspension to effectively preventing their escape.

Nutrients will be sampled at MEPA compliance sites and the nearest four reference sites. Metals will be sampled at MEPA compliance sites only (Table 4.4). A minimum[6] of three grabs incorporating the upper 2 cm of sediment will be taken at each site. Each of the grabs shall be homogenised to form one sample as shown in Figure 4.3. The sample will be divided into identical aliquots for nutrient analysis and metals analysis. All aliquots will be frozen for transport to the laboratory, but only half of the subsamples will be analysed immediately. The other half are to be retained as a back-up samples (see Section 5.2).

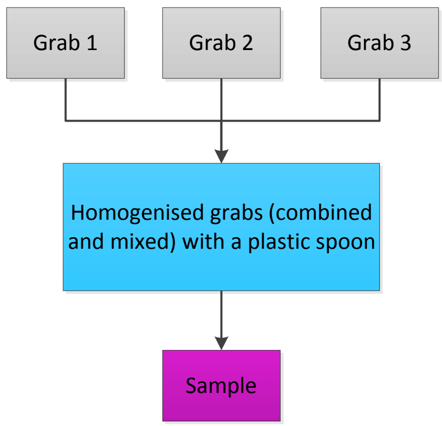


Figure 4.3 Sampling protocol for sediment

[6] *It may be necessary to use more than two grabs if two grabs fails to yield enough sample for analysis. Whatever the requirement, the number of grab samples should be kept consistent.*

Infauna sampling methods

Sampling for infauna will be undertaken once at the beginning of the autumn season and again at the end of the autumn season. The approach to sampling is largely same as that applied to sediment sampling, except that sampling will also be undertaken at the nearest four reference sites (Figure 4.2). At each site, operators are required to collect four Van Veen grabs, each incorporating the upper 2-5 cm of sediment. Unlike the approach to sediment sampling, the grab samples shall be brought aboard the vessel immediately, with no requirement to immerse the sampling device in a water filled container. Following collection, the contents of two of the grabs will be consolidated to form one sample, and the content of the other two, to form another. The content of one of the samples will be gently washed through a series of graded sieves (1-4 mm). Any material retained on the sieves will be fixed in 10% formalin in seawater. This process should then be repeated for the other sample. One of the samples will be sent to the laboratory, and the other stored for later analysis as necessary (see Section 5.2). Infauna samples will be processed by laboratories specialising in invertebrate taxonomy. Individual organisms will be identified to family level and counts of each taxonomic group will be recorded.

Although best-practice is to enumerate the number of infauna families present using standard microscopy, it is also recognised that the process is costly and laborious. In the last five years there has been significant progress in 'eDNA' techniques. These methods offer potentially accurate, cost effective and rapid assessments of infauna taxonomy, particularly if only presence/absence resolution is required. It is recommended that future Proponents investigate the viability of the method and possibly look to use it as an alternative to the approach described above.

4.2.5 EQC

The EQG and EQS for sediments are outlined in Table 4.5 and Table 4.6 respectively. In the first five years of operation, EQG for sediments are restricted to the MEPA in recognition of the point source nature of aquaculture, together with the expectation that effects will commence under the cages before gradually extending beyond the cages as production increases. Despite the absence of EQG, the ecosystem integrity of the HEPA will be assessed under the EQS criteria, using semi-quantitative and quantitative video assessment methods.

In some instances, the EQS have multiple criteria. The EQS will be exceeded if one of more of the criteria is exceeded. For details on how to assess the EQG and the EQS, refer to Section 5.

Table 4.5 Environmental quality guidelines for sediments

Effect	EQG	High protection	Moderate protection
Nutrient enrichment	TN TP	Median nutrient concentration at any MEPA site located 100m from sea cages, over a three month period, must be less than the 80th %ile of reference site data[2].	Median nutrient concentration over a three month period at any MEPA compliance site must be less than the 95th %ile of reference site data.
	TOC	Median concentration of TOC at any MEPA site located 100m from sea cages, over a three month period, must be less than the 80th %ile of reference site data[2].	Median concentration of TOC over a three month period at any MEPA compliance site must be less than the 95th %ile of reference site data.
Toxicity	Copper Zinc	Median metal concentration over a three month period at any MEPA compliance site must be less than the Interim Sediment Quality Guidelines - Low (ANZECC/ARMCANZ 2000) (65 mg/kg for copper; 200 mg/kg for zinc).	Median metal concentration over a three month period at any MEPA compliance site must be less than the Interim Sediment Quality Guidelines - Low (ANZECC/ARMCANZ 2000) (65 mg/kg for copper; 200 mg/kg for zinc).

Notes:

1. TN = total nitrogen; TP = total phosphorus; TOC = total organic carbon
2. Assessed at the MEPA site 100m from sea cages as a surrogate assessment against the high protection criteria

Table 4.6 Environmental quality standards for sediments

Effect	EQS	High protection	Moderate protection
Nutrient enrichment	TN TP TOC	(i) Video surveys undertaken under or at any distance from the sea-cages shall not record the presence of bacterial mats (*Beggiatoa* spp.) or spontaneous outgassing of hydrogen sulphide, relative to earlier baseline assessments. (ii) No detectable change in the % abundance and/or species richness of BPPH at the MEPA/HEPA boundary relative to reference sites, or the earlier baseline assessments, as determined via (video based) quantitative methods.	(i) The number of infauna families recorded (across pooled MEPA sites) is not to be different from the number of families recorded during baseline surveys, or relative to the reference sites in two consecutive sampling events. (ii) Median bottom water DO at any MEPA compliance site must be greater than 60% saturation and not the result of a regional event as indicated by similar reductions in DO at the reference sites. (iii) Video surveys undertaken under or at any distance from the sea-cages shall not record the presence of bacterial mats (*Beggiatoa* spp.) or spontaneous outgassing of hydrogen sulphide, relative to earlier baseline assessments.
Toxicity	Copper Zinc	The number of infauna families recorded (across pooled MEPA sites) is not to be different from the number of families recorded during baseline surveys, or relative to the reference sites in two consecutive sampling events.	The number of infauna families recorded (across pooled MEPA sites) is not to be different from the number of families recorded during baseline surveys, or relative to the reference sites in two consecutive sampling events.

Notes:

1. TN = total nitrogen; TP = total phosphorus; TOC = total organic carbon
2. The environmental quality standard for copper and zinc is commensurate with EQS E in Table 3 of EPA (2014). EQS E requires that there be no significant changes in a biological or ecological indicator that can be demonstrably linked to the contaminant.

4.2.6 Reporting

All records associated with the sediment and infauna monitoring programs, including the results of statistical analyses and assessments against the EQC, will be included in the Annual Compliance Report (see Section 8.1). Any exceedances of the EQS will be reported to the OEPA and the DoF within 7 days of first detecting the exceedance.

4.3 Benthic quality (video)

4.3.1 Objectives

In addition to the quantitative measurements described above, further qualitative and semi-quantitative assessments will be undertaken using underwater video. The objective of the video assessment is to provide observational data based on known indicators of sediment organic enrichment, and/or indicators of changes in BPPH health. The use of such criteria is well established in other parts of Australia, and its use here forms complementary but essential data for comparison with the EQS.

The data collected under this program is intended to provide confidence that any changes detected in the MEPA have not extended to the HEPA boundary, and/or have not resulted in secondary effects to HEPA benthic communities.

4.3.2 Timing

Video assessment will be undertaken prior to commencement of stocking and then at six monthly intervals during operations (timed to coincide with the autumn and late winter monitoring programs). Video assessments may also be triggered at the MEPA/HEPA boundary following exceedance of certain trigger criteria (Table 4.3, Table 4.6). Complementing the standard program of monitoring, video assessments may also be undertaken as part of the 'campaign' monitoring program (Section 5.3), recommended to investigate transitions in sediment appearance before and after significant storms or treatment with pharmaceuticals.

4.3.3 Monitoring program design

Video assessments will be undertaken along a 350 m long transect both sides of the sea cages and at strategically placed locations along the perimeter of the MEPA/HEPA boundary. Transects both sides of sea-cages should intersect the information gathering sites, as shown in Figure 4.2.

Video transects of at least 100 m should also be undertaken at the nearest four reference sites and at recovery sites (if established in the first five years). Recovery site transects are also required to intersect the information gathering sites used during operations.

For assessments at the MEPA/HEPA boundary, proponents are advised to place transects strategically to capture sites with higher BPPH coverage. Pilot investigations may be required to determine the suitability of sites. An example design is provided in Appendix B (Sections 4.3.4 and 5.2.3 also provide further context).

4.3.4 Approach to sampling

Sediment quality

To capture video footage an appropriate sled or remotely operated vehicle (ROV) carrying an underwater video camera will be flown along the transect. One pass will be made along each transect. Video footage will be analysed and a database of observations will be generated.

The presence and number of sighted benthic fauna and flora (including the presence of Beggiatoa spp.) will be recorded along with observations of other benthic characteristics, including evidence of spontaneous outgassing, sediment colour and bioturbation. An example template for semi-quantitative and qualitative observations is provided in Table 4.7, with red cells indicating observations of concern, some of which form part of the EQS outlined in Table 4.6.

Table 4.7 Example template showing potential semi-quantitative and qualitative criteria for video surveys

LEP	Distance	Colour					
		Baseline	**June 2016**	**Jan 2017**	**June 2017**	**Jan 2018**	**June 2018**
MEPA	Centre	White	Off white	Brown	Brown	Near black	Black
	0 m	White	Off white	Off white	Off white	Off white	Brown
	50 m	White	White	Off white	Off white	Off white	Off white
	100 m	White	White	White	Off white	Off white	Off white
	150 m	White	White	White	White	White	White
	200 m	White	White	White	White	White	White
	250 m	White	White	White	White	White	White
HEPA	300 m	White	White	White	White	White	White
	350 m	White	White	White	White	White	White
LEP	**Distance**	**No. burrows (per m^2)**					
		Baseline	**June 2016**	**Jan 2017**	**June 2017**	**Jan 2018**	**June 2018**
MEPA	Centre	15	16	10	5	2	0
	0 m	21	24	24	12	6	1
	50 m	15	16	18	8	7	5
	100 m	21	17	21	19	15	10
	150 m	14	13	14	12	14	21
	200 m	12	10	12	24	12	14
	250 m	24	52	24	17	24	12
HEPA	300 m	17	19	17	21	15	24
	350 m	20	21	17	23	16	15
LEP	**Distance**	**Presence of *Beggiatoa* spp.**					
		Baseline	**June 2016**	**Jan 2017**	**June 2017**	**Jan 2018**	**June 2018**
MEPA	Centre	Nil	Nil	Nil	Nil	Present	Present
	0 m	Nil	Nil	Nil	Nil	Nil	Present
	50 m	Nil	Nil	Nil	Nil	Nil	Nil
	100 m	Nil	Nil	Nil	Nil	Nil	Nil
	150 m	Nil	Nil	Nil	Nil	Nil	Nil
	200 m	Nil	Nil	Nil	Nil	Nil	Nil
	250 m	Nil	Nil	Nil	Nil	Nil	Nil
HEPA	300 m	Nil	Nil	Nil	Nil	Nil	Nil
	350 m	Nil	Nil	Nil	Nil	Nil	Nil

Notes:

1. Table dates are hypothetical. Categories are indicative only. Qualitative categories (i.e. colour, No. burrows and presence of Beggiatoa spp.) are not exhaustive. Proponents may add categories as they see fit.

Benthic primary producing habitats

To capture video footage of BPPHs, proponents will use the same set up as described under sediment quality. Video assessments will be undertaken along the perimeter of the MEPA/HEPA boundary. It is recommended that at least six permanent 100 m transects are established along the perimeter, and preferably stratified to include known BPPHs, especially those of added complexity and/or elevation above the sand sheet.

Random still images from each transect will be sampled from the video footage and analysed using appropriate software (i.e. *TransectMeasure* (SeaGIS 2013)) to determine the richness and percentage cover of BPPH taxa. These data will be compared with data obtained during baseline assessments (prior to stocking of sea cages) and to the reference sites and analysed using appropriate statistical techniques (i.e. Analysis of Variance (ANOVA) procedures). The sensitivity of the design will be determined using appropriate statistical power analysis, taking into account the background variability, alpha, sampling effort, effect size and probability of detection (power).

Proponents will be expected to specify the power and sensitivity (i.e. effect size) of their design following analysis of the baseline data set, and prior to commencement of operations. OEPA will be given the opportunity to comment and provide concurrence on the design prior to implementation.

4.3.5 Reporting

All records associated with the video monitoring program, including the results of statistical analyses and assessments against the EQS, will be included in the Annual Compliance Report (see Section 8.1). Any exceedances of the EQS shall be reported to the OEPA and the DoF within 7 days of first detecting the exceedance.

4.4 Aesthetics

4.4.1 Objective

The EQO to maintain aesthetic values aims to ensure that the aesthetic values of Western Australia's coastal waters are protected. The Abrolhos Islands are multi-use with an array of stakeholders, all of which have vested interest in preserving the unique features of the Islands and the surrounding marine environment.

The objective of the aesthetic management program is to assess whether the EQG and EQS have been met at the MEPA boundary, and to provide contextual information about the extent of aesthetic changes in the vicinity of the sea-cages. The results of semi-quantitative measurements will be compared against the EQG and EQS in Table 4.8, following those recommended in EPA (2015b).

4.4.2 Timing

Monitoring will be undertaken twice each year, in summer and winter. Monitoring will coincide with the seasonal water quality and sediment monitoring (Sections 4.1 and 4.1.6).

4.4.3 EQC

Aesthetic quality will be assessed against the EQG and EQS in Table 4.8 using a combination of semi-quantitative and qualitative assessments. The required management response following an exceedance of the EQC is set out in Section 6.

Table 4.8 Environmental quality criteria for the environmental quality objective of maintenance of recreation and aesthetics

Environmental Quality Indicators	Environmental Quality Criteria	
	Environmental Quality Guideline (EQG)	Environmental Quality Standard (EQS)
Nuisance organisms	Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae and sewage fungus should not be present in excessive amounts.	There should be no overall decrease in the aesthetic water quality values of the Zeewijk Channel, Abrolhos Islands, using direct measures of the community's perception of aesthetic value.
Faunal deaths	There should be no reported incidents of large-scale deaths of marine organisms relating from unnatural causes.	

Water clarity	The natural visual clarity of the water should not be reduced by more than 20%	
Colour	The natural hue of the water should not be changed by more than ten points on the Munsell scale (see EPA 2015b).	
Surface films	Oil and petrochemicals should not be noticeable as a visible film on the water or detectable by odour.	
Reflectance	The natural reflectance of the water should not be changed by more than 50%.	
Surface debris	Water surfaces should be free of floating debris, dust and other objectionable matter, including substances that cause foaming.	
Odour	There should be no objectionable odours.	

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 an 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.

4.4.4 Visual indicators

In addition to monitoring against the EQG and EQS in Table 4.8, the visual appearance of the marine environment will be compared against the visual criteria in Table 4.8. Assessment against the EQG will be supplemented via a questionnaire supplied to field personnel (Table 4.9). The questionnaire will be completed during the seasonal surveys and will be based on observations made adjacent to sea-cage clusters, and in the MWADZ generally.

Proponents will provide community users of the Abrolhos Islands 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 MWADZ. The DoF 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 4.8). Instances of complaints will be recorded and documented in the Annual Report. All records associated with the monitoring, will be included in the Annual Compliance Report.

Table 4.9 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	
Dead marine organisms visible?	Yes/No	
Is water clarity within the normal range?	Metres	
Noticeable change in hue?	Yes/No	
Oil or other films visible on surface?	Yes/No	

Floating debris visible on the surface?	Yes/No	
Noticeable odour associated with water?	Yes/No	

4.4.5 Reporting

All records associated with the aesthetics monitoring program, including the results of assessments against the EQC, shall be included in the Annual Compliance Report (see Section 7.1). Any exceedances of the EQS shall be reported to the OEPA and the DoF within 7 days of first detecting the exceedance.

4.5 Farm operations

4.5.1 Objective

The overarching intent of this Plan is to protect sediment and water quality within the broader MWADZ and to improve the understanding of aquaculture / environmental interactions. Key to this is gaining an understanding of day to day farming statistics, including inputs of feed, stock growth rates (and FCRs) and estimates of total standing biomass. The intent is to gather data to determine the extent of correlation between farm inputs / farm performance and environmental observations, such as sediment nutrient content and the appearance of sediments.

4.5.2 Timing

Farming operations and performance will be monitored continuously, with numerical records presented as time-series data.

4.5.3 Parameters

Proponents are required to estimate and keep monthly records (at least) of the following parameters / details, at the scale of sea-cage cluster, or where appropriate, individual sea cages within a cluster:

- Standing stock biomass (kg)
- Cage volume (m^3)
- Stocking density (kg/m^3)
- Feed quantities (kg/d)
- Food Conversion Ratio (FCR)
- Cage location (GPS)
- Depth of water (m)
- Current speeds (m/s) and direction (via surface drogue)
- Water temperature (°C)
- Feed type
- N:P:C ratio feed
- Rate of N input (kg/d); Rate of P input (kg/d); Rate of C input (kg/d)
- Incidence, type and quantity of antifoulants, pharmaceuticals and / or feed supplements administered
- Type and frequency of any supplementary monitoring undertaken

4.5.4 Code of practice

Proponents will be required to adhere to the Environmental Code of Practice (CoP) prepared by DoF and the Aquaculture Council of Western Australia (ACWA/DoF 2013). The CoP outlines a series of voluntary codes, which if followed, allow Proponents to demonstrate that they are operating within the principles of Ecologically Sustainable Development. Proponents can demonstrate conformity with this Code by undertaking an Internal Audit (using the ACWA Audit

Checklist which is available on the ACWA website: www.aquaculturecouncilwa.com) followed by a self-declaration by the Licensee.

The CoP outlines a number of controls to minimise environmental impacts. The following subset of controls is considered relevant to the EPAs environmental objectives, and Proponents will follow the controls wherever practicable:

- Develop and implement environmental monitoring regimes to recognise and mitigate negative impacts to ecologically important ecosystems
- The parameters measured and the monitoring interval may be varied, depending on the system, species and stage of development
- Should any parameters depart from the acceptable range, steps should be taken to immediately identify the problem and affect a remedy as soon as possible
- Wherever possible locate facilities away from rock outcrops or coral bottom or seagrass beds
- Use specialised anchoring systems to reduce the foot-print on the seafloor
- Ensure moorings, anchor warp and its attachments do not drag on the bottom
- Employ fallowing regimes as necessary to mitigate against sediment build-up
- Bottom of suspended infrastructure to maintain a minimum clearance of at least 2 m above the seafloor
- Any adverse effects resulting from operations to be contained within the licensed area (i.e. MEPA), with no unacceptable impacts outside the licensed area (i.e. HEPA)

4.5.5 Changes in procedure

Aquaculture technologies are evolving rapidly and there is an expectation that procedures will change in response to learning and/or the availability of new products i.e. antifoulants or pharmaceuticals. Operators are required to report the nature and timing of major operational changes and provide evidence that the potential ramifications of the change (negative or positive) have been considered and evaluated, prior to implementing the changes. The timing and results of major changes will be documented in the Annual Report such that any resulting shifts in environmental quality can be accurately correlated.

4.5.6 Reporting

All records associated with the farm operation and performance shall be included as an appendix to the Annual Compliance Report (see Section 8.1). It is recommended that the main body of the Annual Compliance Report include time series data showing average sediment nutrient concentrations (TN, TP and TOC) against (as a minimum) average feed inputs, average standing biomass and average FCR. The Annual Compliance Report will also clearly document any changes in procedure, along with a description of the proposed advantages and/or disadvantages.

5. Assessing the EQC

Comparison with the guidelines and standards requires calculation of simple test statistics (medians [50th percentiles] and 80th and 95th percentiles) and the application of more advanced ANOVA techniques. Upon completion of sampling, relevant test statistics shall be calculated and compared against the EQG criteria in Table 4.2 and Table 4.5, and the EQS criteria in Table 4.3 and Table 4.6.

5.1 Guideline level

5.1.1 VSS, LAC and Chlorophyll-a

Assessment shall be undertaken at the completion of the three month winter sampling period and again at the end of the three month autumn sampling period. The EQG for VSS is to be assessed at individual MEPA sites, and the EQG for LAC and Chl-a at individual Area boundary sites (HEPA)[7].

The EQG test statistics for VSS shall be calculated by pooling the monthly replicates at:

- individual MEPA compliance sites (median from n=3 replicates)
- individual 'information gathering' sites (median from n=3 replicates) and
- combined reference sites (80th[7] & 95th percentile from n = 3 x 6 = 18 replicates[8])

The EQG test statistics for LAC & Chl-a shall be calculated by pooling the monthly replicates at:

- individual Area boundary (HEPA) sites (median from n=3 replicates) and
- combined reference sites (80th percentile from n = 3 x 6 = 18 replicates)

5.1.2 DO

Assessment shall be undertaken after each sampling event. Upon recording a DO value less than 80% (or 90%[7]) saturation, daily measurements shall be undertaken at the exceeding site for a period of one week (7 days) to generate measurements from which to calculate the median value and continued on a daily basis until DO is greater than 80% (or 90%[7]) saturation. The EQG test statistics for DO shall be calculated by pooling the weekly replicates across:

- individual MEPA compliance sites (median from a minimum of n=7 replicates)
- individual 'information gathering' sites (median from a minimum of n=7 replicates)

5.1.3 TN, TP and TOC

On completion of the each of the autumn and winter seasonal sampling periods, the relevant EQG test statistics for TN, TP and TOC will be calculated by pooling the monthly replicates at:

- individual MEPA compliance sites (median from n=3 replicates)
- individual 'information gathering' sites (median from n=3 replicates)and
- combined reference sites (80th[7] & 95th percentile from n = 3 x 6 = 18 replicates)

5.1.4 Metals

On completion of the each of the autumn and winter seasonal sampling periods, the relevant EQG test statistics for copper and zinc shall be calculated by pooling the monthly replicates at:

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[7] *Note however the requirement to also assess high protection criteria at MEPA 100 m sites.*

[8] *Depending on the Zone being sampled (n=12 in the case of the southern Area; and n=18 in the case of the northern Area). .*

- individual MEPA compliance sites (median from n=3 replicates) and
- individual 'information gathering' sites (median from n=3 replicates)

5.1.5 Aesthetics

On completion of the seasonal surveys, the aesthetic appearance will be compared against the criteria in Table 4.8. Assessment against the EQG will be facilitated by a questionnaire supplied to field personnel (Table 4.9). The questionnaire will record observations made around the perimeter of the MEPA.

5.2 Standard level

5.2.1 DO

Assessment will be undertaken after each sampling event. Upon recording a DO value less than 60% saturation, proponents will undertake daily measurements at the exceeding site for a period of one week (7 days), thus generating multiple measurements from which to calculate the median value. The EQS will be exceeded where the median value is less than 60% saturation, provided it has occurred in the absence of a similar exceedance at the reference sites, which may indicate a natural regional event.

The EQS test statistics for DO will be calculated by pooling the weekly replicates across:

- individual MEPA compliance sites (median from a minimum of n=7 replicates) and
- individual 'information gathering' sites (median from a minimum of n=7 replicates)

5.2.2 Benthic quality (video)

Upon completion of the seasonal video surveys, an assessment shall be undertaken to determine the colour and physical appearance of sediments, noting particularly the presence of bacterial matts or the spontaneous outgassing of hydrogen sulphide (see also other suggested criteria in Table 4.7). The EQS will be exceeded if video footage shows the presence of bacterial mats or spontaneous outgassing of hydrogen sulphide anywhere in the MEPA - both characteristics widely held to be indicative of poor sediment quality and very high levels of organic enrichment (Hargrave et al. 2008; Hargrave 2010).

5.2.3 Benthic Primary Producing Habitats

Upon completion of the baseline and post operational surveys, the extent to which the type and percentage cover of the major BPPH morphological groups has changed since the commencement of operations shall be analysed using quantitative image analysis using appropriate statistical procedures, preferably of the ANOVA or GLM families.

To ensure a robust assessment, it is recommended that proponents utilise the Before-After-Control-Impact (BACI) designs of Underwood (1991; 1992; 1994). BACI designs are useful for their ability to separate anthropogenic change from natural change, and are therefore applicable in situations where exceedances are based on evidence of attribution. To assist operators, a worked BACI example is provided in Appendix B; however, proponents are advised to seek assistance from qualified practitioners experienced in the application and statistical power of such designs prior to commencing baseline surveys.

5.2.4 Infauna

The EQS for infauna is consistent with the guidance in EAG 15 (EPA 2015) and has been developed in consultation with the OEPA. The intent is to demonstrate that the number of infauna families across MEPA and information gathering sites (pooled) does not differ from the number observed during the baseline assessment, and does not differ from those observed at the reference sites in ongoing assessments.

OEPA recognises that the high family richness together with its highly variable abundance may lead to false positives where a family(ies) is excluded simply by chance (i.e. the family is actually present at the site, but was missed in the sampling due to its rareness).

To counter this, the EQS is based upon families with a greater than 20% probability of detection in a single sample over the summer period and within a specific area (either north or south). Therefore there is a reasonable chance of detecting each of these families provided five or more samples are collected and provided the family is present. Table 5.1 provides the list of families for each of the aquaculture areas, and their probability of detection based on their abundance during the baseline surveys.

Table 5.1 Families included in the EQS for infauna with their probability of detection

Southern Area			Northern Area		
Family	**Taxa**	**Probability of detection**	**Family**	**Taxa**	**Probability of detection**
Ampeliscidae	Worm	30%	Glycymerididae	Worm	21%
Phoxocephalidae	Worm	21%	Psammobiidae	Worm	45%
Caprellidae	Worm	21%	Veneridae	Bivalve	33%
Ostracoda (Class)	Crustacean	24%	Ampharetidae	Worm	24%
Glycymerididae	Bivalve	21%	Eunicidae	Worm	36%
Psammobiidae	Worm	52%	Lumbrineridae	Worm	24%
Retusidae	Worm	21%	Onuphidae	Worm	36%
Eunicidae	Worm	30%	Orbiniidae	Worm	27%
Onuphidae	Worm	45%	Phyllodocidae	Worm	21%
Orbiniidae	Worm	24%	-	-	-
Phyllodocidae	Worm	21%	-	-	-

The intent is to (a) maintain a moderate level of ecological protection across the zone by demonstrating no change in the infauna families across the MEPA generally and (b) to build a comprehensive understanding of the type and number of infauna present, and the effect of aquaculture on these assemblages as the pressure grows over time. This understanding will likely be used in the future to develop a new EQS based on a surrogate indicator (see Section 8.2). The utility of the approach will be reviewed at the completion of the 5 year interim period in consultation with the OEPA upon receipt of an appropriate data-set.

5.2.5 Aesthetics

Assessment against the EQS would only be undertaken upon an exceedance of the EQG. Under the EQS, there should be no overall decrease in the aesthetic water quality values of the Zeewijk Channel, Abrolhos Islands, using direct measures of the community's perception of aesthetic value.

5.3 Additional sampling and analyses

5.3.1 Supplementary monitoring

Assessments against the EQS should be undertaken carefully and with consideration of the potential for making a Type I or II statistical inference error. For assessments against the EQS, Proponents are advised to increase the level of replication at the appropriate sites, or relevant boundaries, wherever practicable. The sensitivity of parametric analyses for example should be determined a priori using appropriate statistical power analysis, taking into account the background variability, alpha, sampling effort, effect size and probability of detection (power).

Proponents are also advised to consider undertaking further analyses that may serve as additional lines of evidence. Additional analyses such as multivariate statistical procedures for example may be used to provide either early warning and/or context to the observed changes in infauna communities, which may be driven by a combination of species richness and/or abundance measures. Suggested approaches include the use of visual tools such as control charting, non-metric Multidimensional Scaling (nMDS), and hypothesis-based statistical methods such as PERMANOVA (following Anderson et al. 2008).

Supplementary monitoring should also be undertaken in the event of certain EQG exceedances, particularly those for chlorophyll-a and metals (copper and zinc). Examples of supplementary monitoring may include sampling for the presence of potentially toxic microalgae or sampling demersal finfish (beneath sea cages) to assess the potential for bioaccumulation. Although not specifically required under this plan, the additional analyses are considered useful for demonstrating compliance with the EQO for seafood safe for human consumption (see Table 3.1).

5.3.2 Campaign monitoring

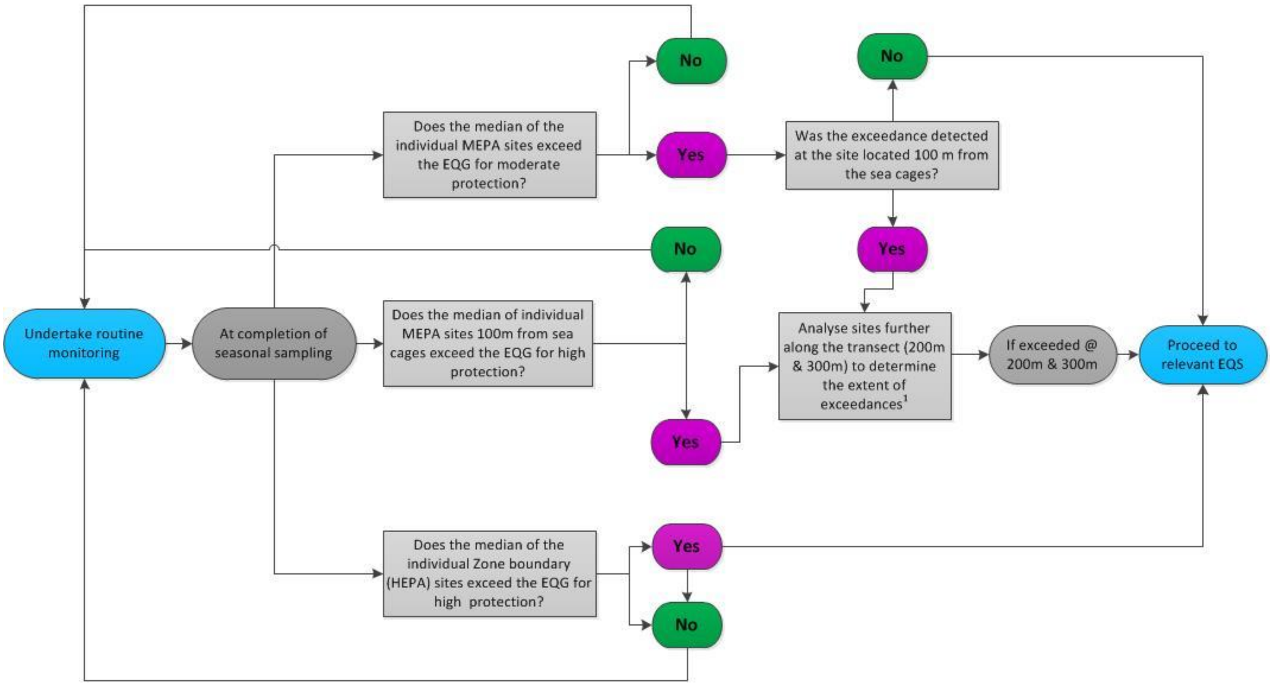
Given the interim nature of the Plan, proponents are advised (wherever practical) to undertake monitoring before and after significant events, such as severe storms or treatment with antibiotics. It is envisaged that the greatest effects of these events may be realised at the benthic level. Hence, monitoring in the form of additional sediment sampling or custom flown video surveys may be most appropriate.

The results of campaign monitoring are expected to contribute greatly to the 'information gathering' process, to: (a) ground-truth the environmental model used in the EIA process (b) determine the importance of storm events to benthic resetting processes (to further validate the model) and (c) determine the effect (if any) of antibiotics on benthic flora communities. The data accumulated may be used in the future to provide justification for removal of certain monitoring commitments, thus reducing the burden on industry.

6. Upon exceeding the EQC

6.1 Guideline level

The hierarchical decision scheme for assessing the EQG is outlined in Figure 6.1. In the event an EQG is exceeded, assessment against the relevant EQS should begin as soon as reasonably practicable, but no more than 30 days.



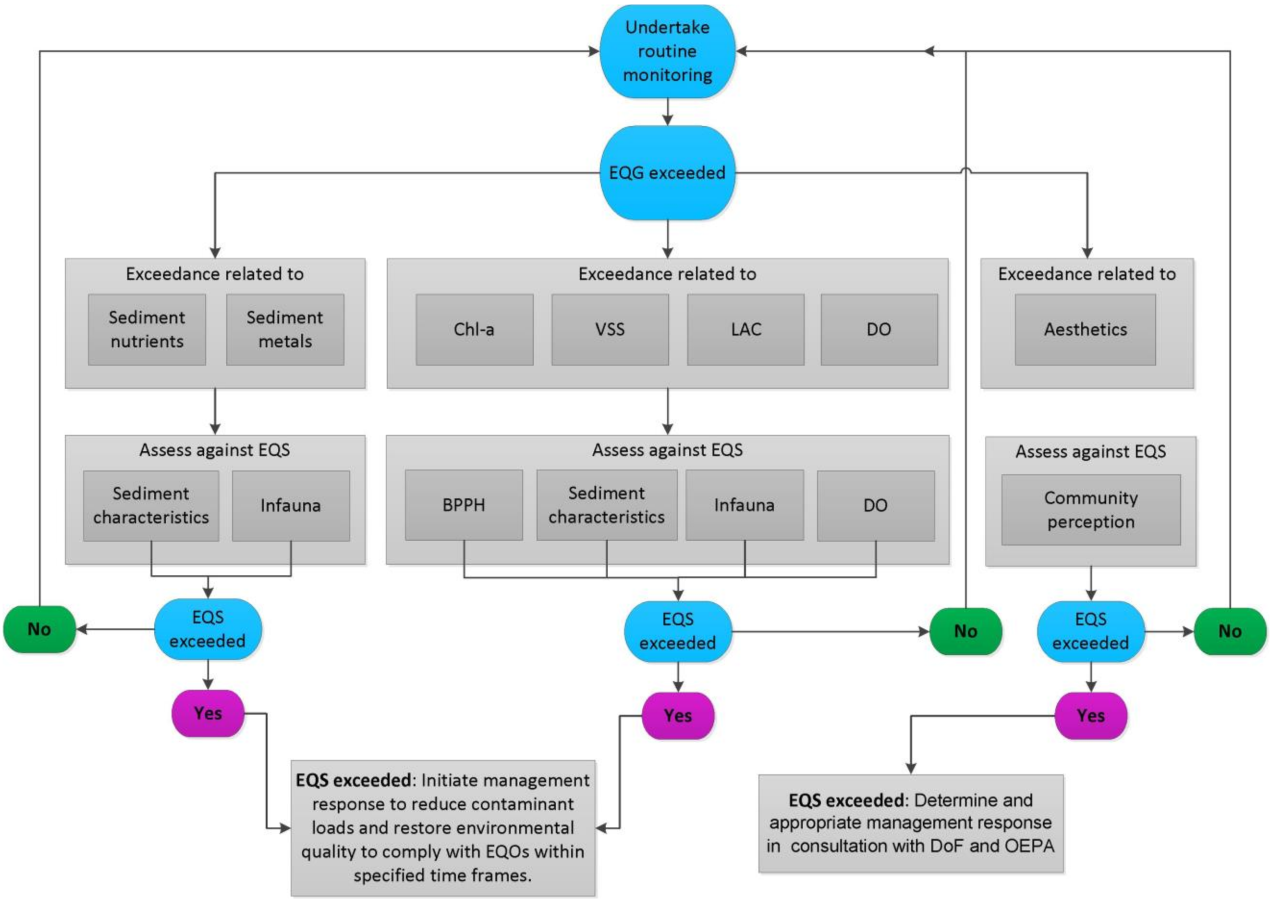
Notes:

1. If sampling and analysis is required further along the transect, this will be done within 30 days of exceeding EQG at 100m. The values at the 200 m and 300 m distances will also be compared against the high protection criteria.
2. Values at any MEPA site 100 m from sea cages will also be compared against the high protection criteria.

Figure 6.1 Decision scheme for assessing the environmental quality guidelines

6.2 Standard level

The hierarchical decision scheme for assessing the EQS is outlined in Figure 6.2. In the event an EQS is exceeded, the Proponent will report the matter to DoF and the OEPA within 24 hours of detecting the exceedance and will commence management to (i) reduce the effect and/or mitigate the source of the contaminants, and (ii) to restore environmental quality to a level commensurate with the specified LEP. The timeframe for demonstrating restoration will be negotiated with DoF and the OEPA at the time of the exceedance, but should be no more than 60 days. Management responses are outlined in Section 7.



Notes:

1. EQS = environmental quality standard; Chl-a = chlorophyll-a; LAC = light attenuation coefficient; VSS = volatile suspended solids; DO = dissolved oxygen; TN = total nitrogen; TP = total phosphorus; TOC = total organic carbon; EQO = environmental quality objectives

Figure 6.2 Decision scheme for assessing environmental quality standards

7. Management Responses

Upon exceeding an EQS, management is required to reduce or eliminate the source of the pressure to restore environmental quality and achieve the relevant EQO.

This section of the plan outlines the management responses available, and what is required of Proponents to demonstrate sites are recovering to levels commensurate with the agreed level of ecological protection.

7.1 Water and Sediment quality

7.1.1 Fallowing of stock

One of the advantages of aquaculture (over ocean outfalls for example) is that aquaculture infrastructures can be rested, or if not entirely relocated, in a process known as fallowing.

Fallowing is effective for reducing the pressure on the environment, providing it an opportunity to return to baseline conditions. The timing of recovery depends on the starting level of organic enrichment and the characteristics of the receiving environment. Fallowing may be undertaken for reasons of best practice, or in response to an exceedance of an EQS.

7.1.2 Other options

If fallowing of sea cages is not feasible, the following temporary measures may also be effective in reducing the pressure on the environment:

- Use of stock rotation
- Reduction in stocking density
- Partial harvest of stock
- Management of feed inputs
- Management of stocking density

7.2 Recovery monitoring

7.2.1 During routine fallowing

As described above, relocation and or the resting of sea-cages may be undertaken in response to an exceedance, or as part of best practice operations. In either case, Proponents will be required to monitor the fallowed sites to capture the transition from impacted to remediated conditions.

Sampling will be undertaken at a subset of the former MEPA compliance sites (Section 4.1.6), referred to subsequently as recovery sites (Figure 3.5, Figure 4.1 and Figure 4.2). Sampling will be undertaken at distances: centre, 0 m, 25 m and 50 m and will incorporate the parameters shown in Table 4.4. Monitoring will be undertaken in autumn and supplemented with qualitative benthic video assessment. Recovery will be monitored until the sediment chemistry at the fallowed site is commensurate with a high LEP. To assess recovery, data from the recovery sites will be compared against data from baseline or reference sites using appropriate statistical methods. The Proponent will report the results of recovery monitoring program to DoF and the OEPA annually (Section 8.1).

7.2.2 Following an exceedance

All of the EQSs in this Plan are designed to be assessed within the MEPA or at the HEPA boundary. For an exceedance within the MEPA, the most appropriate course of action may be to fallow or implement the approaches in Section 7.1.2. If fallowing is selected, then the timing and extent of monitoring shall proceed as per Section 7.2.1. If the Proponent chooses to implement other forms of management, the Proponent will be required to consult with DoF and OEPA for endorsement of intended actions and will monitor the impacted site on a monthly basis, until an appropriate level of environmental quality has been restored.

For an exceedance at the northern or southern zone boundaries (HEPA), management will be determined in consultation with DoF and OEPA. Management options such as those listed in Section 7.1.2 will be considered. During the consultation phase, monitoring of the impacted site will proceed on a monthly basis, until the approach to management has been decided.

During the contingency management phase, the Proponent will be required to report the results of the monitoring to DoF and the OEPA on a quarterly basis (four times per annum) until it can be demonstrated that an appropriate level of environmental quality has been restored, and is being maintained.

7.3 Aesthetics

The decision scheme for assessing EQG and EQS related to aesthetics, including the management response upon an exceedance of the EQS is summarised in Table 7.1.

Table 7.1 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 (Section 8.1).	If there is a decrease in the aesthetic values of the Abrolhos marine environment as determined suing direct measures of the community's perception of aesthetic values, the Proponent will consult with DoF and OEPA to determine an appropriate management response.

8. Implementation

8.1 Reporting

Proponents will submit an Annual Compliance Report summarising the results of the monitoring to the OEPA and DoF by 1 June annually in accordance with the conditions of their approval.

Annual Compliance Reports should include as a minimum:

- An executive summary summarising the results of the program
- A methods statement
- A description of the results of the program, including the appropriate use of Tables and Figures to summarise the outcomes of:
  - Water and sediment quality monitoring and analyses
  - Benthic video surveys and analyses
  - Farm operational data, including any correlations with environmental data
  - Campaign monitoring, if undertaken during the reporting period
  - Any additional analyses i.e. multivariate or control charting analyses
- Appropriate appendices, providing farm operational data and results of any reviews / risks assessments.

In addition, any exceedance of the EQS will be reported to the CEO of the OEPA within 7 days of first detecting exceedance.

8.2 Program evolution

The Plan is an interim plan designed to monitor the effects of aquaculture in the first five years of operation. The Plan will be reviewed and revised at the end of the five year period, or when production reaches 30% of the allocated standing biomass (24 000 tonnes)[9]. The intent of the review is to ensure the program is appropriately scaled to the level of risk, which may increase with increasing production.

Although to be agreed in consultation with the OEPA, it is expected that at the completion of the five year period, the revised program will:

- Be extended to distances 200 m and 300 m down-current of the sea cages, with a requirement for fixed monitoring stations at the HEPA boundary
- Allow for an increase in the number of monitoring transects, probably to adjoining sea cage clusters
- Allow for a change in the infauna criteria based on lessons learnt in the first 5 years
- Focus on only one side of the sea cages (once the prevailing current direction and its effect on the benthic footprint are understood)
- Retain zone boundary compliance (HEPA) and reference sites
- Retain the requirement to fly towed video surveys

The potential spatial arrangement of water and sediment sampling sites under the post 5 year development EMMP is shown in Figure 8.1.

[9] *Whichever occurs first.*

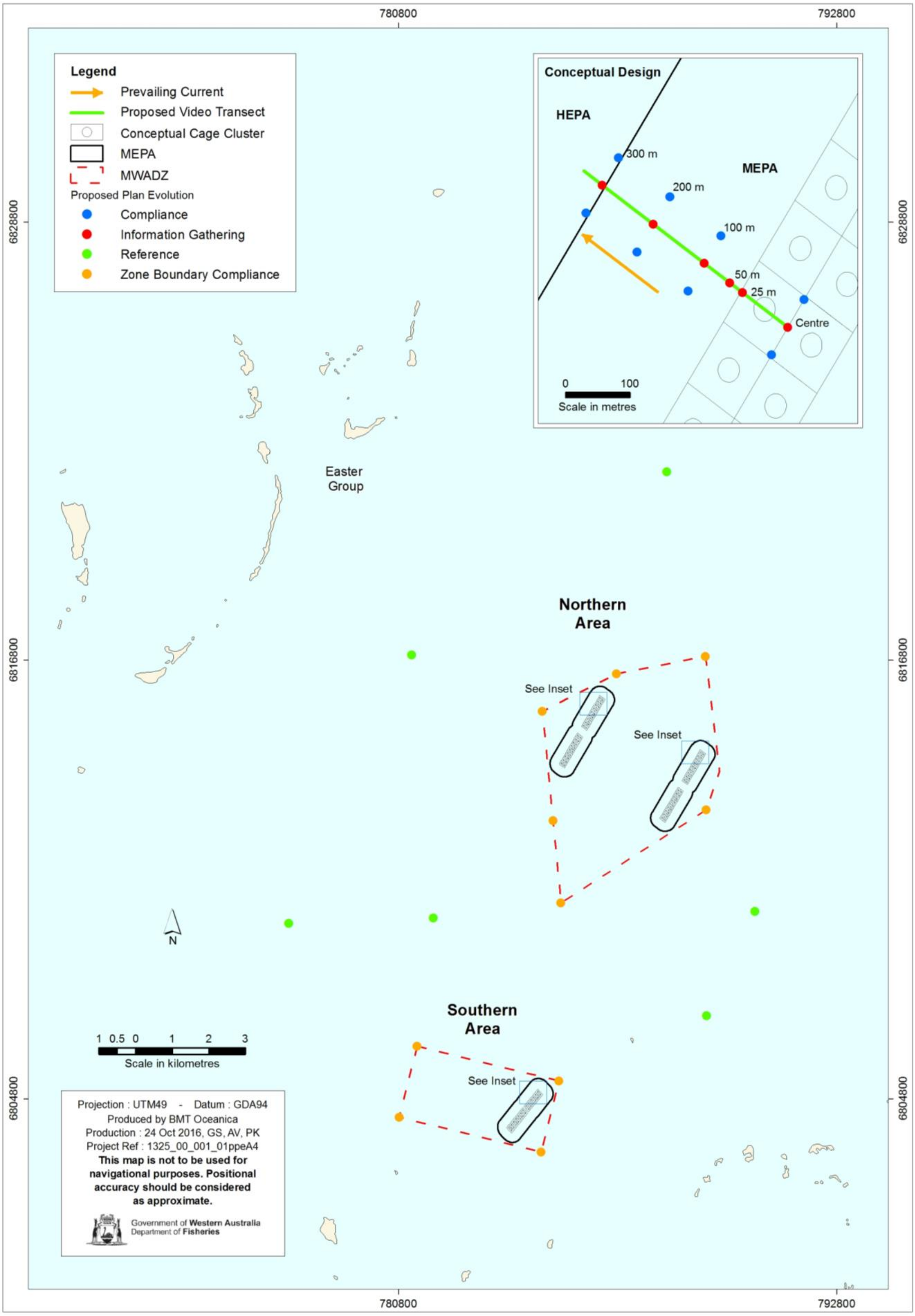


Figure 8.1 Potential spatial arrangement of water and sediment sampling sites under a revised EMMP post 5 year development

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Appendix A

Sample Site Coordinates

Appendix B

Example BACI Design

Appendix C

Biosecurity Requirements

9.1 Appendix C - Biosecurity

9.2 Biosecurity

9.2.1 Objectives

The objective of the biosecurity section of this Environmental Monitoring and Management Plan is to minimise risks associated with disease, parasites, marine pests and the potential for adverse genetic effects. Potential risk factors relevant to biosecurity were investigated as part of the EIA for the Hin West Aquaculture Development Zone (MWADZ) project (DoF 2015c). The assessment identified and assessed individual hazard pathways associated with each of three primary biosecurity risks, namely:

2. spread of pathogen disease from an infected aquaculture facility;
3. impacts on the (genetic) sustainability of wild fish following escape of aquaculture stock; and
4. the introduction and, or, spread of marine pests associated with aquaculture(?)

The biosecurity management protocols described below outline the approach to reducing these risks through a number of mitigation protocols and management strategies.

9.2.2 Protocols

A high level of biosecurity will be maintained using a combination of best-practice and proactive infrastructure management. Reactive management strategies will be employed to manage incidents as they arise. The proposed approaches to risk mitigation and incident management follow a comprehensive analysis of risks and a review of best practice mitigation strategies undertaken by DoF (2015c); the proposed management protocols outlined below are excerpted directly from that document (DoF 2015c).

Infrastructure management

Infrastructure will be managed as follows:

- Prior to commencement of operations, the proponents will seek input on biosecurity measures from the Western Australian Department of Fisheries (the Principal Research Scientist Fish Health). Prior to stocking, each proponents will develop and implement biosecurity management arrangements, as part of a Management and Environmental Monitoring Plan, in accordance with the Zone Management Policy and in consultation with DoF. These arrangements will cover all aspects of biosecurity management including a disease testing regime and relevant response protocols, translocation, biosecurity and quarantine including management of vessels, equipment and infrastructure. Responses to biosecurity hazards and incidents will be informed by the development and implementation of the biosecurity management arrangements; all operational staff will receive appropriate training to enable them to implement the biosecurity management arrangements to effectively deal with biosecurity hazards and, or, incidents as they arise;
- Sea-cage systems will be designed and maintained to eliminate or reduce the likelihood of fish escapes and, or, the breach of sea-cage netting by external predators, including ETP species; in addition, proponents will be required to conduct regular inspections of the sea-cage systems to ensure integrity, by looking for and resolving any issues that may increase the probability of escapes;
- The proponent will continually review and update their approach to biosecurity and associated protocols as agreed with DoF;

- All pelletised feeds used in open sea-cages must be Australian Quarantine and Inspection Service (AQIS) approved or produced by a manufacturer that complies with AS/NZS ISO 9001:2008 standards or equivalent. Wet feeds, such as pilchards, are not permitted in the MWADZ;
- Proponents will use best management practices to prevent escapes from sea-cages, including observing the Aquaculture Council of Western Australia (ACWA) marine based finfish Environmental Code of Practice, which has been designed to encourage environmentally responsible behaviour in the aquaculture industry. Proponents are required to operate in accordance with the Zone Management Policy and the conditions of an aquaculture licence, which require the prevention of stock escapes. The Zone Management Policy also documents the importance of the suitable site location (i.e. frequency of storm events, degree of exposure), minimizing risks during stock transfers, using strong and durable materials for culture unit construction and regularly inspecting and adjusting the infrastructure to quickly repair tears or openings;
- Proponents must develop site-specific contingency plans (escape emergency plans) that describe actions to be taken in the event of any major stock escapes. Guidance on what to do in the event of an escape is provided in the Fish Resources Management Regulations 1995. The use of any recapture nets requires authorisation of the CEO of DoF;
- To prevent the introduction and spread of introduced marine pests, proponents will undertake regular inspection and cleaning of sea-cage nets; prior to bringing aquaculture gear into the MWADZ, thoroughly inspect and clean any used equipment or infrastructure (including vessels) sourced from areas outside the MWADZ. In addition to the biosecurity management arrangements mentioned above, proponents will observe the National Biofouling Management Guidelines for the Aquaculture Industry.

Reactive management

Reactive management actions will include:

- Proponents must (with DoF) develop incident response plans detailing the procedures to be followed in the event of (1) disease outbreaks, (2) escapes of significant volumes of stock or (3) detection of introduced marine pests. The intent of these plans is to ensure adequate reporting of the events, manage the escaped fish and any predators including ETP species, prevent wherever practicable, the establishment and proliferation of pests or diseases, aiming to control and potentially eradicating that pest or disease, and to minimise the risk of that pest or disease being transferred to other locations within Western Australia;
- All unusually high levels of mortalities, or suspicions or signs of diseases or conditions, must be recorded and details (quantity of stock/circumstances) reported in writing to the Principal Research Scientist Fish Health, within 24 hours of becoming aware, or suspecting, any fish at the property are affected. The proponent will work with DoF to resolve the issue using an agreed response plan or as otherwise determined with DoF;
- ALL species listed as pests or noxious fish and any other species that appear to have clear impacts or invasive characteristics must be reported to DoF via FISHWATCH (ph. 1800-815-507) or by email at biosecurity@fish.wa.gov.au,within 24 hours following (a) initial detection and (b) subsequent analysis and confirmation of identity. If the species is positively identified as a marine pest, the proponent will work with DoF to resolve the issue using an agreed response plan or as otherwise determined with DoF;
- Any use of treatment chemicals and, or, pharmaceuticals, under advisement of the DoF Principal Research Scientist Fish Health, will be recorded and reported to DoF and the OEPA in accordance with approved protocols;

- All instances of suspected significant (i.e. greater than 100 fish) stock escapes must be recorded and details (quantity of stock and circumstances) reported to the CEO of DoF within 24 hours of the event. Interactions with ETPs, which result in escapes, should be reported to the relevant authority. The pproponent must investigate and determine how an escape occurred and what is required to prevent future similar escapes; the findings of the investigation shall be reported to DoF within five working days of the event. The proponent will work with DoF to resolve the issue using an agreed response plan or as otherwise determined by DoF;
- All biosecurity incidents (including stock escapes) and use of pharmaceuticals and other treatment chemicals must be recorded in the Annual Compliance Report. Best management practices to facilitate biosecurity will be maintained for the life of the MWADZ. The proponent will review and adapt management practices to remain in step with best-practice approaches.

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