CONE BAY 1,000 TONNE BARRAMUNDI PRODUCTION PROPOSAL

Public Environmental Review Document

April 2008

Maxima Pearling Company Pty Ltd
Broome, Western Australia

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Printed: April 2008

Maxima Pearling Company Pty Ltd would like to acknowledge the assistance, advice and support from the following organisations.

Doroudi Consultants
Asia-Pacific Applied Science Associates (APASA)
Marine Produce Australia (MPA)
Environmental Protection Authority Services Unit

in the preparation of this document.

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PEARLING CO PTY LTD

ACN 009 251 441 / ABN 70 009 251 441

Cone Bay 1000T Barramundi Production Proposal

Public Environmental Review

April 2008

Maxima Pearling Company Pty Ltd
PO Box 843
Broome, WA 6725

Invitation to Make a Submission

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal. If you are able to, electronic submissions emailed to the EPA Service Unit project officer would be most welcome.

Maxima Pearling Company Pty Ltd is proposing to apply for an increase in production of the existing aquaculture licence in Cone Bay to 1,000 tonnes per annum of Barramundi in an effort to increase the commercial potential of this species. In accordance with the Environmental Protection Act, a Public Environmental Review (PER) has been prepared which describes this proposal and its likely effects on the environment. The PER is available for a public review period of four weeks from 21 April 2008 to 19 May 2008. Comments from government agencies and from the public will help the EPA to prepare an assessment report in which it will make recommendations to government.

Where to get Copies of this Document?

A downloadable pdf copy of the document will be made available on the Marine Produce Australia Limited website:

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Why Write a Submission?

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

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

Why Not Join a Group?

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

Developing a Submission

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

When making comments on specific elements of the PER:

- Clearly state your point of view;
- Indicate the source of your information or argument if this is applicable;
- Suggest recommendations, safeguards or alternatives.

Points to Keep in Mind

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

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

Remember to include:

- Your name;
- Address;
- Date; and
- Whether and the reason why you want your submission to be confidential.

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

The closing date for submissions is:

19 May 2008.

Submissions should ideally be emailed to:

shirree.blazeski@dec.wa.gov.au

OR addressed to:

Environmental Protection Authority Service Unit
Department of Environmental Conservation

Locked Bag 33	Level 8, The Atrium
Cloisters Square	168 St. Georges Terrace
PERTH WA 6850	PERTH WA 6000

Attention: Shirree Blazeski

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Acronyms:

<	less than
>	greater than
$^{o}/_{oo}$	parts per thousand
ABFA	Australian Barramundi Farmers Association
ANZECC	Australian and New Zealand Environment and Conservation Council
APASA	Asia-Pacific Applied Sciences Association
AQIS	Australian Quarantine and Inspection Service
AquafinCRC	Aquafin Cooperative Research Centre
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AS	Australian Standard
AVPMA	Australian Veterinary Practice Management Association
BHMEP	Barramundi Health Management and Emergency Plan
BOM	Bureau of Meteorology
BPP	Benthic Primary Producers
BPPH	Benthic Primary Producer Habitats
CALM	Department of Conservation and Land Management
Chl-a	Chlorophyll-a
CO_2	Carbon Dioxide
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CVO	Chief Veterinary Officer
DAC	Darwin Aquaculture Centre
DEC	Department of Environment and Conversation (Formerly CALM and DoE)
DEH	Department of Environment and Heritage
DNA	Deoxyribonucleic Acid
DO	Dissolved Oxygen
DoD	Department of Defence
DoE	Department of Environment
DoF(WA)	Department of Fisheries (Western Australia) (also called WA Fisheries)
DPI	Department for Planning and Infrastructure
ECS	Environmental Compliance Scorecard
eg	Example
EMMP	Environmental Monitoring and Management Program
EMS	Environmental Management System
EPA(WA)	Environmental Protection Authority (Western Australia)
EPASU	Environmental Protection Authority Service Unit
EPBC Act	Environmental Protection and Biodiversity Conservation Act 1999
EQC	Environmental Quality Criteria
EQG	Environmental Quality Guideline
EQMF	Environmental Quality Management Framework
EQO	Environmental Quality Objective
EQS	Environmental Quality Standard
ESD	Ecological Sustainable Development
etc	Etcetera, so on and so forth
EV	Environmental Value
FCR	Food Conversion Ratio
FRDC	Fisheries Research and Development Corporation
FRMA	Fish Resources Management Act 1994
Ha	Hectare
IEP	Indigenous Employment Program
IMCRA	Interim Marine and Coastal Regionalisation for Australia
KLC	Kimberley Land Council
LEP	Level of Ecological Protection
MFF	Maxima Fish Farms Pty Ltd
MPC	Maxima Pearling Company Pty Ltd

NT	Northern Territory
NWQMS	National Water Quality Management Strategy
NZS	New Zealand Standard
OH&S	Occupational Health & Safety
PER	Public Environmental Review
pers. com.	Personal Communication
pH	Measure of acidity
PIRSA	Department of Primary Industries and Resources of South Australia
R&D	Research and Development
ROV	Remotely Operated Vehicle
SARDI	South Australian Research and Development Institute
SD	Scoping Document
SOP	Standard Operating Procedures
sp	Species
spp	Species (plural)
SWQM	State Water Quality Management
TAFE	Technical and Further Education
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TP	Total Phosphorous
TSS	Total Suspended Solids
WA	Western Australia
WAFD	Western Australia Fisheries Director
WC Act	Wildlife Conservation Act 1950
WMP	Waste Management Plan

Glossary

Aesthetic - of or concerning the appreciation of beauty or good taste.

Benthic Primary Producers - are plants (eg seagrasses, mangroves and seaweeds etc) or animals (invertebrates such as scleractinian corals) which convert carbon from the seawater or air to organic compounds by photosynthesis.

Benthic Primary Producer Habitats - are the Benthic Primary Producer communities as well as the substrate that support those communities.

Biota - refers to the combined flora and fauna of a region.

Chlorophyll-a - is a photosynthetic green pigment found in plants. Chl-a concentrations are an indicator of phytoplankton abundance and biomass in coastal and estuarine waters.

Dissolved Oxygen - a measure of the quantity of oxygen present in water.

Ecosystem - a community of organisms, interacting with each other, plus the environment in which they live and react.

Ensiler – a unit that turns fish and/or fish waste into silage. Units are vary in size and capacity and are relatively mobile.

Fallowing - refers to a period of time in which the sea cages will be left empty with no fish or feeding procedures occurring to allow for the benthic substrate to rehabilitate and return to a normal state, or as near as.

Fingerlings - a young or small fish.

Hydrodynamic Modelling - a study of the forces and motions of water bodies. Usually involves the investigation of a number of scenarios resulting in changes in the characteristics of the water bodies.

Hydrology - the science of the occurrence, circulation, distribution and properties of the waters of the earth and atmosphere.

Inorganic Matter - are non-living substances of mineral origin. Do not contain carbon.

Intertidal Zone - area of the foreshore lying between the low and high water spring tides.

Invertebrates - animals without backbones.

Organic Matter - a living substance or its remains. All organic matter contains carbon.

Parameter - is a particular environmental characteristic being measured eg temperature or salinity etc.

Percentile - is a value on a scale of one hundred that indicates the percent of a distribution that is equal to or below it. For example, a parameter being in the 80^{th} percentile means that the value is greater than or equal to 80% of all the given values.

Percentile based calculation - compares the sample site values with the distribution (or range) of the reference site values to determine if the parameter falls within an acceptable range ie within the 20^{th} and 80^{th} percentile.

pH - is a measure of the acidity and alkalinity (or base) of a solution. The range is from 1 – 14 where 1 is highly acidic and 14 is highly alkaline (or basic).

Photosynthesis - the process in green plants and some other organisms where carbohydrates are synthesised from carbon dioxide and water using light as energy. Most forms of photosynthesis release oxygen as a byproduct.

Physico-chemical - relating to both physical and chemical properties

Reference sites - are the sites selected away from the point of discharge in order to capture the changes in ambient environmental conditions. The sample sites values are then compared to the reference sites so as to confirm if any changes are due to the proposal or if they are natural fluctuations.

Salinity - is the concentration of soluble salts in the water. Usually refers to the sodium chloride content.

Sample sites - are the sites selected close to the point of discharge in order to capture any changes in environmental quality due to the proposal.

Silage - the resultant aqueous product from the process of storing and fermenting of fish or fish waste. Produces no odour, requires little energy and/or equipment and resultant product is non-toxic and can be used in many fertilisers.

Spatial (Scale) - relating or pertaining to space.

Substrate (also called Benthic Substrate) - the surface of the sea floor. Substrate also can refer to the surface on which an organism grows or is attached, ie the seabed.

Subtidal Zone - below the low tide mark. This area is constantly submerged.

Temporal (Scale) - relating or pertaining to time.

Total Nitrogen - is a measure of all the forms of nitrogen found in a water sample. TN consists of inorganic and organic forms including organic proteins, nitrate, nitrite, ammonia (un-ionised and ionised) and nitrogen gas.

Total Phosphorous - is a measure of all the forms of phosphorous found in a water sample. TP consists of dissolved and particulate forms. Phosphorous is a nutrient required by all living organisms for the basic processes of life.

TSS - is a measure of the mass of fine inorganic particles suspended in the water column. The suspended particles are captured by filtering water through a 1.2μm glassfibre filter paper.

Turbidity - is a measure of the 'cloudiness' of water where the more turbid the murkier it is. Turbidity is directly related to TSS were the more turbid the more suspended particles are present in the water column.

Water Quality - refers to the state of "health" of a water body and is defined by it's physical, chemical, biological and aesthetic characteristics.

Executive Summary

I. Introduction

The shareholders of Maxima Pearling Company (MPC) currently own and operate a pearling and aquaculture venture in the Cone Bay region of Yampi Sound. The aquaculture operation is managed as a joint venture with a closely related company, Maxima Fish Farms Pty Ltd (MFF) who undertake the operational aspects of the aquaculture venture. The shareholders of both MPC and MFF believe that there is scope for the addition of other aquaculture ventures in the surrounding area and at the Cone Bay site where existing infrastructure is currently under utilised.

The current Barramundi project is being operated by MFF under MPCs aquaculture licence (No. 1465) in Cone Bay and is looking to expand into a commercialised venture with an annual production level of 1,000 tonne. This PER is for environmental approval of an application for a new aquaculture licence to produce 1,000 tonne of Barramundi per annum in an effort to increase the commercial potential of this species.

II. The Proposal

Initially, a pilot scaled Barramundi operation was developed two years ago. The results of this trial were highly successful and the potential for commercial sea cage culture of Barramundi was realised. Following the success of the pilot study, a number of variations and sea cage trials were undertaken to confirm the commercial potential of the species.

As a result of the success observed in these subsequent trials, MPC is now applying for an increased production level of 1,000 tonne of Barramundi per annum in Cone Bay, in an effort to increase the commercial potential of this species for regional WA.

The infrastructure required to achieve this is expected to consist of a nursery sea cage system with up to eight 6x6x5m square cages and a grow-out sea cage system with up to twenty polar circle sea cages ranging from 40 – 80m in circumference.

Fingerlings will be sourced from accredited hatcheries and all disease translocation protocols and requirements associated with the transport of Barramundi will be strictly adhered to. Feed, stocking densities, harvesting and waste management practices will all be conducted and appropriately managed with the intent to maintain environmental sustainability and protection by avoiding or minimising any potential environmental impacts.

As Turtle Island is already the operational work base for MPC and MFF, all staff and equipment, except for the extra sea cages and a centralised feed barge, will continue to be accommodated on Turtle Island and staff will commute to the sea cage mooring site each day.

III. Public Environmental Review

The EPA has determined that this proposal warranted a formal assessment in accordance with the *Environmental Protection Act (1986)* (EP Act), and has set the level at Public Environmental Review (PER), with a 4 week public review period. Maxima Pearling Company Pty Ltd has prepared this Public Environmental Review to describe the existing environment within and surrounding the proposal site and the potential environmental impacts that may result from the proposal.

Various studies and investigations have been conducted, as described in the Environmental Scoping Document submitted to and approved by the EPA in December 2006, and the results of these are given in the PER together with the resulting management strategies that MPC and MFF, as the operational company, proposes to implement to avoid or minimise any potential impacts and monitor the effects of the proposal.

In addition, public consultation was undertaken by MPC in order to determine the public perception of the proposal and to incorporate and address in the PER, any issues that various relevant stakeholders and interested parties may have. Details of the public consultation conducted are presented in Section 7.

IV. Existing Environment

Land, Climate, Topography and Hydrology

The existing environment in Cone Bay is considered to be in a "natural and undisturbed" state. The land surrounding Cone Bay consists of King Leopold sandstone, Alluvium, Ruins Dolerite and Cone Hill Granite (Figure 3.2) with the predominant being King Leopold Sandstone and Cone Hill Granite. In most parts the rock face is a minimum of 10m above the high tide mark (IMCRA, 1998) rising steeply out of the water (Figure 3.6).

The land bordering the southern side of Cone Bay is Commonwealth land used by the Australian Department of Defence (DoD) and the land to the eastern side of Cone Bay is utilised by the Dambimangari claimants with a small community set up at the north-eastern end of the bay inhabited by the Larinuwar Community members (Figures 3.10 & 3.11).

Within the bay are numerous small beaches (0.2km to 0.5 km long) and mangrove communities interspersed along the northern and southern coastline, and two large mangrove communities located at the back of the bay Figure 3.4). The mangrove communities stretch along sections of the Cone Bay coastline and range in size between 0.3km and 7.3km.

The area comes under the WA Department of Fisheries (DoF) legislation for lease marking. All new developments are subject to assessment according to the EP Act with all activities coming under the CALM and Wildlife Conservation Act.

The climate of Cone Bay is characterised as tropical monsoon with distinct 'wet' and 'dry' seasons. The 'wet' (or summer) typically brings high rainfall associated with hot and humid conditions and the 'dry' (or winter) can be associated with a mild Mediterranean-style climate with cool nights and warm, sunny days. Average daily temperatures of the region range between 21.0°C in the dry and 33.0°C in the wet and an annual average rainfall of between 600-800mm. A number of cyclones (ranging anywhere between Category 1 and Category 3 on average) pass through the Kimberley each season and generally follow a south-westerly route down the coastline passing near, or over the Buccaneer Archipelago region.

The licence site 1465 is situated on the southern side of Cone Bay (Figures 3.1 and 3.3) and encompasses Turtle Island. The depth within this site varies greatly (3-25m) as it does in the rest of Cone Bay (3-36m) (Figure 3.3). The main hydrological influences on the Cone Bay water body is the 9 to 11 metre tidal range, high velocity currents (average speed of 0.3m/s during a spring tide; maximum of 0.75 m/s (see Section 2.3.1.2, Appendix B)) and the large amount of run-off from the steep coastline from heavy rains during the wet season.

The waters of Cone Bay and surrounding areas are not listed under any marine park conservation area or other areas of special interest. However, it was a recommendation of the Marine Parks and Reserves Selection Working Group in June 1994 that "the waters of the Buccaneer Archipelago (which includes Cone Bay) should be considered for reservation as a multiple-use marine park".

The water quality within Cone Bay and surrounding areas is in a natural state. Natural fluctuations associated with seasonal variations do occur, however, this is characteristic of the Buccaneer Archipelago (CALM, 1994).

Fauna

Migratory birds are known to pass over the area and it is assumed that they would use the surrounding terrestrial landscape to rest, shelter and feed. Birds that have been sighted include the Sea Eagle, occasional Frigate bird, Sulphur Crested Cockatoos and a variety of finches. The current sea cage operation has not encountered any impacts to the seabird population to date.

Crocodile activity is commonly observed in Cone Bay due to the physical characteristics of the bay (eg mudflats and small beaches). Very little turtle activity in relation to nesting is observed in the bay or surrounding areas although turtles are observed on an occasional basis swimming in the waters. No known sightings of whales or dugongs have been reported as a part of the pearling or aquaculture operations to date and dolphin activity has been reported on an occasional basis in Cone Bay and surrounding areas.

The Yampi Sound (which includes the King Sound) has a large diversity of finfish species ranging from pelagic fish, sedentary reef or territorial fish and an abundant variety of other reef fish. Finfish that have been commonly observed and recreationally fished within the Buccaneer Archipelago include Barramundi, Fingermark, Triple-tail, Mackerel species, Blue-fin tuna, Nor-west snapper, Tiger sharks, Sleepy Sharks, Black-tip & White-tip reef sharks, Garfish, Mullet and a variety of others including emperors, cods, groupers, snappers and baitfish. Larger pelagic fish have been reported (eg Sailfish) in the King Sound area, however only one sighting in Cone Bay has been recorded in the last 15 years. Sharks are occasionally seen in Cone Bay as a part of both the pearling and aquaculture activities.

Marine Habitats

There are no mangrove communities within the proposal site; however a survey identified a number of mangrove communities along the Cone Bay coastline. The identification and mapping of the mangrove communities was undertaken by investigating charts (Chart: AUS 733-Australian Hydrographic Service, 1992 and Oceanvision Software Package) and aerial photographs (source: googleearth.com and personnel digital photographs) and ground level observations were then used to confirm those BPPH noted from charts and to identify any other BPPH areas not represented or indicated in the charts and/or aerial photographs (see Section 3.6). The majority of the mangroves are located at the back of the bay with two large communities existing on either side. One community stretches approximately 7.3km along the coastline and the other 4.2km. The rest of the mangrove communities are small (approximately 0.25km to 3.6km) and interspersed throughout the northern and southern coastline of the bay (see Figure 3.4).

No coral reefs exist within the aquaculture licence area. There is however, one coral reef community observed within Cone Bay but it is located some distance (5.76km) from the licence site on the north-western side of the bay (Figure 3.5). Again this investigation was conducted in the same manner as was undertaken to identify mangrove communities (see Section 3.6). All coral reefs are considered to be in a natural state subject to natural seasonal disturbances.

Cone Bay, including the licence area, demonstrates similar characteristics in benthic structure to the rest of the King Sound and Buccaneer Archipelago. This being predominantly mud with large areas of solid rock characteristic of the surrounding coastal landscape. Current sediment disturbances result from high tidal range (9-11 metres) and fast water movement occurring year round. This is exacerbated during severe or cyclonic weather (on an annual basis), where the conditions result in the sediments being forced into suspension and circulated throughout the bay and out into the King Sound.

There are no seagrass meadows in Cone Bay or in the surrounding waters outside the entrance. Underwater video imagery collected and analysed from within aquaculture licence site 1465 demonstrates the lack of seagrass and all other BPPHs (see Appendix K). Consequently there have been no sightings of dugong within the vicinity of Cone Bay and the traditional landowners do not hunt dugong in the waters within or locally surrounding Cone Bay.

Current Social Use

Recreational use that occurs in Cone Bay is predominantly fishing and camping. Due to the remoteness of the area only people who own or have access to a boat are able to utilise this area for recreational purposes.

There are no known commercial aquaculture or fishing licences in Cone Bay. MPC, in conjunction with MFF, already operates an existing pearling and Barramundi aquaculture venture based in Cone Bay. The mining industry has interests on Cockatoo and Koolan Islands (~45.6km NNE) with vessels regularly navigating between the mine sites and the Port of Derby.

Many tourist charter operators, such as fishing charter operators, luxury boat/holiday operators and air charter operators currently conduct activities in the King Sound and Buccaneer Archipelago. Charter boats are known to enter Cone Bay and the majority of these operators have developed mutually beneficial relationships with the existing pearling and aquaculture operations undertaken by MPC and MFF.

The coastline and land surrounding Cone Bay is commonwealth land that is utilised by the Department of Defence (DoD). The area is currently utilised on a sporadic basis by the DoD for training purposes.

Aboriginal and Cultural Heritage

The aquaculture licence 1465 site is located within state waters and there are no World Heritage properties, National Heritage places, Ramsar wetlands, listed Commonwealth Heritage places or areas of remnant native vegetation within the vicinity of the site (Figure 3.10). The area was included in the CALM 1994 Report of the Marine Parks and Reserves Selection Working Group (*A Representative Marine Reserve System For Western Australia)* whereby it was recommended that the area be considered for conservation but zoned as multiple-use to include ventures such as this proposal.

The Kimberley region has 24 native title claims currently in progress, with 9 claims already under active management and two of these nearby the licence area. The closest native title claim is Dambimangari, which incorporates the majority of Cone Bay. Another native title claim that also encompasses part of Cone Bay and lies directly next to Dambimangari claim is Mayala.

A small community exists at the north-eastern end of Cone Bay, the Larinuwar (Yaluun) Community. Yaluun and its members have been a part of the consultative process with MPC since the pearling venture inception which MPC has maintained to this date. Through all past and more recent communications MPC (and MFF) has established that no aboriginal site issues exist in the area. Further detail is provided in Section 3.8.

V. Investigations

a. Presentation of Existing EMMP Results

An EMMP was developed for the existing sea cage operation in Cone Bay in 2005 and was approved by the EPA and implemented in February 2006. Environmental quality data has been collected for the Cone Bay area since 2004 coinciding with the introduction of the pilot project and thus the first sea cage.

The EMMP was developed using much of the information obtained from hydrodynamic studies conducted in Cone Bay by Brown & Root (formerly Kinhill) in early 2000. These studies were undertaken for the pearling venture in existence at the time, however provides the basic information of the bay and sample sites that was incorporated into the Cone Bay EMMP.

A detailed report is presented in Appendix D and a summary of important characteristics of the area ascertained from the results of the Cone Bay EMMP is given below.

Water Quality

- Distinct seasonal patterns have been observed in parameters such as water temperature, dissolved oxygen (DO) and Chlorophyll *a* (chl-a).
- Salinity and pH demonstrate relatively consistent results over time. Salinity ranged between 32.8‰ and 36.7‰ and pH between 7.34‰ and 9.92‰.
- Other water quality parameters do not necessarily demonstrate seasonal patterns; however have presented highly variable results that coincide with changes in the ambient environmental conditions (ie large tidal ranges, high flushing rates and high variability in ambient conditions experienced in the area).
- No unacceptable water quality impacts have been observed to date as a result of the implementation of the sea cages. All sea cage sites show similar results to reference sites on any given sampling date.
- Ambient environmental changes have shown to have a greater impact on environmental quality in the area in comparison to the sea cages.

Benthic Quality

- TKN makes up the total nitrogen value indicating that the sediments are made up of organic nitrogen.
- TN is highly variable and ranged between 160 and 863mg/kg for the sampling period.
- Overall, benthic sediment quality demonstrates very high inter- & intra-site variability and no distinct patterns can be ascertained.
- On most occasions the reference sites have demonstrated higher values than the cage sites indicating that ambient environmental changes appear to have a greater effect on sediment quality than the sea cages.
- Although visual observations of the mud samples have shown slight changes to the benthic substrate directly beneath the cages, no unacceptable benthic substrate changes to the sediment chemistry have occurred. In addition, no trigger values have been exceeded and thus no unacceptable impacts have been recorded.

Benthic Infauna

- Infaunal species diversity and abundance is very low (3 samples analysed has only 1 individual present).
- There is high variability both inter- and intra-site.
- Only 3 sites were observed to have more than one species represented at that site.
- The majority of samples had only one species and/or one individual present in the sample.
- The sea cage samples were observed to have the second highest abundance (5 individuals) and diversity (5 species) with Gerald Bay demonstrating the highest diversity and abundance (12 taxa represented by 17 individuals).

Mangrove Communities

Two mangrove communities in Cone Bay have been selected as a part of the EMMP (Figure 3.12).

Both mangrove sites are in a healthy and natural state with the predominant species being *Avicenna marina* and *Rhizophora sp.* The monitoring results have shown that over time there has been no loss of size or health of the communities (see Appendix D).

Coral Reef Communities

One coral reef community in Cone Bay has been selected as a part of the EMMP (Figure 3.13).

The state of the coral reef in Sir Richards Pass is considered to be in a healthy and natural state. The reef extends over a large area and is comprised of many types of corals, sponges, invertebrates and fish species. The corals are predominantly hard corals including those from the families Faviidae (brain corals), Acorpora (staghorn and plate corals) and Poritidae (stony corals). Further detail is presented in Appendix D.

Biota

Since the inception of the EMMP all observations of marine biota present at a visible distance from the sea cages has been recorded. The majority of species sighted are various types of baitfish (eg garfish, scat), batfish, crocodiles and herons. Other species that have been observed on a less regular basis include:

- Fish – Reef sharks, Mackerel, Tuna, Trevally, Cobia, Grouper, other tropical reef fish, Queenfish, Lemon Shark, Sleepy Shark, larger sharks (eg Bronze whaler and Tiger) and one manta ray.

- Reptiles – one turtle.
- Birds – Frigates, Terns, Sea Eagles, Brahminy Kites.

A complete list of fauna observed within sea cage vicinity between February 2004 and March 2007 is presented in Appendix D. Abundance and behaviour of each species on any given day is also noted.

b. Development and Improvement of the Environmental Monitoring & Management Program (EMMP)

MPC developed an EMMP that was approved and implemented in early 2006. As a result of this proposal to increase production a revised edition of the EMMP has been developed to ensure all potential impacts are addressed and that the proposal adheres to the environmental commitments that are outlined in Section 8 of this PER. The revised Cone Bay EMMP is provided in Appendix F.

The EMMP includes close monitoring of parameters such as water quality, benthic substrate, benthic habitats (mangrove areas and coral reefs), Benthic Infauna and general marine biota observations. The EMMP also incorporates auditing of the monitoring results and regular review of the monitoring procedures and effectiveness.

c. Benthic Primary Producer Habitat (BPPH) Identification and Evaluation

The identification and mapping of the BPPH areas within Cone Bay was undertaken by investigating charts (Chart: AUS 733-Australian Hydrographic Service, 1992 and Oceanvision Software Package), and aerial photographs (source: googleearth.com and personnel digital photographs).

Ground level observations and underwater video imagery were then used to confirm those BPPH noted from charts and to identify any other BPPH areas not represented or indicated in the charts and/or aerial photographs. All results are presented in Section 3.6 and Appendices D, E and K.

d. Identification of Environmental Values (EV) and Development of the Environmental Quality Objectives (EQO) and Management Strategies

Environmental values (EVs) can be broadly divided into two main areas: Ecological and Social. Ecological values are those characteristics of the environment that play an essential role in the biodiversity of the area and incorporate biophysical factors and pollution management (CALM, 2005). Social values are those characteristic of an area that have any cultural, recreational, aesthetic, commercial or economic significance (CALM, 2005). The environmental values determined for this proposal are similar to those determined in the *Pilbara Coastal Water Quality Consultation Process* (DoE, 2006) and are detailed further in Section 6.4.

For each EV one or more EQOs have been defined and are simply the management goals that maintain the environmental quality of the relevant EV, thereby protecting it from or minimising the effects of the proposal. The EVs, EQOs, subsequent levels of protection assigned to the proposal site and surrounding area and the Environmental Quality Criteria (EQC) established are described in detail in Section 6.

e. Hydrodynamic Modelling

Two hydrodynamic studies have been conducted in Cone Bay. The first by Brown and Root in 2000 and the second by Asia-Pacific Applied Science Associates (APASA) in 2006. The objectives of the Brown and Root study were to investigate:

- Flushing rates within the bay;
- Circulation patterns within and at the opening of the bay;
- Predicted dispersion of neutrally buoyant particles within the bay;
- Base-line nutrient levels and distribution within the bay; and
- Tidal range and cycle.

As the Brown and Root study did not incorporate any potential impacts resulting from the proposal, MPC commissioned APASA to undertake additional hydrodynamic modelling in 2006. The objectives of this study were:

- Simulation of the circulation within the bays, based on the existing morphology and the introduction of the sea cages;
- Quantification of the flushing rates for the adjacent bays, based on the existing bottom friction conditions and after the inclusion of the sea cages/increased bottom friction;
- Simulation of the dispersion and settlement patterns of fish food and fish waste from the fish farm operation in Cone Bay; and
- Estimate the dispersion and accumulation of dissolved nutrients in the case of total production of the two adjacent fish farms once operating at full capacity.

A detailed report of the results from both studies is given in Appendix B however a summary of results is given below:

Overall both the studies demonstrated similar outcomes regardless of the year each study was undertaken, which provides an increased confidence and accuracy in interpreting the results and making predictions. The main conclusions that can be taken from both of these studies relevant to the proposed 1,000T Barramundi production proposal include:

- No changes to the circulation patterns of the bay will occur,
- Slight reduction of current speeds (from 0.45m/s to 0.25m/s) at the peak springs are expected to occur with the implementation of the cages,
- A slight decrease in the flushing rate (from 2 days to 3 days) may occur during the neap tides,
- Solid waste products from the fish farms may be deposited up to 250m from the sea cages, however at very low concentrations (0.01 – 0.05g/m^2/day) with the majority settling close to the sea cages (0.1 -0.5g/m^2/day),
- No interaction or potential accumulation of dissolved nutrients is expected to occur as a result of the two adjacent farms operating at full capacity.

VI. Environmental Management System

A summary of the environmental objectives, potential impacts, investigations addressed and proposed environmental management is given in Table A. A more detailed presentation of the impacts, risk assessment and management is given in Section 4.0

A summary of the proponent's commitments is provided in Table B. A detailed discussion of the development of the proponents' environmental management system is given in Section 6.0.

VII. Conclusions

The results of the investigations undertaken for this PER have verified that the majority of potential impacts to the surrounding environment will be avoided and that the ambient environmental conditions are causing greater impacts to the water, sediment and BPPH quality. These discussions have also demonstrated how those potential impacts that cannot be avoided, such as dissolved and solid waste outputs, will be minimised by incorporating appropriate and effective management strategies that uphold the levels of environmental protection assigned to the proposal site and surrounding area. It should also be noted that the environment is biologically very active, particularly at higher water temperatures and yet no allowance has been made in the hydrodynamic model for assimilation of nutrients due to environmental factors.

VIII. TABLE A: Summary Table of the Environmental Impacts and Management

Environmental Factor	Relevant Area	EPA Objective	Potential Impacts	Investigations Addressed	Environmental Management	Predicted Outcome
Biophysical Factors						
Fauna – Disease Transfer	Proposal site and surrounding areas.	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	Spread of endemic disease across the Barramundi population within the region.	• A Barramundi Fish Health Management Plan (BFHMP) has been developed and includes measures to prevent disease and a contingency plan in the event of a disease or parasite outbreak (see Appendix H), and • A procedures manual for sea cage grow-out is currently being developed and a draft copy is included as Appendix L.	• Ongoing development of procedures manual for sea cage grow-out (see Appendix L), • Translocation protocols to be adhered to, • Regular health monitoring and disease testing of farm stock and stringent disease testing of all new stock before introduction to the Cone Bay facility, • Development of a net inspection and cleaning protocol which is included in the procedures manual for sea cage grow-out (see Appendix L), • Staff training and education in animal health issues, • Vaccination of fish to prevent disease and • Development of a disease contingency plan (see attachment H).	Due to the management protocols proposed the risk of adverse impact is minimal and the EPA's objectives will be met.
Fauna – Introduction of Disease	Hatchery, proposal site and surrounding areas.	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	Introduction of exotic diseases and organisms.	• A Barramundi Fish Health Management Plan (BFHMP) has been developed and includes measures to prevent disease and a contingency plan in the event of a disease or parasite outbreak (see Appendix H).	• Translocation protocols to be adhered to, • Stringent disease testing before introduction to the Cone Bay facility, • Conservative stocking densities whilst in hatchery, • Improvement in hatchery techniques,	Due to the management protocols proposed the risk of adverse impact is minimal and the EPA's objectives will be met.

					• Use of endemic brood stock whenever possible, • Sterilisation and maintenance protocols of hatchery and associated equipment, • Minimise handling, • Staff training, • Vaccination of fish to prevent disease and • Disease contingency plan to be in accordance with the requirements and suggestions provided by the WA Fish Health Laboratories (see Appendix H).	
Fauna – Genetic Variation	Proposal site and surrounding areas.	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	Impact of Fish Escapes.	• A procedures manual for sea cage grow-out which includes fish transfer protocol is currently being developed and a draft copy is included as Appendix L, and • A procedures manual for harvesting activities is currently being developed and a draft copy is included as Appendix M.	• Utilisation of steel nets currently in use at the aquaculture site with proven capability of withstanding pressures from adverse weather and predation, • Development of a procedures manual for harvesting activities (see Appendix M), • Staff training in the correct procedures of the above mentioned activities, • Regular net inspections, and • Use of endemic brood stock whenever possible.	The impact to the genetic diversity of endemic fauna will be minimal to nil due to the management procedures and protocol practices in place to prevent fish escapes.
Fauna – Genetic Variation	Proposal site and surrounding areas.	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	Impact of Sexually Mature Fish.	• A procedures manual for harvesting activities is currently being developed and a draft copy is included as Appendix M.	• The majority of fish will be harvested from the sea cage system before reaching sexual maturity.	The impact to the genetic diversity of endemic fauna will be minimal to nil due to low numbers of sexually mature fish within the sea cage system.

Fauna – Marine Wildlife	Proposal site.	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	Provision of Additional Food Source from Waste Feed.	• A procedures manual for sea cage grow-out which details feeding protocol is currently being developed and a draft copy is included as Appendix L, • An Environmental Monitoring and Management Program (EMMP) has been developed and includes a biota log to record all marine fauna sightings within vicinity of the sea cage operation (see Appendix F). The records of marine biota observed to date are presented in Section 8, Appendix D.	• Feeding will be closely monitored by use of video imaging to determine the most efficient feeding regime, • A biota log has been developed to record all observations of marine fauna including number, species and behaviour, and • Feeding to be conducted at "slack" tide to reduce the probability of feed being dispersed outside of cage.	The geographic distribution and diversity of fauna will not be adversely impacted as results from the Cone Bay logging program demonstrate. It is predicted that a number of species will be sited within close proximity to the sea cages but for short periods.
Fauna – Marine Wildlife	Proposal site.	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	Entanglement of Marine Life in Nets.	• A procedures manual for sea cage grow-out which details equipment inspection and maintenance protocols is currently being developed and a draft copy is included as Appendix L, • An Environmental Monitoring and Management Program (EMMP) has been developed and includes a biota log to record all marine and terrestrial fauna sightings within vicinity of the sea cage operation (see Appendix F), and • Investigations were conducted regarding the potential use and advantages of nets constructed of other materials such as plastic. The results of this investigation are presented in Section 2.3.2 Grow-Out Cage System – Construction and Carrying Capacity.	• Development of a log to record all sightings of marine and terrestrial fauna (marine mammals, fish, sharks, birds, turtles, crocodiles etc), • Use of heavy gauge wire mesh to reduce the risk of predation by sharks and crocodiles, • Utilise overhead netting made of heavy gauge polyethylene or nylon to exclude birds and ensure the netting is pulled taut to prevent entanglement, • Regular inspections of equipment and strict maintenance programs will be implemented, • Minimise equipment requirements for operations and ensure all dismantled equipment is stored appropriately when not in use, and • Adequate spatial separation of cages will	Fauna populations will not be adversely impacted on by sea cage structure and possibility of entanglement is very low.

					allow ample room for passage of underwater marine animals.	
Fauna – Marine Wildlife	Proposal site.	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	Provision of Artificial Habitat to Marine Fauna.	• An Environmental Monitoring and Management Program (EMMP) has been developed and includes a biota log to record all marine and terrestrial fauna sightings within vicinity of the sea cage operation (see Appendix F). The records of marine biota observed to date are presented in Section 8, Appendix D.	• Equipment requirements to be kept to a minimum, • Feeding closely monitored by use of video image to reduce risk of attracting marine fauna, and • Maintenance of daily logs and other records.	The geographic distribution and diversity of fauna will not be adversely impacted as results from the Cone Bay logging program demonstrate. It is predicted that a number of species will be sited within proximity to the sea cages for short periods of time.
Fauna – Predators	Proposal site.	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	Attraction of and Impact to and from Predators.	• A procedures manual for sea cage grow-out which details feeding protocol is currently being developed and a draft copy is included as Appendix L, and • An Environmental Monitoring and Management Program (EMMP) has been developed and includes a biota log to record all marine and terrestrial fauna sightings within vicinity of the sea cage operation (see Appendix F).	• Equipment requirements to be kept to a minimum, • Feeding closely monitored by use of video image to reduce risk of attracting marine fauna, • Removal of mortalities and correct disposal to reduce attraction of predators within the vicinity, • Maintenance of daily logs that record all observations of marine fauna including predators, and • Ensure all staff are aware of the perils and correct procedures associated with working in an environment with dangerous predators (eg crocodiles).	The geographic distribution and diversity of fauna is not expected to be adversely impacted on as results from the Cone Bay logging program demonstrate. It is predicted that baitfish schools will predominantly be in close proximity to the cages, but other species of marine biota are expected to be observed for short periods of time.

Fauna - Baitfish	Proposal site.	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	Fish Feeding on Naturally Occurring Food Sources.	• A procedures manual for sea cage grow-out which details feeding protocol is currently being developed and a draft copy is included as Appendix L, and • An Environmental Monitoring and Management Program (EMMP) has been developed and includes a biota log to record all marine and terrestrial fauna sightings within vicinity of the sea cage operation (see Appendix F).	• Closely monitored feeding levels (by video monitoring) to determine the most efficient feeding regime, and • Maintenance of daily logs and other records.	Minimal numbers of baitfish will be removed from the food chain as the cultured fish will receive adequate manufactured feed on a daily basis. Results from the Cone Bay logging program demonstrate that the occurrence of baitfish is evident however, the baitfish are mainly observed outside the sea cages.
Flora – Benthic Primary Producer Habitats	Surrounding areas.	To maintain the abundance, diversity, geographic distribution and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	Impacts on Mangrove systems and Coral Reefs (Benthic Habitats).	• An Environmental Monitoring and Management Program (EMMP) has been developed and includes Mangrove System Management (see Section 4, Appendix F) and Coral Reef System Management (see Section 5, Appendix F). Recorded observations are presented in Appendix F, Sections 4 and 5 and photographs are presented in Appendix E, • The location and extent of mangrove and coral reef systems within vicinity of the licence site was investigated and observations are recorded in Sections 3.6.1 and 3.6.2 and diagrammatically represented in Figures 3.4 and 3.5.	• Site was selected due to low abundance of mangroves and coral reefs in the bay, • All anchoring systems will be a minimum of 100 metres from mangroves and reefs and the cages a minimum of 200 metres, and • Mangroves and coral reefs will be regularly monitored and compared against baseline data.	No direct physical impact to mangrove and coral reef systems. Indirect impact caused by nutrient loading will be minimal and environmental monitoring and management will ensure the EPA's objectives can be met.

Flora – Seagrass Beds	Proposal site.	To maintain the abundance, diversity, geographic distribution and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	Shading Effect.	• An Environmental Monitoring and Management Program (EMMP) has been developed and includes Water Quality Management (see Section 2, Appendix F) in addition to a Fallowing Program (see Section 3.6, Appendix F), and • Underwater video imagery has been collected and analysed to demonstrate the lack of Benthic Primary Producer Habitats (BPPH) within the licence site (see Appendix K).	• The site was selected due to the substrate consisting of mud and the complete absence of seagrass beds in the vicinity of the proposal site. Underwater video imagery of the licence site is provided in Appendix K.	No direct contact with seagrass beds as the bottom is void of any seagrass. Water quality monitoring program will detect any changes in Chl-a levels, thus minimising the impact of shading from increasing plankton levels. Fallowing program will reduce impacts associated with the shading effect of sea cages.
Land (marine) – Benthic Substrate	Proposal site.	To maintain the integrity, ecological functions and environmental values of the seabed and coast.	Benthic substrate changes below sea cages and within the zone of influence.	• An Environmental Monitoring and Management Program (EMMP) has been developed and includes Benthic Quality Management (see Section 3, Appendix F). In addition results for the benthic analysis (including benthic biota diversity and abundance) are presented in Appendix D, • The potential impact and risk assessment of the sea cages on the benthic substrate has been determined (see Sections 4.8 to 4.14) utilising hydrodynamic modelling information (see Appendix B), • Environmental Quality Criteria (EQCs) have been developed as a percentile-based calculation for the sea cage operation. Further detail is provided in Section 6.6.2, and • A procedures manual for sea cage grow-out which details	• Benthic monitoring program to assess changes in substrate and diversity and abundance of macro-invertebrates below the sea cages and in the zone of influence (see Appendix D and F), • Anchor systems specifically designed for mud bottoms to be utilised, • Conservative stocking densities, feed monitoring and conservative feed regimes, • Fallowing of sites will be introduced and become standard practice, and • Any unacceptable impacts detected outside the lease area will trigger an immediate management response.	No unacceptable impacts to the benthic environment directly beneath the cages or within the zone of influence to occur. Fallowing of sites will result in rehabilitation of the substrate.

				feeding protocol is currently being developed and a draft copy is included as Appendix L.		
Land (marine)	Proposal site.	To maintain the integrity, ecological functions and environmental values of the seabed and coast.	Impacts from Sea Cage Infrastructure.	• Underwater video imagery has been collected and analysed to demonstrate the lack of Benthic Primary Producer Habitats (BPPH) within the licence site (see Appendix K).	• The site was selected due to the substrate consisting of mud and the complete absence of seagrass beds in the vicinity of the proposal site, • Anchor systems specifically designed for mud substrates to be utilised, and • Sea cages anchored a minimum of 100 metres from coral reef and mangrove systems.	No direct contact with seagrass beds, coral reef or mangroves.
Water (marine) – Hydrodynamic Changes	Proposal site and surrounding areas.	To maintain the quantity of water so that existing and potential environmental values, including ecosystem maintenance are protected.	Impact of Hydrodynamic Changes caused by Sea Cage Infrastructure.	• A procedures manual for sea cage grow-out which details equipment inspection and maintenance protocols is currently being developed and a draft copy is included as Appendix L.	• Aquaculture site situated in a high energy tidal environment, • Infrastructure utilised to be minimal and fouling on cages will be regularly monitored and maintained as required to reduce the probability of water restrictions.	No impact is predicted and as a result the EPA objective will be met.

Conservation Areas	Proposal site.	To protect the environmental values of areas identified as having significant environmental attributes.	Potential to impact the ecology of the region (ie Ecological Consequences).	• An Environmental Monitoring and Management Program (EMMP) has been developed (see Appendix F) and includes: • Water Quality Management, • Benthic Quality Management, • Mangrove System Management, • Coral Reef System Management, and • Biota Management.	• Stringent environmental monitoring and management program (EMMP), • Continual improvement and development of the EMMP and EMS, • Programs to increase staff environmental awareness, • Specifically designed equipment and procedures that reduce the level of impact to the surrounding environment, and • Regular communications with appropriate regulatory organisations to ensure efficient management practices are in place.	Due to the management protocols proposed the risk of adverse impact is minimal and the EPA's objectives will be met.
Pollution Management Factors						
Water Quality (Marine)	Proposal site and surrounding waters.	To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.	Water pollution from biological inputs (fish faeces and other nutrient inputs).	• Environmental Values (EVs), Environmental Quality Objectives (EQOs), subsequent Environmental Quality Criteria (EQC) and management strategies have been identified and developed and are discussed in detail in Section 6. • Cause-effect pathways used to identify key ecological processes have been developed and are diagrammatically represented in Section 6, figures 6.1, 6.2 and 6.3, • Hydrodynamic modelling within the Cone Bay region was conducted to use as a tool to predict the potential impacts of nutrient input and is presented in Appendix B.	• Aquaculture site selected in high energy tidal environment, • Water monitoring program to assess changes in water quality at the site and in the zone of influence, • Conservative stocking densities and feed regimes, • Removal of mortalities, • Fallowing of cage sites, • Construction of the cages utilising products that require little or no cleaning, • Effective net cleaning/changing maintenance schedules, and • Regular maintenance of buildings and existing infrastructure.	The environmental objective for water quality will be achieved through the utilisation of environmental monitoring and management practices in place.

				The potential impact and risk assessment of the nutrient input on the environment is further discussed in Section 4.13, • An Environmental Monitoring and Management Program (EMMP) has been developed and includes Water Quality Management (see Section 2, Appendix F) in addition to a Fallowing Program (see Section 3.6, Appendix F), and • A procedures manual for sea cage grow-out which details feeding practice and equipment inspection and maintenance protocols is currently being developed and a draft copy is included as Appendix L.		
Water Quality (Marine)	Proposal site and surrounding waters.	To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.	Water pollution from chemical inputs.	• A Barramundi Fish Health Management Plan (BFHMP) has been developed and includes measures to prevent disease and a contingency plan in the event of a disease or parasite outbreak (see Appendix H), • A procedures manual for sea cage grow-out is currently being developed which details equipment inspection and cleaning protocols and a draft copy is included as Appendix L, • A Toxic and Hazardous Substances (THS) Management Protocol has been developed and details storage, use and accidental spill contingency plan of THS and a draft copy is included as Appendix I, and	• Conservative stocking densities, • Stringent disease testing before transporting to the Cone Bay facility, • If required, treatment of fish with chemicals will commence only after consulting the WA Fisheries Senior Fish Pathologist, • Staff training in hygienic fish husbandry techniques, • Development of a disease contingency plan, • Construction of the cages utilising products that require little or no cleaning, and • Development of an oil and fuel spill protocol.	No adverse impact to water quality from chemical inputs as chemicals will not be utilised in daily operation and only as a "last resort".

				• Environmental Quality Criteria (EQCs) have been developed as a percentile-based calculation for the sea cage operation. Further detail is provided in Section 6.6.2.		
Waste Disposal	Proposal site and surrounding area.	To ensure that liquid and solid wastes do not affect groundwater or surface water quality, nor lead to soil contamination.	Potential for litter.	• A Waste Management Plan (WMP) has been developed for all aspects of operations and a draft copy is included as Appendix J, and • An Environmental Management System (EMS) is currently being developed and includes staff training (induction and ongoing) programs which emphasise staff environmental obligations. A draft copy is provided in Appendix N.	• Staff will commute to the site on a daily basis and all rubbish and discarded material will be removed and transported to the Cone Bay land base site for correct disposal (see Appendix J), • Regular inspections of sea cages and associated equipment, • Petrol and diesel powered vessels will be serviced, maintained and refuelled on the island, and • Programs developed to increase environmental awareness of staff and induction of all new staff with emphasis on environmental obligations.	Appropriate management of litter waste to meet EPA's objective.
Air Quality – Boat Emissions	Proposal site and surrounding area.	To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.	Emissions from boat exhausts.		• All boats are regularly serviced and maintained to reduce exhaust emissions and fuel consumption, and • Site selected due to close proximity to Cone Bay land base.	Appropriate management of boat emissions to meet EPA's objective.

Air Quality – Fish Odour	Proposal site and surrounding area.	To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.	Potential for fish odour.		• Conservative stocking densities, • Regular health checks, and • Fish mortalities will be removed when first observed and disposed of in correct manner.	The environmental objective for air quality will be achieved through utilisation of fish handling and management practices in place.
Noise	Proposal site and surrounding area.	To protect the amenity of nearby residents from noise impacts resulting from activities associated with the proposal by ensuring the noise levels meet statutory requirements and acceptable standards.	Potential to disturb biota.		• All boats are regularly serviced and maintained to reduce noise emissions, • Boat activity is minimal due to close proximity of proposed site to Cone Bay land base, and • All staff are adequately trained and educated in proper boat handling skills and a Code of Conduct policy will be developed as a part of the SOP to ensure inappropriate vessel navigation is avoided.	EPA's objectives will be met as there are no nearby residents to impact upon and noise levels will be minimal.
Social Surrounds Factors						
Recreation	Proposal site.	To ensure that existing and planned recreational uses are not compromised.	Access loss to marine environment due to sea cages, resulting in perceived alienation of other marine resource users and competition for sheltered waters.	• MPC undertook a public and stakeholder consultative process in order to allow any interested parties to provide comments and suggestions (see Section 7). The comments provided allowed MPC to investigate actions that may benefit other marine users. Actions taken to date are discussed in greater detail in Table 7.1.	• Sea cages arranged in neat orderly manner and clearly marked to allow safe passage, • Ongoing public consultation with appropriate groups to ensure all users are aware of the proponents activities, and • Surrounding area not deemed exclusive to aquaculture operators.	The proposal allows for easy passage within the area and no adverse affect on recreational uses is predicted.

Cultural Heritage	Proposal site.	To ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation.	Impacts on native title or culturally significant areas.	• MPC undertook a public and stakeholder consultative process in order to allow any interested parties to provide comments and suggestions (see Section 7).	• Continued communications and liaisons with traditional occupiers, and • Site selected to maintain a distance from reefs and mangrove areas in addition to areas of cultural significance.	Proposal does not impose on any known native title or culturally significant areas and as such the EPA's objective can be met.
Visual Amenity	Proposal site.	To ensure that aesthetic values are considered and measures are adopted to reduce visual impacts on the landscape as low as reasonably practicable.	Perceived lowering of aesthetic value due to the presence of sea cages.		• Sea cages are low profile and dark in colour, • Navigational markers are constructed in an aesthetically pleasing way to minimise visual impact, and • All accommodation and storage facilities are located on the island.	Sea cage system will blend well with existing environment and the EPA's objective can be met.
Other Factors						
Unknown, Unpredictable or Irreversible Impacts	Proposal site.	To ensure, as far as practicable, that rehabilitation achieves a stable and functioning landform which is consistent with the surrounding landscape and other environmental values.	Irreversible changes to the proposal site and surrounding areas.	• Environmental Values (EVs), Environmental Quality Objectives (EQOs), subsequent Environmental Quality Criteria (EQC) and management strategies have been identified and developed to aid in preventing irreversible changes to the proposal site and are discussed in detail in Section 6.	• Use of purpose built anchor systems specific for mud substrates, • Structure of the cages is such that there is very little effort and resources required to dismantle and remove if necessary, and • Environmental monitoring will allow management practices to be implemented to prevent any irreversible environmental damage and as a result the environment should return to it's 'pre-proposal' state if the project were to end.	Decommissioning of the sea cage system will ensure no or minimal impact within the area and allow for the rehabilitation of the substrate to a stable and functioning form consistent with the surrounding region.

IX. TABLE B: Summary Table of the Proponents Commitment

No.	Topic	Action	Objectives	Timing	Advice from
1.	Environmental Monitoring and Management Plan	The proponent will prepare a more comprehensive Environmental Monitoring and Management Plan (EMMP) that addresses: 1) Water Quality Management, 2) Benthic Quality Management, 3) Mangrove System Management, 4) Coral Reef System Management, 5) Biota Management, 6) Environmental Quality Criteria (EQC) and trigger values developed, 7) Management Responses, and 8) Auditing, review and liaison procedures.	To minimise direct and indirect impacts associated with the sea cage system on fauna, flora, water quality, coral reef systems, mangroves and benthic substrate.	Preparation prior to commencement of proposal.	EPA, WA DoF, WA DEC, WA Private Consultants
2.	Environmental Monitoring and Management Plan	Implement the approved EMMP referred to in commitment 1.	As for objectives in commitment 1.	Prior to, during and post operation.	EPA, WA DoF, WA DEC, WA
3.	Water Quality Management	Prepare a Water Quality Management program as a part of the EMMP that: 1) Identifies the concentration of nutrients and other environmental parameters in the water column, 2) Develops a comprehensive monitoring schedule, 3) Creates EQC for parameters that may have an impact on water quality, and 4) Develops a management plan in the event that unacceptable nutrient levels are detected or environmental parameters are impacted (EQC are exceeded).	To maintain acceptable water quality within the proposal site and the surrounding waters.	Preparation prior to commencement of proposal.	EPA, WA DoF, WA DEC, WA
4.	Water Quality Management	Implement the approved Water Quality Management Program referred to in commitment 3.	As for objectives in commitment 3.	Prior to, during and post operation.	EPA, WA DoF, WA DEC, WA

5.	Benthic Substrate Management	Prepare a Benthic Quality Management Program as a part of the EMMP that: 1) Identifies the concentration and zone of nutrients and other environmental parameters within the benthic substrate, 2) Creates EQC for parameters that may have an impact on the benthic substrate and benthic biota, 3) Develops a fallowing program, 4) Develops a comprehensive monitoring schedule, and 5) Develops a management action plan in the event that unacceptable nutrient levels are detected or environmental parameters are impacted (EQC are exceeded).	To maintain acceptable levels of environmental impact on the benthic substrate and to maintain abundance and diversity of benthic biota.	Preparation prior to commencement of proposal.	EPA, WA DoF, WA DEC, WA
6.	Benthic Substrate Management	Implement the approved Benthic Quality Management Program referred to in commitment 5.	Achieve the objectives in commitment 5.	Prior to, during and post operation.	EPA, WA DoF, WA DEC, WA
7.	Mangrove System Management	Prepare a Mangrove Management Program as a part of the EMMP that: 1) Avoids direct and minimises indirect impacts on all mangrove systems within Cone Bay and the zone of influence, 2) Where mangroves may be impacted, managements objective will be no net loss of function or value, 3) Develops a monitoring schedule, 4) Creates EQC for parameters that may have an impact on the mangrove systems, and 5) Develops a management plan in the event that environmental parameters are impacted (EQC are exceeded).	To minimise impacts (both direct and indirect) on mangrove systems to ensure no net loss of function or value.	Preparation prior to commencement of proposal.	EPA, WA DoF, WA DEC, WA

8.	Mangrove System Management	Implement the approved Mangrove Management Program referred to in commitment 7.	Achieve the objectives in commitment 7.	Prior to, during and post operation.	EPA, WA DoF, WA DEC, WA
9.	Reef System Management	Prepare a Coral Reef Management Program as a part of the EMMP that: 1) Avoids direct and minimises indirect impacts on all reef systems within Cone Bay and the zone of influence, 2) Where reefs may be impacted, managements objective will be no net loss of function or value, 3) Develops a monitoring schedule, 4) Creates EQC for parameters that may have an impact on the reef systems, and 5) Develops a management plan in the event that environmental parameters are impacted (EQC are exceeded).	To minimise impacts (both direct and indirect) on reef systems to ensure no net loss of function or value.	Preparation prior to commencement of proposal.	EPA, WA DoF, WA DEC, WA
10.	Reef System Management	Implement the approved Coral Reef Management Program referred to in commitment 9.	Achieve the objectives in commitment 9.	Prior to, during and post operation.	EPA, WA DoF, WA DEC, WA
11.	Biota Management	Prepare Biota Management Program as a part of the EMMP that: 1) Minimises impacts on all biota at the proposed site and within the region, 2) Implements strategies to minimise attraction of fauna to the sea cage system, 3) Minimises boating activity, 4) Promotes boating regulations and awareness of boating safety to protect mega fauna and other marine biota in the region, and 5) Records all biota observations and activities.	To minimise impacts (both direct and indirect) on marine biota.	Preparation prior to commencement of proposal.	EPA, WA DoF, WA DEC, WA

12.	Biota Management	Implement the approved Biota Management Program referred to in commitment 11.	Achieve the objectives in commitment 11.	Prior to, during and post operation.	EPA, WA DoF, WA DEC, WA
13.	Disease and Parasite Management	Prepare a Barramundi Health Management and Emergency Plan (BHMEP) which: 1) Minimises the occurrence of disease or parasite outbreak by utilising biosecurity best practices, 2) Abides by translocation legislation, 3) Notifies the Chief Veterinary Officer (CVO) and WA Department of Fisheries Director (WAFD) of any suspected disease or parasite outbreak of pathogenic origin immediately, 4) Limits the spread of disease by best isolating suspected infected fish and/or culling, 5) Develops a sampling protocol to enable correct diagnosis by the Veterinary Health Laboratories, 6) States all instructions given by the CVO and WAFD in regards to treatment of diseased fish must be adhered to, and 7) Develops a contingency plan for any disease outbreak.	To minimise the occurrence of disease or parasite outbreaks and if suspected minimise the impact the disease or parasite outbreak has on the environment.	Preparation prior to commencement of proposal.	DoF, WA, Veterinary Health Laboratories
14.	Disease and Parasite Management	Implement the approved BHMEP referred to in commitment 13.	Achieve the objectives in commitment 13.	Prior to, during and post operation.	DoF, WA, Veterinary Health Laboratories

15.	Cyclone Procedures Management	Update and improve the current Cyclone Procedures Protocol that incorporates: 1) Preparation procedures for the land-based nursery system, 2) Preparation procedures for the sea cage system, 3) Preparation procedures for staff, equipment and other island infrastructure, and 4) A contingency plan in the event cyclone damage occurs.	To minimise the impacts associated with cyclone damage of sea cage and island infrastructure to the surrounding environment.	Prior to and during operation	DoF, WA DEC, WA
16.	Cyclone Procedures Management	Implement the Cyclone Procedures Protocol referred to in commitment 15.	Achieve the objectives in commitment 15.	Prior to, during and post operation.	DoF, WA DEC, WA
17.	Fuel and Chemical Management	Prepare a toxic and hazardous substances protocol which will include: 1) Fuel and chemical storage facilities, 2) Best practice usage, and 3) A fuel spill contingency plan.	To minimise the use of fuel and chemicals and in the event of a fuel or chemical accident minimise the impact to the environment.	Preparation prior to commencement of proposal.	EPA, WA DEC, WA Private Consultants
18.	Fuel and Chemical Management	Implement the approved Fuel and Chemical Management Plan referred to in commitment 17.	Achieve the objectives in commitment 17.	Prior to, during and post operation.	EPA, WA DEC, WA
19.	Staff and Stock Management	Prepare a standard operating procedures protocol for the purpose of staff training and stock management that will include the requirements and procedures for: 1) The nursery facility, 2) The sea cages, 3) Feeding, 4) Harvesting & transport , 5) Biosecurity, 6) Environmental monitoring, 7) Animal Husbandry techniques, 8) Occupational, Health & Safety, and 9) Code of Conduct	To provide all staff with the training and knowledge to ensure correct husbandry techniques and procedures are continuously upheld and allow for a successful operation and a safe working environment.	Preparation prior to commencement of proposal.	DoF, WA, Veterinary Health Laboratories Private Consultants

20.	Staff and Stock Management	Implement the approved standard operating procedures protocol referred to in commitment 19.	Achieve the objectives in commitment 19.	Prior to, during and post operation.	DoF, WA, Veterinary Health Laboratories
21.	Environmental Management System	Prepare an Environmental Management System (EMS) in alignment with the ISO 14001 standards that includes: 1) Monitoring of key environmental factors, 2) Management of environmental impacts from the sea cages, 3) Processes to ensure the planning, implementation and operation of actions meets environmental requirements, 4) Measurement and evaluation of environmental improvement 5) Review and improvement of all management programs, and 6) Reporting requirements	To monitor environmental performance by managing the environmental impacts and implementing regular reviews of all operating procedures and programs to ensure environmental best practice.	Preparation prior to and during operation	DEC, WA EPA , WA Private Consultants
22.	Environmental Management System	Implement the approved EMS referred to in Commitment 21.	Achieve the objectives in commitment 21.	During and post operation.	DEC, WA EPA, WA
23.	Waste Management Plan	Prepare a Waste Management Plan that incorporates: 1. Waste minimisation, reduction, reuse and recycling principles and strategies, 2. Procedures and processes for waste disposal, and, 3. Environmental best practice of waste disposal and management.	To ensure that waste generated is managed and disposed of in a practicable manner so as not to become litter.	Preparation prior to and during operation	DEC, WA EPA, WA Private Consultants
24.	Waste Management Plan	Implement the approved WMP referred to in Commitment 23.	Achieve the objectives in commitment 23.	During and post operation.	DEC, WA EPA, WA

25.	Best Practice	Undertake research and development into improving all aspects of the proposal operations including: 1. Annual analysis of industry wide research and development, practices and processes. 2. Research into the use and/or incorporation of improved and relevant techniques, equipment and processes. 3. Regular communications with national R&D organisations including: • Australian Barramundi Farmers Association (ABFA) • Fisheries Research and Development Corporation (FRDC) • Aquafin Cooperative Research Centre (Aquafin CRC)	To ensure continual improvement in all operations and procedures of the proposal and that best practice is being implemented.	During operations	Private and Commercial Businesses Private Consultants SARDI, SA DEC, WA DoF, , WA EPA, WA

1. Introduction

1.1. Background

The shareholders of Maxima Pearling Company (MPC) currently own and operate a pearling and aquaculture venture in the Cone Bay region of Yampi Sound. The aquaculture operation is managed as a joint venture with a closely related company, Maxima Fish Farms Pty Ltd (MFF) who undertake the operational aspects of the aquaculture venture. Research conducted by both MPC and MFF demonstrates scope for the addition of other aquaculture ventures in the surrounding area and at the Cone Bay site where existing infrastructure is currently under utilised.

MPC have an administration office located in Broome, WA and the existing farming operations based in Cone Bay, Yampi Sound, WA. The current Barramundi project is being operated by MFF under MPCs aquaculture licence (No. 1465) in Cone Bay and is looking to expand into a commercialised venture with an annual production level of 1,000 tonne. Through the operational management company, MFF, the current aquaculture venture employs 4 permanent staff involved in administration and management, based in both Broome and Cone Bay and 10-20 staff are outsourced from local employment agencies to undertake the farming operations in Cone Bay.

1.2. The Proposal

A pilot scaled Barramundi operation was initially developed two years ago. As part of the project pre-feasibility study, a variation was sought and granted from Department of Fisheries WA (DoF) to allow Barramundi aquaculture in a land based recirculation system within Cone Bay. This was conducted to assess the capacity of Barramundi aquaculture in the region and to research optimum grow out conditions and system efficiency. The results of this trial were highly successful and above average growth rates and food conversion ratios were achieved.

Following this, MPC established the viability of a sea cage based grow out facility and the costs associated with grow out and harvesting. Initially DoF granted MPC an exemption to produce a maximum of 1 tonne of Barramundi in a sea cage system. This was followed by a DoF variation and a Department of Environment and Conservation (DEC – formerly Department of Environment (DoE)) works approval licence to permit production of 15 tonne of Barramundi in sea cages in Cone Bay. This also proved to be successful so MPC, working with the DoF and the DEC (formerly DoE), applied for a variation to Aquaculture Licence No. 1465 to increase production levels to a commercial sized operation of 150 tonne. Approval for this was received in November 2005.

As a result of the success seen in both the pilot study and the subsequent sea cage grow out trial, MPC is now applying for an increased production level of 1,000 tonne of Barramundi per annum in Cone Bay, in an effort to increase the commercial potential of this species for regional WA.

1.3. The Public Environmental Review

This PER has been completed and submitted by Maxima Pearling Company, however a number of consultants and scientists have provided their specialist expertise and knowledge in the development of this project including:

- Doroudi Consultants
- 360 Environmental
- Asia-Pacific Applied Science Associates (APASA)

2. The Proposal

2.1. Proponent Details and Contacts

Maxima Pearling Company Pty Ltd
PO Box 843
Broome, WA, 6725

(08) 9193 7290 Phone
(08) 9193 7291 Fax

Contact: Guy Westbrook
guywestbrook@maximapearling.com

Alternative Contact: Nicholas Miller
namiller@maximapearling.com

2.2. Proposal Location

The existing aquaculture site (licence no. 1465) is approximately 699.41 hectares and is located in Cone Bay, Yampi Sound, Western Australia. Cone Bay is located approximately 215 km NNE of Broome in the north-west of Western Australia. The bay is approximately 20 km long and 6.5 km wide near its west-facing opening and is fringed by sandstone cliffs on both sides (Figure 2.1). The aquaculture site is situated in the southern part of the bay and encompasses Turtle Island where infrastructure exists for both pearling and aquaculture activities. Figure 2.2 demonstrates the area representing Licence No. 1465 and the boundary coordinates are stated below.

Boundary Corner Coordinates: Datum GDA94 (approximates WGS84):

Point	Latitude	Longitude
A	16° 28.0238'S	123° 29.2597'E
B	16° 29.7783'S	123° 32.7484'E
C	16° 30.2572'S	123° 32.4888'E
D	16° 28.5037'S	123° 29.0001'E

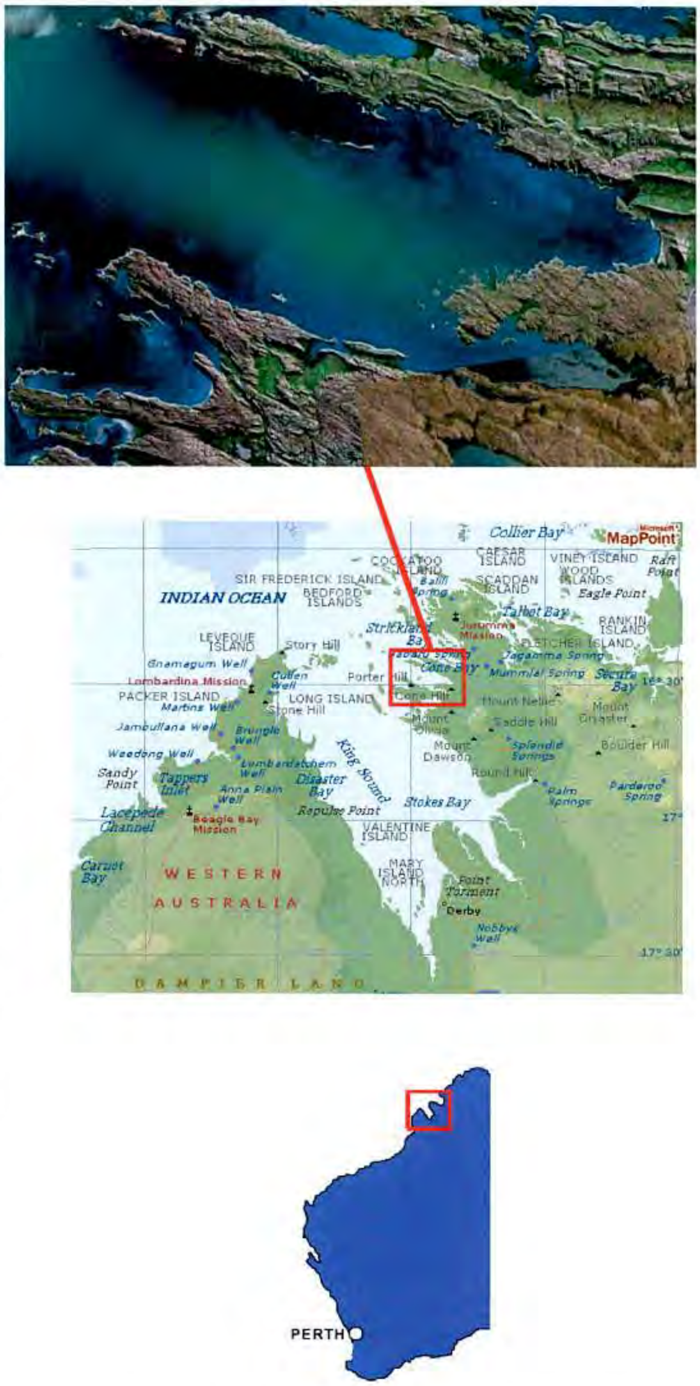


Figure 2.1: Cone Bay location, Yampi Sound, Western Australia.

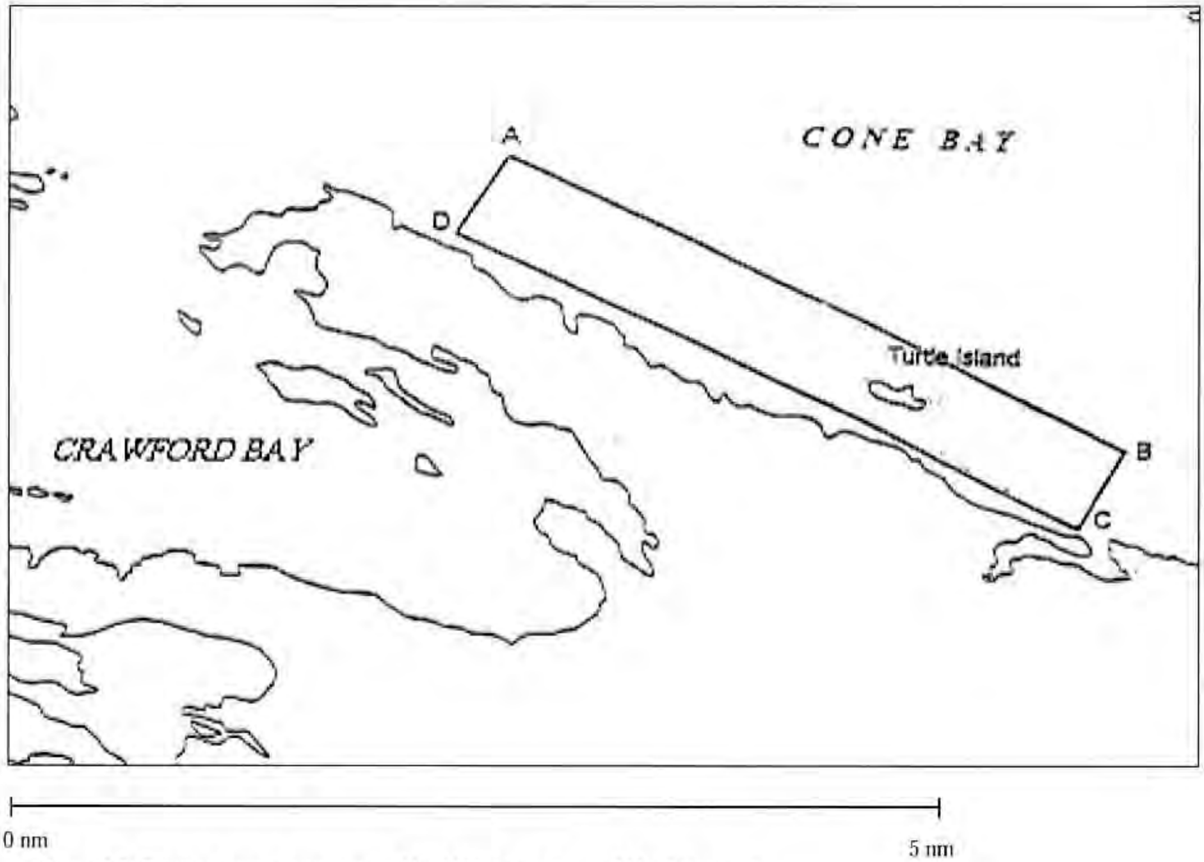


Figure 2.2: Existing Aquaculture Licence No. 1465 Area. Area = 699.41 Hectares.

2.3. Proposal Description

It is proposed that a maximum of 20 grow out cages and 8 nursery cages will be utilised to produce a maximum of 1,000 tonne of Barramundi per annum within Cone Bay.

2.3.1. Nursery Cage System - Construction and Carrying Capacity

It is proposed that the nursery cage system will consist of a maximum of 8 square cages. The dimension of the Barramundi nursery cages will be 6x6x5 metres and will consist of 4 pairs of cages running parallel to each other divided by a working platform. The mesh size of the polyester knotless nets utilised will range between 6 and 10mm.

Each cage will consist of 2 nets to allow easy removal of 1 net for regular cleaning without disruption to production. The fingerlings will be retained in the nursery cage system until they reach a minimum of 160mm and a maximum of 250mm before being transferred into the grow-out cage system. It is intended to stock the nursery cage system at 10 to 15 kg per cubic metre. An outer net of 3.2mm gauge galvanised steel wire or high density polyethylene (HDPE) will be installed to protect stock from predators such as sharks and crocodiles and 50mm polyethylene or nylon bird exclusion nets will be utilised to prevent bird entanglement and fish escapes.

Assembly will occur on a steeply sloping beach at the high tide level to minimise impacts to the environment. Whilst being constructed the sea cage will only require light anchoring on the beach at points above the high tide mark. Once completely assembled including attachment of the outer net, the nursery cage system will be "floated" off the beach at high tide and towed and secured into position at the pre-installed mooring system.

2.3.2 Grow-out Cage System – Construction and Carrying Capacity

The grow-out cage system will consist of 20 sea cages the structure of these demonstrated in Figure 2.3. It is proposed that the circumference of the polar circle grow-out cages will range between 40 and 80 metres and the net will have 5 metre deep sidewalls, which will result in a maximum depth of 8 metres in the centre. The grow-out cage system will also be anchored in a mooring grid designed to withstand cyclonic conditions (Figure 2.4) utilising a mooring system shown in Figure 2.5.

The main collars of the floatation device, handrail and stanchions are constructed of a polyethylene material. The polyethylene pipe that forms the collars and handrail are joined using a technique known as butt-fusion. The collar pipes are foam filled to ensure flotation in the event of a pipe being holed or split.

Nets of 2 differing dimensions (25mm or 32mm) will be utilised but all will be constructed using a marine wire produced by One Steel. The 25mm net consists of a 2.8mm wire and the 32mm has a 3.2mm gauge, which is heavily galvanised to provide multiple layers of protection from corrosion. The net is joined using wire coils of the same dimension as the net for added strength. The net is then secured to the collars at 0.5 metre intervals to 2 cables using 50mm wide webbing straps and galvanised D-shackles or 16mm double braid polyester rope.

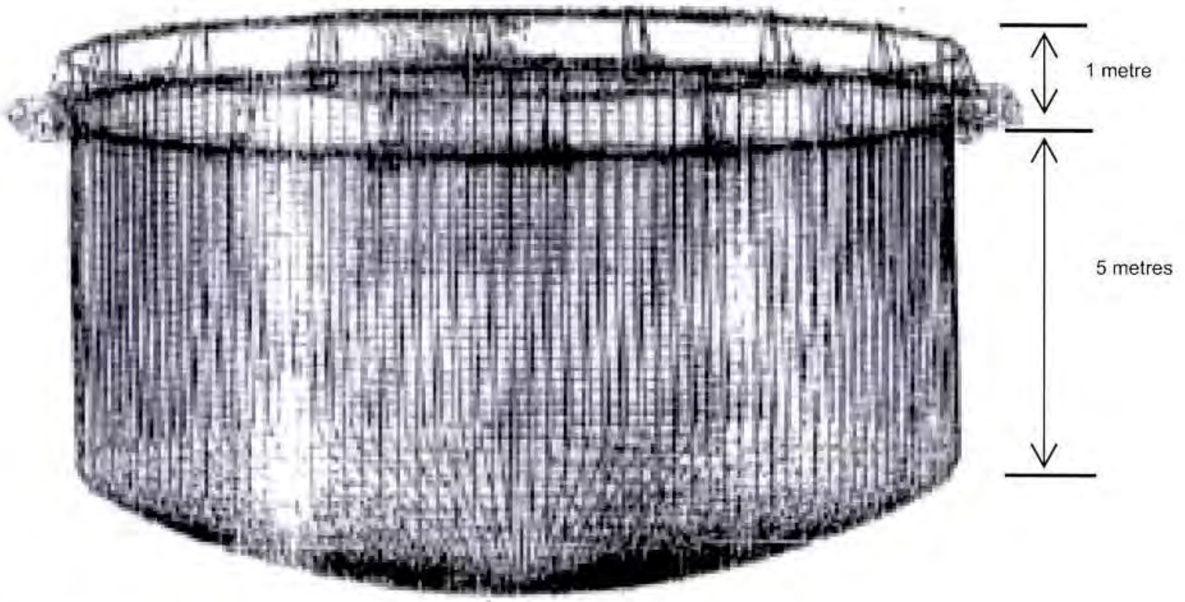


Figure 2.3: Side view of sea cages. Maximum depth at bottom centre of cage is 8m. Circumference of sea cages will range between 40m and 80m.

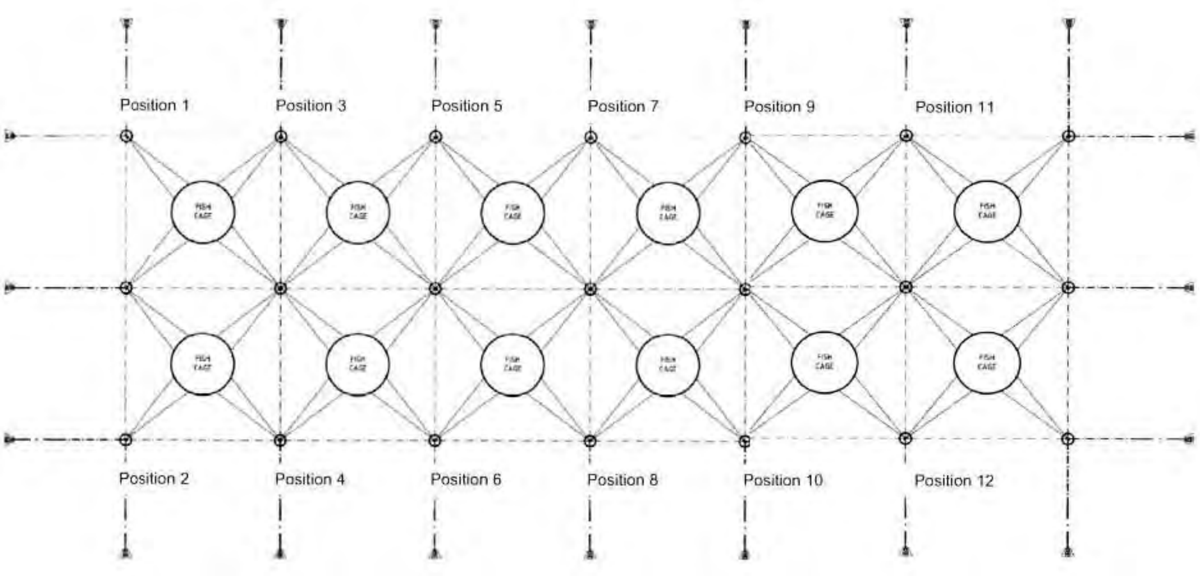


Figure 2.4: Proposed layout of mooring grid.

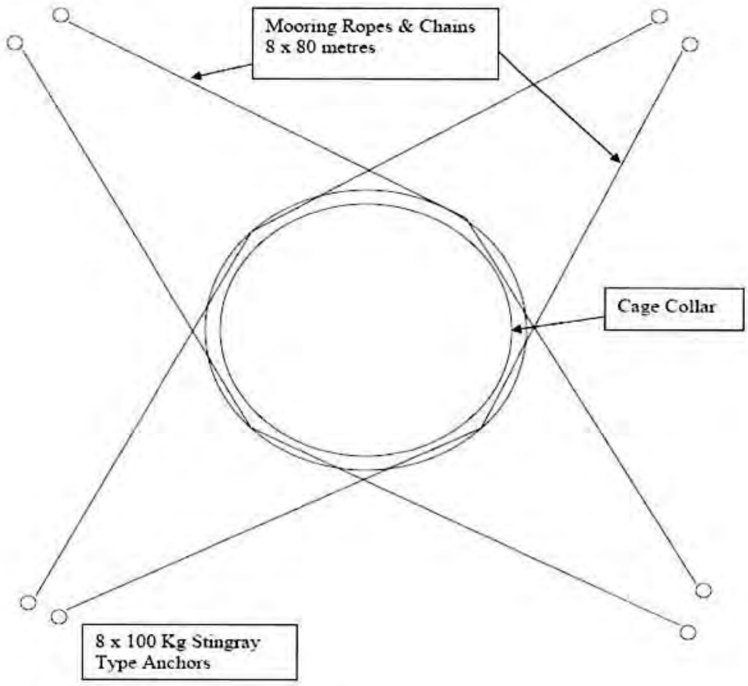


Figure 2.5: Proposed Sea Cage Mooring System.

Bird exclusion nets will be utilised for each individual cage and will be pulled taut over the tops of each cage as demonstrated in Figure 2.6.

Figure 2.6: Bird exclusion net fully covering top of cage.

MPC in conjunction with MFF is currently exploring the possibility of future trials using netting manufactured of HDPE plastic. One particular type is the Kikko Net manufactured by Fukui North America (website: http://www.fukuina.com/finfish/kikko_net.htm).

It has proven strength in aquaculture applications and continual tears do not occur because "knitting" Tetron plastic wire with the original technology composes the structure. Trials by Blue Water Barramundi in Cardwell, Queensland have proven to be effective over 3 years against predation and general maintenance requirements (*pers com.* Kerry Briggs, Manager, Blue Water Barramundi).

Another is the cost effective AQUAGRID™ net, which has proven appropriate for a variety of species, including barramundi, and is utilised in more than 11 countries worldwide. The AQUAGRID™ net is designed for farming, not fishing, and provides better containment, improved strength, less maintenance, and better predator protection. The extra strength and tough UV resistant coating also mean longer life, which further reduces the costs of operation.

However, all existing and any newly constructed steel mesh cages will continue to be used even in the event that MPC implements any plastic nets as standard practice in the future.

The volume of the smaller cage (40 metre circumference) is approximately 636 cubic metres and conservatively has a carrying capacity of 12.5 tonne (stocking density of 20 kg/m3). The volume of the 80 metre circumference cage is approximately 2,547 cubic metres, resulting in a conservative carrying capacity of 51 tonne. The stocking density of the grow-out cage system will range between 15 to 20 kg per cubic metre and will not exceed 60 kg per cubic metre.

Assembly will occur on a steeply sloping beach at the high tide level to minimise impacts to the environment. Whilst being constructed the sea cage will only require light anchoring on the beach at points above the high tide mark. Once completely assembled including attachment of the outer net, the nursery cage system will be "floated" off the beach at high tide and towed and secured into position at the pre-installed mooring system. Completed, in-situ sea cages are demonstrated in Figures 2.7 and 2.8.

Figure 2.7: The first complete sea cage in position for the existing licence in Cone Bay.

a)

b)

Figure 2.8: Photographs of the sea cages from a distance. Figure a) is looking at the sea cages from a distance of approximately 100m to the East of the cages. Figure b) demonstrates the view of the sea cages from a distance of approximately 1km to the north-west of the sea cages.

2.3.3 Infrastructure, Staff Facilities and Storage

At the onset of the proposal with the exception of additional sea cages, no other infrastructure is required within Cone Bay.

All staff will be accommodated on the existing base, Turtle Island, Cone Bay and will commute by boat to the aquaculture site, which encompasses the island, on a daily basis. Turtle Island is an operational work base for pearling and aquaculture ventures within Cone Bay where housing and work facilities are in existence (Figure 2.9a & b).

The island base has an air conditioned storage container in which all hazardous products are kept. Diesel fuel is stored in a 40,000 litre tank and unleaded fuel is stored in 200 litre sealed drums.

Figure 2.9a: Turtle Island Pearling and Aquaculture Operations Base, Cone Bay, Yampi Sound, WA.

Figure 2.9b: Existing Infrastructure on Turtle Island.

2.3.4 Stock

All fingerlings will be sourced from an accredited hatchery. The accreditation body in WA is the Animal and Fish Health Laboratories, WA Department of Agriculture and in the NT it is the Berrimah Veterinary Laboratories, Berrimah Farm. It will be preferable to source the fingerlings from the Kimberley College of TAFE or Darwin Aquaculture Centre (DAC), NT provided that the number ordered is available when required. If not, fingerlings will be sourced from other accredited hatcheries according to the Fisheries WA Barramundi translocation protocol (Fisheries Management Paper No. 159).

Health testing of the fingerlings will be conducted by the Animal Health Laboratories, WA Department of Agriculture or by another laboratory under the WA Fisheries senior pathologists' instructions to ensure freedom from disease. Initially, the fingerlings will be reared in the land based nursery system located in Cone Bay until an average weight of 40 – 60g (minimum length of 90mm for net retention) is obtained at which point they will be transported to the nursery or grow-out cage system.

The fingerlings will be stocked conservatively to reduce stress and in turn reduce the risk of disease or parasite infection.

2.3.5 Feeding

The fish will be fed a manufactured pellet ranging in size between 4.0mm and 11.0mm dependent on the average size of the fish within each cage at the given time. The existing project in Cone Bay has been recording an average Feed Conversion Ratio (FCR) of 0.9 – 1.0, however it has been observed as low as 0.7 and the highest at 1.2. From these results, MPC is using an FCR of 1.5 to calculate all nutrient waste outputs and subsequent prediction impacts.

As all previous results have shown, the actual output from the project will be substantially lower than the 'predicted' output. Using an FCR of 1.5 it is estimated that 1,500 tonne of feed will be required per annum once the total production reaches 1,000 tonne of fish each year. Also using the highest output figures (Skretting Nova ME/Ridley Marine 45-20) the maximum Nitrogen and Phosphorous waste output is estimated to be 238kg/day (calculations provided by Dr Brett Glencross, Principle Research Scientist, Aquaculture and Aquatic Animal Health, DoF, WA).

The Ridley Aqua-feed and Skretting Nova data sheets and relevant calculations are given in Appendix A. The total waste output is represented diagrammatically in Figure 2.10. Feeding regimes and behaviour will be closely monitored by video image to prevent overfeeding and wastage. Size data will continue to be collected and utilised to calculate growth rates and feed conversion rates on a regular basis.

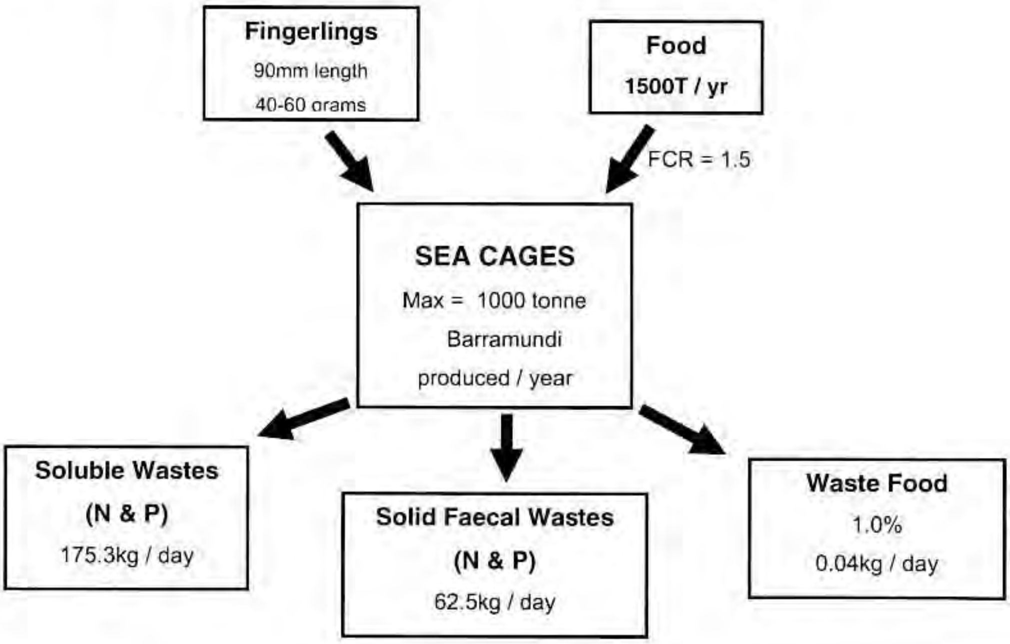


Figure 2.10: The predicted maximum sea cage inputs and outputs for 1000 tonne per annum Barramundi production. Calculations are based on the discharge amounts for the Skretting Nova ME/Ridley Marine 45-20 feed pellets as provided by Dr Brett Glencross (DoF, WA).

2.3.6 Harvesting

Harvesting will be conducted using a seine net and fish pump or wet brail. The fish will be pumped whole into large slurry bins with lids and transported to the Port of Derby by a suitable vessel. A refrigeration transport truck will then distribute the fish to Perth for processing and marketing.

All harvesting and transportation activities will follow the protocol and procedures detailed in the Fisheries Translocation Protocol of Barramundi, Fisheries Management Paper No. 159 (Department of Fisheries, 2002).

2.3.7 Waste Management

All rubbish, discarded equipment and fish mortalities will be returned to the Cone Bay land based site for sorting. Materials that can be, will be reused, all food waste is composted, paper and card products are incinerated and plastics and aluminium are crushed and stored in 200 litre drums and transported to Derby for recycling.

An ensiler, a unit for turning dead fish into silage, will be utilised for any fish mortalities. It operates by mincing fish into a specialised container along with Formic Acid whereby the mixture is pumped repeatedly through a macerating pump and turned into a stable liquid with a pH of 3.8 or less. At this pH, no bacteria can develop and there is no unpleasant odour. The resulting liquid is stored in an enclosed tank until removal from the island at which point it is decanted into transport containers, transported to Derby where it can be mixed with organic waste to make garden mulch. Any other waste products that do not fit these categories are disposed of in 200 litre drums and transported to the Derby waste management facility. A detailed Waste Management Plan (WMP) will be developed as a part of the EMS.

2.4 Staging of the Project

The staging of this proposal has been extended slightly as a result of the application process and thus the timing stated in this PER differs to the assessment schedule stated in the Scoping Document. This delay to the timeline is not expected to increase environmental impacts as it is only expected to delay the initial date by up to 3 months.

Currently MPC has a licence to culture 150 tonne of Barramundi per annum and at present 6 sea cages are being utilised and are stocked with approximately 100 tonne of fish. As biomass is rapidly increasing MPC intends to firstly install an additional 6 sea cages and required mooring system by August 2007. Total production will then increase to 35 tonne of fish per month over a period of time. In conjunction, is the collection of environmental data through continued implementation of the Environmental Monitoring and Management Plan (EMMP).

The next stage is to install the remaining 8 cages by March 2010. As each new cage is installed, fish production levels will increase in increments to a maximum of 80 tonne per month (approximately 1000 tonne per year). The expectation is that this will be achieved by March 2010.

The EMMP will continue throughout this period with regular reports being submitted to the DEC (formerly DoE). Table 2.1 gives a basic description of the expected time line.

Table 2.1: Staging of the Cone Bay Barramundi Expansion Project.

Date	Production (~Tonne/mth)	No. Cages
August 2007	35	12
July 2008	50	15
July 2009	65	18
March 2010	75	20

2.5 Key Characteristics of the Proposal

The key characteristics of the proposed 1000 tonne Barramundi operation in Cone Bay are summarised in Table 2.2.

2.6 Justification and Alternatives

The fact that Cone Bay Aquaculture Licence No. 1465 is an existing and successfully operating Barramundi farm means that site selection was pre-determined. Given that the existing licence is not being utilised to its full potential and 150 tonne per annum is not considered to be commercially competitive, Cone Bay is deemed the most appropriate for the 1,000 tonne Barramundi production proposal.

In addition, the existing accommodation infrastructure and operation base on Turtle Island is situated within the boundary of the licence are. Therefore, minimal infrastructure changes will be required and consequently, minimal environmental impacts will occur at the aquaculture site. The only additional infrastructure required are the sea cages and associated mooring systems.

Table 2.2 – Key characteristics of the proposal to increase Barramundi production to 1,000 ton per annum.

Element	Description
Life of project	• Increase production over 3 years to a maximum of 1000T/yr. • Ongoing
Location	• Aquaculture Licence Site 1465, Cone Bay, Yampi Sound, Western Australia, ~215 km NNE of Broome
Species cultured	• Barramundi (*Lates calcarifer*)
Expected Barramundi production • Maximum	 • 1,000 tonnes/annum
Size of aquaculture licence 1465 area • Maximum	 • 699.41 hectares
Maximum number of cages • Nursery • Grow out	 • Up to 8 • Up to 20
Size of cages • Nursery • Grow out	 • 6m (length) x 6m (width) x 5m (depth) • Between 40m, 60m and 80m circumference.
Volume of cages (dependent on circumference) • Nursery • Grow out	 • 180 cubic metres • 636-2,547 cubic metres
Stocking density within cages • Nursery • Nursery maximum • Grow out • Grow out maximum	 • 10-15 kg/m^3 • 20 kg/m^3 • 15-20 kg/m^3 • 60 kg/m^3
Feed input • Maximum • Source	 • 1,500 tonnes/annum • Appropriate commercial feed from an Australian feed manufacturer
Waste produced (Nitrogen and Phosphorous in solid and dissolved form) • Maximum (based on FCR of 1.5)	 • 238 kg/day

NB: All calculations of wastes produced for both Ridley Aquafeed and Skretting are given in Appendix A.

Cone Bay also demonstrates increased water flow rates and high tidal and current dynamics in comparison to other areas in the region and therefore has faster flushing rates. This in conjunction with the hydrodynamic modelling results, indicate that the area is more than capable of supporting an increase in production levels to 1000 tonne and greater.

Aquaculture licence 1465 in Cone Bay has areas of optimal depth and benthic structure (i.e. mud) for additional sea cages, which minimises impacts to the site.

The waters of the Buccaneer Archipelago and therefore, aquaculture licence site 1465 within Cone Bay provide the perfect environmental conditions that Barramundi require to grow successfully. Warm, tropical waters with moderate-high turbidity and highly variable nutrient levels support Barramundi populations in Northern Australia and the Asia-Pacific region and are found naturally in the bays and waters surrounding the aquaculture site. In addition, the market preference for high quality 'salt-water'

Barramundi compared to fresh water farmed Barramundi has become increasingly evident in recent years.

A number of environmental benefits can also be attributed to the proposal, particularly in terms of sustainable development. The development of new and expansion of existing aquaculture ventures assists in:

- reducing increasing fishing pressures on declining wild populations of fish species,
- reducing environmental degradation due to destructive fishing techniques (eg ocean trawling),
- reducing population declines in non-target species resulting from high rates of bycatch seen in some commercial fishing methods, and
- providing improved regularity of supply and in many cases, 'fresher' product to the markets.

The information and data collected as a result of the development of this proposal (eg environmental monitoring programs, hydrodynamic studies etc) provides an increasing amount of knowledge and understanding of the environmental processes and conditions of the Kimberley coastline and marine environment.

The development of the Cone Bay expansion proposal will also have economic and social benefits including utilisation of local resources and businesses and the employment, training and education of the local indigenous communities and surrounding regional areas.

2.7 Legislative Framework

The key legislation to which the proposal will be subject to is the *Fish Resources Management Act* 1994 and the *Environmental Protection Act* 1986. MPC has lodged a referral and environmental scoping document with the Environmental Protection Authority WA (EPA), and a variation to the existing environmental licence will be submitted with the DEC (formerly DoE) at the same time as this PER is lodged.

Communications with the DoF have determined that a variation to the Aquaculture licence is not required as the licence for 150 tonne production is considered commercial production according to the DoF requirements.

A referral application for a recent Crawford Bay aquaculture application was submitted to the Department of Environment and Heritage (DEH) under Chapter 4 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). However, the DEH declared that the proposal is not a controlled action and approval is therefore not needed at a national level. Due to the similarities between the Crawford Bay and Cone Bay proposals and the fact that the Cone Bay Aquaculture licence is an existing licence that was approved prior to the implementation of the EPBC Act, it was suggested that a similar conclusion would result for the Cone Bay proposal. As a result, a referral application to the DEH was not submitted.

Cone Bay aquaculture licence 1465 site is located within state waters and there are no World Heritage properties, National Heritage places, Ramsar wetlands, listed Commonwealth Heritage places or areas of remnant vegetation within the vicinity of the site. The land surrounding the bay is Commonwealth land used by the Australian Department of Defence (DoD).

The region falls under the jurisdiction of the Derby/West Kimberley Shire who to date, through verbal and written communications, have supported all proposals submitted by MPC and MFF within the area.

The Department for Planning and Infrastructure (DPI) requested that each of the cages be equipped with Category 2 navigational lights. MPC has already implemented this request in the trial project and will be adhering to this request for the Cone Bay expansion proposal until a total of 7 cages have been implemented. As a result of recent discussions with the DPI, once more than 7 cages are in operation MPC will mark an "active area" of the lease as the large number of lights required for each cage in close proximity to each other could cause potential confusion and/or distraction. The lease area also comes under the DoF "Standardised Lease Marking Incorporating Prescriptive Requirements for Different Leases".

Other legislative matters that the proposal comes under and that the proponent will abide by include the *Conservation and Land Management Act* 1984 and the *Wildlife Conservation Act* 1950.

3. Existing Environment

3.1. Introduction

The existing aquaculture licence 1465 site as described in Section 2.2, is located in the southern part of Cone Bay and encompasses an area of 699.41 hectares. Under the EPA *Guidance Statement No. 29, Benthic Primary Producer Habitat Protection for Western Australia's Marine Environment, June 2004* a management unit for proposals such as this one is to be identified as a location "within a defined geographic area".

The Guidance Statement No. 29 states that the size of the management unit can be site specific depending on the aspects of the surrounding environment. In accordance with the Guidelines, the management unit described in this proposal is the licence area which is 699.41 hectares (or 7 km^2). This is considered to be ample size as hydrodynamic studies conducted for MPC both in 2000 (Brown & Root, 2000) and 2006 (APASA, 2006) found that the flushing rates of Cone Bay are extremely high and when water and/or particles reach the entrance of the bay, they are swept away and mixed into oceanic waters rapidly by strong currents (see Appendix B).

In addition the settlement distance for fish waste was estimated as up to 250 m from a given discharge source strictly along the main east-west tidal axis. For the fish pellets, this distance was reduced to approximately 130-140 m due to the quicker settling rate (APASA, 2006). As a result it is intended that all sea cages will be a minimum of 250 metres from the western and eastern boundaries of the licence site to reduce the potential to impact outside of the management unit.

The management unit is diagrammatically represented in Figure 3.1.

3.2. Land, Topography and Soils

Cone Bay is situated in Yampi Sound of the Buccaneer Archipelago, north of Derby. The land surrounding Cone Bay consists of King Leopold sandstone, Alluvium, Ruins Dolerite and Cone Hill Granite (Figure 3.2) with the predominant being King Leopold Sandstone and Cone Hill Granite. In most parts the rock face is a minimum of 10m above the high tide mark (IMCRA, 1998) rising steeply out of the water. The land bordering the southern side of Cone Bay is Commonwealth land used by the Australian Department of Defence (DoD) and the land to the eastern side of Cone Bay is utilised by the Dambimangari claimants with a small community set up at the north-eastern end of the bay inhabited by the Larinuwar Community members.

Geomorphology in Cone Bay has not been disturbed by human activity, however the seasonal occurrence of cyclones and adverse weather conditions has demonstrated naturally occurring disturbance such as erosion, rocky substrate damage, and changes in the distribution of the benthic substrate (i.e. beaches, muddy and rocky shorelines).

The existing licence area (Aquaculture Licence 1465), comes under the WA Fisheries legislation for Lease Marking and all new developments are subjected to assessment according the EPA Act and the EPBC Act and all activities are encompassed under the CALM and Wildlife Conservation Act.

3.3. Climate

The climate of Cone Bay is characterised as tropical monsoon with distinct 'wet' and 'dry' seasons. The 'wet' (or summer) typically brings high rainfall associated with hot and humid conditions and the 'dry' (or winter) can be associated with a mild Mediterranean-style climate with cool nights and warm, sunny days. The closest Bureau of Meteorology (BOM) stations are situated in Derby and Cygnet Bay, which are generally representative of the annual averages in temperature and rainfall in Cone Bay.

According to the BOM site, the average daily temperatures of the region range between 21.0°C in the dry and 33.0°C in the wet and receives an annual average rainfall of between 600-800mm. Temperatures have been recorded as low as 5-7°C during the dry and maximums have been recorded at around 40-42°C during the wet, usually just prior to the onset of the seasonal rains. Humidity recorded at the Cygnet Bay meteorological station is more representative of Cone Bay than Derby and has been recorded between 58-76% (mean 9am relative humidity) and 45-69% (mean 3pm relative humidity).

A number of cyclones, ranging between Category 1 and Category 3 on average, pass through the Kimberley each season and generally follow a southwesterly pathway down the coastline passing near, or over the Buccaneer Archipelago region. Although the Cone Bay area has not previously been in the direct path of a cyclone, adverse weather conditions and damage are commonly experienced when a cyclone or low pressure system passes the area.

Figure 3.1: Area demonstrating the designated 'management unit' for the Cone Bay 1,000T Barramundi Production Proposal.

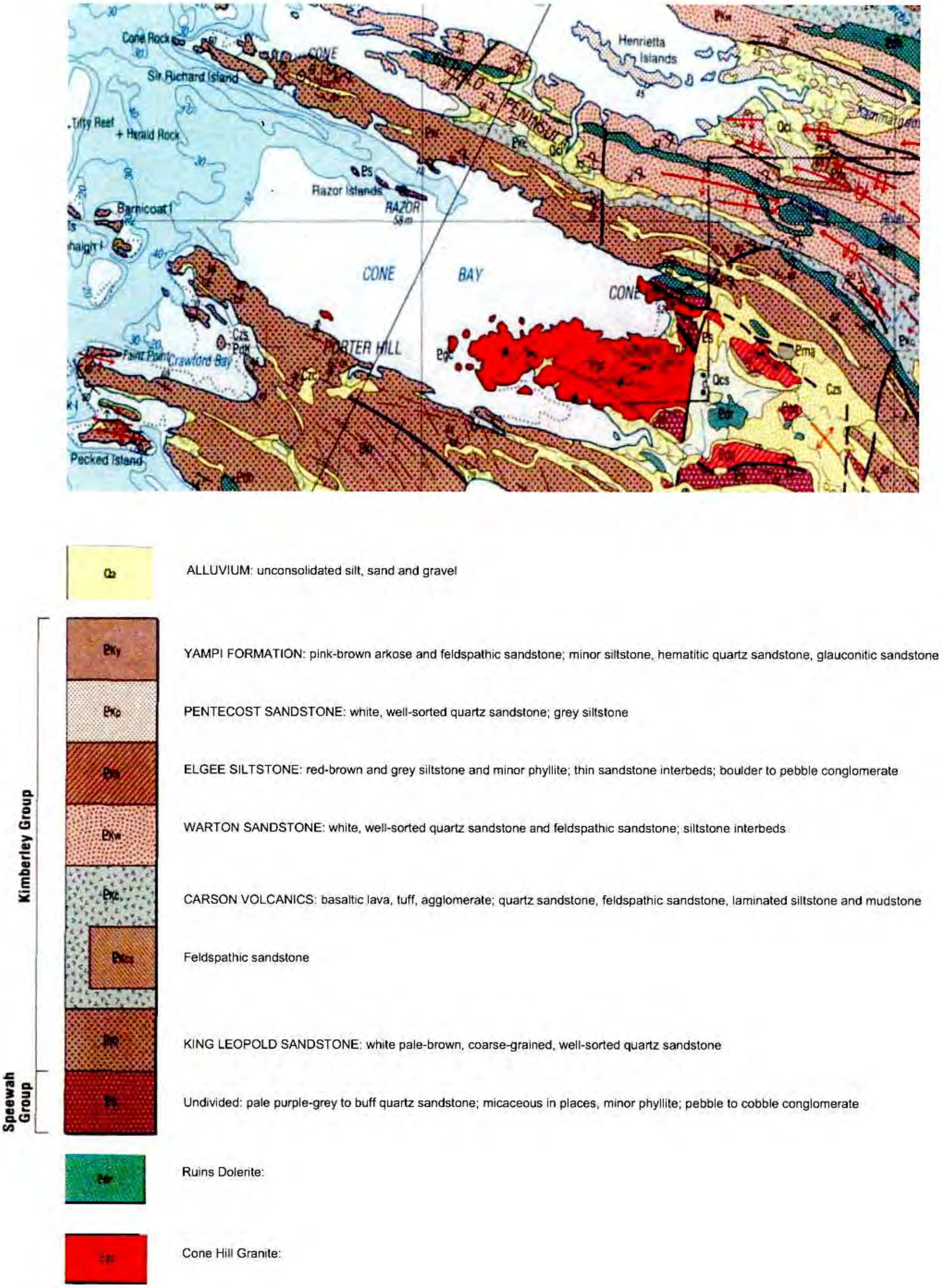


Figure 3.2: Geology of Cone Bay – Consists of King Leopold Sandstone, Alluvium, Ruins Dolerite and Cone Hill Granite.

3.4. Hydrology

Licence site 1465 is situated on the southern side of Cone Bay (Figure 3.1 and 3.3) and encompasses Turtle Island. The depth within this site varies greatly (3-25m) as it does in the rest of Cone Bay (3-36m) (Figure 3.3). The main hydrological influences on the Cone Bay water body is the 9 to 11 metre tidal range, high velocity currents and the large amount of run-off from the steep coastline from heavy rains during the wet season.

Hydrodynamic modelling of Cone Bay undertaken by both Brown & Root in January 2000 and APASA in 2006 have demonstrated that the current speeds ranged between 0.11 ms^{-1} and 0.8 ms^{-1} (depending on neap or spring tide) with an average of ~0.4-0.5 ms^{-1}. The modelling also demonstrated that Cone Bay, including the aquaculture licence area has a very rapid flushing rate, with 95% of the water flushed within 2 hours (Brown & Root, 2000).

The results have also shown that the aquaculture licence area was completely flushed within 2 days. The western section of Cone Bay demonstrates faster flushing than the eastern parts of the bay. A detailed report of the hydrodynamic studies undertaken by both Brown & Root in 2000 and APASA in 2006 is given in Appendix B.

Water quality parameters monitored as a part of the existing EMMP have shown:

- Water temperatures range between 24°C and 33°C and patterns are directly related to seasonal influences.
- Dissolved oxygen (DO) show similar patterns to temperature with levels increasing as temperature decreases and decreasing as temperature increases. DO levels have known to range between 4.6mg/L and 8.0mg/L
- Salinity is relatively constant ranging between 32‰ and 36‰
- pH averages around 8.0, however can get as low as 6.0.
- Turbidity is highly variable and is dependant on tidal cycle and other environmental conditions.
- Nutrients such as Chlorophyll-a (Chl-a), Total Nitrogen (TN), Total Phosphorous (TP) and Total Suspended Solids (TSS) are highly variable with chl-a, TN and to some extent TSS showing strong correlations with season. Levels are generally lower in the dry season and higher in the wet season.

More detailed water quality information for Cone Bay is provided in Section 3.8 that summarises the results from the existing ongoing Environmental Monitoring and Management Program (EMMP).

The waters of Cone Bay and surrounding areas are not listed under any marine park conservation area or other areas of special interest. However, it was a recommendation of the Marine Parks and Reserves Selection Working Group in June 1994 that "the waters of the Buccaneer Archipelago (which includes Cone Bay) should be considered for reservation as a multiple-use (including aquaculture) marine park".

The water quality within Cone Bay and surrounding areas is in a natural state. Natural fluctuations associated with seasonal variations do occur, however, this is characteristic of the Buccaneer Archipelago (CALM, 1994).

3.5. Fauna

3.5.1 Birds

All birds are protected under the WC Act with 4 species considered to be vulnerable under the EPBC Act 1999. Of these four species only one, the partridge pigeon (see Table 3.1), has been observed in Cone Bay. Migratory birds are known to pass over the area and it is assumed that they would use the surrounding terrestrial landscape to rest, shelter and feed.

Birds that have been sighted as a part of the biota log sheet used in the current EMMP, include the Sea Eagle, occasional frigate bird, Terns, Sulphur Crested Cockatoos and a variety of finches. However, the Gouldian Finch, considered endangered, has not been sighted at all. The current Cone Bay sea cage project has not encountered any unacceptable impacts to the seabird populations to date.

Although rarely seen in this vicinity, it is assumed that the land surrounding the aquaculture site would house a number of nesting sites. These sites will not be impacted upon as the licence area is on water and already in operation. This project to date has demonstrated that no known adverse impacts have occurred to the one known Sea Eagle nest that exists towards the back of Cone Bay, which has been actively utilised over many years. In addition, no entanglements in the closely fitted bird-exclusion nets over the sea cages in the Cone Bay project have been observed to date.

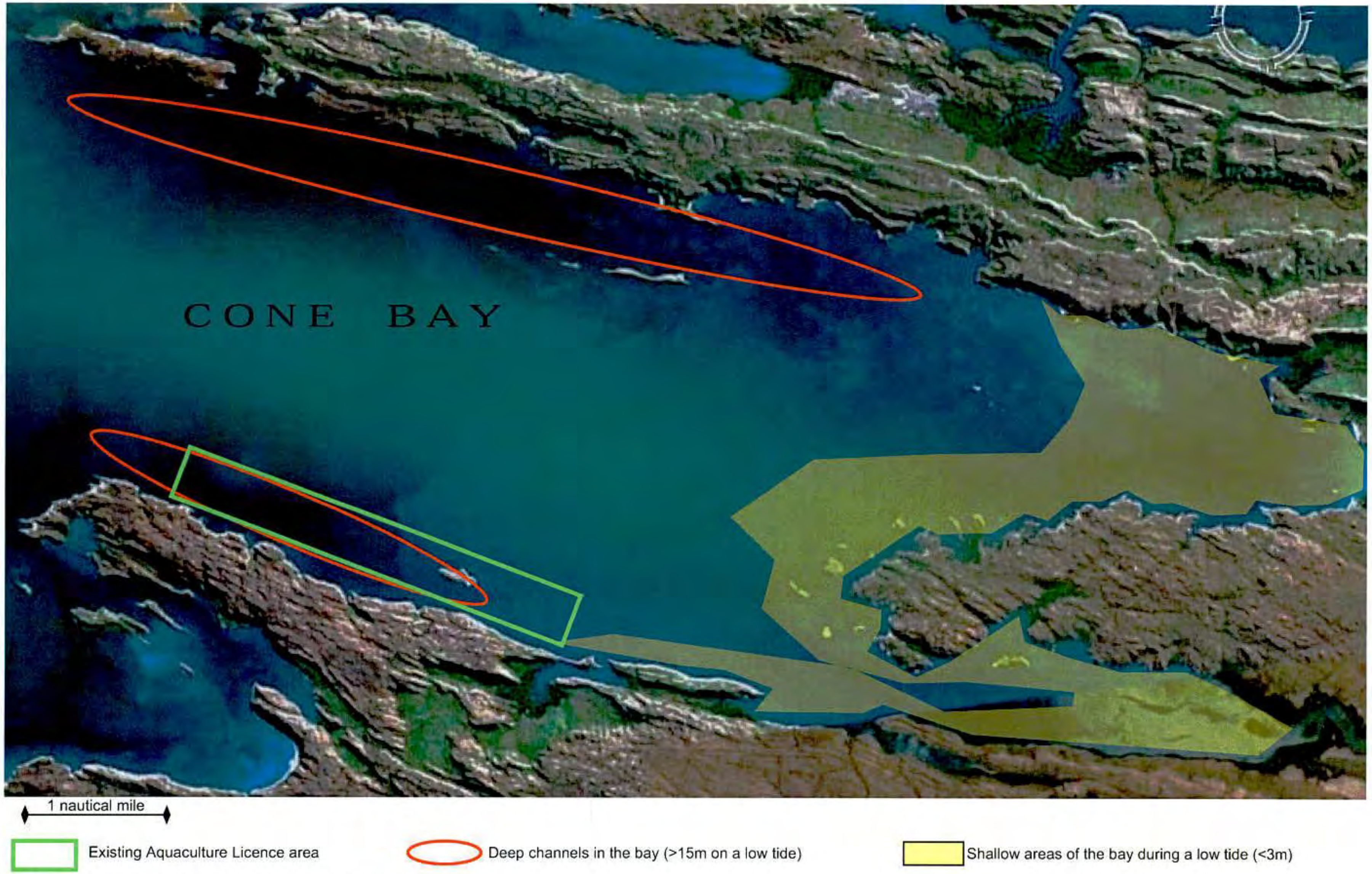


Figure 3.3: Major bathymetrical features of Cone Bay.

3.5.2 Marine Reptiles

Turtles

Turtles exist globally in most climatic regions including tropical, subtropical and warm temperate waters (CALM, 2005). The Loggerhead, Green and Hawksbill turtles have been sighted within the King Sound area, and although not sighted, the Leatherback and Flatback turtles may occur in the area according to the *Species of National Environmental Significance Database*, (DEH website). All of the above turtle species are protected under the WC Act 1950 as threatened species. The EPBC Act 1999 (*Environmental Protection and Biodiversity Conservation*) lists the Hawksbill, Green, Leatherback and Flatback turtles as threatened. The Loggerhead is considered endangered under the same Act.

Turtles are a fundamental part of coastal Aboriginal traditional culture in this area, particularly in the communities within the Sunday Strait and Cape Leveque region. However, the local indigenous community head further north and over to the Cape Leveque and Sunday Strait areas to hunt turtle.

Very little turtle activity in relation to nesting is observed in the bay or surrounding areas although turtles are observed on an occasional basis swimming in the waters. The beaches do not possess the characteristics required for turtle nesting and as such the proposed expansion will not interfere with this activity. The current pressures on turtles in the King Sound area are from hunting by the surrounding Indigenous communities.

Crocodiles

Crocodiles are found in varying densities throughout the tropical region of Australia ranging from as south as Port Hedland in WA through NT and throughout Queensland. Crocodiles may occur in the area according to the *Species of National Environmental Significance Database*, (DEH website) and are protected under the WC Act 1950.

Crocodile activity is commonly observed in Cone Bay due to the physical characteristics of the bay (eg mudflats and small beaches). Crocodiles have been observed within close proximity to the licence area and the sea cages in place but on most occasions it is thought that the crocodiles are travelling to and from their territory located towards the back of the bay. Since the inception of the existing sea cage system, the number of crocodiles sighted nearby whilst fish feeding activity is conducted has increased, however no signs of aggressive behaviour or activity close to the cages has been observed. This behaviour is considered to be mainly due to curiosity, however all staff are made completely aware of the dangers associated with working in the vicinity of crocodile activity and management strategies are altered accordingly. For more detail on the management practices see Section 4.6.

3.5.3 Marine Mammals

Marine mammals are fully protected under the WC Act throughout Australian waters. The humpback whale has been declared a threatened species under the EPBC Act 1999 and many marine mammals are migratory, passing the King Sound in their annual movements. The Cone Bay aquaculture licence site is not in any migratory pathways due to its geographic location in the King Sound (see Figure 2.1). Humpback breeding grounds are thought to be further north than the King Sound and no sightings of breeding or calving whales have been observed in Cone Bay.

Dolphins are reported on an occasional basis within the aquaculture site and surrounding areas. Dugongs have not been observed in Cone Bay but are known to occur amongst the Sunday Strait islands and the Cape Leveque area where the Aboriginal communities in that area hunt them. The local indigenous community (Yaluun) are known to head much further north to hunt dugong. No known seagrass meadows exist in Cone Bay, or nearby in the surrounding waters to support dugong populations, therefore future sightings of dugong are not expected to occur.

3.5.4 Finfish and Sharks

The Yampi Sound has a large diversity of finfish species ranging from pelagic fish, sedentary reef or territorial fish and an abundant variety of other reef fish species. Finfish that have been commonly seen and recreationally fished within Cone Bay and the surrounding areas include:

- Barramundi, fingermark and triple-tails,
- Mackerel and tuna species,
- Snapper species,
- Sharks including:
    - Black-tip and white-tip reef sharks,
    - Tiger sharks,
    - Sleepy sharks,
- Baitfish including:
    - Garfish,
    - Mullet and many others,
- Emperor species,
- Cod and grouper species.

Larger pelagic fish have been reported (eg sailfish) in the King Sound area, however they are not commonly sighted. As such only one sighting in Cone Bay has been recorded in the last 15 years.

In accordance with the *Fish Resources Management Act 1994* (FRMA), recreational fishing in Western Australia is managed by the DoF (WA). The FRMA exists to help protect and maintain the abundance and diversity of finfish in WA and covers both recreational and commercial fishing. Recent amendments to the bag and size limits of fish and possession limits have been established to ensure protection levels are adequately maintained.

The aquaculture licence area within Cone Bay is not an area that provides a significant shelter and niche habitats for finfish species due to its mud bottom. However, nearby to the licence site are a few areas considered to potentially provide habitats and protection to some species including mangrove areas (Figure 3.4), protected coves and/or small embayments along the southern coastline of Cone Bay and the creek system at the back of the bay.

There is no known commercial fishing lease areas within Cone Bay or the surrounding waters. Due to the remote location of Cone Bay, recreational fishing is limited to tourist charter boat operations, privately owned boats (eg from Derby) embarking on a weekend fishing trip and the indigenous communities surrounding the area.

3.5.5 Marine Invertebrates

Marine invertebrates represent the vast majority of marine biodiversity and include, for example, sponges, corals, jellyfish, worms, shells, sea urchins, starfish, crustaceans, sea cucumbers and nudibranchs to name a few. All marine invertebrates, as their name suggests, do not have a backbone and can be found in a wide range of habitats within the marine environment. Invertebrates are a main source of food for other larger marine fauna such as fish and birds and some invertebrates such as oysters and many gastropods are also considered to be commercially and recreationally important.

Despite the huge diversity and abundance of marine invertebrates, little is known about many of the species. This is particularly so in the King Sound as few studies have been undertaken focusing on invertebrate species in this area. As a part of the EMMP, the benthic Infaunal assemblages have been identified at some sites and the results have shown that the main taxa existing in the benthos are crustaceans (crabs) and polychaetes (marine worms). Further details of the benthic Infaunal assemblages present in Cone is given in Section 3.8

Other groups of invertebrates have been observed as a normal part of the daily operations and the EMMP and include:

- Edible oysters, flat oysters, barnacles, mussels, limpets etc
- A large variety of marine worms (Tube worms & flat worms)
- Brittle Stars, Sea urchins
- Hard corals, soft corals, sponges, live shells, nudibranchs
- Small shrimps and a variety of crabs (mud crabs, reef crabs & swimmer crabs)

Marine invertebrates are regulated under the FRM Act 1994 by the DoF WA, who is responsible for the management of commercial and recreational removal of invertebrate species (CALM, 2005). Currently there are no major pressures on the invertebrate species in Cone Bay, excepting natural, seasonal variations. There is no known commercial fishing for invertebrates in the bay and although there is the presence of a pearling lease in Cone Bay, regulations imposed on the pearling industry ensure that removal from areas outside of any lease area is monitored. Recreational removal is considered to be minimal mainly due to the remoteness of the area and the limited number of people visiting Cone Bay.

3.5.6 Threatened & Migratory Species

A search on the DEH website (www.deh.gov.au) resulted in a list describing 14 threatened species and 24 migratory species within a 3 nautical mile radius of the coordinates 16° 28′ S and 123° 29′ E. A large proportion of these have never been sighted, however as stated on the DEH website may occur in the area. The species listed are given in Appendix C.

3.6 Marine Habitats

Benthic Primary producers (BPP) are organisms that convert CO_2 from the surrounding marine environment to organic compounds, which are made available to a myriad of marine animals. BPP's consist of marine plants (eg seagrass, mangroves, algae) and coral reefs. A Benthic Primary Producer Habitat (BPPH) is made up of the BPP communities and the substrata/seabed that they are attached to (EPA Guidance Statement No. 29, 2004).

The ecological value of BPPHs varies depending on a range of factors including geographic location, species abundance/dominance and the contribution of 'productivity' to the community (EPA Guidance Statement No. 29, 2004). BPPH's provide primary production (food) via photosynthesis, substrate/shelter to other marine biota and physical stability to the seabed/coastline. Because of their potentially important status in an area, all development proposals such as this one need to assess the potential impacts that can either directly and/or indirectly cause loss of or damage to the BPPH (EPA Guidance Statement No. 29, 2004).

The identification and mapping of the BPPH areas within Cone Bay was undertaken by investigating charts (Chart: AUS 733-Australian Hydrographic Service, 1992 and

Oceanvision Software Package) and aerial photographs (source: googleearth.com and personnel digital photographs) and ground level observations were then used to confirm those BPPH noted from charts and to identify any other BPPH areas not represented or indicated in the charts and/or aerial photographs.

3.6.1 Mangroves

Mangrove areas are important BPPH and are the main type of BPPH in Cone Bay due to the predominately muddy seabed. Mangroves are protected under the *Wildlife Conservation Act 1950 (WC Act)*. The EPA in accordance with the *Guidance Statement No. 29, Benthic Primary Producer Habitat Protection for Western Australia's Marine Environment, June 2004* must assess all development proposals that may impact mangrove areas. The EPA's environmental objective in regards to mangrove areas is "*To maintain the abundance, diversity, geographic distribution and productivity.... through the avoidance or management of adverse impacts and improvement in knowledge*".

Mangroves typically support a diverse community of flora and fauna including crustaceans, molluscs, benthic invertebrates, epiphytic invertebrates by providing habitats and primary productivity. Mangroves trap and bind sediments and act as nutrient sinks by taking up available nutrients within the water column, the sediments and terrestrial runoff.

Ground-truthing of the mangrove communities was undertaken by boat in which the entire coastline of Cone Bay was navigated and the GPS locations of the communities recorded. This data was then inputted into the Oceanvision software program to identify the locations on a chart. The results were then extrapolated onto a template map of Cone Bay and presented in this PER.

The survey identified a number of mangrove communities within Cone Bay that account for ~42% of the coastline and two small communities on the largest island in the north of the bay, Razor Island. The majority of the mangroves are located at the back of the bay with two large communities existing on either side. The rest of the mangrove communities are small and interspersed throughout the northern and southern coastline of the bay.

The location and extent of mangrove communities in Cone Bay are schematically represented in Figure 3.4. Also included in Figure 3.4 is the closest distance (in kilometres) that some of the mangrove communities are from the aquaculture licence No. 1465 boundaries. The mangrove communities are not within the boundaries of the aquaculture licence and the closest mangrove community is 290 metres from the southern boundary of the licence site.

The current status of mangrove communities in Cone Bay is considered to be undisturbed and is described in more detail in Section 3.8.

3.6.2 Coral Reefs

Coral reef areas are important BPPH, however, are not the dominant type of BPPH in Cone Bay due to the predominately muddy seabed. Coral reefs are protected under the WC *Act 1950*. The EPA in accordance with the *Guidance Statement No. 29, Benthic Primary Producer Habitat Protection for Western Australia's Marine Environment, June 2004* must assess all development proposals that may impact coral reef areas. The EPA's environmental objective in regards to coral reef areas is "*To maintain the abundance, diversity, geographic distribution and productivity.... through the avoidance or management of adverse impacts and improvement in knowledge*".

Ground-truthing of the coral reef communities was undertaken in the same manner as for the mangrove communities, however specific areas identified from the charts were investigated to determine the existence of coral reef structures. This data was then inputted into the Oceanvision software program to confirm their locations on a chart. The results were then extrapolated onto a template map of Cone Bay and presented in this PER.

No coral reefs exist within the aquaculture licence area. There is however, one coral reef community observed within Cone Bay but it is located some distance (5.76km) from the licence site on the north-western side of the bay and is schematically represented in Figure 3.5.

The current status of the coral reef area in Cone Bay is considered to be in an undisturbed state except from natural seasonal variations and is described in more detail in Section 3.8.

3.6.3 Sub-tidal Benthic Substrate

Cone Bay, including the licence area, demonstrates similar characteristics in benthic structure to the rest of the King Sound and Buccaneer Archipelago. This being predominantly mud with large areas of solid rock characteristic of the surrounding coastal landscape (CALM, 1994; IMCRA, 1998; Pearson *et al*, 1998; Brown & Root, 2000).

A study undertaken by Enzer Marine Environmental Consulting in 1998 confirmed this by undertaking a series of benthic samples as a requirement for an application to vary the existing pearling licences.

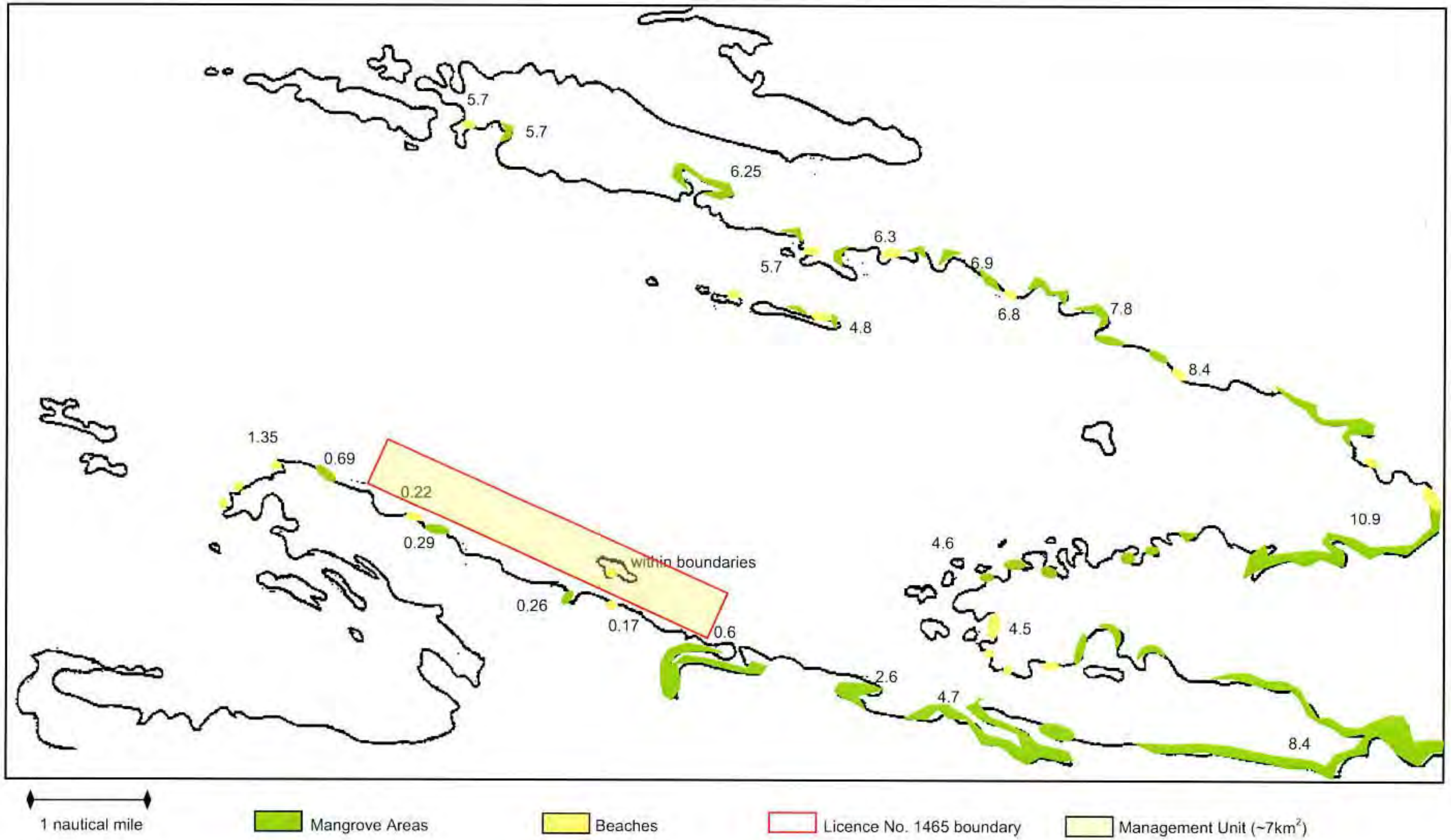


Figure 3.4: Location and extent of mangrove areas and beaches in Cone Bay. The numbers refers to the closest distance (in kilometres) from the aquaculture licence boundary that the particular beach or mangrove community is located.

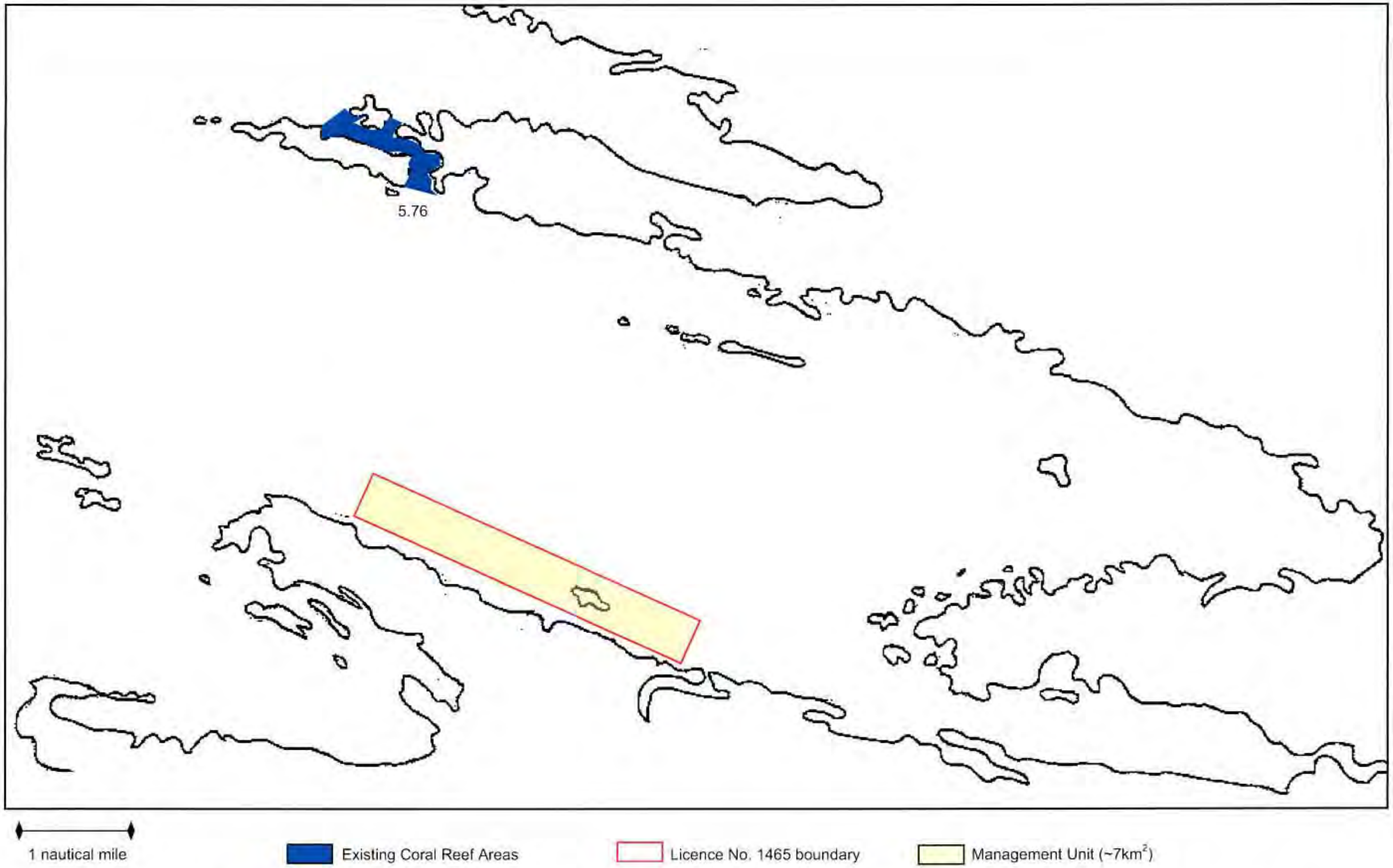


Figure 3.5: Location and extent of coral reef areas in Cone Bay. The number refers to the closest distance (in kilometres) that the coral reef community is from the aquaculture licence boundary.

As a part of the pearling lease variation/application, the then Department of Environmental Protection (now DEC) required a survey of the BPPH of the area surrounding the proposed leases. As a result, MPC commissioned Enzar Marine Environmental Consulting to provide a report of the benthic substrate and BPPH within the area. The report, *Marine Habitats in Cone Bay; Report to Maxima Pearling Company Pty Ltd* (Enzer, 1998) described the following characteristics:

- That mangroves occur in the mid to upper intertidal levels of the shoreline,
- The waters tend to be too turbid to for the development of major coral reefs, although many small fringing reefs occur in the shallow waters of the outer islands,
- The benthic substrate is primarily mud, however there are areas where basaltic rock and limestone dominates, and;
- There were no turtle or significant seabird nesting areas on any of the islands.

The mud bottoms of the King Sound are generally considered to be 'hostile' environments, which do not support a large number of benthic communities (Pearson *et al*, 1998). However, results from the EMMP have demonstrated that a small variety of benthic infauna does exist in the sub-tidal mud bottoms of the aquaculture site.

Muddy benthic communities are protected under the WC Act and the FRM Act. Proposals that may affect the structure of the benthic substrate are subject to assessment in accordance with the *Guidance Statement No. 29, Benthic Primary Producer Habitat Protection for Western Australia's Marine Environment, June 2004* (EPA, 2004; CALM, 2005).

Very little research into the quality of the sediment has been conducted for the King Sound area. Initial studies undertaken by Pearson *et al* (1998) showed that the abundance and diversity of the macrozoobenthic species (from 30cm depth core samples) was very low, indicating that the sediments (mud flats) are "very hostile, especially for sessile animals" (Pearson *et al*, 1998). The Benthic Infauna of Cone Bay (and the associated reference sites) has been described as a part of the improved EMMP and is discussed further in section 3.8.

Current sediment disturbances result from high tidal range and fast water movement occurring year round. This is exacerbated during severe or cyclonic weather (on an annual basis), where the conditions result in the sediments being forced into suspension and circulated throughout the bay and out into the King Sound.

3.6.4 Seagrass Meadows

Seagrass areas are protected in WA under the WC Act and the *FRM Act 1994* and any development proposals that are near any seagrass communities are subject to environmental impact assessment by the EPA in accordance with the *Guidance Statement No. 29, Benthic Primary Producer Habitat Protection for Western Australia's Marine Environment, June 2004* (EPA, 2004; CALM, 2005).

There are no seagrass meadows in Cone Bay or in the surrounding waters outside the entrance. Consequently there have been no sightings of dugong within the vicinity of Cone Bay and the traditional landowners do not hunt dugong in the waters within or locally surrounding Cone Bay.

The nearest seagrass meadow to Cone Bay is situated near Sunday Island on the western side of the King Sound (Enzer Marine Environmental Consulting, 1998) approximately 35km in distance from Cone Bay and the existing aquaculture licence boundary. The seagrass meadow at Sunday Island has been examined in detail in a study undertaken by the Western Australian Museum and in the same study an active search resulted in no evidence of other seagrass areas in any of the surrounding areas.

As stated before, the benthic substrate in Cone Bay is predominantly mud or solid rock.

3.6.5 Intertidal Flats & Rocky Shores

Sand & mudflat intertidal areas with their associated communities are protected under the WC Act and the FRM Act. Proposals that may affect the structure of the benthic substrate are subject to assessment in accordance with the *Guidance Statement No. 29, Benthic Primary Producer Habitat Protection for Western Australia's Marine Environment, June 2004* (EPA, 2004; CALM, 2005).

Much of the coastline of Cone Bay is characterised by steep cliff faces rising up out of the water (see Figure 3.6). These surfaces do not support a large variety of invertebrates due to the harsh physical wave and tidal action. Only those invertebrates that are able to attach themselves resiliently to these vertical surfaces survive (eg limpets, flat oysters, barnacles etc).

In areas where shorelines are exposed with the flow and ebb of the tide, the shores are largely dominated by mud flats that can extend many metres out into the bay or encompass a small embayment (Figure 3.7). Intertidal areas that demonstrate a rocky substrate become mud bottom below the low tide level. Some intertidal areas are sand or rocky/muddy reef areas generally only exposed at low spring tides and are not comprised of any coralline structures. The intertidal areas are subject to very strong tidal action and currents within the bay that cause sediments to be removed and deposited continuously in random fashion on a seasonal basis throughout the bay.

There are a number of small beaches that exist within Cone Bay. The majority of these beaches are located on the northern side and eastern end of the bay (Figure 3.4). At high spring tides many of these beaches become submerged or reduced to a very small size (Figure 3.8). Most of the beaches are steeply sloping with many larger rocks interspersed throughout the sand. Since the inception of the pearling activities within the bay approximately 20 years ago, no turtle nesting activity has been observed.

The current status of the intertidal areas of Cone Bay is considered to be undisturbed except for natural/seasonal variation. All intertidal areas are schematically represented in Figure 3.9.

a)

b)

Figure 3.6: Steep Rock Cliff Faces of Cone Bay. Photos a & b demonstrate the steep rock cliff faces of Cone Bay that rise directly out of the water. This is characteristic for the majority of Cone Bay.

Figure 3.7: Intertidal mud-flats of Cone Bay. The above photos demonstrate the characteristically exposed mud flats during low tides.

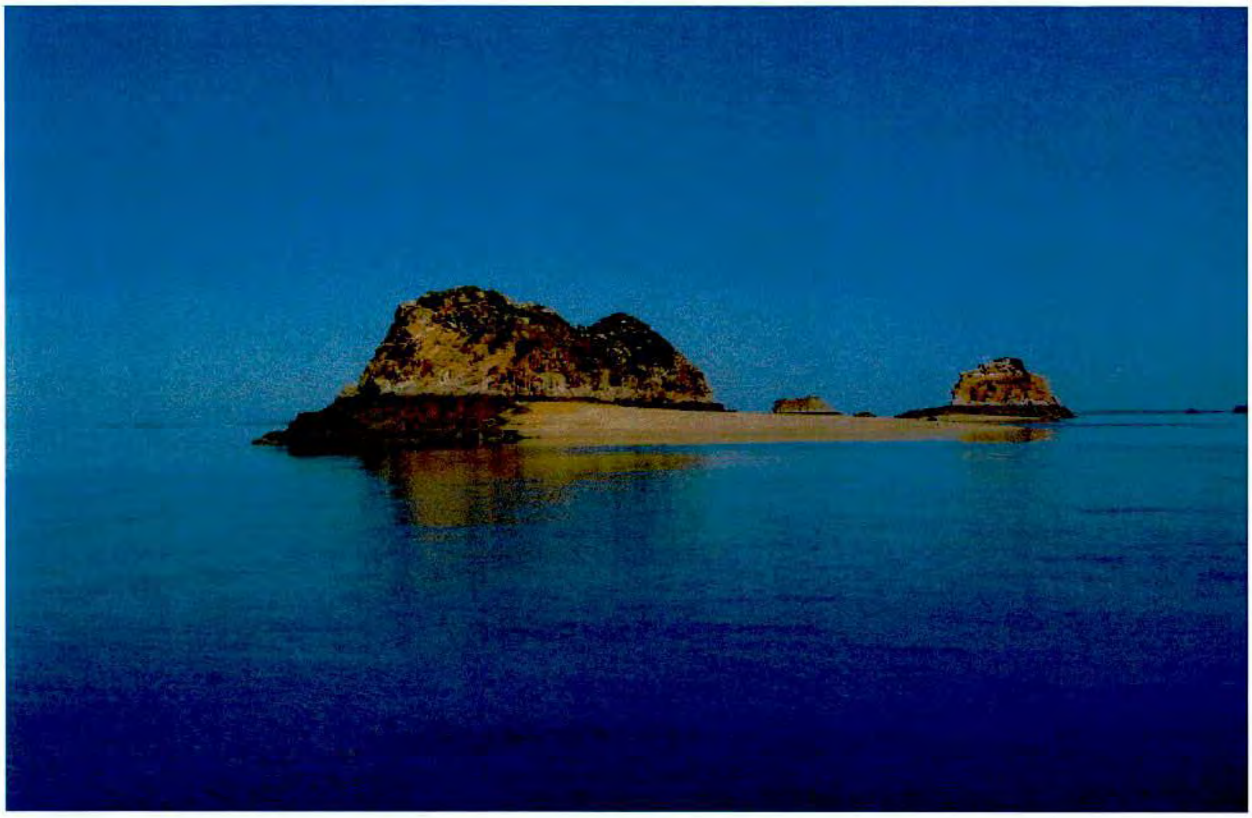


Figure 3.8: Typical example of a beach in Cone Bay. The photograph demonstrates the extent to which the tide covers the beach during a high tide (high tide mark indicated by the change in colour from dark to light on the rocks.

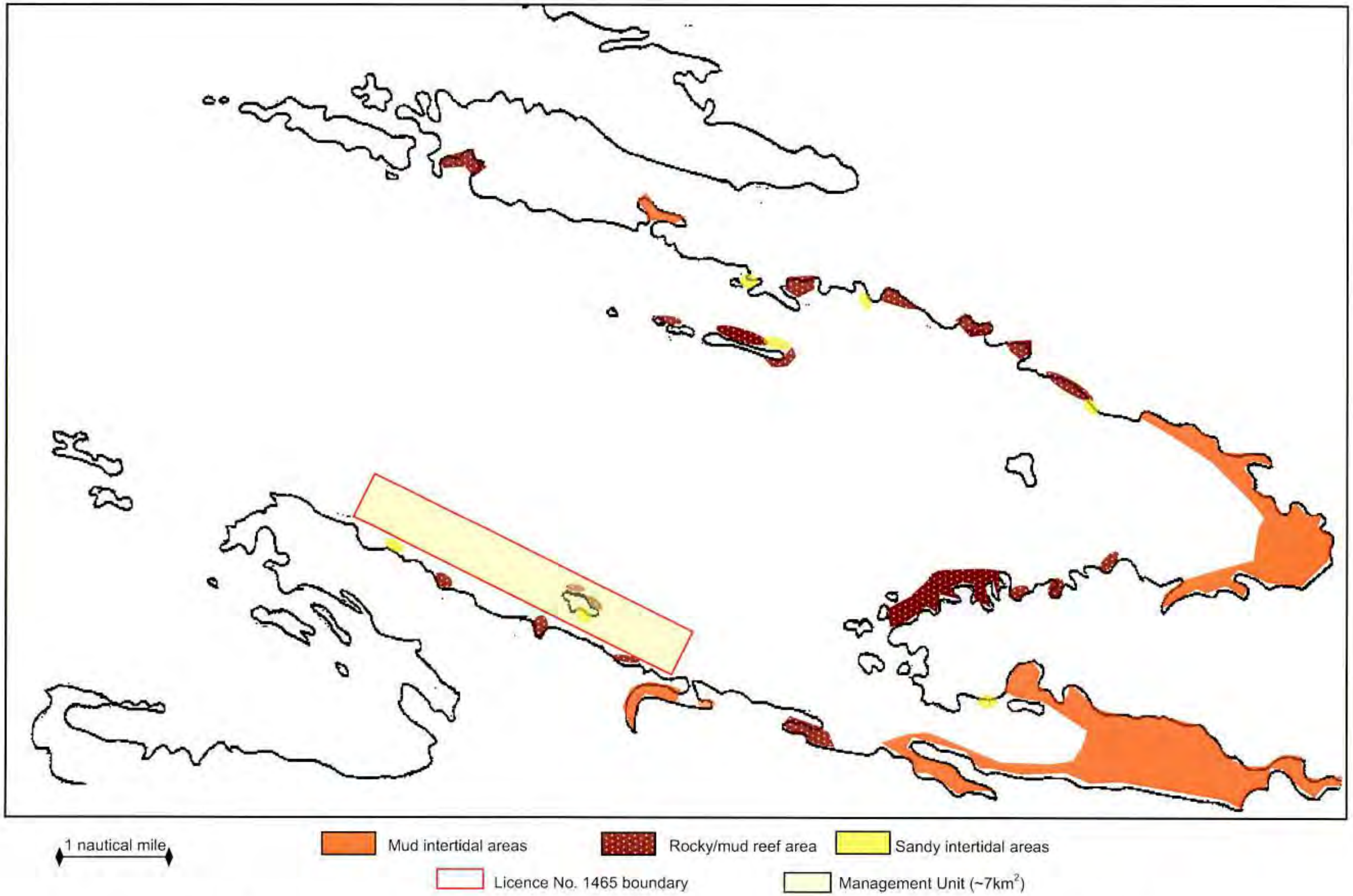


Figure 3.9: The three main types of intertidal zones evident in Cone Bay. The relative distances from the licence boundaries are similar to those given in Figure 3.4.

3.7 Current Social Use

3.7.7 Recreational

Recreational use that occurs in Cone Bay is predominantly fishing and camping. People swim at their own risk due to the presence of crocodiles and no skiing or recreational diving has been observed in the bay. People who camp in the area have been known to collect mud-crabs, however once again this is done at their own risk due to the presence of crocodiles. Due to the remoteness of the area only people who own or have access to a boat are able to utilise this area in a recreational sense.

To ensure the site remains accessible for recreational users the area will continue to be clearly marked in accordance with DoF WA and DPI navigational requirements and the site will not be deemed exclusive to aquaculture operations. All additional sea cages constructed and implemented, as a part of this proposal will also be clearly marked.

3.7.2 Commercial

There are no known commercial fishing licences in Cone Bay. A number of fishing licences have the capacity to fish in the King Sound, however this is due to their licence enabling them to fish all waters within the state. No commercial fishing activity has been observed recently in Cone Bay and is expected that Cone Bay would not be a productive fishing area relative to other areas in the King Sound.

MPC already operates an existing pearling and barramundi aquaculture venture based in Cone Bay. MPC have an indefinite lease agreement for Turtle Island, however own and operate the infrastructure that provides water, power and housing utilised by both ventures. As a result no additional land based infrastructure needs to be constructed to accommodate extra staff required for the proposed expansion.

There are no other known commercial industries operating within Cone Bay. The mining industry has interests on Cockatoo and Koolan Islands (~45.6km NNE) and as a result, vessels regularly navigate past Cone Bay, travelling between the mine sites and the Port of Derby. However, these vessels pass Cone Bay at an approximate distance of 18km west of and do not enter the bay at all (see Figure 6.4).

3.7.3 Tourism

Many tourist charter operators currently conduct activities in the King Sound and Buccaneer Archipelago and these include fishing charter operators, luxury boat/holiday operators and air charter operators. Charter boats are known to enter Cone Bay and the majority of these operators have developed mutually beneficial relationships with the existing pearling and aquaculture operations undertaken by MPC and MFF.

To ensure the aquaculture site remains accessible for charter operators and other tourism operators, the area will continue to be clearly marked in accordance with DoF (WA) and DPI navigational requirements. The site is not deemed exclusive to aquaculture operations and all current sea cages are clearly marked, as will all additional sea cages constructed and implemented as a part of this proposal.

3.7.4 Government

The coastline and land surrounding Cone Bay is commonwealth land that is utilised by the DoD. The terrestrial area is currently utilised on a sporadic basis by the DoD for training purposes. The DoD has not stated any concerns regarding the Cone Bay aquaculture site in any previous communications.

Recently, MPC in conjunction with MFF has been in discussions with the DoD in regards to their concerns about accessibility and future use of the areas surrounding and to the south of Cone Bay. The DoD has intentions to use the Yampi Sound Training area on a far more regular basis in the future and these issues have been factored into this proposal as discussed in more detail in Sections 4 and 7. Figure 3.10 demonstrates the location and extent of the land utilised by the DoD.

3.8 Aboriginal & Cultural Heritage

The aquaculture licence 1465 site is located within state waters and there are no World Heritage properties, National Heritage places, Ramsar wetlands, listed Commonwealth Heritage places or areas of remnant native vegetation within the vicinity of the site (Figure 3.10). The area was included in the CALM 1994 Report of the Marine Parks and Reserves Selection Working Group (*A Representative Marine Reserve System For Western Australia)* whereby it was recommended that the area be considered for conservation but zoned as multiple-use to include ventures such as this proposal.

The Kimberley region has 24 native title claims currently in progress, with 9 claims already under active management and two of these nearby the licence area. The Kimberley Land Council represents the majority of the native title claims in the Kimberley. The closest native title claim is Dambimangari, which incorporates the majority of Cone Bay. Another native title claim that also encompasses part of Cone Bay and lies directly next to Dambimangari claim is Mayala. However, this claim has not yet been determined. The next closest determined native title area is the Bardi Jawi territory which encompasses the tip of the Dampier Peninsula and extends over the ocean (see Figure 3.11). The native title areas that are nearby the aquaculture licence area are shown in Figure 3.11.

A small community exists at the north-eastern end of Cone Bay, the Larinuwar (Yaluun) Community. Yaluun and its members have been a part of the consultative process with MPC since the pearling venture inception which MPC, and now also MFF, has maintained to this date. Through all past and more recent communications MPC has established that no aboriginal site issues exist in the area.

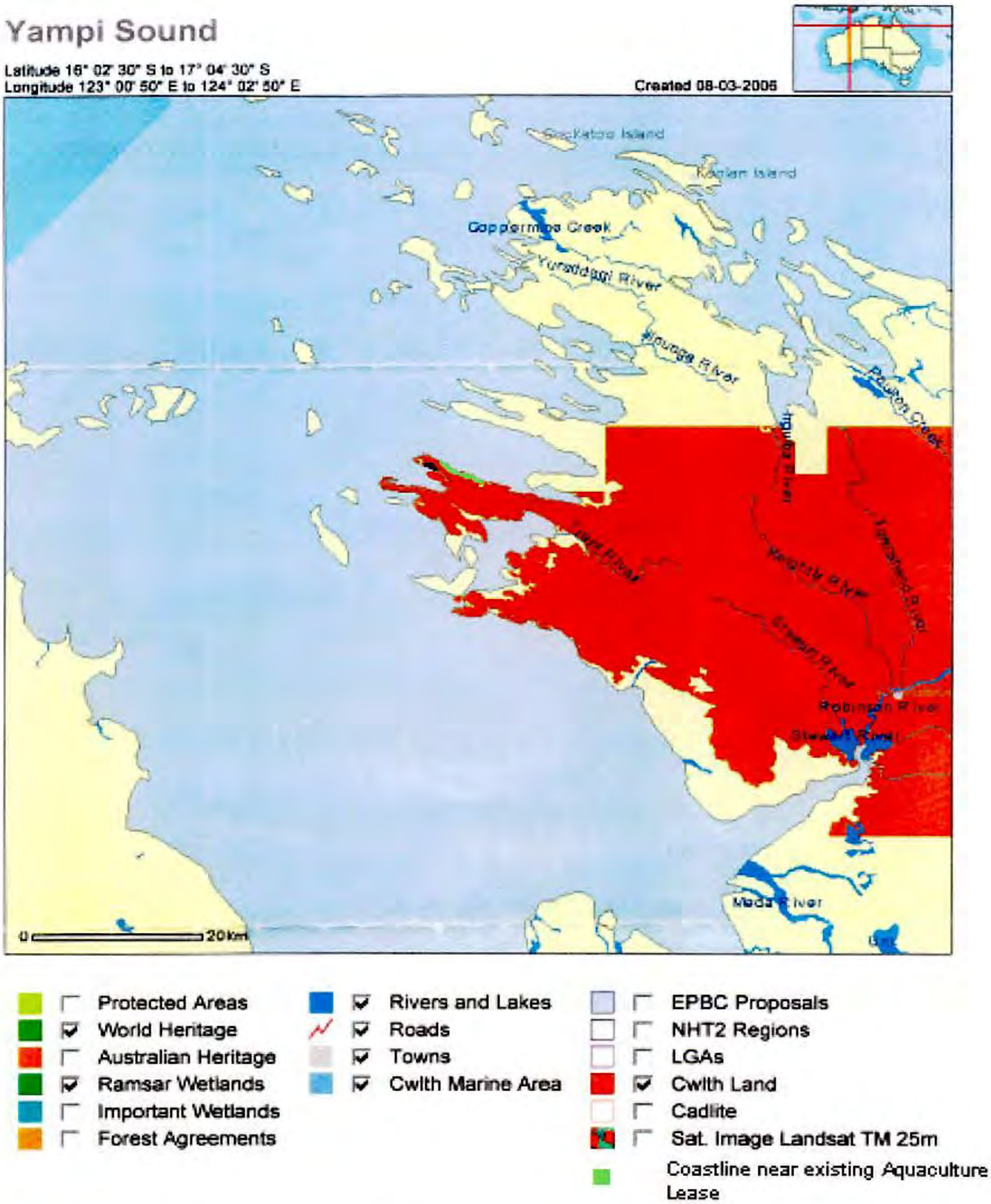


Figure 3.10: Location and extent of DoD land in the Yampi Sound. Areas of coastline that existing and proposed aquaculture leases are adjacent to the DoD land are also shown.

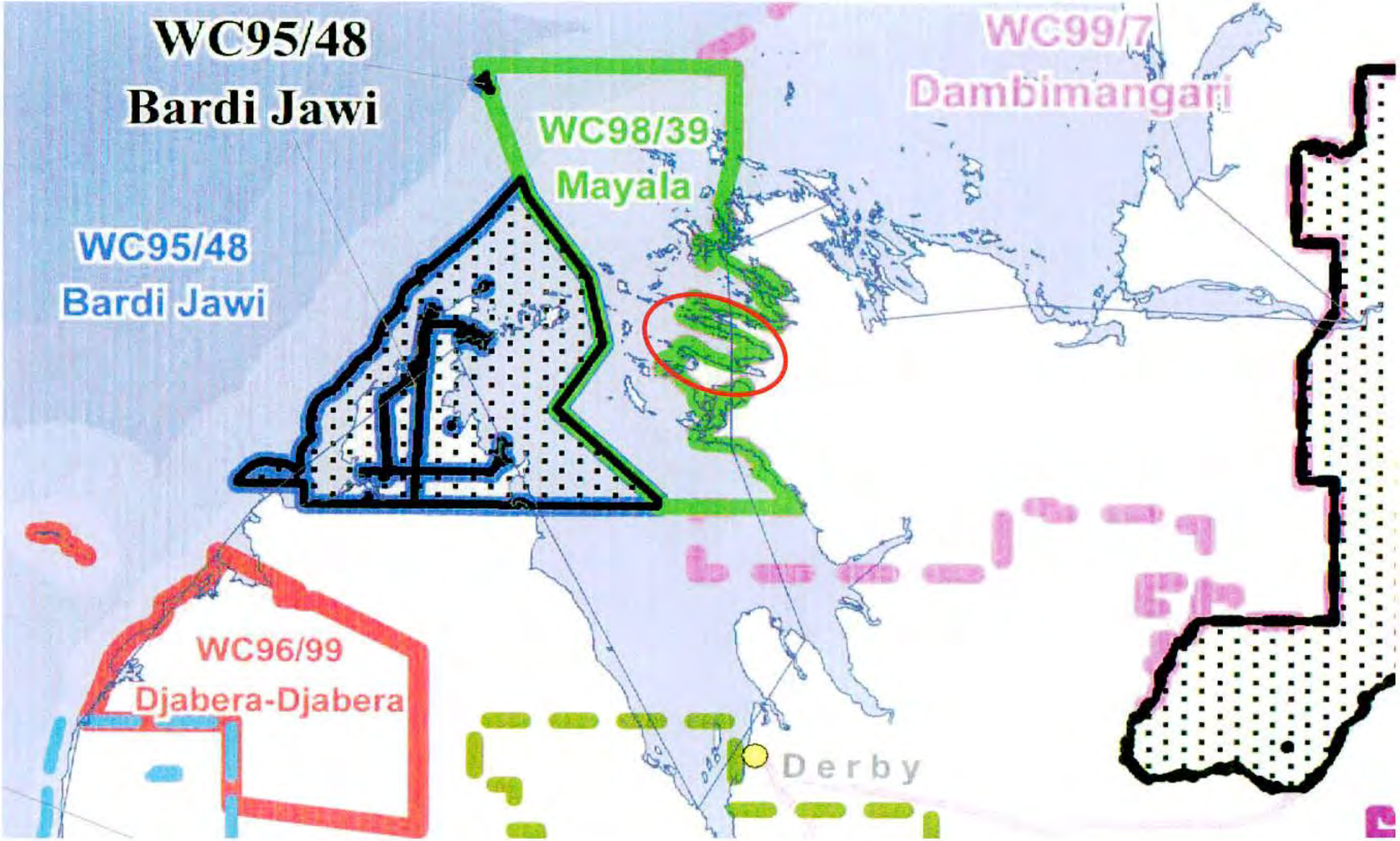


Figure 3.11: Native title claims surrounding Cone Bay (denoted by the red circle). Sourced from: www.nntt.gov.au (National Native Title Tribunal) *Western Australia Native Title Applications and Determination Areas – as per the Federal Court: 30 June 2006.*

3.9 Cone Bay Environmental Monitoring & Management Program

3.9.1 Introduction

An EMMP was developed for the existing sea cage operation in Cone Bay in 2005 and was approved by the EPA and implemented in February 2006. Environmental quality data has been collected for the Cone Bay area since 2004 coinciding with the introduction of the pilot project and thus the first sea cage.

It is important to note that sediment quality data, benthic infauna assemblages, mangrove monitoring and coral reef monitoring were not introduced into the Cone Bay EMMP until February 2006 and as a result the data presented for these parameters in this section is limited.

The EMMP was developed using much of the information obtained from hydrodynamic studies conducted in Cone Bay by Brown & Root (formerly Kinhill) in early 2000. These studies were undertaken for the pearling venture in existence at the time, however provides the basic information of the bay and sample sites that was incorporated into the Cone Bay EMMP.

A summary of important characteristics of the area ascertained from the results of the Cone Bay EMMP is given below (see section 3.9.2). A more detailed presentation of this data is provided in Appendices D and E.

3.9.2 Findings

<u>Water Quality</u>

Water samples have been collected on a six weekly basis since the inception of the EMMP and the parameters measured include temperature, pH, salinity, turbidity, Dissolved Oxygen (DO), Total Nitrogen (TN), Total Phosphorous (TP), Chlorophyll-*a* (chl-a) and Total Suspended Solids (TSS). The main environmental characteristics of Cone Bay and the surrounding area include:

- Distinct seasonal patterns for parameters such as water temperature, dissolved oxygen (DO) and Chlorophyll *a* (chl-a).
- Salinity and pH demonstrate relatively consistent results over time.
- Other water quality parameters do not necessarily demonstrate seasonal patterns; however have presented highly variable results that coincide with changes in the ambient environmental conditions (ie large tidal ranges, high flushing rates and high variability in ambient conditions experienced in the area).
- No unacceptable water quality impacts have occurred to date as a result of the implementation of the sea cages. All sea cage sites show similar results to reference sites on any given sampling date.
- Ambient environmental changes have shown to have a greater impact on environmental quality in the area in comparison to the sea cages.

<u>Benthic Quality</u>

Sediment samples are collected from the same sites utilised for water sampling, but after water samples are taken to avoid water contamination. Sediment sampling is undertaken on a 3 monthly basis and parameters analysed at each site include TN, Total Kjeldahl Nitrogen (TKN), particulate organic matter (LOI), and redox potential. The following results were found:

- TKN makes up the total nitrogen value indicating that the sediments are made up of organic nitrogen.
- TN is highly variable.
- Overall, benthic sediment quality demonstrates very high inter- & intra-site variability and no distinct patterns can be ascertained.
- On most occasions the reference sites have demonstrated higher values for parameters such as TN, TKN and Total Organic Matter (LOI) than the cage sites indicating that ambient environmental changes appear to have a greater effect on sediment quality than the sea cages.
- Although visual observations of the mud samples have shown slight changes to the benthic substrate directly beneath the cages, no unacceptable benthic substrate changes to the sediment chemistry have occurred. In addition, no trigger values have been exceeded and thus no unacceptable impacts have been recorded.

<u>Benthic Infauna</u>

The diversity and abundance of the benthic macro-invertebrates to Family level have been assessed at 3 reference sites and at Sea Cage #1. Results are as follows:

- Infaunal species diversity and abundance is very low.
- There is high variability both inter- and intra-site.
- Only 3 sites were observed to have more than one species represented at that site.

- The majority of samples had only one species and/or one individual present in the sample.
- The sea cage samples were observed to have the second highest abundance and diversity with Gerald Bay demonstrating the highest diversity and abundance.

Mangrove Communities

Two mangrove communities in Cone Bay have been selected as a part of the EMMP (Figure 3.12). These sites were selected due to their proximity to the licence area although it is not expected that these or any other mangrove communities will be impacted by the proposed production increase.

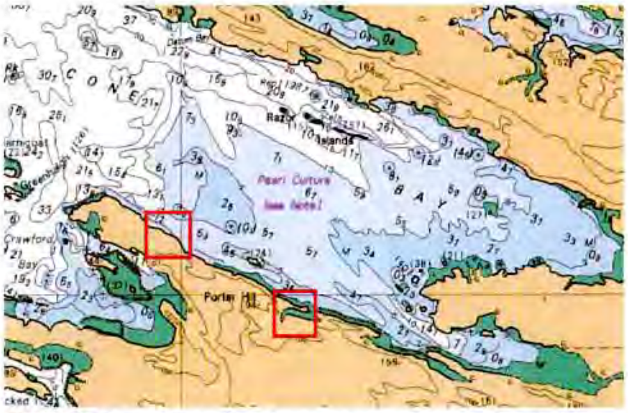


Figure 3.12: Location of the two selected mangrove sites for the Cone Bay EMMP.

The community located inside the inlet known as 'Snapper Cove' (indicated by "1") is a large community that extends along the coastline and far into the inlet. The community indicated by "2" is a small community towards the entrance of the bay is far more exposed. Both areas are characterised by large expanses of muddy benthos exposed during low tides.

Both mangrove sites are in a healthy and natural state with the predominant species being *Avicenna marina* and *Rhizophora sp.* The monitoring results have shown that over time there has been no loss of size or health of the communities.

More details and photographic archives of the mangrove sample sites are presented in Appendices D and E.

Coral Reef Communities

One coral reef community in Cone Bay has been selected as a part of the EMMP. This site was selected as it is the only known coral reef to exist in Cone Bay (Figure 3.13).

This reef is a large extensive reef that is located on the north-western part of the bay and encompasses the entire area known as "Sir Richards Pass" that winds around between a couple of islands and the mainland into Gerald Bay.

Figure 3.13: Location of the selected coral reef site for the Cone Bay EMMP.

The state of the coral reef in Sir Richards Pass is considered to be in a healthy and natural state. The reef extends over a large area and is comprised of many types of corals, sponges, invertebrates and fish species. The corals are predominantly hard corals including those from the families Faviidae (brain corals), Acorpora (staghorn and plate corals) and Poritidae (stony corals).

The reef is considered to be in an undisturbed state with some evidence of natural disturbance (ie broken coral colonies). The ongoing monitoring has shown that no loss of structure, function and/or health has occurred.

More details and photographic archives of the coral reef sample site is presented in Appendices D and E.

Biota

Since the inception of the EMMP all observations of marine biota present at a visible distance from the sea cages has been recorded. The majority of species sighted are various types of baitfish (eg garfish, scat), batfish, crocodiles and herons. Other species that have been observed on a less regular basis include:

- Fish – Reef sharks, Mackerel, Tuna, Trevally, Cobia, Grouper, other tropical reef fish, Queenfish, Lemon Shark, Sleepy Shark, larger sharks (eg Bronze whaler and Tiger) and one manta ray,
- Reptiles – one turtle,
- Birds – Frigates, Terns, Sea Eagles, Brahminy Kites.

A more detailed account of the number of individuals and behaviour of the marine biota observed is presented in Appendix D.

3.9.3 Conclusion

The overall conclusions that can be made from the results of the Cone Bay EMMP are:

- Water quality is relatively consistent between sites on any given sampling date and that for some parameters, such as temperature, chlorophyll-a (and to some extent TSS), salinity and DO, distinct seasonal patterns have been observed.
- Other parameters such as TN, TP and turbidity that do not shown distinct seasonal patterns, have demonstrated high variability over time that can be attributed to the ambient environmental conditions at the time of sampling (eg spring or neap tide, large amount of terrestrial run-off etc).
- Sediment quality is highly variable, both temporally and spatially (ie within and between sites) and no distinct patterns have been detected.
- Reference sites have shown both higher levels and variability of some parameters than observed at the sea cage sites, indicating that environmental conditions may have greater impacts than the sea cages.
- To date, no unacceptable impacts to the sediment have occurred and no EQCs have been exceeded.
- The mangrove and coral reef areas sampled are considered to be maintaining a healthy and natural state.
- Biota records have shown that although baitfish and some other species are commonly observed around the cages, these have not always been in large numbers and can vary seasonally.

Overall the results of the Cone Bay EMMP have demonstrated that no unacceptable changes to water, sediment or BPPH quality have occurred as a result of the existing Barramundi farm. In fact, the results have clearly shown that ambient environmental conditions, such as rainfall, cyclones and other seasonal conditions cause greater fluctuations in nutrient levels than do the outputs from the cages.

4. Potential Impacts, Risk Assessment and Management

This section outlines the potential impacts that may occur as a result of the proposed production increase in Cone Bay and the proposed management strategies that MPC considers will avoid or minimise those impacts. These have already been briefly described in Table A. Discussions on the predicted impacts determined from the studies and investigations conducted by MPC prior to this PER are also included. These results have been discussed in detail in Section 3 and Section 6.

A risk assessment for the potential and predicted impacts has been provided. Nikki Jack and Donna Cahill conducted the risk assessment as the principal developers of this document. Both Ms Jack and Ms Cahill have a scientific background with substantial experience and knowledge of biological and aquaculture processes. Other scientific professionals such as environmental consultants and aquaculture scientists also provided advice, recommendations and expertise in the development of the risk assessments.

The assessment and description tables have been extrapolated from an environmental workshop report released by the Fisheries Research and Development Corporation (FRDC Project No. 2001/99; Environmental Risk and Assessment of the Pearling Industry (Jernakoff, 2002)).

Information relevant to the proposal was extrapolated and modified to fit the scope of the proposed impacts. The risk assessment considers the range of potential consequences and how likely those consequences are to occur. Consequence and likelihood are combined to produce an estimated level of risk associated to the particular impact in question (Jernakoff, 2002). Table 4.1 shows the risk assessment matrix that was used to determine the level of risk associated with each impact.

The shading of each area in the risk matrix indicates the risk ranking (utilising equal weight on consequence and likelihood and a linear scale). The risk rankings are represented in table 4.2.

The consequence categories used in the risk matrix are further explained in table 4.3 for species level, table 4.4 for habitat level and table 4.5 for ecosystem level. The likelihood assessment guidelines are described in table 4.6.

Table 4.1 – Risk Matrix

		Consequences					
		1	2	3	4	5	6
Likelihood		Negligible	Minor	Moderate	Severe	Major	Catastrophic
6	Likely	6	12	18	24	30	36
5	Occasional	5	10	15	20	25	30
4	Possible	4	8	12	16	20	24
3	Unlikely	3	6	9	12	15	18
2	Rare	2	4	6	8	10	12
1	Remote	1	2	3	4	5	6

Table 4.2 – Risk Ranking

Risk Level	Score	Description/Action
H	Greater than and equal to 20	High Risk – Immediate action is required.
M	Greater than and equal to 8 but less than 18	Moderate Risk – Risks are acceptable as long as risk reduction is applied to reduce risks to 'as low as reasonably practicable'.
L	Less than 6	Low Risk – Risks are broadly acceptable and are managed by current procedures.

Table 4.3 – Species Level Consequence Categories

#	Level	Descriptor
1	Negligible	Undetectable for this population. Insignificant impacts to habitat or population. Unlikely to be measured against background variability.
2	Minor	Localised and no impact on population size or dynamics. Insignificant impacts to habitat or populations. Rapid recovery measured in days to months.
3	Moderate	Full exploitation rate where long-term recruitment/dynamics not adversely impacted. Recovery measured in months.
4	Severe	Affecting recruitment levels of stocks/or their capacity to increase. Recovery measured in months to years.
5	Major	Likely to cause local extinctions. Recovery period measured in years to decades.
6	Catastrophic	Local extinctions are imminent/immediate. Long-term recovery period measured in decades.

Table 4.4 – Habitat Level Consequence Categories

#	Level	Descriptor
1	Negligible	Affecting < 1% of area of habitat. Insignificant impacts to habitat or population. Unlikely to be measurable against background variability.
2	Minor	Affecting < 5% of total habitat area. Localised or insignificant impacts to habitat. Rapid recovery would occur if activity stopped, measured in days to months.
3	Moderate	5-30% of habitat affected; or If occurring over a wider area, the impact to habitat from activity is not severe. Recovery measured in months.
4	Severe	30-60% of habitat is affected/removed. Recovery measured in months to years.
5	Major	60-90% of habitat is affected/removed. Recovery period measured in years to decades.
6	Catastrophic	> 90% of habitat is affected/removed. Long-term recovery measured in decades.

Table 4.5 – Ecosystem Level Consequence Categories

#	Level	Descriptor
1	Negligible	Interactions may be occurring, although unlikely that there would be any change outside of natural variation. Insignificant impacts to habitat or population. Unlikely to be measurable against background variability.
2	Minor	Localised and insignificant impact. Only minor changes in relative abundance of other constituents. Rapid recovery measured in days to months.
3	Moderate	Measurable changes to the ecosystem components without there being a major change in function. No loss of function. Recovery measured in months.
4	Severe	Ecosystem function altered measurably and some function or components are missing/declining/increasing outside of historical range and/or allowed/facilitated new species to appear. Recovery measured in months to years.
5	Major	Detrimental effect that will cause a significant effect on local ecosystem structure and function (different dynamics now occur with different species/groups now the major targets of capture). Recovery period measured in years to decades.
6	Catastrophic	Large-scale detrimental effect that is likely to cause a highly significant effect on local ecosystem factors such as water quality, nutrient flow, community structure, food webs and biodiversity. Long-term recovery period measured in decades.

Table 4.6 – Likelihood Assessment Guidelines

#	Level	Descriptor
1	Remote	Never heard of.
2	Rare	May occur in exceptional circumstances.
3	Unlikely	Could occur at some time.
4	Possible	Some evidence to suggest that it is possible.
5	Occasional	Will probably occur in most circumstances.
6	Likely	It is expected to occur in most circumstances.

4.1 Introduction of Disease and Parasites

4.1.1 EPA Objective

To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

4.1.2 Potential Impacts

Potential impacts from the potential introduction of diseases and parasites include:

- Introduction and transfer of exotic diseases and organisms to wild fish; and
- Spread of endemic disease across the Barramundi population within the region.

Consequence = 4; Likelihood = 3; Risk Rating = 12 (Moderate)

4.1.3 Predicted Impacts

The 150 tonne Cone Bay sea cage trial has demonstrated that the utilisation of quality fish, handling procedures, conservative stocking levels, disease testing and steel mesh nets has resulted in a disease-free and parasite-free sea cage system.

It is proposed that these methods and procedures will continue to be used in the expanded operation, therefore reducing the risk of a disease or parasite outbreak. In addition, a 1999 discussion paper on the translocation of Barramundi (Fisheries Management Paper No. 127) stated that "Although information from the salmonid and marine prawn farm industries suggests some deleterious effects on wild stocks... there are no documented instances of cultured fish causing disease epidemics among wild fish. Evidence of farmed stocks affecting wild stocks is circumstantial ...... wild fish are not exposed to the stresses experienced by cultured fish, so are unlikely to be affected by pathogens that may be released from aquaculture operations" (Fisheries WA, 1999).

As there have been no observed mortalities of the wild Barramundi stock in the surrounding area from the existing 150 tonne venture and given the strict management strategies developed, it is therefore predicted that an increase in the total production of the licence area will not threaten wild fish health.

Consequence = 4; Likelihood = 3; Risk Rating = 12 (Moderate)

4.1.4 Proposed Management

A Barramundi Health Management and Emergency Plan (BHMEP) has been developed which includes procedures to prevent a disease and/or parasite outbreak, in addition to a contingency plan in the unlikely event of an outbreak. Management procedures include the following best practice measures:

- Development of a procedures manual for sea cage culture which includes conservative stocking densities, minimal handling, daily monitoring of fish health, regular net inspections and cleaning protocol;
- Adhering to Fisheries WA translocation regulations;
- No introduction of stock from overseas sources;
- Any equipment or manufactured feed obtained from overseas sources will satisfy and comply to the standard Customs and Australian Quarantine and Inspection Service (AQIS) regulations and approvals;
- Stringent disease testing before fish are transported to the Cone Bay land based facility;
- Fingerlings to be sourced from an accredited hatchery (accreditation given by the states Animal Health Laboratory, Department of Agriculture or similar regulatory body);
- Development of a procedures manual for land based culture which includes conservative stocking densities, minimal handling, daily monitoring of fish health, sterilisation and maintenance protocols of land based facility and associated equipment and improvement in hatchery techniques;
- Development of a staff training program in fish handling, biology, behaviour and health monitoring;
- Vaccination of fish to prevent disease; and
- Consultation with the DoF Fish Pathologist/Chief Veterinary Officer (CVO) and the WA Fisheries Director (or representative) and development of a disease contingency plan in accordance to his/her recommendations.

Predicted Outcome

Potential impacts and the proposed management of such impacts have been considered and the risk of adverse impact is minimal. As a result the EPA objective will be met.

4.2 Genetic Variation

4.2.1 EPA Objective

To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

4.2.2 Potential Impacts

The potential impact of escaped fish and/or the occurrence of sexually mature fish within the sea cage system could result in the variation of the genetic profile of the endemic wild Barramundi population.

Consequence = 2; Likelihood = 3; Risk Rating = 6 (Low)

4.2.3 Predicted Impacts

The cages and construction design have proven to be able to withstand pressures from adverse weather conditions and predation. As a result there have been no recorded fish escapes due to cage construction and future escapes are not predicted.

It is assumed that escaped fish would breed with the local population but it is probable to have minimal if not negligible impact on the genetic makeup of local barramundi stocks due to the use of endemic brood stock where possible.

The *Fisheries Management Paper No. 127 (Fisheries WA, 1999)* has also stated that 'other scientifically recognised authorities believe there is no direct evidence that mixing gene pools will have detrimental effects on local endemic barramundi populations and have argued that, among barramundi stocks, genetic differences have been demonstrated only for populations, not for individual fish, and that it is the proportion of the genes present that differs between different river systems, not the actual genes' (Fisheries WA, 1999).

The majority of fish in the existing Cone Bay system have been harvested before reaching sexual maturity and it is assumed that all fish are harvested before protandry occurs. This minimises the possibility of fertilised eggs being released into the wild and deems the impact negligible.

Consequence = 2; Likelihood = 3; Risk Rating = 6 (Low)

4.2.4 Proposed Management

Prevention is the management focus as there is no practical 'post-escape' contingency plan for such an open system. As a result steel mesh nets already tested and proven to be capable of withstanding adverse weather conditions and predators in Cone Bay will continue to be utilised for grow out culture, and routine inspection and replacement of nets will occur.

A "Procedures and Protocol" manual for net changing, fish transfer and fish harvesting activities has been developed to reduce fish escapes during these processes. The manual will be utilised during staff induction and training sessions and will be reviewed on a regular basis.

MPC and MFF are also currently exploring the possibility of trialling plastic nets. The first constructed by Kikko Netting is made of HDPE plastic. It has proven strength in aquaculture applications and continual tears do not occur because "knitting" Tetron plastic wire with the original technology composes the structure. Trials by Blue Water Barramundi in Cardwell, Queensland have proven to be effective over 3 years against predation and general maintenance requirements (*pers com.* Kerry Briggs, Manager, Blue Water Barramundi).

Another is the cost effective AQUAGRID™ net, which has proven appropriate for a variety of species, including barramundi, and is utilised in more than 11 countries worldwide. The AQUAGRID™ net is designed for farming, not fishing, and provides better containment, improved strength, less maintenance, and better predator protection. The extra strength and tough UV resistant coating also mean longer life, which further reduces the costs of operation.

Further research needs to conducted before these nets will be incorporated into the operations, however if they are incorporated, the existing sea cages will continue to be utilised together with the improved versions.

The use of endemic broodstock, where possible, will also avoid any potential impacts associated with genetic variation of the wild stocks.

4.2.5 Predicted Outcome

Taking into consideration the potential and predicted impacts and proposed management measures, it is expected that the impact to genetic diversity of endemic fauna will be negligible. As a result the EPA objective for genetic variation will be achieved.

4.3 Provision of Additional Food Source from Waste Feed

4.3.1 EPA Objective

To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

4.3.2 Potential Impacts

The potential impacts of providing an additional food source from waste feed could include:

- Attraction of fish and other marine fauna to the sea cage system which in turn effects the distribution of these populations within the region; and
- The unknown effects of ingestion and digestion of manufactured feeds on fish and other marine fauna.

Consequence = 2; Likelihood = 4; Risk Rating = 8 (Low – Moderate)

4.3.3 Predicted Impacts

Initial investigations obtained from the Cone Bay sea cage trial have shown that minimal feed is consumed by wild populations of fish or other marine fauna as these species are not always observed in close vicinity to the sea cages.

Initially, use of the floating pellets resulted in some floating outside the cage and being consumed by wild populations, however feed was changed to sinking pellets to avoid this problem.

To date, feeding and feed rates have also been closely monitored to reduce the amount of waste feed escaping the confines of the sea cages. Thus it is predicted that the impacts associated with waste feed will be minimal.

Consequence = 2; Likelihood = 4; Risk Rating = 8 (Low – Moderate)

4.3.4 Proposed Management

For both environmental and economical reasons, the proposed 1,000 tonne Cone Bay operation will be utilising high quality manufactured feed and will be closely scrutinised to ensure minimal feed is lost to the surrounding water. Feed will be preferably sourced from Ridley Aqua-feed (Marine 45/20 sinking pellets), the composition of which is described in Appendix A. If required feed sourced from other manufactures will also be of high quality manufactured origins and satisfy all required Customs and AQIS regulations.

Feed rates will be managed through the use of feed tables and tide tables and monitored through video. Feeding will be conducted on a daily basis and feed placement will be appropriate to the tidal movement. This will allow farmed fish ample time to consume the feed pellet before it is 'swept' out of the cages by tidal movement. Video monitoring will enable 'fine-tuning' or adjustment of feed rates on a daily basis to reduce waste.

Feeding is currently conducted by 'hand' in conjunction with video monitoring, which allows visual observation of feeding activity thereby further minimising waste feed generation (ie fish are fed as close to 'satiation' as possible).

All feed information will be recorded on a daily basis to allow further calculations of feed rates and feed conversion rates to ensure the operation is running at its optimum. This will also allow calculation of feed rates for future implementation of an automated feeding system.

A biota log sheet has been developed and will be used on a daily basis to record all observations such as number, species, proximity and behaviour of marine fauna.

4.3.5 Predicted Outcome

Taking into consideration the potential and predicted impacts, proposed management measures and observations made during the sea cage trial and current commercial operation based in Cone Bay, it is expected that the geographic distribution and diversity of fauna surrounding Cone Bay will not be adversely impacted on if production levels are increased to 1,000T per annum. As a result the EPA objective will be achieved.

4.4 Entanglement of Marine Life in Nets

4.4.1 EPA Objective

To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

4.4.2 Potential Impacts

The potential loss of nets or damaged nets and/or mooring systems could potentially lead to the entanglement of marine life in sea cage system equipment.

Consequence = 3; Likelihood = 2; Risk Rating = 6 (Low)

4.4.3 Predicted Impacts

The risk of marine life becoming entangled in nets whilst attached to the pontoons is considered rare to remote as the nets are constructed of solid steel mesh and all moorings are designed with no loose fittings or lengths of rope. In addition, the aquaculture licence area in Cone Bay is not considered to be an area that has or supports a large amount of marine wildlife activity.

A daily log sheet recording all marine life sightings within close proximity to the Cone Bay sea cages has been maintained since the inception of the trial. The log demonstrates that a small number of marine animals are sighted within close vicinity to the cages and with the exception of small baitfish, some larger fish species and birds.

Since the construction and operation of the first sea cage in Cone Bay the only marine life observed within the sea cages have been small baitfish and other small fish species. Only one large fish of a different species (Rock Cod - *Epinephalus coioides*) has been observed in one sea cage and due to it's size when first observed is thought to have entered as a very small juvenile and grown with the Barramundi. Since the installation of bird exclusion nets, the number of birds sighted within close proximity to the sea cages has reduced.

To date, the Cone Bay trial has shown that the cages, steel mesh nets and construction design have proven to be able to withstand pressures from adverse weather conditions and predation. As such the risk that the net will be damaged or displaced from the pontoon and/or mooring system is considered extremely low thereby reducing the likelihood of entanglement or injury to marine life to virtually remote.

Consequence = 3; Likelihood = 2; Risk Rating = 6 (Low)

4.4.4 Proposed Management

Heavy gauge steel mesh nets already tested in Cone Bay will continue to be utilised for grow out culture in addition to overhead bird exclusion nets made with heavy gauge polyethylene or nylon. The bird exclusion nets will be taut over the cages (Figure 2.6) to prevent entanglement.

All mooring lines and ropes are kept to a minimum with no loose ropes or fittings. Regular routine inspection of nets and mooring equipment will occur and a strict maintenance and replacement program will be implemented. Any damaged equipment will be immediately repaired or replaced and all discarded equipment will be disposed of in the correct manner. Equipment requirements are minimal and all equipment will be dismantled and stored appropriately when not in use.

Adequate spatial separation of sea cage systems will allow ample room for passage of marine animals and a biota log sheet has been developed and will be used on a daily basis to record all observations such as number, species and behaviour of marine and terrestrial fauna.

4.4.5 Predicted Outcome

Fauna populations will not be adversely impacted on by the structure of the sea cage system or the increase in sea cage numbers and the possibility of entanglement is considered very low. As a result the EPA objective will be achieved.

4.5 Provision of Artificial Habitat to Marine Fauna

4.5.1 EPA Objective

To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

4.5.2 Potential Impacts

The potential impacts of the provision of artificial habitat to marine fauna include:

- Attraction of fish and other marine fauna to the sea cage system from other areas of the bay; and
- Effects on the distribution of these populations within the region.

The potential attraction of marine fauna may increase as the number of sea cages and associated equipment requirements increase to accommodate a larger production biomass.

Consequence = 2; Likelihood = 4; Risk Rating = 8 (Low – Moderate)

4.5.3 Predicted Impacts

Observations at the Cone Bay aquaculture farm site (demonstrated in a daily log maintained since the inception of the trial) has shown that fish and other marine fauna are attracted to the sea cage system at different times but numbers are very low, it is not predominantly one particular species and the period of time within close proximity is short.

Similar patterns are expected when the proposed production level is increased to 1,000 tonne although the abundance of species may be higher. As a result, the risk of adverse impact to the distribution of fish and marine fauna populations within the region is considered low.

Consequence = 2; Likelihood = 4; Risk Rating = 8 (Low – Moderate)

4.5.4 Proposed Management

The sea cage system already tested has been designed and constructed in such a way that equipment requirements are kept to a minimum. As a result there is less artificial habitat provided to marine species. The same system will continue to be used at the site but the number of cages and associated equipment will increase.

In addition to this, the provision of waste feed will be managed as stated in section 4.3.4 to reduce the attraction of the structure to marine species and a biota log sheet has been developed and will be used on a daily basis to record all observations such as number, species and behaviour of marine fauna.

4.5.5 Predicted Outcome

The current Cone Bay logging program demonstrates that the geographic distribution and diversity of fauna is not adversely impacted. It has shown that a number of species have been observed within close proximity to the sea cages but for short periods of time. It is predicted that similar results will be obtained when the proposed production level increases and the EPA objective will be met.

4.6 Predators

4.6.1 EPA Objective

To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

4.6.2 Potential Impacts

Fauna considered predators include large fish, birds, turtles, sharks and crocodiles. Potential impacts on predators include:

- Attraction of predators to the sea cage system which effects the local distribution;
- Entanglement in nets and/or mooring equipment which has the potential to cause injury; and
- Increase predator numbers within the bay thus increasing the risk to staff members.

Consequence = 6; Likelihood = 3; Risk Rating = 18 (Moderate – High) in relation to human risk.

Potential impacts from predators include increased predation on fish that may aggregate within close proximity to the sea cage system.

Consequence = 2; Likelihood = 3; Risk Rating = 6 (Low)

4.6.3 Predicted Impacts

The existing commercial Cone Bay sea cage venture has shown that the attraction of predators has been minimal. The feed regime is closely managed (see section 4.3.4) to ensure wastage is kept to a minimum thus reducing the attraction of fish seeking an alternative feed source. Bird exclusion nets have deterred birds from perching on sea cages. Since bird exclusion nets were introduced the number of bird sightings within close vicinity to the cages has reduced.

It also appears that potential predators quickly learnt that they were unable to penetrate the steel nets and as a result entry attempts are not made and no injuries have occurred. When the first cage was trialled in Cone Bay, the jump net was constructed of a nylon material that was submerged 0.5 metres below the water surface. Within the first week of operation, small holes were discovered during a routine inspection. It was assumed that these holes resulted from attempted entry by sharks that were sighted regularly in close vicinity to the cage. The nylon jump net was replaced with wire mesh and the occurrence of sharks at the site declined dramatically.

The main concern is the attraction of crocodiles due to staff activity and the potential risk they pose to humans. Crocodiles have been sighted in the vicinity of the sea cages but it does not appear that an attempt to enter the sea cages has occurred. It is considered unlikely that an incident with a large predator will occur but because the consequence is considered catastrophic all measures to ensure staff safety will be utilised.

Consequence = 6; Likelihood = 3; Risk Rating = 18 (Moderate – High) in relation to human risk.

It is deemed possible for fish to aggregate near the sea cages and for larger predators to feed on them but it is not expected to adversely impact on abundance or distribution of any one particular species.

Consequence = 2; Likelihood = 3; Risk Rating = 6 (Low)

4.6.4 Proposed Management

The sea cage system already tested has been designed and constructed in such a way that equipment requirements are kept to a minimum. As a result there is less artificial habitat provided to marine species such as small fish that would attract larger predators. The proposed expansion will utilise the same system.

In addition to this, the provision of waste feed will be managed as stated in section 4.3.4 to reduce the attraction of the structure to marine species and all mortalities will be immediately removed and correctly disposed of. A biota log sheet has been developed and will be used on a daily basis to record all observations such as number, species and behaviour of marine fauna including predators.

If a crocodile sighting is made, it is company policy for staff to alter feed schedules on a daily basis and to remain within the boat at all times. It is clear that no one is permitted to work from platforms located on the sea cage structure when a sighting has been made.

4.6.5 Predicted Outcome

It is predicted that the impacts to and from predators will be avoided and/or minimised due to the management strategies developed. Thus, the EPA objective will be met.

4.7 Fish Feeding on Naturally Occurring Food Sources

4.7.1 EPA Objective

To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

4.7.2 Potential Impacts

There is potential for the farmed Barramundi to feed on naturally occurring food sources such as baitfish small enough to swim through the wire mesh and into the cages. This could have two effects:

- Changes to the distribution and abundance of small baitfish; and
- Impacts on the distribution and abundance of larger fish due to the removal of small baitfish from the food chain.

Consequence = 2; Likelihood = 4; Risk Rating = 8 (Low – Moderate)

4.7.3 Predicted Impacts

The proposed increased production level is not predicted to adversely impact on naturally occurring food sources as an adequate feed regime has been developed and is continuously modified as required. As discussed in sections 4.3 and 4.5 it does not appear that the sea cage operation in Cone Bay has become a "magnet" for fauna.

The Cone Bay biota log demonstrates that although baitfish occur at the cage sites on a regular basis, numbers are generally limited to small schools for the most part and numbers increase once or twice yearly for a short period of time. It appears that the fluctuation is influenced by seasonal activity and not farm operations. A similar impact is expected if production increases to a proposed 1,000 tonne per annum.

Consequence = 2; Likelihood = 4; Risk Rating = 8 (Low – Moderate)

4.7.4 Proposed Management

To ensure both environmental and economical best practice, the proposed Cone Bay 1,000 tonne operation will be closely scrutinised to ensure minimal feed is lost to the surrounding water. Feeding will be managed through the use of feed tables and tide tables and monitored through video.

Feeding will be conducted on a daily basis and feed placement will be appropriate to the tidal movement. This will allow farmed fish ample time to consume the feed pellet before it is 'swept' out of the cages by strong tidal movement.

Video monitoring will enable 'fine-tuning' or adjustment of feed rates on a daily basis to ensure the farmed fish are receiving adequate quantities of manufactured feed. This in turn should reduce the need to feed on naturally occurring food sources that may occur at different times of the year.

A biota log sheet has been developed and will be used on a daily basis to record all observations such as number, species and behaviour of marine fauna.

4.7.5 Predicted Outcome

Taking into consideration the potential and predicted impacts and proposed management measures, it is expected that the impact to the abundance, diversity, distribution and productivity of fauna at species and ecosystem level will be negligible. As a result the EPA objective will be achieved.

Benthic Primary Producer Habitats

EPA Objective

To maintain the abundance, diversity, geographic distribution and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

Potential Impacts

BPPHs have the potential to be directly impacted by:

- Broken mooring anchors; and
- Nets that have broken free from the sea cage system.

Consequence = 4; Likelihood = 2; Risk Rating = 8 (Low – Moderate)

Potential indirect impacts include:

- The potential deposition and/or accumulation of faeces or uneaten feed;
- The potential changes in hydrodynamics caused by the presence of the sea cage system; and
- The potential accumulation of excess nutrients in the water column and consequently the impact to water quality.

Consequence = 3; Likelihood = 4; Risk Rating = 12 (Moderate)

Predicted Impacts

To date, the Cone Bay trial has shown that the cages, steel mesh nets, moorings and construction design have proven to be able to withstand pressures from adverse weather conditions and predation. As such the risk that the net will be damaged or displaced from the pontoon and/or mooring system is considered extremely low. In addition, moorings will be regularly inspected and reset if "dragging" has occurred thereby reducing the likelihood of direct impact to BPPHs.

Consequence = 4; Likelihood = 2; Risk Rating = 8 (Low – Moderate)

The hydrodynamic study conducted by APASA (appendix B) demonstrated that settlement of fish faeces may occur up to 250 metres from the sea cages, however the main area of accumulation was shown to be directly under the cages (0.1 -0.5 $g/m^2/day$) and up to an approximate distance of 20 metres from the sea cages. Waste feed accumulation was also shown to follow a similar pattern, however is not expected to extend out as far as fish faeces.

The study also demonstrated that the presence of the proposed number of sea cages did not significantly alter the circulatory patterns of the area and only slightly reduced the current speeds during spring tides (from $0.45ms^{-2}$ to $0.25ms^{-2}$) around the cages.

In addition, the data collected as a part of the Cone Bay EMMP, has shown that the natural seasonal variation in water quality greatly exceeds the input of nutrients from the fish farm operations and thus accumulation of nutrients in the water column is more a result of seasonal influences than the Barramundi farm. It is also indicative in the environmental data collected to date that the increase in biomass since the inception of the operation has had no measurable environmental impact.

Mangrove monitoring in Port Hurd, Darwin, NT in 2003 undertaken by Aquanel Pty Ltd for Marine Harvest over a period of two years showed that there were no changes to the mangrove community health attributable to the pilot Barramundi project. They also found that there was no epiphytic algal growth on the roots of mangrove trees sampled near the sea cages (~1.3km from lease site) (Enesar, 2006).

As a result of these findings the predicted impacts to the surrounding BPPH's are expected to be minimal.

Consequence = 3; Likelihood = 4; Risk Rating = 12 (Moderate)

Proposed Management

Steel mesh nets and mooring equipment already tested in Cone Bay will continue to be utilised for grow out culture of the proposed 1,000 tonne. Routine inspection and replacement of nets and mooring systems will occur as a part of the SOP. All anchors and mooring components will be set a minimum of 100 metres and cages a minimum of 200 metres from BPPH systems such as mangroves and reefs to prevent damage in the event that moorings "drag".

A comprehensive EMMP has been developed, incorporating a BPPH management system in accordance with the EPA Guidance Statement No. 29, *Benthic Primary Producer Habitat Protection for Western Australia's Marine Environment* (EPA, 2004) and its implementation will enable detection of any impacts to the surrounding mangrove and coral reef systems.

In addition, to prevent indirect impacts from occurring, all sea cage mooring systems will be positioned within the proposed site in accordance with the findings of the hydrodynamic study so as to avoid settlement and deposition outside the licence boundaries. As such, all cages will be a minimum of 250 metres from the east and west boundaries as the hydrodynamic study conducted by APASA (appendix B) demonstrated fish faeces may settle a maximum of 250 metres from the sea cages.

Ongoing monitoring of benthic sediment quality within close vicinity and at a distance from the cages will allow for future positioning of sea cages within the area and the development of an effective fallowing strategy.

Predicted Outcome

It is predicted that no direct physical impact to BPPHs will occur. However, some indirect impacts caused by nutrient loading are possible but will be minimised through management practices and best practice measures to ensure EPA's objectives are met.

Shading Effect

EPA Objective

To maintain the abundance, diversity, geographic distribution and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

Potential Impacts

Shading effect as a result of sea cage aquaculture has the potential to directly or indirectly impact the surrounding environment.

Direct impacts include the physical presence of sea cages reducing the amount of light reaching BPPHs such as seagrass beds or coral reefs.

Consequence = 4; Likelihood = 1; Risk Rating = 4 (Low)

Indirect impacts include the potential effect of increased phytoplankton and TSS (resulting from fish farm wastes and/or feed pellets) in the water column acting to also reduce light penetration to the BPPHs.

Consequence = 3; Likelihood = 3; Risk Rating = 9 (Moderate)

Predicted Impacts

The likelihood of impact to seagrass beds or coral reefs as a result of shading is remote as the site is void of these habitats.

Consequence = 4; Likelihood = 1; Risk Rating = 4(Low)

Data from the existing Cone Bay EMMP has demonstrated that there have been no noticeable changes in the chl-a or TSS levels in the water column since the inception of the operation. In fact the two years of data collection has demonstrated that any changes in these levels have been predominantly influenced by natural seasonal variation (Appendix D).

The existing operation in Cone Bay has also demonstrated a consistent feed conversion ratio (FCR) of 1.0 or less. This associated with continual improvements in feed composition and quality means that the predicted nutrients inputs calculated in this PER greatly exaggerate actual nutrients emitted into the water. Thus negligible shading impacts are predicted to occur.

Consequence = 3; Likelihood = 3; Risk Rating = 9 (Moderate)

Proposed Management

The site is void of seagrass and coral reef and consists of mud in which impact caused by shading would be minimal.

A more comprehensive EMMP has been developed (Appendix F) and its implementation will enable detection of any impacts to the surrounding water quality as production levels increase. Ongoing monitoring and analysis of water and sediment quality within the aquaculture site and comparison with reference sites and appropriate trigger values will allow early detection of impacts, and thus a management response if required.

Strict feeding regimes ensure that waste feed levels are minimised and that the most efficient FCR is maintained, thus reducing the level of nutrients released to the environment.

Predicted Outcome

It is predicted that no direct impacts will occur due to shading effect. However, some indirect impacts are possible but will be minimised through the management program to ensure EPA's objectives are met.

4.10 Benthic Substrate Changes

4.10.1 EPA Objective

To maintain the integrity, ecological functions and environmental values of the seabed and coast.

4.10.2 Potential Impacts

The benthic substrate below the sea cage system and within the zone of influence can potentially be impacted by:

- Deposition and/or accumulation of uneaten feed and fish faeces; and
- Deposition and/or accumulation of excess nutrients.

Consequence = 4; Likelihood = 3; Risk Rating = 12 (Moderate)

4.10.3 Predicted Impacts

As stated in 4.8.3, the hydrodynamic study demonstrated that settlement of fish faeces may occur up to 250 metres from the sea cages and the settlement of waste feed up to 130 - 140m from the sea cages. As also discussed, the main area of accumulation was shown to be directly under the cages (0.1 – 0.5 g/m^2/day) and up to an approximate distance of 20 metres from the sea cages. As a result the zone of influence is expected to be within 250 metres of each individual cage and minimal impact is expected outside the licence boundary.

To date, field observations from the Cone Bay Barramundi operation has demonstrated that impacts to the benthic substrate does occur directly below the cages, however no changes to the sediment quality have been detected and no visual changes have been detected at a distance of 50m from the sea cages (including the east-west directional settlement pattern described by the hydrodynamic study).

As a result of the findings from the hydrodynamic study and the current Cone Bay EMMP it is predicted that impacts to the benthic substrate within the licence boundaries are likely to occur and therefore a moderate to high risk rating has been assigned. However the predicted impacts to the benthic substrate outside the aquaculture licence area is expected to be avoided by ensuring appropriate sea cage positioning (ie within 250 metres of the boundary), strict monitoring and development of a fallowing program.

Consequence = 4; Likelihood = 6; Risk Rating = 24 (Moderate - High) within the proposed licence area.

Consequence = 4; Likelihood = 3; Risk Rating = 12 (Moderate) outside the proposed licence area.

4.10.4 Proposed Management

A more comprehensive EMMP has been developed and its implementation will enable the detection of any impacts to the benthic substrate both within and outside the licence site as fish biomass increases.

To further minimise impacts, all additional sea cage equipment will be positioned within the licence site in accordance with the findings of the hydrodynamic study so as to avoid settlement and deposition outside the licence boundaries (ie sea cages within 250 metres within the licence boundaries).

Ongoing monitoring and analysis of sediment quality within and near to the licence site and the comparison with reference sites and the appropriate trigger values will allow early detection of impacts, and in turn a management response if required. Results obtained will also enable the development and ongoing refinement of an effective fallowing program, which will be incorporated into the EMMP.

In addition, strict feeding regimes will ensure that waste feed levels are minimised and the most efficient FCR is maintained, thus reducing the level of nutrients released to the environment.

4.10.5 Predicted Outcome

Taking into consideration the potential and predicted impacts and proposed management strategies, it is expected that the impact to the integrity, ecological functions and environmental values of the seabed and coast will be minimal. As a result the EPAs objective will be achieved.

4.11 Impacts from Sea Cage Infrastructure

4.11.1 EPA Objective

To maintain the integrity, ecological functions and environmental values of the seabed and coast.

4.11.2 Potential Impacts

Potential impacts from the sea cage infrastructure include:

- Seabed disturbance during the implementation of additional mooring systems and sea cages;
- Seabed disturbance resulting from dragging anchors (eg during cyclonic weather with strong currents, high swell and strong wind conditions);
- Marine fauna disturbances potentially leading to entanglement; and
- Impacts to the surrounding environment during cage construction.

Consequence = 4; Likelihood = 3; Risk Rating = 12 (Moderate)

4.11.3 Predicted Impacts

Due to cage design, materials and assembly method, it is predicted that minimal impacts will occur to the seabed and/or surrounding areas during construction (see also Section 2.3.1 and 2.3.2).

It is predicted that seabed disturbance will occur during the implementation of the mooring system and in adverse weather as a result of dragging anchors but the consequence is minor as the mud substrate within the proposed site is void of seagrass and reef as evident in the underwater video imagery (see Appendix K) and the high tidal dynamics of the area would enable rapid recovery of disturbed areas.

Consequence = 2; Likelihood = 3; Risk Rating = 6 (Low)

4.11.4 Proposed Management

The site is void of seagrass and coral reef and consists of mud in which impacts from sea cage infrastructure would be minor. To reduce anchor drag, a purpose built anchoring system suitable for mud bottom has been designed and will be utilised for additional cages. This anchoring system has been tested at this site with favourable results. Also all additional mooring equipment will be anchored a minimum of 100 metres from coral reef and mangrove systems.

Construction and assembly of the additional sea cages will occur on a steeply sloping beach to allow the assembled sea cage to be easily floated off the beach during a high tide. Construction on a sloping, sandy beach free of any rocks or other obstacles will avoid major disturbances as the equipment will not get tangled with any objects when being floated off the beach.

Light anchoring of the sea cages in the sand above the high tide mark whilst in construction will minimise any disturbances to the intertidal region during ebb and flow of the tide.

4.11.5 Predicted Outcome

Taking into consideration the potential and predicted impacts and proposed management measures, it is expected that the impact to the integrity, ecological functions and environmental values of the seabed and coast will be minimal. As a result the EPAs objective will be achieved.

4.12 Hydrodynamic Changes

4.12.1 EPA Objective

To maintain the quantity of water so that existing and potential environmental values, including ecosystem maintenance are protected.

4.12.2 Potential Impacts

The potential impacts of hydrodynamic changes include:

- Local changes in water current flow and direction; and
- Local disturbance to marine flora and fauna.

Consequence = 34; Likelihood = 3; Risk Rating = 9 (Low – Moderate)

4.12.3 Predicted Impacts

Results obtained from a hydrodynamic numerical modelling study conducted in Cone Bay (Appendix B) predict that there will be no changes to the circulatory patterns of the area. Results indicate that peak current speeds are predicted to be reduced from $0.45ms^{-2}$ to $0.25ms^{-2}$ in the proposed cage site area during spring tides (ie faster tide flows) and marginal retardation during neap tides.

This retardation was predicted to occur in the proposed cage site area due to the protection given by Turtle Island. The modelling predicted that the eastern end of the aquaculture licence, which shows faster current speeds would show no reduction in current speeds with the installation of any cages (APASA, 2006).

Additional simulations indicated that flushing times for Cone Bay would not be greatly affected by the introduction of the sea cages with the predicted increase in flushing times from 2 days to 3 days.

Consequence = 3; Likelihood = 3; Risk Rating = 9 (Low – Moderate)

4.12.4 Proposed Management

Aquaculture licence site 1465 was specifically selected for sea cage aquaculture as the site is located in protected waters and consists of high energy characteristics including fast flushing rates and dynamic circulatory patterns.

Hydrodynamic modelling of the site and the surrounding area has been conducted to determine flow direction and rate for various tidal regimes. This information will be utilised to best place proposed additional sea cage infrastructure to reduce adverse impact in and around Cone Bay (ie individual cages a minimum of 250 metres from the east and west boundaries).

Infrastructure requirements will be kept to a minimum and a clearance zone of at least 2 metres between the lowest point of the cages and the benthic substrate will be maintained. Cages will be regularly monitored for fouling and cleaned as required to maximise water flow through the cages.

In addition, regular review and ongoing research and development of cage and mooring systems as a part of the EMS will ensure continuing best practice measures.

4.12.5 Predicted Outcome

Taking into consideration the potential and predicted impacts and proposed management measures, it is expected that the impact to the hydrodynamics of the area will be minimal. As a result the EPAs objective will be achieved.

4.13 Pollution from Biological Inputs (Fish Faeces and Nutrient Inputs)

4.13.1 EPA Objective

To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.

4.13.2 Potential Impacts

Potential impacts of biological inputs such as fish faeces and nutrients could include:

- Accumulation of fish faeces on the seabed;
- Effects on water quality;
- Algae growth and/or blooms;
- Effects on the benthic substrate;
- Effects on fauna; and
- Effects on benthic infauna.

Consequence = 4; Likelihood = 4; Risk Rating = 16 (Moderate)

4.13.3 Predicted Impacts

The predicted impacts from biological inputs from the sea cages are expected to be minimal outside the licence area due to the management strategies that have already been implemented and which are set to continue.

The predicted impacts from biological pollution within the licence area are expected to include impacts to the benthic substrate directly below the sea cages and possibly up to 250m from the sea cages. However, results obtained to date from the Cone Bay EMMP and further implementation of the proposed management strategies is expected to reduce the settlement distance to less than 50m from the sea cages. Environmental data collected to data also indicates that an increase of biomass from 15 tonne to 150 tonne has incurred no impact to the environment.

It is not expected that water quality will be unacceptably impacted by the proposed increase to production levels. Instead, it is expected that seasonal variation experienced in the region will continue to have a greater influence on water quality than the increased production level.

Consequence = 4; Likelihood = 4; Risk Rating = 16 (Moderate)

4.13.4 Proposed Management

An EMMP has been developed and implemented to assess water quality, benthic quality, mangrove ecology, coral reef ecology, fauna and flora impacts at the site and within the zone of influence. Pollution from biological inputs should be minimal due to many of the management practices discussed previously such as:

- Fallowing of cage sites;
- Conservative fish stocking densities;
- Daily feed monitoring;
- Conservative feed regimes; and the
- Ongoing environmental monitoring program.

4.13.5 Predicted Outcome

Taking into consideration the potential and predicted impacts and proposed management measures, it is expected that the EPA's objectives will be met.

4.14 Pollution from Chemical Inputs

4.14.1 EPA Objective

To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.

4.14.2 Potential Impacts

Chemical inputs can potentially impact upon:

- Water quality;
- Benthic quality;
- The BPPHs (marine habitat); and

- Fish and other marine fauna.

Consequence = 4; Likelihood = 2; Risk Rating = 8 (Low)

4.14.3 Predicted Impacts

To date, there has been no disease or parasite outbreak at the Cone Bay sea cage operation and as such, no chemicals have been utilised. Management practices are to remain conservative to reduce the risk of outbreak and in turn the probability that chemicals will be required.

In the event that farmed fish require treatment, the treatment will be incorporated into the feed pellets and thus it is predicted that nominal amounts of chemicals will reach surrounding waters and impact will remain localised as shown by the hydrodynamic model results and simulations.

All chemicals, fuel and related materials are appropriately stored at the island based operation (Turtle Island) in Cone Bay. All boats and equipment are regularly maintained to reduce the probability of fuel spills or leakages.

To date, cage maintenance requirements have been low and have required very minimal amounts of cleaning. It is proposed that if cages become fouled, high-pressure seawater will be used for cleaning purposes. No chemicals or detergents have been or will be utilised and the cages will not be treated with any form of antifouling treatment.

Thus the predicted impacts from chemical pollution are expected to be minimal.

Consequence = 4; Likelihood = 2; Risk Rating = 8 (Low)

4.14.4 Proposed Management

A Barramundi health management and emergency plan (BHMEP) has been prepared to minimise the occurrence of disease and/or parasite outbreak. Continued communication with the WA Fish Health Laboratories and other appropriate regulatory bodies will enable the constant improvement of the BHMEP to ensure best practice.

In the event of an outbreak, any use of chemicals will only be administered under the strict guidance and authorisation of the Principal Veterinarian or Senior Fish Pathologist at the WA Fish Health Laboratories.

A Fuel Spill Contingency Plan (FSCP) has been developed as a part of the existing operation and EMS. All fuels and chemicals will be correctly stored on Turtle Island, Cone Bay and no detergents, chemicals or antifouling treatments will be used for sea cage maintenance.

4.14.5 Predicted Outcome

Taking into consideration the potential and predicted impacts and proposed management measures, it is expected that the EPA's objectives will be met.

4.15 General Litter

4.15.1 EPA Objective

To ensure that liquid and solid wastes do not affect groundwater or surface water quality, nor lead to soil contamination.

4.15.2 Potential Impacts

The occurrence of general litter could potentially:

- Harm marine wildlife if entanglement or ingestion occurs; and
- Spoil the visual amenity of the area.

Consequence = 3; Likelihood = 2; Risk Rating = 6 (Low)

4.15.3 Predicted Impacts

Waste in the form of litter will be generated by the operation but it is expected to be minimal. In addition, due to stringent management practices the impact to the environment is predicted to be low.

Consequence = 3; Likelihood = 2; Risk Rating = 6 (Low)

4.15.4 Proposed Management

Staff accommodation is pre-existing on Turtle Island, Cone Bay in which the aquaculture licence area encompasses. All rubbish and discarded material is removed from the sea-based operation and transported to Turtle Island facilities for re-use, recycling or correct disposal.

As discussed in sections 4.4 and 4.11 regular inspection of all sea cages and associated equipment is conducted to ensure all is intact and unlikely to cause adverse impact. All new employees must partake in an induction that emphasises their environmental obligations prior to commencing and at regular staff meetings, employees are reminded of their environmental responsibilities.

A Waste Management Plan (WMP) will be developed and implemented and will continue to be improved as the production levels increase. To ensure continued best practice the WMP will be reviewed and updated on a regular basis as a part of the EMS.

4.15.5 Predicted Outcome

Taking into consideration the potential and predicted impacts and proposed management measures, it is expected that the EPAs objectives will be met.

4.16 Boat Emissions

4.16.1 EPA Objective

To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.

4.16.2 Potential Impacts

Boat emissions could potentially impact upon:

- Air quality;
- Water quality; and consequently
- Marine flora and fauna.

Consequence = 3; Likelihood = 3; Risk Rating = 9 (Low - Moderate)

4.16.3 Predicted Impacts

Boat emissions are likely to have some limited impacts on air quality and water quality, predominantly due to engine odours and greenhouse gas emissions and consequently marine flora and fauna.

It is predicted that emissions will be minimal as the sea cage system is in close proximity to Turtle Island and boats are utilised for transport of staff, feed and equipment to the water based site once or twice daily and rarely utilised once there. As a result the impact is predicted to be low to moderate at worst.

Consequence = 3; Likelihood = 3; Risk Rating = 9 (Low - Moderate)

4.16.4 Proposed Management

Currently there is a servicing and maintenance schedule for all boats that is conducted and logged. Boats are regularly serviced and maintained to reduce exhaust emissions and fuel consumption. All new motors used are four stroke outboards that effectively minimise noise and other emissions.

In addition, the aquaculture site is close to the Cone Bay land base and as a result boating hours will be kept to a minimum.

4.16.5 Predicted Outcome

Taking into consideration the potential and predicted impacts and proposed management measures, it is expected that the EPAs objectives will be met.

4.17 Fish Odour

4.17.1 EPA Objective

To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.

4.17.2 Potential Impacts

Air quality could potentially be impacted by fish odour that may arise from dead fish.

Consequence = 2; Likelihood = 3; Risk Rating = 6 (Low)

4.17.3 Predicted Impacts

It is predicted that fish odour will not adversely impact the environment. To date, fish mortalities within the sea cage system have been very low. Similar management strategies will continue to be utilised at the site as production levels rise to ensure the same result is obtained. It is also common practice to remove and dispose of all mortalities as soon as possible to reduce any odour emitted.

Consequence = 2; Likelihood = 3; Risk Rating = 6 (Low)

4.17.4 Proposed Management

As stated in section 4.17.3 similar management strategies already utilised in Cone Bay such as conservative stocking densities will continue. The Cone Bay aquaculture site is situated in a high-energy tidal region and management will be locating any additional sea cage systems in a position that best uses this attribute to reduce the potential for fish odour.

Management guidelines also state that all mortalities are to be removed and correctly disposed of when first observed or as soon as possible if adverse conditions exist.

All mortalities will be returned to Turtle Island, Cone Bay where they will either be reduced to ashes or ensiled as described in Section 2.3.7.

4.17.5 Predicted Outcome

The surrounding environment will not be adversely impacted on by fish odour as it expected that minimal fish mortalities will occur and in the event that mortalities occur, they will be removed before creating any measurable impact. As a result the EPA objective will be achieved.

4.18 Noise

4.18.1 EPA Objective

To protect the amenity of nearby residents from noise impacts resulting from activities associated with the proposal by ensuring the noise levels meet statutory requirements and acceptable standards.

4.18.2 Potential Impacts

Potential noise impacts may occur due to the use of outboard motors and effects on the occurrence and distribution of marine wildlife.

Consequence = 2; Likelihood = 3; Risk Rating = 6 (Low)

4.18.3 Predicted Impacts

Noise generation from the outboard motors is not expected to adversely impact the occurrence and distribution of marine wildlife within the region, as the amount of travel and number of vessels required is minimal. Any impact that may occur will be localised and is not expected to be permanent.

Consequence = 2; Likelihood = 3; Risk Rating = 6 (Low)

4.18.4 Proposed Management

Boats are regularly serviced and maintained to reduce noise emissions. In addition, the aquaculture site is close to the Cone Bay land base and as a result boating hours will be kept to a minimum.

All staff will be adequately trained and educated in correct boat handling procedures to ensure no unacceptable vessel manoeuvres will occur. A Code of Conduct policy stipulating the company's attitude and position on acceptable and unacceptable staff behaviour will be developed and implemented into the EMS.

4.18.5 Predicted Outcome

It is predicted that the wildlife in the surrounding environment will not be adversely impacted on by noise generated by outboard motors. As a result the EPA objective will be achieved.

4.19 Access Loss to Marine Environment

4.19.1 EPA Objective

To ensure that existing and planned recreational uses are not compromised.

4.19.2 Potential Impacts

The presence of the sea cage system could potentially impact:

- Recreational boating including fishing and other recreational activities;
- Tourism operators;
- Commercial fishers; and
- Other relevant users (eg DoD).

Consequence = 2; Likelihood = 3; Risk Rating = 6 (Low)

4.19.3 Predicted Impacts

Recreational boating and tourism companies operate in the region and visitation is more frequent during the dry season (May-October).

There are no known commercial fishing licences specific to the King Sound area. However, statewide commercial fishing licences are currently in operation and include the waters within the Yampi Sound region. That said, commercial fishing vessels are rarely seen in the Cone Bay vicinity and it is not expected that these vessels would enter the aquaculture site.

MPC has also been operating in the region for many years and during this time has been called upon for assistance by both recreational and commercial operators on a number of occasions. This has led to the development of open communications and beneficial relationships with many individuals and organisations.

The introduction of sea cages in Cone Bay has not adversely affected any activities and public consultation on all previous applications and/or variations to the existing operations has resulted in the majority of these industries either supporting the venture or having no objections. From these findings a similar result is predicted for the proposed production increase.

The results of the public consultation conducted for this PER have indicated that issues associated with access loss have been satisfactorily dealt with and thus the predicted impacts are expected to be avoided.

In the Crawford Bay Aquaculture licence application (proponent – MFF), the DoD had raised particular concerns regarding the loss of ability to conduct amphibious and Naval manoeuvres within the area as a direct result of the proposal and also the potential for the future loss of strategic values of the surrounding available area through the continued expansion of the aquaculture industry and development of large-scale aquaculture projects. MFF and MPC have developed open communications with the DoD on this issue and has incorporated management strategies to help minimise this impact.

The predicted impact to the DoD is expected to be minimal due to the venture already being operational and previous and current communications having been established with the inception of the pearling operation in the early 1990s. In addition, the adjacent coastline is characterised by steep, rocky cliffs considered impractical for training purposes.

Consequence = 2; Likelihood = 3; Risk Rating = 6 (Low)

4.19.4 Proposed Management

To ensure any inconvenience is minimised, sea cages will be arranged in a neat orderly manner to allow ample room for safe access and passage of vessels around the aquaculture site and sea cages.

Currently, the aquaculture licence area and the sea cages are clearly marked to ensure safe navigation at all times and all additional cages will be marked according to DPI and DoF requirements. The site is not deemed exclusive to aquaculture operators, however MPC expects that reasonable due care and consideration of the aquaculture activities is undertaken by all other users and that the active licence area and equipment is avoided. Continued open communications with relevant stakeholders will ensure there is no access loss to the marine environment.

In respect to the DoD concerns for future strategic plans, both MPC and MFF have developed an open relationship with the department which includes the notification and liaison with the DoD for all future aquaculture licence applications within the areas potentially utilised by the DoD. MPC is committed to continuing this relationship so as to ensure amicable agreements pertaining to land and water usage are beneficial to all users of the surrounding areas.

Ongoing consultation will continue to ensure no access loss to all relevant stakeholders. Regular reviews will ensure any new stakeholders are identified and incorporated into the consultative process.

4.19.5 Predicted Outcome

It is predicted that recreational, commercial and other relevant activities will not be adversely impacted on by the variation to the aquaculture venture. As a result the EPA objective will be achieved.

4.20 Impacts to Native Title or Culturally Significant Areas

4.20.1 EPA Objective

To ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation.

4.20.2 Potential Impacts

Potential impacts to native title or culturally significant areas could include the disturbance of traditional values and beliefs such as fishing and hunting grounds.

Consequence = 3; Likelihood = 3; Risk Rating = 9 (Low – Moderate)

4.20.3 Predicted Impacts

MPC has been responsible in its approach to management of cultural heritage protection matters and to date the traditional owners have expressed no concerns. Our relationship with the traditional owners would have allowed for their expression of concern or intervention if Maxima had breached or inadvertently trespassed on areas that may be of cultural significance to their customs or traditions. Past and current activities in the licence area would have provided ample opportunity for this to occur.

Past and more recent discussions including an organised tour of the aquaculture site with local Aboriginal groups, have indicated that there are no areas of cultural or native title significance within or surrounding the licence area. Thus the predicted impacts are expected to be minimal.

Consequence = 3; Likelihood = 3; Risk Rating = 9 (Low – Moderate)

4.20.4 Proposed Management

Currently MPC, in conjunction with MFF is developing an Indigenous Employment Program (IEP) with the traditional owners to integrate community members into the Barramundi farm's workforce. MPC will continue to communicate and liaise with appropriate groups and seek advice from them in relation to the location of sea cage systems within the site that best suits accessibility to areas within the bay. This communication process has been, and will continue to be, ongoing throughout the life of this and all future operations.

4.20.5 Predicted Outcome

It is predicted that native title or culturally significant areas will not be adversely impacted on by the proposed aquaculture venture. As a result the EPA objective will be achieved.

4.21 Lowering of Aesthetic Value

4.21.1 EPA Objective

To ensure that aesthetic values are considered and measures are adopted to reduce visual impacts on the landscape as low as reasonably practicable.

4.21.2 Potential Impacts

Further development of the sea cage system could potentially impact the aesthetic values of the bay by:

- Reducing the visual appeal; and
- Perceived loss of remoteness and naturalness.

Consequence = 2; Likelihood = 2; Risk Rating = 4 (Low)

4.21.3 Predicted Impacts

The sea cages have a low profile and are dark in colour and camouflage well with the surrounding environment (Figure 2.8). When possible, suitable colours will be chosen to 'blend in' with the surrounding environment.

Navigational markers do visually impact but are required by regulation for navigational safety. However the impact is not considered to lower the aesthetic value of the area.

The remoteness of the area also acts to minimise the impacts.

Consequence = 2; Likelihood = 2; Risk Rating = 4 (Low)

4.21.4 Proposed Management

MPC will continue to use sea cages with a low profile and dark colour and all cages and markers will be set in a neat and orderly manner with consideration to minimising the visual impact.

4.21.5 Predicted Outcome

It is predicted that the aesthetic value of the area will not be adversely impacted on by the proposed expansion. As a result the EPA objective will be achieved.

4.22 Unknown, Unpredictable or Irreversible Impacts

4.22.1 EPA Objective

To ensure, as far as practicable, that rehabilitation achieves a stable and functioning landform, which is consistent with the surrounding landscape and other environmental values.

4.22.2 Potential Impacts

Commissioning of the sea cage system could potentially impact the environment in such a way that the impact may be irreversible even after decommissioning.

Unpredictable impacts such as cyclones may potentially impact the environment by causing large-scale damage to the island infrastructure causing both litter and other environmental damage.

Consequence = 4; Likelihood = 3; Risk Rating = 12 (Moderate)

4.22.3 Predicted Impacts

The sea cage system consists of pontoons, steel nets and mooring equipment. Purpose-built anchors are the only equipment to come into contact with the benthic mud substrate at the site. It is therefore predicted that there will be no permanent or irreversible damage to the physical state of the environment. Trigger values should prevent any irreversible damage to the biology or ecology of the environment and taking into consideration results from other fish farming industries, it is predicted that the site would return to its pre-proposal state if the venture were discontinued.

The predicted impacts from cyclone damage are also expected to be minimal due to the Cyclone Procedures Plan (CPP) that has been developed for the existing aquaculture and pearling operations.

Consequence = 4; Likelihood = 3; Risk Rating = 12 (Moderate)

4.22.4 Proposed Management

A stringent EMMP has been implemented at the site and EQC values will be assigned to a number of monitoring parameters that MPC will be required to meet. If this is not attained MPC will be required to reduce the impact as discussed in the EMMP.

Structure of the cages is such that there is very little effort and resources required to dismantle and remove from the site if the venture were to cease. MPC is committed to managing the site to ensure impacts are minimised and rehabilitation of the site is achieved.

A current CPP has been developed for the existing aquaculture venture in Cone Bay. This procedures plan includes the procedures for the preparation of the island infrastructure and equipment and also procedures for the preparation of the sea cages prior to the onset of a cyclone.

The plan also incorporates a contingency for staff, boats and island infrastructure. The CPP will be incorporated into the EMS and will be reviewed on a regular basis to ensure all operations are covered and that environmental best practice is maintained.

4.22.5 Predicted Outcome

It is predicted that the area will not be adversely impacted on by the proposed expansion to the aquaculture venture and full rehabilitation will be achieved. As a result the EPA objective will be achieved.

4.23 Potential Ecological Consequences and Conservation Areas

4.23.1 EPA Objective

To protect the environmental values of areas identified as having significant environmental attributes.

4.23.2 Potential Impacts

Potentially direct and indirect impacts of ecological consequence could occur as a result of expanding the sea cage aquaculture venture at the Cone Bay site.

Potential direct impacts include:

- Physical presence of the sea cage system (sections 4.4, 4.5, 4.8, 4.9, 4.10, 4.11, 4.12 and 4.22);
- Changes to water quality (sections 4.12, 4.13, 4.14 and 4.16);
- Changes to the benthic substrate (sections 4.8, 4.9, 4.10, 4.11, 4.12, 4.13, 4.14 and 4.15);
- Changes to marine flora (sections 4.8, 4.9, 4.10, 4.11, 4.12, 4.13 and 4.14);

- Changes to the distribution and abundance of wild fish populations (sections 4.3, 4.5, 4.6 and 4.7);
- Changes to marine fauna (sections 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8 4.10, 4.11, 4.12, 4.15, 4.16 and 4.18);
- Changes to water hydrodynamics (section 4.12); and
- Disturbances caused by additional activities in and on the water (sections 4.18 and 4.19).

Consequence = 4; Likelihood = 3; Risk Rating = 12 (Moderate)

Indirect impacts could potentially affect a wider area than the licence site due to changes in water and benthic quality. This could in turn potentially affect the growth of marine and coastal plant species such as sea grasses, coral reefs and mangrove systems and therefore the habitats for fauna species directly and indirectly dependent on these.

Consequence = 4; Likelihood = 3; Risk Rating = 12 (Moderate)

The distinct seasonal patterns characteristic of the tropical environment can potentially cause ecological impacts as a result of the wastes discharged from the proposal over an annual cycle. High temperatures, high rainfall, cyclonic conditions and a predominant increase in nutrients that occur naturally during the Wet Season have the potential to be exacerbated by the increased waste discharge from the proposed 1,000T venture. This can then potentially cause elevated levels of water and benthic nutrients to persist into the Dry Season. Consequently the ecological consequences would be a compounding effect of ever increasing nutrients in the area that at some point would not be sustainable by the region.

Consequence = 4; Likelihood = 3; Risk Rating = 12 (Moderate)

There are also potential ecological consequences associated with the potential accumulation and interaction of wastes discharged from both this proposal (ie 1,000T expansion of existing venture in Cone Bay) and the proposed 1,000T Barramundi Aquaculture Licence in adjacent Crawford Bay when both are operating at full capacity. The proximity of the two licence areas is demonstrated in Figure 4.1. Wastes from both proposals have the potential to mix, accumulate and/or be deposited further a field which can have negative impacts on the surrounding environment.

Consequence = 4; Likelihood = 3; Risk Rating = 12 (Moderate)

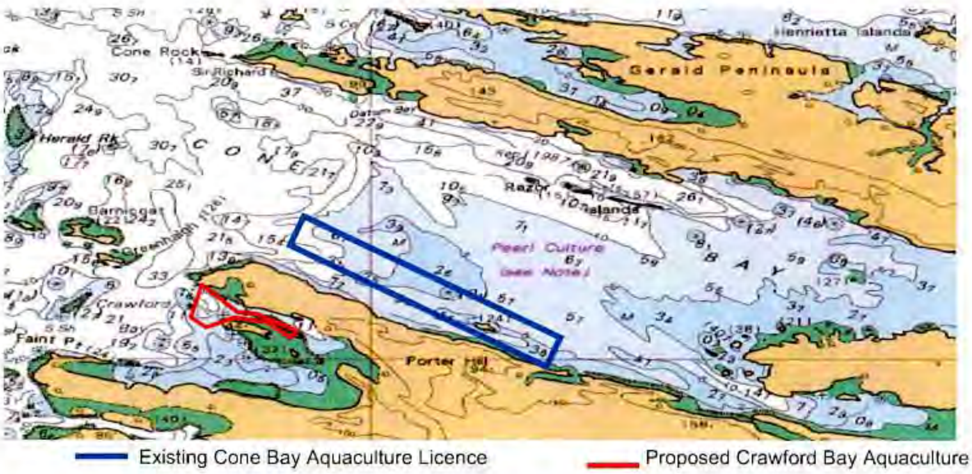
4.23.3 Predicted Impacts

The predicted impact for each of the individual direct and indirect potential impacts stated in section 4.23.2 is detailed in sections 4.1 through to 4.22.

Direct physical impacts on seagrasses, coral reefs and mangroves are unlikely given their distance in relation to the licence site. Seagrasses are not known to occur in the aquaculture site or surrounding area and should not be indirectly impacted upon.

Although Cone Bay does contain several mangrove areas, results from the hydrodynamic study indicate that indirect impacts will be insignificant due to their distance and location in relation to the licence site. This is also the case for the one known coral reef area in the northern part of the bay (Figure 4.1).

A 1994 report of the marine parks and reserves selection working group recommends that "the waters of the Buccaneer Archipelago, including Cygnet Bay in the South West and Talbot Bay in the east (in which Cone Bay is encompassed), should be considered for reservation as a multiple-use (including aquaculture) marine park".



Existing Cone Bay Aquaculture Licence — Proposed Crawford Bay Aquaculture Licence

Figure 4.1: Proximity of the two aquaculture licence areas: Licence 1465 in Cone Bay and the proposed licence in adjacent Crawford Bay.

As a result, it is predicted that risk from direct and/or indirect impacts on the local fauna habitats and in turn the local fauna will be at worst moderate. The recommendation that Cone Bay be utilised as a multiple-use marine park will not be jeopardised.

Consequence = 4; Likelihood = 3; Risk Rating = 12 (Moderate)

Results from the hydrodynamic modelling study (Appendix B) demonstrated that there were no significant differences in waste deposition/settlement and flushing abilities of Cone Bay between the two seasons (the dry and the wet).

Although the model showed that there were some differences between tidal states (ie spring and neap), they were minimal and only increased the flushing ability of Cone Bay by one day (ie from 2 to 3 days). The deposition and settlement of waste feed and/or fish faeces was seen to be identical over the seasons and the only tidal influence was an east-west deposition pattern.

Thus the predicted impact of waste discharges and seasonality are expected to be minimal.

Consequence = 4; Likelihood = 3; Risk Rating = 12 (Moderate)

Results from the hydrodynamic modelling study (Appendix B) also demonstrated that when "worst case scenario" information was inputted into the model (including a lower value for ambient nutrient levels) for the two adjacent fish farms operating at full production capacity, no mixing, regional accumulation or increased spread of dissolved waste is evident. The modelling did indicate that concentrations of dissolved TN & TP could be slightly higher during the wet season with the maximum concentration reaching levels of 20µg/L. Thus the predicted ecological impacts associated with two 1,000T Barramundi farms is expected to be negligible.

In addition, given that the ambient background levels are significantly higher than those used in the modelling scenario (ie 130 µg/L compared to 10 µg/L), and that the natural variation of TN and TP can range between 50 µg/L - 570 µg/L and 7 µg/L - 50 µg/L respectively (Appendix B), the predicted impacts resulting from the either of the two aquaculture sites are expected to be unidentifiable when compared to natural variation.

Consequence = 4; Likelihood = 3; Risk Rating = 12 (Moderate)

4.23.4 Proposed Management

A stringent EMMP (Appendix F) has been implemented at the site and trigger values have been assigned to a number of monitoring parameters that MPC will be required to meet. If this is not maintained and the trigger values are exceeded, MPC will undertake a management response to reduce the specific impacts.

The EMMP incorporates management strategies that take aspects of the Wilson Report into account and upholds the conservation values of the area. Management strategies will be regularly assessed and reviewed as a part of the EMS.

4.23.5 Predicted Outcome

It is predicted that the area will not be adversely impacted on by the proposed expansion to the aquaculture venture and its status as a multiple-use marine park will be upheld. As a result the EPA objective will be achieved.

5. Environmental Principles

As a part of the *Environmental Protection Act 1986* a core set of principles are applied to all proposals submitted to the EPA. In the assessment of the environmental factors and potential impacts, MPC has considered the principles of environmental protection relating to this proposal. These principles are addressed in Table 5.1.

Table 5.1 - Principles relevant to this proposal

Principle	Relevant Yes/No	If yes, consideration
1. The precautionary principle Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In application of this precautionary principle, decisions should be guided by: • careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and • An assessment of the risk – weighted consequences of various options.	No	
2. The principle of intergenerational equity The present generation should ensure that the health, diversity and productivity of the environment is maintained and enhanced for the benefit of future generations.	Yes	MPC supports the concept of sustainable development and has liaised with relevant agencies to create sustainable practices, which are reflected in the management strategies (Section 4). Ongoing environmental monitoring exists to ensure the environment is maintained for future generations to enjoy.
3. The principle of the conservation of biological diversity and ecological integrity Conservation of biological diversity and ecological integrity should be a fundamental consideration.	Yes	Conservation of biological diversity and ecological integrity has been a fundamental consideration in this proposal. Site selected to minimise impact on natural resources. Ongoing environmental monitoring exists to assess water and benthic parameters and BPPH. The management strategies have been developed to continually monitor and assess any impacts from the project including the development of triggers and management actions.
4. Principles relating to improved valuation, pricing and incentive mechanisms - Environmental factors should be included in the valuation of assets and services. - The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance and abatement. - The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste. - Environmental goals having been established, should be pursued in the most cost effective way, by establishing incentive structure, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solution and responses to environmental problems.	Yes	Environmental factors have been duly considered in the development of the project operations. Licence costs reflect proposed nutrient loading factors so the project is designed to ensure impacts are minimal. The proposed infrastructure (sea cages and mooring equipment) have been designed to be cost effective and minimise environmental impact.
5. The principle of waste minimisation All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.	Yes	All reasonable and practicable measures will be taken to minimise the generation of waste. Monitoring of feed regimes to reduce wastes produced. Regular equipment maintenance and the implementation of reduce, reuse and recycle waste ethos. Development of a WMP.

6. Environmental Management

6.1 Introduction

Environmental management is the foundation of any successful and productive aquaculture venture. Without a healthy environment, aquaculture itself cannot continue as it relies on a clean environment to be productive. The quality of the aquaculture product is directly related to the quality of the environment that the product was cultured in. As a result, aquaculture operators are not only required by law, but also by the very nature of aquaculture to protect and maintain the environment in which they are operating and to consider the potential environmental impacts of their activities.

Environmental management is made up of a number of components that all function to determine the key environmental issues, how best to monitor these issues, the development of effective monitoring standards and/or guidelines and the actions that need to be undertaken if a monitoring standard is not being met.

The potential impacts (environmental and social) of the proposal have already been discussed in Section 4, as have a number of management strategies. This section focuses on the development of the components that ensure best practice environmental management.

6.2 Conceptual Models

Conceptual models are developed to schematically show the 'cause-effect' pathways that are most likely to occur as a result of the proposal. These cause-effect pathways aim to demonstrate what the key stressors are in that environment which in turn show which parameters will provide the most relevant data and therefore need to be monitored. Once the parameters to be monitored have been determined, the development of the EMMP can begin. The conceptual models designed for this proposal are shown in Figures 6.1 – 6.3.

The first model, Figure 6.1, shows the potential effects that the infrastructure of the cages may have on the surrounding environment. Sea cage infrastructure refers to the cages themselves and the associated mooring systems.

This model demonstrates that simply the presence of sea cages may have an impact on the biota (benthic & marine), the benthic substrate and the surrounding mangroves and coral reefs. As described in Section 4, the likelihood of these impacts is considered to be low and with the implementation of the management strategies is minimised even further.

The second model, Figure 6.2, demonstrates how waste discharges from the sea cages has the potential to impact the same environmental characteristics as for the sea cage infrastructure model described above. The likelihood of impacts from waste products is higher and somewhat more complex due to the intricate relationship that these characteristics have with one another and the surrounding marine environment. Waste products will come from two main sources: uneaten food and excretory products (ie faeces) in the form of Nitrogen and Phosphorous and will be made up of dissolved organics and organic and inorganic particulates.

The third model, Figure 6.3, represents the potential impacts resulting from the stocking of farmed fish in an "open water" system. Impacts may include changes in genetic diversity of endemic barramundi populations and changes to the population dynamics of naturally occurring marine faunal populations (marine and benthic biota). The major cause of these impacts is from potential fish escapes and the potential introduction of disease from poor husbandry techniques (see Section 4). As for the first model, sea cage infrastructure, the likelihood is considered to be low due to the stringent husbandry protocol and management strategies.

6.3 Environmental Quality Management Framework

The EPA has recently developed an Environmental Quality Management Framework (EQMF) in order to allow the strategic management of activities that have the potential to affect the quality of marine ecosystems and is based on the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy Paper No. 4* (ANZECC & ARMCANZ, 2000).

This management framework is currently being implemented in the Perth Coastal Waters, Cockburn Sound and the *Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives* (EPA, 2000; Government of Western Australia, 2005; DoE, 2006).

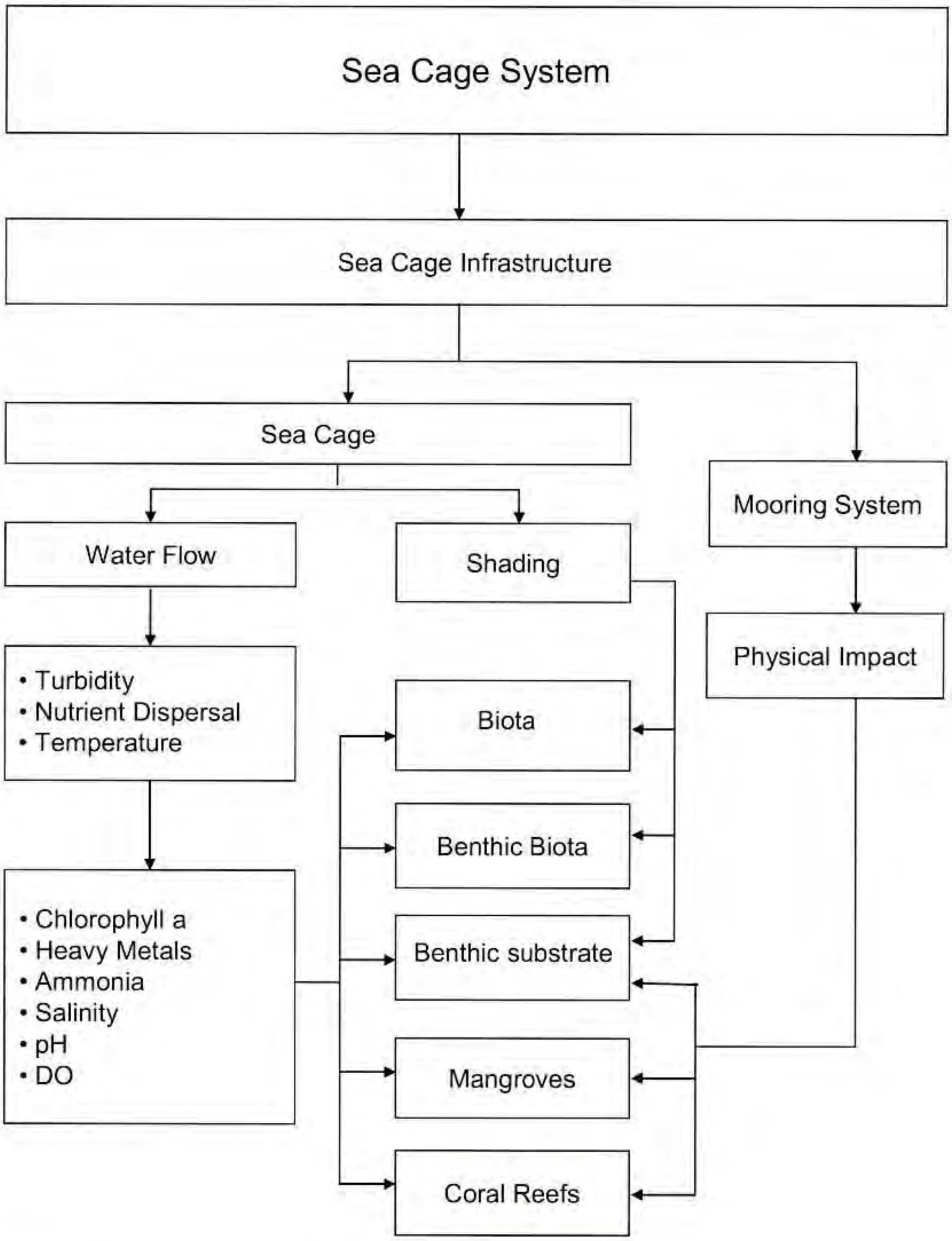


Figure 6.1: Conceptual Model of Sea Cage Infrastructure.

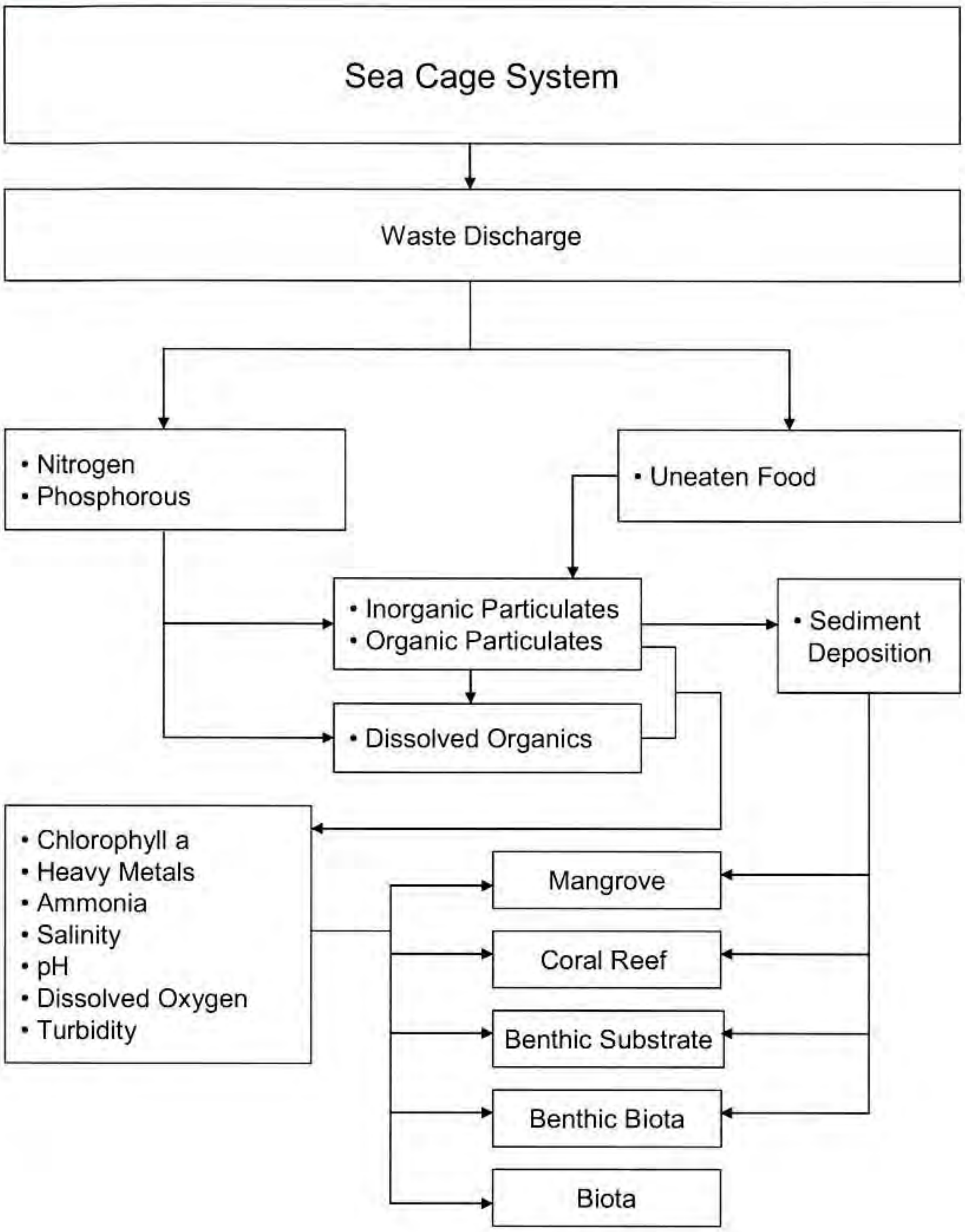


Figure 6.2: Conceptual Model of Waste Discharges.

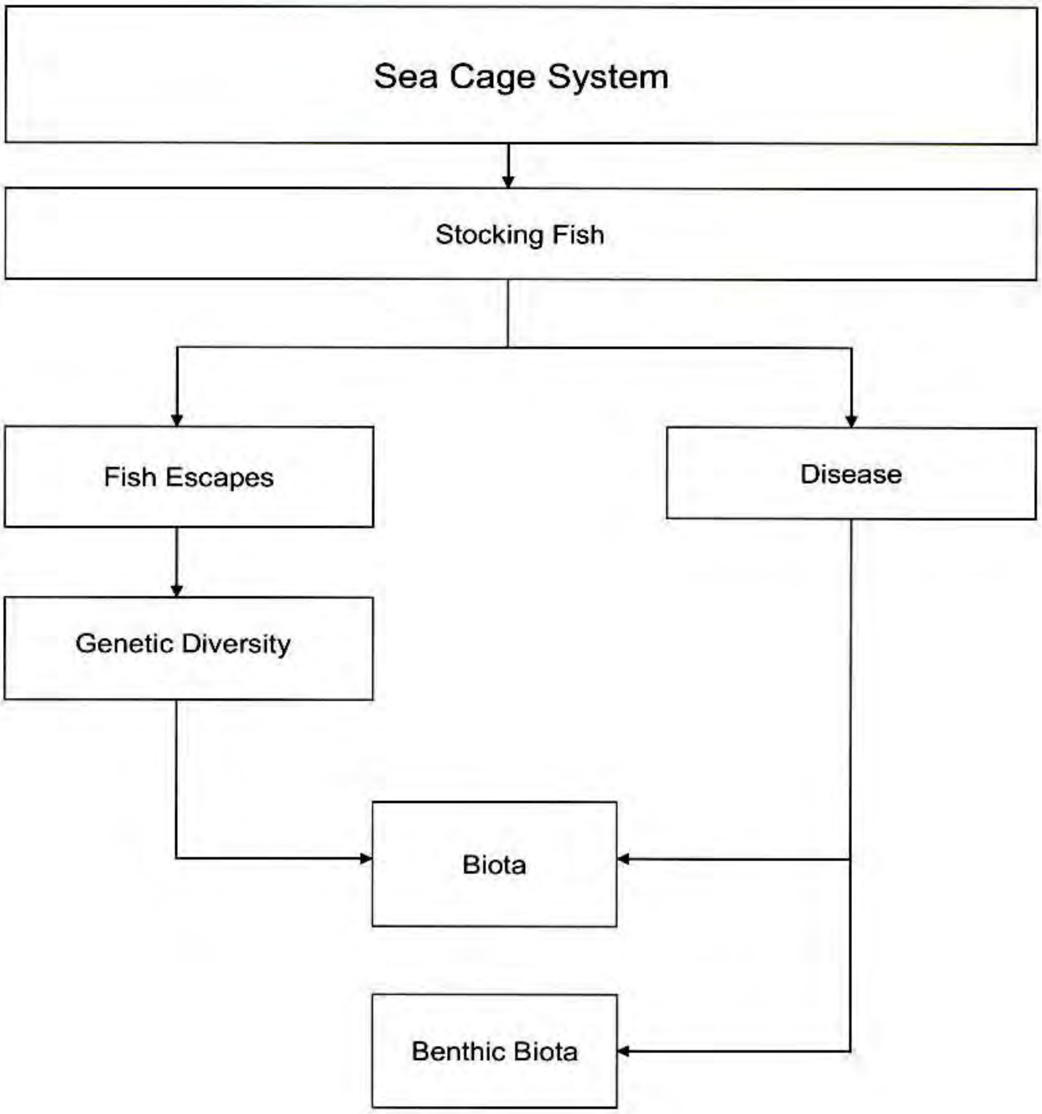


Figure 6.3: Conceptual Model of Farmed Fish Stock.

The EQMF aims to establish the Environmental Values (EVs) that are to be protected and maintained in the marine waters, the Environmental Quality Objectives (EQOs) and the Environmental Quality Criteria (EQC) that are to be achieved so that the environmental values are maintained (Government of Western Australia, 2004; EPA 2005).

EVs are defined as *"particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health, and which require protection from the effects of pollution, waste discharges and deposits"* (ANZECC, 2000).

The EVs are determined from community and stakeholder consultation (Section 7) and the identification of the key ecosystem processes described in Section 3 that are applicable to this proposal. These EVs are also representative of the environmental factors described in Table A.

For each EV an EQO is determined which may be further defined into a number of more specific objectives. The EQOs identify what the main aims of management are and highlight the responsibilities in protecting that value, that is, they are specific management goals (CALM, 1994; EPA, 2005).

The EQCs provide the benchmark that ongoing monitoring data is compared to so as to determine if the EQO is being maintained or met (DoE, 2006). A diagrammatic representation of the EQMF for this proposal is described in Figure 6.4. Regular review of the EQMF relating to all MPC's current and future operations will be undertaken as a part of the EMS.

6.4 Environmental Values & Environmental Quality Objectives

Environmental values (EVs) can be broadly divided into two main areas: Ecological and Social. Ecological values are those characteristics of the environment that play an essential role in the biodiversity of the area and incorporate biophysical factors and pollution management. These characteristics are physical, biological, geological or chemical and are usually measured in terms of their significance in maintaining the health, composition and function of the ecosystem (CALM, 2005). Social values are those characteristics of an area that have any cultural, recreational, aesthetic, commercial or economic significance (CALM, 2005). The environmental values determined for this proposal are similar to those determined in the *Pilbara Coastal Water Quality Consultation Process* (DoE, 2006) and are listed in Table 6.1.

The social value relating to Industrial Water Supply is not particularly relevant to this proposal as there are no industrial areas in the surrounding area. However, it has still been considered as a part of the framework due to the presence of industrial areas to the North at the entrance of the King Sound and to the South at the base of the King Sound. These include the mining leases on Koolan and Cockatoo Islands and the Derby Port and township respectively and the subsequent vessel activity between the two. The proximity of these areas to the licence site is depicted in Figure 6.5.

For each of these EVs one or more EQOs have been defined which are also depicted in Table 6.1. The EQOs, as explained previously, are simply the management goals that maintain the environmental quality of the relevant EV, thereby protecting it from or minimising the effects of the proposal.

It is important to note at this point that in reality, no recreational activity in the water (ie EQO 5) is considered safe within the aquaculture site or surrounding areas, or in fact the Kimberley region at all, due to the presence of large, aggressive predators such as crocodiles. However, MPC is maintaining this EQO in terms of water quality to allow recreational users the ability to undertake activities in the water if they are so inclined.

6.5 Levels of Ecological Protection

For the ecological value of ecosystem health a number of levels of protection can be assigned to the associated EQO to maintain ecosystem integrity (Sim & Masini, 2004). These levels of protection can range from maximum protection (Level 1) through to low protection (Level 4). The basic levels of protection are described in Table 6.2.

Because the value of Ecosystem Health is such a large and complex matter it can be broken down into the following key elements:

- Ecosystem processes (growth rates, primary production, nutrient cycles etc);
- Biodiversity (variety and types of organisms in the area);
- Abundance and biomass of marine life (number/density of plants and animals);
- The quality of water, sediments and biota (contaminants, levels of measurable parameters).

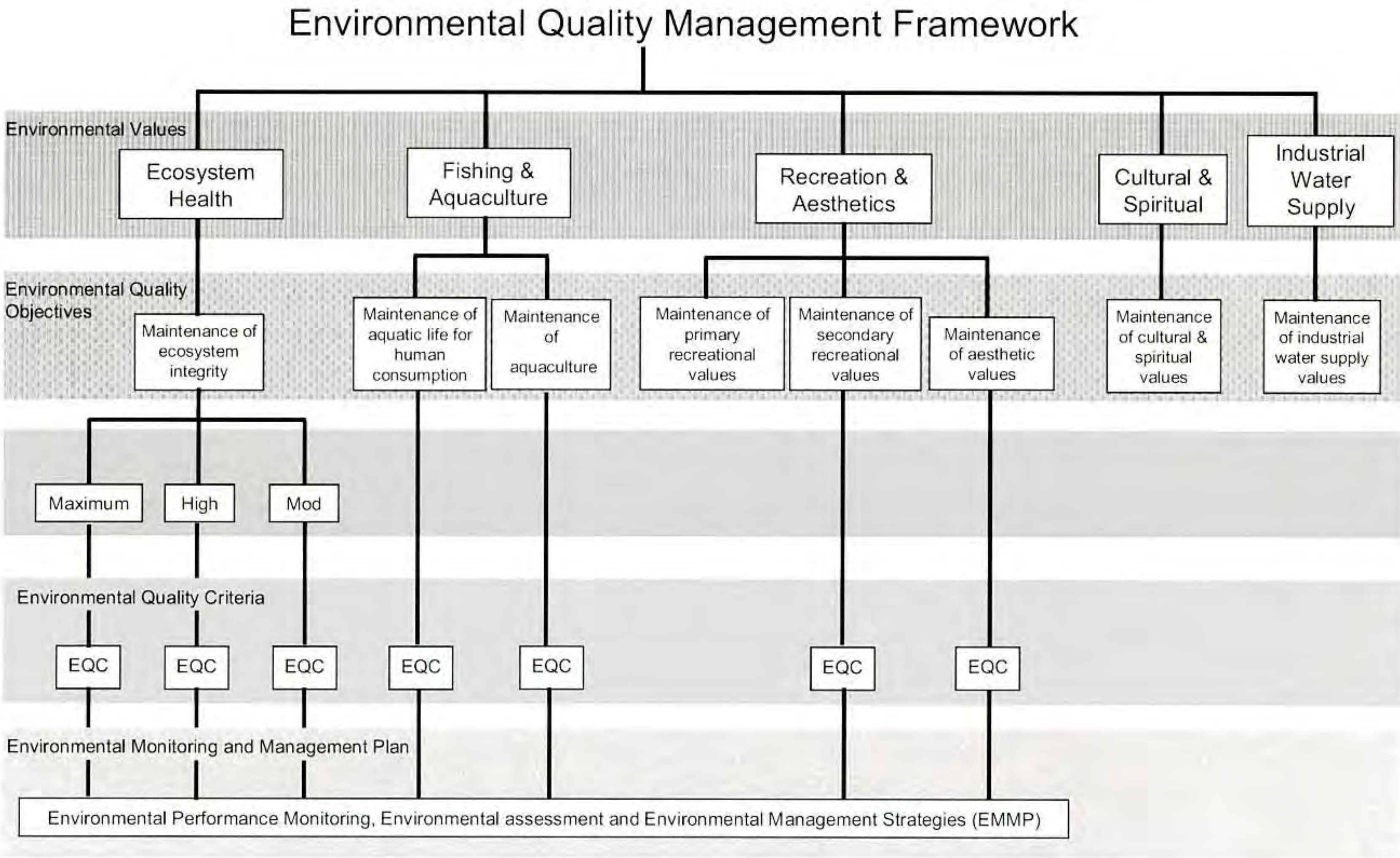


Figure 6.4: Environmental Quality Management Framework flow diagram for the Cone Bay Aquaculture proposal.

Table 6.1: Environmental Values and Their Associated Environmental Quality Objectives Within and Surrounding the Licence Area.

Environmental Value (EV)	EQO	Description
Ecosystem Health ecological value	EQO 1	Maintain ecosystem integrity Maintaining the structure and functions of the marine ecosystem within and surrounding the proposal area (eg the diversity and abundance of fauna & flora and the food chains and nutrient cycles of the environment)
Fishing & Aquaculture social value	EQO 2	Water quality is suitable for surrounding aquaculture purposes/ventures
	EQO 3	Seafood (caught or grown) is of a quality safe for eating
Recreation and Aesthetics social value	EQO 4	Water quality is safe for recreational activities on the water (eg boating)
	EQO 5	Water quality is safe for recreational activities in the water (eg swimming)
	EQO 6	The aesthetic values of the marine environment within and surrounding the proposal area are protected.
Cultural & Spiritual social value	EQO 7	Cultural and spiritual values of the marine environment within and surrounding the proposal area are protected.
Industrial Water Supply social value	EQO 8	Water quality is suitable for industrial supply purposes.

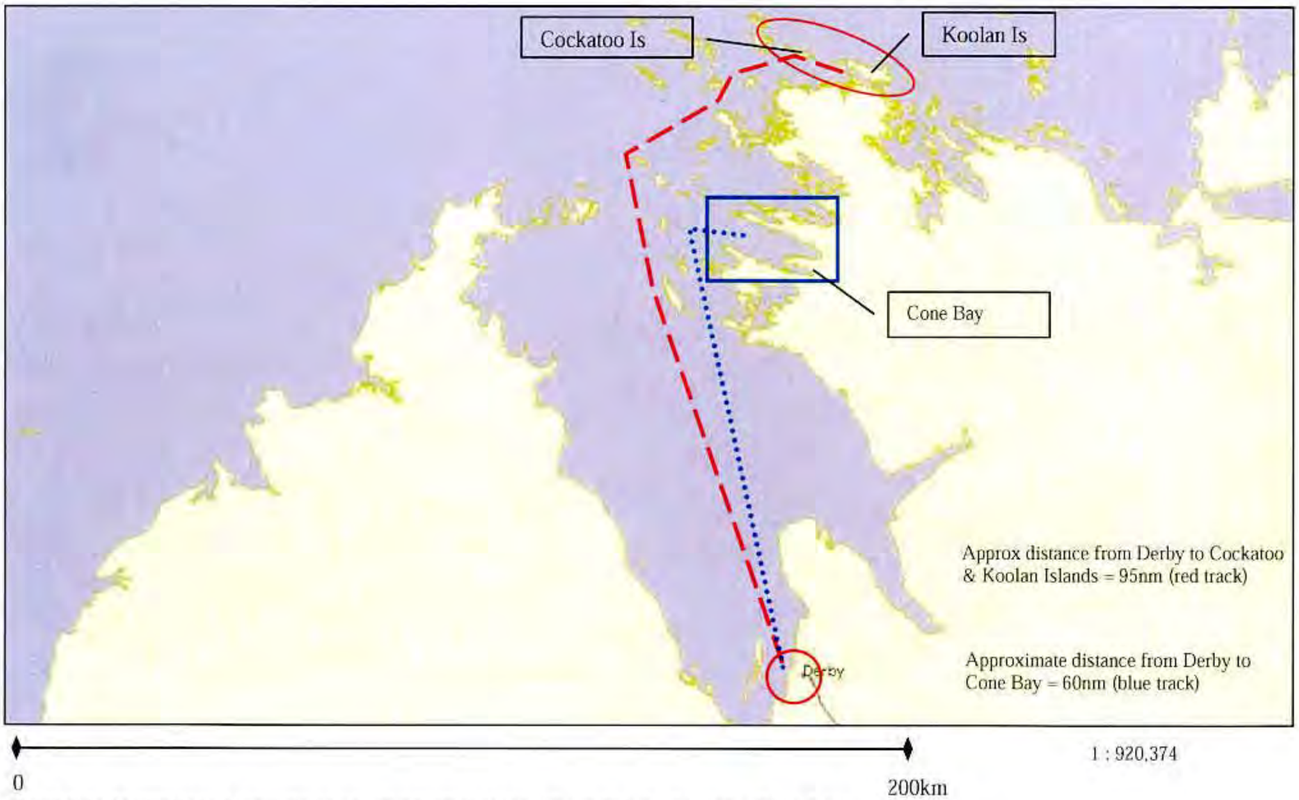


Figure 6.5: Proximity and estimated route of industrial areas relative to the proposal in Cone Bay.

Table 6.2: Four levels of protection for the Environmental Value of Ecosystem Health (taken from: *Perth's Coastal Waters: Environmental Values and Objectives* (EPA, 2000)).

Level of Protection	Relative protection	Limit of Acceptable Change
Level 1	Maximum (or total) protection	No detectable changes form natural variation
Level 2	High protection	Allow some small changes beyond natural variation but with no adverse effects
Level 3	Moderate protection	Allow moderate changes beyond natural variation but with no permanent adverse effects
Level 4	Low protection	Allow large changes beyond natural variation but with no bioaccumulation or permanent adverse effects

NB; Detectable change from natural variation refers to the median of a test site parameter being outside the 20^{th} or 80^{th} percentile of the reference sites as described in *6.6 Environmental Quality Criteria.*

These key elements enable the basic level of protection for EQO1 to be described in further detail according to limits of acceptable to change. This is shown in Table 6.3.

Prior to the submission of the PER, two levels of protection were temporarily assigned to the proposal area and surrounding waters. These included a maximum level of protection outside the licence area and a high level of protection within the proposal site whose boundaries have been stipulated in Section 2.2. These two levels of protection will still apply however the areas directly beneath the sea cages will have a moderate level of protection assigned as impacts are expected to occur in these areas.

The justification for this comes from other fish farming industries (eg the Tasmanian Salmon and South Australian Bluefin Tuna Industries) where many years of research and environmental monitoring has demonstrated that significant benthic changes can and do occur directly beneath the sea cages. Many of the impacts that occur would exceed any trigger values assigned to those levels of protection. Trigger values are not expected to be realised to this same extent as the environment within this region is very dynamic and productive (ie fast current speeds and high bacterial activity).

However, these industries have also shown that with the development of fallowing programs the impacts to the benthic substrate are minimised by allowing the sediments to return as close as possible to pre-farming conditions (CSIRO Huon Estuary Team, 2000; Macleod & Forbes, 2004; Woods *et al*, 2004; Cheshire *et al*, 2005; Loo *et al*, 2006b).

The different levels of protection assigned to the expansion proposal are diagrammatically represented in Figure 6.6. The blue area represents a maximum level of protection for the waters surrounding the aquaculture licence area and the purple area represents the aquaculture licence area assigned with a high level of protection.

As the sea cages will be moved around the licence area as part of the fallowing program, the areas directly beneath the sea cages cannot be demonstrated in Figure 6.6. Thus Figure 6.7 shows a more accurate representation of the area under a typical sea cage that is expected to be impacted upon which may at times exceed the trigger values. Figures 6.6 and 6.7 are also representative of the zones of effect and influence on the surrounding BPPHs as described in Section 4.9.

Research into the benthic impacts from sea cage aquaculture has shown that these impacts do not extend far from the areas directly beneath the cages (Woods *et al*, 2004; CSIRO Huon Estuary Team, 2000). However, no research has shown that any of these changes are permanent and with appropriate management strategies, particularly fallowing, these effects are significantly minimised.

The tuna aquaculture industry has demonstrated that since the inception of sea cage farming in 1990, there have been limited impacts to the benthic environment. Studies by SARDI have shown that although significant changes have been detected in the sediment quality and the benthic

Table 6.3: The limits of acceptable change for each of the key elements of ecosystem health and the associated levels of protection (taken from: *Perth's Coastal Waters: Environmental Values and Objectives* (EPA, 2000); Sim & Masini, 2004).

Key Elements of Ecosystem Integrity and Their Limits of Acceptable Change		Level of Protection for Maintenance of Ecosystem Integrity			
Key Elements	Limits of Acceptable Change	Level 1 (Maximum)	Level 2 (High)	Level 3 (Moderate)	Level 4 (Low)
Ecosystem Processes (primary production, nutrient cycles, food chains)	Ecosystem processes are maintained with the limits of natural variation (no detectable change)	√	√		
	Small changes in rates, but not types of ecosystem processes			√	
	Large changes in rates but not types of ecosystem processes				√
Biodiversity (eg variety and types of naturally occurring marine life)	Biodiversity as measured on both local and regional scales remains at natural level (no detectable change)	√	√	√	
	Biodiversity measure on a regional scale remains at natural levels although possible change in variety of biota at a local scale				√
Abundances and Biomasses of Marine Life (eg number or density of individual animals, the total weight of plants)	Abundances and biomasses of marine life vary within natural limits (no detectable change)	√	√		
	Small changes in abundance and/or biomasses of marine life			√	
	Large changes in abundance and/or biomasses of marine life				√
The Quality of Water, Sediment and Biota (eg types and levels of contaminants, dissolved oxygen content of water, water clarity etc)	Levels of contaminants and other measures of quality remain within limits of natural variation (no detectable changes)	√			
	Small detectable changes beyond limits of natural variation but no resultant effect on biota		√		
	Moderate changes beyond limits of natural variation but not to exceed specified criteria			√	
	Substantial changes beyond limits of natural variation				√

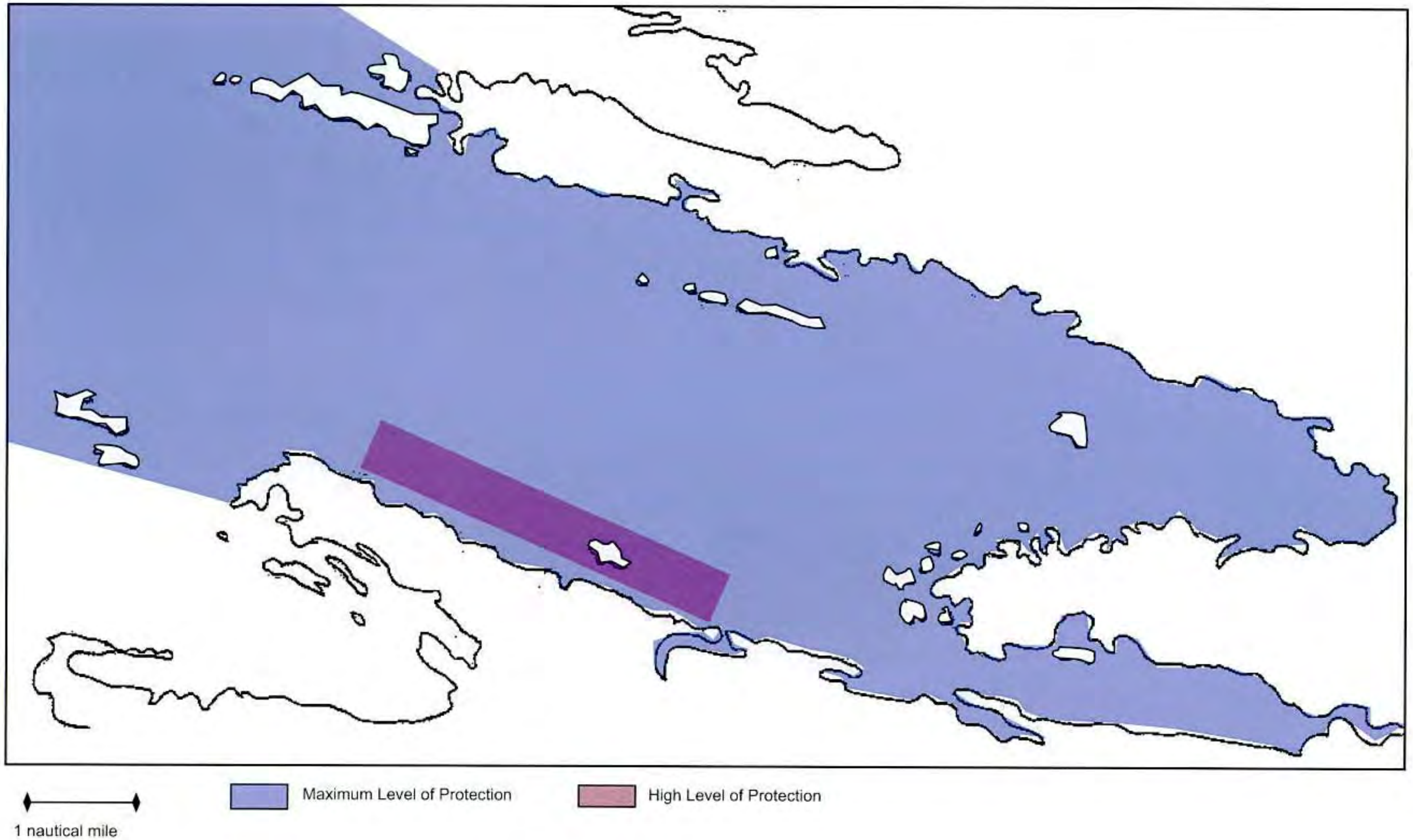


Figure 6.6: Levels of protection assigned to the Aquaculture Licence No. 1465 in Cone Bay.

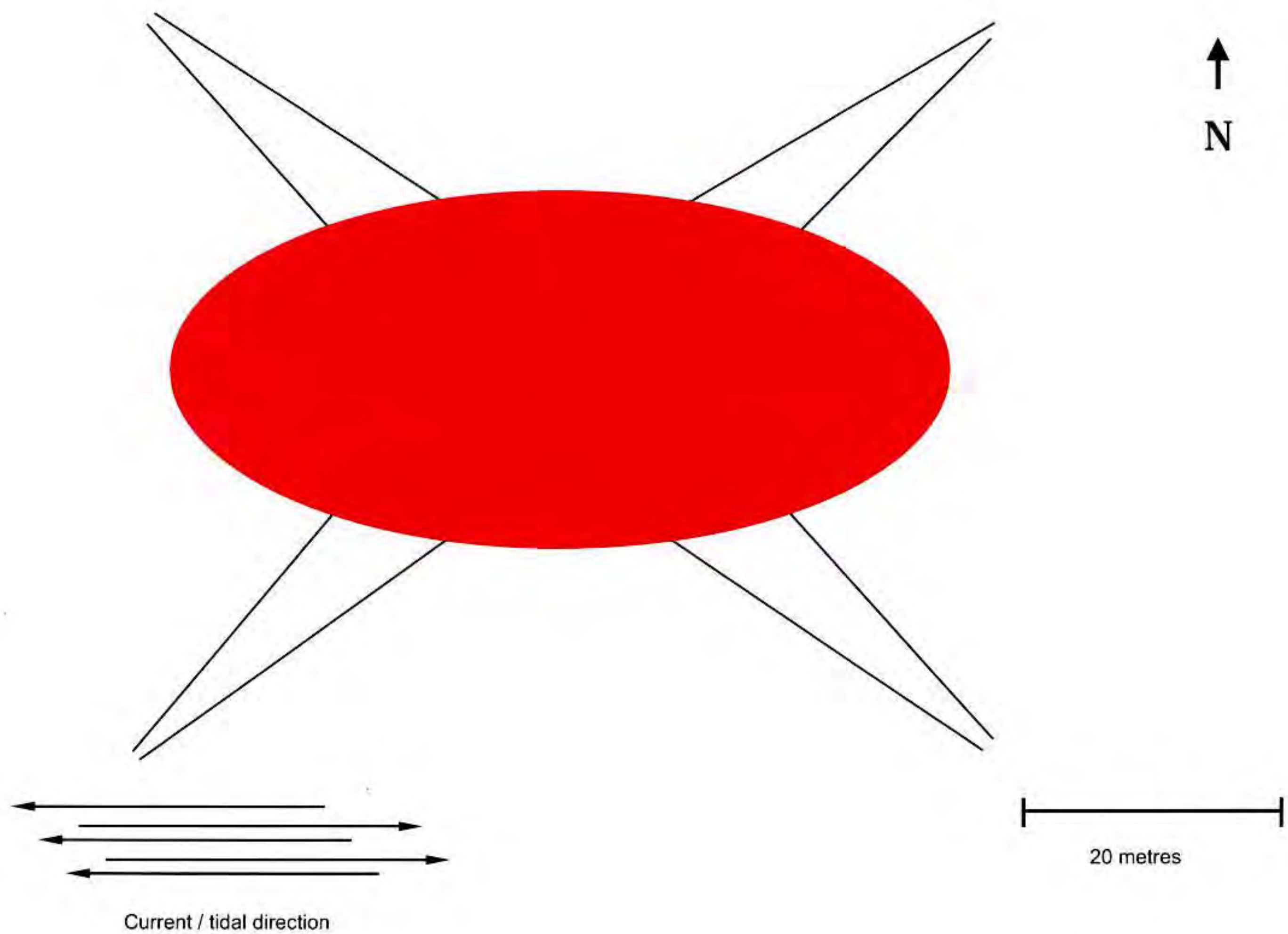


Figure 6.7: Areas under the sea cages where impacts are expected to occur.

organisms, no permanent effects have been detected and recovery (described as a return to normal function) of the benthic environment occurs within 3-6 months (Cheshire *et al*, 2005).

This pattern is also evident in the Tasmanian salmon industry and many overseas marine aquaculture ventures including Norway, Mediterranean, South America and Ireland to name a few (BIM; Cabarcas-Nunez & Alston, 2005; Santulli, 2005; Vita-Barberan & Marin, 2005, Woods *et al*, 2004; CSIRO Huon Estuary Team, 2000).

As a result, MPC acknowledges that impacts may occur directly under the sea cages, however, with adequate management strategies in place (as described in Section 4 and the revised EMMP) none of these changes are expected to be permanent.

In fact, data from the Cone Bay EMMP has shown that, to date, the level of impact has actually been less than expected with no changes observed in sediment chemistry.

6.6 Environmental Quality Criteria

6.6.1 Introduction

As stated previously the EQCs are the benchmarks against which the ongoing environmental data is compared to ensure the EQOs are being met and that the EVs are being protected (Government of Western Australia, 2005). EQCs can be numerical values or narrative statements and when using a 'risk-based' approach there are two main types of EQCs: Environmental Quality Guidelines (EQGs) and Environmental Quality Standards (EQSs). The EPA has defined EQGs and EQSs as follows (EPA, 2005):

- Values (or statements) that do not exceed an EQG imply that there is a high probability that the associated EQO is being achieved and therefore there is a low risk of adverse environmental effects.
- Values (or statements) that are in between the EQG and the EQS (ie exceeding the EQG, but not the EQS) indicate that there is an increasing level of risk of adverse environmental effects and therefore there is uncertainty that the associated EQO is being achieved.
- Values (or statements) that exceed an EQS indicate that there is an unacceptably high risk of adverse environmental effects and therefore it is considered the EQO is not being achieved.

If an EQC is exceeded in any way, a management response is immediately triggered in order to maintain the EQO for the associated EV.

If an EQG is exceeded, the management response is for further investigations to not only confirm that it has been exceeded, but also to determine the cause and the level at which it has exceeded. (ie against the EQS).

If an EQS is exceeded, this triggers an immediate management response that implements measures and actions to reduce or address the problem. Figure 6.8 has been taken from the *State Water Quality Management Strategy No. 6* to demonstrate the relationship between the two types of EQCs.

6.6.2 Percentile Based Calculations

The results of the ongoing EMMP (Appendix D) and the hydrodynamic modelling (Appendix B) have clearly demonstrated that the area is highly variable. Due to this high variability it is extremely difficult to assign default EQS. This is in part, because there are no Australia-wide standards to compare the baseline results to, particularly so in regards to sediment quality.

The Cone Bay EMMP results (Section 3.9) have also shown that the seasonal variation is difficult to define and use as background data. Discussions with the EPA in the development of the Cone Bay EMMP resulted in the agreement that the EQC would be most effective as a percentile-based calculation.

For water quality analysis this is determined by comparing median of the sample site results (ie the cage sites) to the reference sites for each given sampling date.

For sediment analysis this is determined by comparing the median of the sample sites (in this case the sample sites will be a distance of 50m from the sea cage) to the reference sites for each given sampling date. To ensure environmental best practice an extra set of reference sites have been included for sediment quality analysis at a distance of 200m from the sea cages. This will allow for the maintenance of the assigned levels of protection.

The NWQMS (National Water Quality Management System) indirectly supports the development of site specific EQCs and confirms that developing sediment quality guidelines is difficult due to the high variability of sediment quality in marine waters. The NWQMS also suggests that as a result of the high variability there is difficulty in determining what changes in quality are a result of 'external' inputs (ie such as aquaculture nutrient inputs etc) or natural variability.

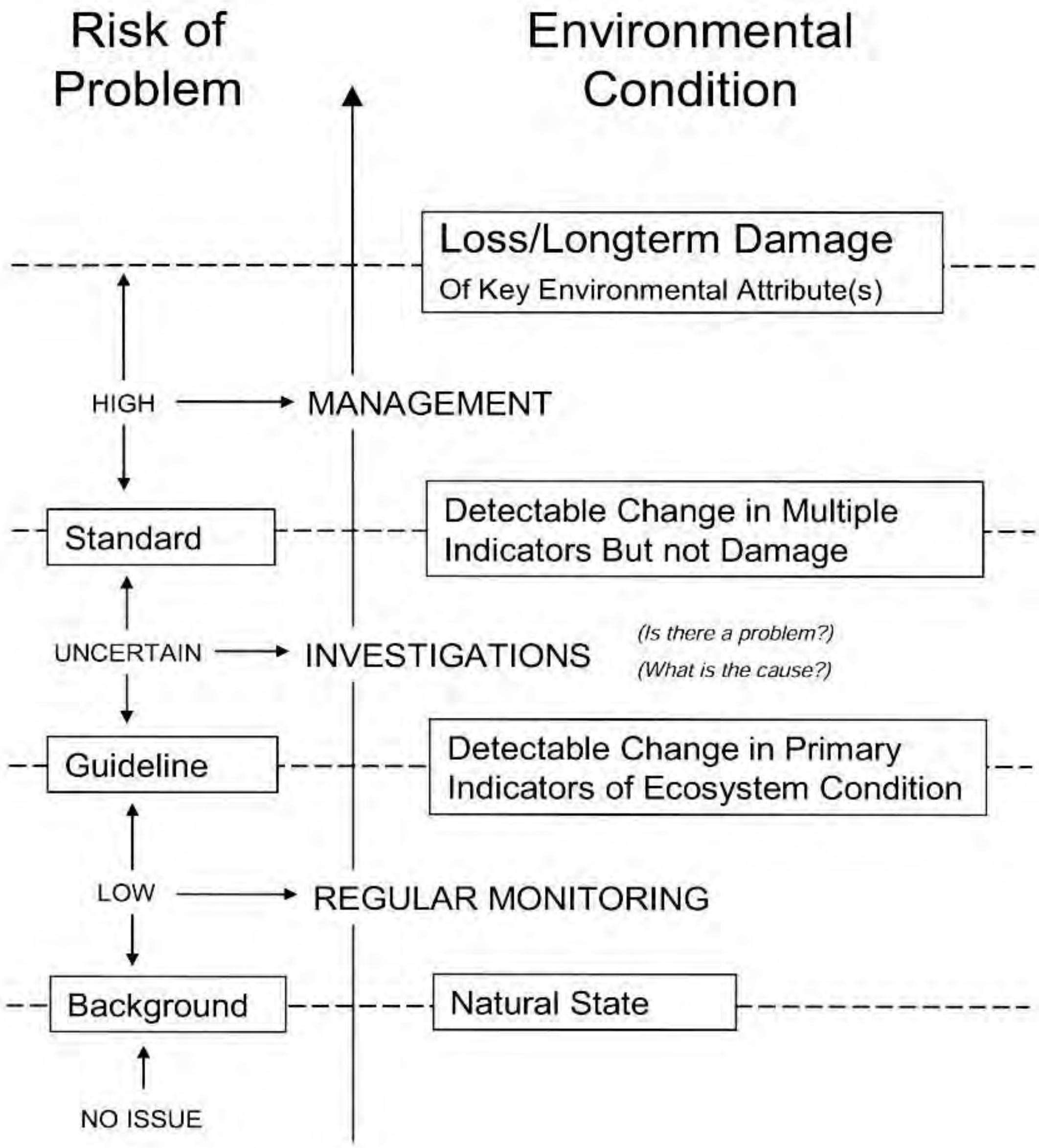


Figure 6.8: Diagram demonstrating how the two types of EQC are utilised and assessed against the environmental condition (SWQ No. 6, WA Government).

Thus, in line with the current Cone Bay EMMP, the medians of the data obtained from the reference sites on any given sampling date will continue to be considered as the EQGs and as the ongoing monitoring program progresses through a number of seasons, EQSs may be able to be established and incorporated as a part of the continual development and improvement of the monitoring program and EMS.

The percentile based calculation, in relation to the sea cage operation, works under the premise that the median of each cage site must lie between the 20th and 80th percentile of natural distribution at the reference site for a biological parameter (SWQMS Report No. 6), where:

- A median is the middle value of a sequence of numbers. Half the values are numerically smaller and half are numerically larger (also known as the 50th percentile); and
- A percentile is the division of a frequency distribution of data into one hundredths. The p^{th} percentile of a distribution of data is the value that is greater than or equal to the p% of all values of the distribution. For example, the 80th percentile is greater than or equal to 80% of all values or 80% of all values are less than or equal to the 80th percentile.

If the values from the sample sites on any given sampling date exceed the EQC (ie fall below the 20th percentile or are higher than the 80th percentile), then a response by management will be triggered.

Figure 6.9 demonstrates the fundamental basis of the above explanation in a less complicated manner. Simply put, the trigger values are A &/or B. Thus the sample site values must remain between A & B for any given sampling date. If a value falls below A or is higher than B, the trigger values have been exceeded and a management response will be put into action.

6.6.3 Management Responses

A management response is an action that is automatically implemented if a trigger value is exceeded. Management responses are incorporated into the EMMP and are continually reviewed as a part of the EMS to ensure best practice is being maintained.

If a trigger value for any parameter of the Cone Bay EMMP is exceeded, the immediate response will be to undertake a repeated assessment to confirm that the criteria have in fact been exceeded.

If the second analysis shows a result that falls between the 20th and 80th percentile (ie A & B in Figure 6.9) then sampling will return to the original schedule and methodology.

If the second analysis confirms that an EQC has been exceeded then MPC would immediately implement any or all of the following management actions as deemed appropriate:

- Notification of all relevant licencing bodies including:
  - Department of Environment and Conservation
  - Department of Fisheries, WA;
- An increase in monitoring periodicity;
- A reduction in feed rate;
- A reduction of stocking biomass within the sea cage system;
- Relocation of sea cages;
- Continued monitoring of impacted areas to ascertain the recovery rate; and
- A reduction in the number of sea cages operating at the site.

MPC would continue to monitor all parameters to monitor the recovery rate. The EQCs for each of the EQOs for the Cone Bay proposal are summarised in Table 6.4.

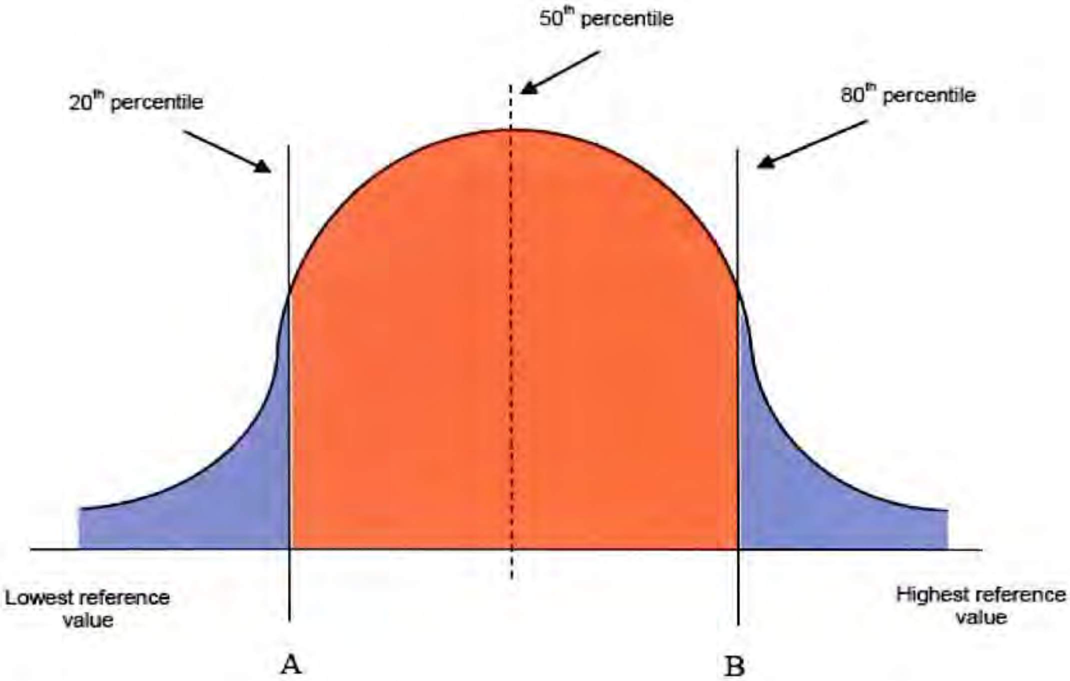


Figure 6.9: Diagrammatic representation of the percentile based calculation and trigger values. The normal distribution of reference site values enables the 20th and 80th percentiles to be determined. The median value of the sample sites can then be compared to these to determine if the environmental quality objective is being met.

Table 6.4: EQCs for the associated EQOs relevant to the Cone Bay 1,000T Barramundi Production Proposal

EQO	Description	Level of Protection	Environmental Quality Guidelines	EQS
1	Maintenance of ecosystem integrity	Maximum	The median sample site value of all water & sediment quality parameters does not fall outside the 30th or 70th percentile of the natural distribution for each parameter at the reference sites for that sampling date.	Not yet developed
		High	The median sample site value of all water & sediment quality parameters does not fall outside the 20th or 80th percentile of the natural distribution for each parameter at the reference sites for that sampling date.	Not yet developed
		Moderate	The median sample site value of all water & sediment quality parameters does not fall outside the 20th or 80th percentile of the natural distribution for each parameter at the reference sites for that sampling date.	Not yet developed
2	Maintenance of Aquaculture	N/A	Water and sediment quality values will not exceed the EQGs stated for EQO 1- Maximum level of protection.	Not yet developed
3	Maintenance of seafood quality	N/A	Water and sediment quality values will not exceed the EQGs stated for EQO 1- Maximum level of protection.	Not yet developed
4	Maintenance of secondary recreation values	N/A	Water and sediment quality values will not exceed the EQGs stated for EQO 1- Maximum level of protection.	Not yet developed
5	Maintenance of aesthetic values	N/A	The presence of sea cages and aquaculture operations will not result in an increased level of general pollution or a lowering of the aesthetic values of the area.	No discernable presence of litter or lowering of aesthetic values

6.7 Cone Bay EMMP Development

MPC have an environmental monitoring and management program (EMMP) in place within Cone Bay that was developed for the current 150 tonne Barramundi venture. As it is proposed to increase production at the Cone Bay aquaculture licence site to 1,000 T/annum the EMMP has been revised and amended to reflect the increased probability of impact and to address all related issues to ensure the proposal adheres to the environmental commitments that are outlined in section 8 of this PER. The amended Cone Bay EMMP is provided in Appendix F.

The EMMP includes close monitoring of parameters such as water quality, benthic substrate, benthic habitats (mangrove areas and coral reefs), Benthic Infauna and general marine biota. The EMMP also incorporates the EQCs developed, the trigger values and management responses, procedures of liaison with relevant licensing bodies, references to other environmental management plans and review and auditing of procedures and timing.

Water quality will be sampled and analysed on a six weekly basis and benthic analysis will be undertaken on a three monthly basis. Comparison of historic data from the Cone Bay EMMP (Section 3.9 and Appendix D), in conjunction with recent results from the base-line study conducted for the Crawford Bay proposal (Jack, unpublished) have clearly shown that the region experiences high seasonal variability as well as high variability in inter- and intra-site environmental quality data. Thus, it is very difficult to determine any kind of base-line dataset against which the sample site data can be compared to over time.

It should be noted however, that MPC will continue to analyse all future monitoring data to ascertain if any distinct seasonal variations or patterns occur over a longer time frame, including any for the newly developed reference sites.

The monitoring procedures and environmental quality criteria (EQC) have been designed so that any adverse changes to any of the parameters will be quickly identified and appropriate management practices can be employed or if required, altered to address the problem in order to minimise any possible impacts. MPC will continually strive to improve the efficiency of the EMMP in full liaison with relevant governing bodies.

Ongoing development and improvement of the EMMP will continue via reviews and in-house auditing to enhance the effectiveness of the monitoring program. MPC is considering incorporating a number of innovative techniques in the future, which will cause many of the current sampling procedures to be considered ineffective and therefore eventually removed from the EMMP.

The incorporation of new techniques and the dropping of 'outdated' techniques are commonly undertaken in many monitoring programs (Tanner *et al*, 2006, Glencross, 2002). However, to ensure full compliance, all future amendments will be discussed with the DEC and DoF prior to any changes taking place. Some of the innovative monitoring techniques that may be incorporated into the EMMP at a later date include:

DNA assaying of the benthic infauna

This procedure is still being developed by the Aquafin CRC subproject 1 (FRDC 2001/102) but to date has demonstrated very positive and accurate results in determining differences and changes in the abundance of benthic infauna between sampling sites and dates. The method is being developed for the South Australian Environmental Compliance Scorecard (ECS) system for the tuna farm operators and has shown to provide the same results as the current system of manual identification but with faster results and more cost effective means in the long term (Loo *et al*, 2006a; Loo *et al*, 2006b). Benthic infauna are the most sensitive indicators of environmental impacts resulting from marine aquaculture and the Southern Bluefin Tuna Aquaculture Environmental Monitoring Program has dropped the standard benthic analysis protocol in favour of using the infauna DNA assaying (Turner *et al*, 2006, *per comm.;* Maylene Loo, Senior Marine Ecologist SARDI).

ROV sampling

Remotely Operated Vehicles (ROV) are used regularly in the Tasmanian Salmon Industry and are generally a remote controlled, self-propelled, underwater vehicle equipped with a digital video camera and other necessary equipment. The advantages of utilising a ROV is that no divers are needed, the video images are verifiable and rather than a random core sample being taken a video image of an entire transect will give a far more accurate representation of the extent of the impacts to the benthic substrate from the sea cages. This in turn will enable the determination of more accurate sampling areas for the benthic analysis. The use of an ROV is also considered to be cost-effective in the long term and will allow for quicker and easier sampling regimes.

The South Australian Primary Industries and Resources department (PIRSA) has stipulated in the *Marine Finfish Aquaculture Environmental Monitoring Program (FEMP) and Reporting Requirements for Licensees* (PIRSA, 2004) that the only benthic assessment required are video transects and infaunal assessment. As a result MPC is considering incorporating both of these technologies in the future to increase the effectiveness of the monitoring program by removing the time-consuming and frequently ambiguous data results obtained by the current benthic analysis procedure.

6.8 Environmental Management System

An Environmental Management System (EMS) is a system which allows an organisation to manage any impacts that their activities may have on the environment as well as integrating other management strategies to ensure both environmental and economic sustainability (AS/NZS ISO 14001:2004). An EMS provides many benefits both to the environment and the organisation by enabling the continual analysis and improvement of procedures, technology and other operational requirements. Thus, an effective EMS allows an organisation to continue to strive for both best practice and cost effective strategies.

MPC is currently developing an EMS that incorporates the principles of ISO14001 standards. The EMS will be an overarching, 'living' document that will encompass all environmental management plans, staff procedures, responsibilities and codes of conduct and review, reporting and auditing procedures and schedules. Auditing will be at the very least, inhouse initially with the potential to incorporate 3rd party audits as the venture progresses.

The aim of the EMS is to ensure that all of MPCs current and future operations are managed in such a way so as to ensure environmental and operational best practice is being maintained at all times.

7. Public & Stakeholder Consultation

Introduction

MPC undertook a public and stakeholder consultative process in order to allow any interested parties to provide comments and suggestions.

Relevant stakeholders were identified by using the standard list of stakeholders contacted by the DoF for the majority of previous applications or amendments undertaken by MPC.

Government department consultation was identified by advice from other government departments (eg referral to the EPA by the DoF and DEC).

Stakeholders were also identified as a result of the recent Crawford Bay Sea Cage Aquaculture Proposal currently being assessed (Jack, 2007). Thus, many local businesses and community groups were contacted directly if the proponent believed that their organisations might be impacted upon in some way by the proposal.

The proposal was also advertised in two local papers and the West Australian in an attempt to notify any other unidentified interested parties.

A flowchart summarising the process of consultation is shown in Figure 7.1

Previous and Current Consultative Processes

Government Agencies:

MPC representatives co-ordinate meetings with the DoF, EPA and DEC (formerly DoE) for preliminary discussions of planned projects, follow up of proposals within the approvals process and in particular to discuss current applications such as this application.

Applicable documentation is then prepared and submitted to each relevant Department to commence the approvals process. MPC continues to extend an ongoing invitation to all relevant Government Agencies to visit the aquaculture licence site.

A brief summary of the consultative process with government agencies is described in Table 7.1.

Community Consultation:

MPC has a very long standing relationship with the traditional owners of the area concerned. This relationship to date has manifested itself where mutual benefit has been derived for both parties including:

- Employment strategies;
- Transportation of freight and people to and from Yaluun community;
- Supply and delivery of fuel and other goods and services when required;
- Engineering contract with CAT (Centre for Appropriate Technology) to service and maintain the community's generator and other equipment;
- Provision of medivacs and cyclone evacuation if required; and
- Financial contributions and support to develop indigenous artistic and cultural activities.

MPC, MFF and Larinuwar [Yaluun] Aboriginal Community meet to discuss any new venture plans or update on existing projects being undertaken within the area and productively work through any issues of cultural and community significance.

In addition, a full time indigenous liaison officer is employed to ensure continued communications. Thus, MPC is confident that under these circumstances and for the purposes of ensuring protection of sensitive areas, indigenous cultural and customary interests have been sufficiently addressed (and will continue to do so in the future).

MPC also distributed a letter notifying and encouraging the relevant stakeholders and community members identified as described previously, to contact MPC directly to obtain a copy of the Cone Bay Environmental Scoping Document.

As well as this, advertising in two local newspapers (the Broome Advertiser and the Muddy Waters – Derby) and the West Australian, was undertaken directing all other interested parties to contact MPC directly to obtain the document for comment.

A complete list of the organisations and interest groups that were contacted directly by letter is given in Appendix G. A brief summary of the community consultative process undertaken is described in Table 7.1.

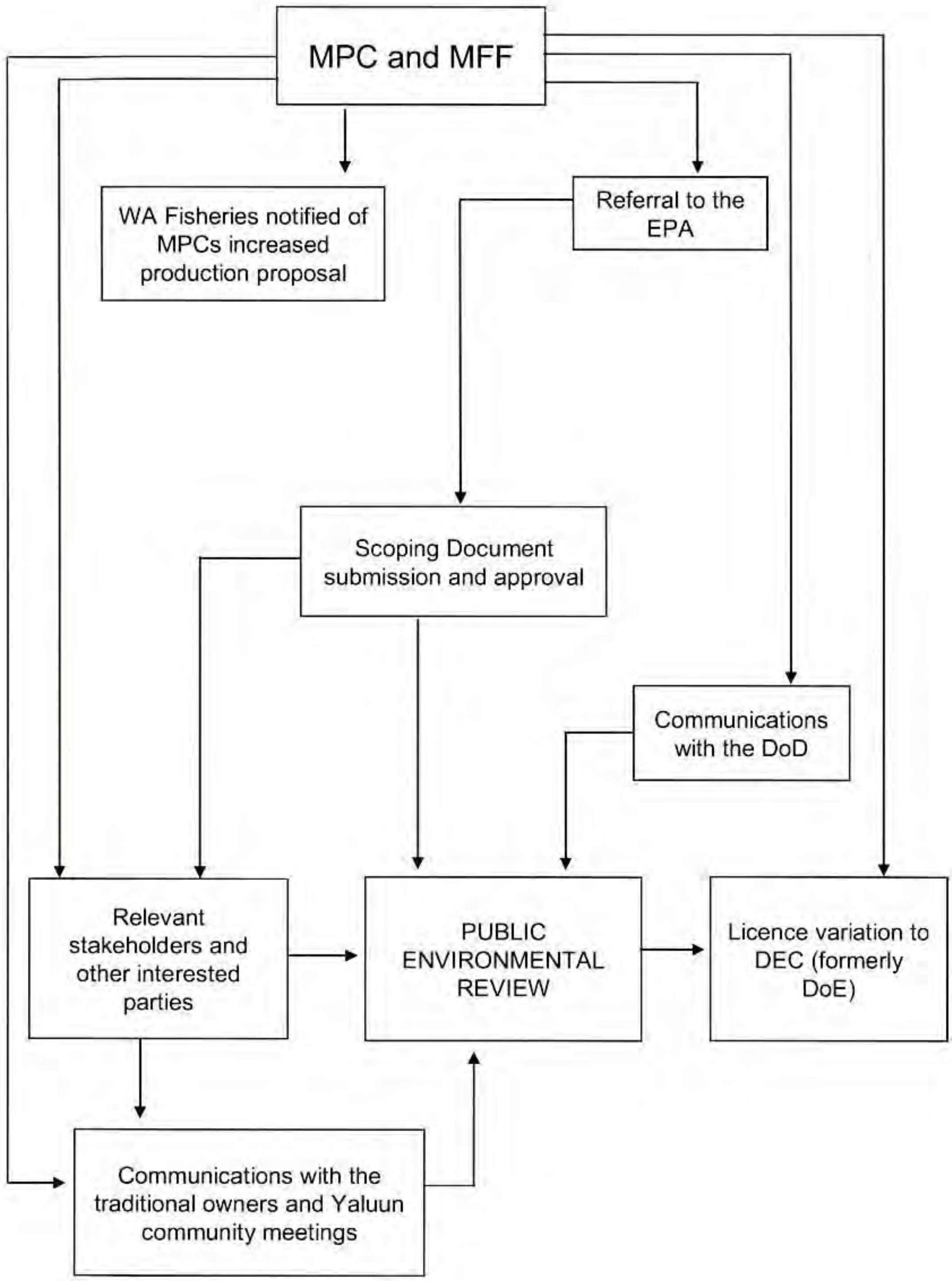


Figure 7.1: Flowchart demonstrating the consultative process undertaken for the Cone Bay proposal.

Table 7.1: Summary of the Consultative Process undertaken by MPC for the Cone Bay Barramundi Production Increase Proposal.

Date	Stakeholder Contacted	Method of Contact	Objective	Response/Outcome	Action
Government Agencies					
February 2006	Department of Fisheries WA – Barbara Sheridan	Telephone contact.	To discuss proposal and inform DoF of proponents intentions to increase production.	Stated that a licence variation is not required as aquaculture licence 1465 already exists as a commercial licence. Advised MPC to refer the proposal to the EPA due to the high production level and the potential environmental impacts. Upon variation to the DEC licence conditions, the DoF will be notified of the changes.	Proposal referred to the EPA.
March 2006	Department of the Environment and Heritage	Email and telephone communications.	To determine whether the proposal required assessment under the EPBC Act 1999.	Concluded that due to the resulting decision from the Crawford Bay application (Jack, 2007), the proposed expansion was not likely to have a significant impact on any matters of national environmental significance protected under the EPBC Act therefore a referral would not be warranted. Suggested discussing the proposed expansion with the DoD.	Contact with the DoD made to discuss the implications of this proposal.
March 2006	Department of Environment and Conservation (formerly DoE) – Joanne Nicol	Telephone contact.	Informed DEC of intentions to increase production to 1000T at Cone Bay licence 1465 site.	Stated that an application for a variation to the existing environmental licence would need to be submitted which could run concurrently with the PER.	Proposal referred to the EPA.
April 2006	Department of Defence	Email communications.	To discuss and resolve concerns raised regarding the potential loss of access to the Yampi Sound Training ground for both the Cone Bay and Crawford Bay proposals.	The DoD expressed concerns with access loss particularly in terms of any future large-scale aquaculture operations reducing the DoD's ability to conduct training manoeuvres in and around the Yampi Sound and King Sound waters.	Discussions led to the development of management strategies to ensure the DoD retains access to both land and water areas conducive to defence training exercises. Further discussions also led to the agreement that MFF (& MPC) would maintain these types of communications for any future proposals and the DoD stated that in any future communications, the DoD would be happy to discuss other suitable areas for DoD purposes in order to help make decisions regarding the location of any future proposals. These issues have been addressed in Sections 3.7 and 4.19.

April 2006	Derby/West Kimberley Shire Council – Noel Myers (Shire Engineer)	Telephone contact.	To discuss proposal and potential concerns.	Stated that he did not foresee any issues with the proposal so long as EPA regulations were adhered to. Advised MPC that the Derby Shire Council would likely support all future proposals utilising Derby as an economic base.	N/A
October 2006	Department for Planning and Infrastructure – Noel Chambers	Telephone contact.	To discuss the Cone Bay expansion in regards to navigational lighting of the sea cages/licence area.	Stated that the active area in which the cages are encompassed could be marked with navigational lighting.	The active area within the Cone Bay aquaculture site has been marked with navigational lighting and will be adjusted in accordance with the expansion of the proposal.
December 2006	Environmental Protection Authority	Submission of the final scoping document.	To outline the proposal and the investigations to be undertaken in the PER document.	Formal approval of the SD given by the EPA on 15th December 2006.	Development of the PER document including investigations and environmental consultation.
Community Consultations					
July 2006	Traditional Owners	Tour around the proposal area.	To show the traditional owners the Barramundi farm operating within Cone Bay and to determine if there were any cultural activities that may be impacted upon by the expansion of this proposal.	The traditional owners stated their excitement about the proposal and the potential for employment programs being developed and implemented as a result of this and any future proposals.	Agreed to send an MPC/MFF representative to the traditional owners meeting organised by the KLC held on 25th & 26th September 2006.
September 2006	Traditional Owners	A MPC/MFF representative attended the traditional owners meeting at Yaluun community, Cone Bay.	To discuss the proposal and potential cultural issues and to discuss the integration of community members into the proposal and any future proposals.	Yaluun continues to be most supportive of the Barramundi venture becoming a commercial project, identifying many positives for their community including employment and training opportunities.	Development of an Indigenous Employment Strategy (IES) that integrates the community into the proposal's workforce.
February 2007	Relevant stakeholders and other community groups and businesses.	Direct contact with identified groups by letter.	To inform community groups and other relevant stakeholders about the proposal and to enable any to provide comments if they wished.	A total of 66 letters were distributed and of those 6 individuals/companies requested a copy of the scoping document. The scoping document was sent to all requesting a copy but to date no responses have been received by MPC.	N/A

February 2007	Relevant stakeholders and other community groups and businesses.	Advertising in the West Australian (24th February 2007).	To inform community groups and other relevant stakeholders about the proposal and to enable any to provide comments if they wished.	No responses were received as a result of the advertisement.	N/A
March 2007	Relevant stakeholders and other community groups and businesses.	Advertising in two local papers: 1. Broome Advertiser (1st March 2007) 2. The Muddy Waters-Derby (1st March 2007)	To inform community groups and other relevant stakeholders about the proposal and to enable any to provide comments if they wished.	A total of 6 individuals and/or organisations responded to the advertisements and contacted MPC to obtain a copy of the scoping document. No responses were received once the scoping document was distributed.	N/A

Further community consultation will occur with the release of this PER, whereby the public will receive ample time to make known their comments as a part of this PER submission and public release.

Ongoing Consultative Processes

Ongoing consultation with relevant stakeholders will continue as a part of the EMS developed. A database of relevant and pertinent stakeholders (ie those who may be affected by the proposals) will be maintained. As a part of the EMS, the needs of each stakeholder will be identified and a strategy for consultative process will be assigned. Annual reviews of existing stakeholders and potential new stakeholders will enable MPC to ensure all relevant organisations are identified.

Consultation with the traditional owners is continually ongoing as a part of the IES, which will automatically be updated as events, proposals and projections vary.

Consultation with the DoD will continue in regards to any future aquaculture licence proposals and their potential locations. Open communications with other relevant stakeholders will also continue to ensure no access loss to the area.

Ongoing consultation with regulatory government departments will be continued as a natural part of licence regulations. Amendments to the project if required will be automatically submitted to a range of relevant stakeholders by both the DoF and DEC (formerly DoE) and advertised state wide to ensure the public have access to the relevant documentation to ensure the consultation process is maintained.

MPC is committed to continued consultation and liaison with all regulatory organisations and relevant localised groups to ensure that open and transparent communication is maintained.

8. Environmental Management Commitment

Maxima Pearling Company recognises that managing environmental issues is an important part of the Cone Bay proposals development and any future aquaculture proposal within the Yampi Sound. As a result, an environmental policy has been incorporated into the EMS that will ensure continual high standard management practices by the proponent in this and all future proposals. The basic principles of MPCs environmental policy include:

- Environmental management, risk reduction and pollution prevention in all procedures and operations,
- Compliance with applicable legislative and other requirements,
- Protection of traditional occupier cultural values of the area,
- Participation, consultation and support of the wider community cultural values of the area,
- Maintain the high standard of management practices, and
- Continual commitment to improve operational procedures and practices.

This section provides a more detailed summary of the environmental and operational commitments that were presented in Table B of the Executive Summary.

Commitment 1: Environmental Monitoring and Management Plan

To ensure environmental best practice the proponent (MPC) will prepare a more comprehensive EMMP that addresses:

1. Water quality management,
2. Benthic quality management,
3. Mangrove system management,
4. Coral reef system management,
5. Biota management,
6. EQC and trigger values development,
7. Management responses, and
8. Auditing, review and regulatory body liaison procedures.

Commitment 2: Environmental Monitoring and Management Plan

The proponent will implement the EMMP. A revised EMMP is presented in Appendix F.

Commitment 3: Water Quality Management

Maintaining water quality to ensure that existing and potential uses, including marine ecology and diversity are protected, the proponent will improve the current Water Quality Management Program as a part of the EMMP that:

1. Identifies the concentrations and zone of nutrients and other environmental parameters in the water column through a comprehensive monitoring schedule of water chemistry,
2. Creates EQC or parameters that may have a direct or indirect impact on water quality,
3. Specifies methods of nutrient control and develops preventative procedures through practices such as stock and feed management,
4. Develops a comprehensive monitoring schedule, and
5. Develop a management action plan in the event that unacceptable nutrient levels are detected or environmental parameters are impacted (EQC are exceeded) which would include procedures to reduce nutrient input and/or rehabilitation.

Commitment 4: Water Quality Management

The proponent will implement the approved Water Quality Management Program.

Commitment 5: Benthic Substrate Management

The proponent will improve the current Benthic Quality Management Program as a part of the EMMP that:

1. Identifies the concentration and zone of nutrients and other environmental parameters within the benthic substrate through a comprehensive monitoring schedule of benthic chemistry and benthic biota,
2. Creates EQC for parameters that may have an impact on the benthic substrate and benthic biota,
3. Develops a fallowing program that utilises hydrodynamic modelling information to reduce the risk of causing adverse impact, and
4. Develops a management action plan in the event that unacceptable nutrient levels are detected or environmental parameters are impacted (EQC are exceeded) which would include procedures to reduced nutrient input and a rehabilitation program.

Commitment 6: Benthic Substrate Management

The proponent will implement the approved Benthic Quality Management Program.

Commitment 7: Mangrove System Management

The proponent will prepare a more comprehensive Mangrove Management Program in accordance with the EPA Guidance Statement No. 29, *Benthic Primary Producer Habitat Protection for Western Australia's Marine Environment* (EPA, 2004), as a part of the EMMP that:

1. Avoids direct impacts on all mangrove systems within Cone Bay by ensuring all sea cages and mooring equipment are anchored a minimum of 100 metres from these,
2. Minimises indirect impacts on all mangrove systems within Cone Bay and the zone of influence by utilising water hydrodynamic information for placement of the sea cages and by minimising nutrient and/or chemical input,
3. Monitors the mangrove communities through the use of photography and permanent quadrants,
4. Creates EQC for parameters that may have an impact on the mangrove systems, and
5. Develops a management action plan in the event that environmental parameters are impacted (EQC are exceeded).

Commitment 8: Mangrove System Management

The proponent will implement the approved Mangrove System Management Program.

Commitment 9: Reef System Management

The proponent will prepare a more comprehensive Coral Reef Management Program in accordance with the EPA Guidance Statement No. 29, *Benthic Primary Producer Habitat Protection for Western Australia's Marine Environment* (EPA, 2004), as a part of the EMMP that:

1. Avoids direct impacts on all reef systems within Cone Bay by ensuring all sea cages and mooring equipment are anchored a minimum of 100 metres from these,
2. Minimises indirect impacts on all reef systems within Cone Bay and the zone of influence by utilising water hydrodynamic information for placement of the sea cages and by minimising nutrient and/or chemical input,
3. Ensures that there is no net loss of function or value of reef systems where reefs may be impacted,
4. Monitors reef systems through the use of photography and general observations,
5. Creates EQC for parameters that may have an impact on the reef systems, and
6. Develops a management action plan in the event that environmental parameters are impacted (EQC are exceeded).

Commitment 10: Reef System Management

The proponent will implement the approved Coral Reef System Management Program.

Commitment 11: Biota Management

The proponent will improve the current Biota Management Program as a part of the EMMP that:

1. Minimises direct impacts on all biota at the aquaculture licence site and within the region,
2. Minimises direct and indirect impacts on habitats that marine biota species are directly and indirectly dependent upon,
3. Implements strategies to minimise attraction of fauna to the sea cage system through minimising waste feed and equipment requirements,
4. Minimise boating activity,
5. Promote boating regulations and awareness of boating safety to protect mega fauna and other marine biota in the region,
6. Daily monitoring and recording of all fauna within the vicinity of the aquaculture licence site, and
7. Review of monitoring results on a regular basis.

Commitment 12: Biota Management

The proponent will implement the approved Biota Management Plan.

Commitment 13: Disease and Parasite Management

The proponent will prepare a Barramundi Health Management and Emergency Plan (BHMEP) that will:

1. Minimise the occurrence of disease or parasite outbreak by utilising best practice such as conservative stocking densities and daily monitoring of fish health,
2. Abide by DoF translocation legislation,

3. Notify the DoF Chief Veterinary Officer (CVO) of a suspected disease or parasite outbreak immediately,
4. Limit the spread of disease by best isolating suspected infected fish and/or culling,
5. Develop a sampling protocol in liaison with the CVO to enable correct diagnosis by pathologists at the Veterinary Health Laboratories,
6. Ensure adherence to all instructions given by the CVO in regards to treatment of diseased fish, and
7. Develop a contingency plan for disease and/or parasite outbreak.

Commitment 14: Disease and Parasite Management

The proponent will implement the approved BHMEP. A draft developed by the operating company MFF, is presented in Appendix H.

Commitment 15: Cyclone Procedures Management

The proponent will update and improve the current Cyclone Procedures Protocol that will incorporate:

1. Preparation procedures for the land-based nursery system,
2. Preparation procedures for the sea cage system,
3. Preparation procedures for staff, equipment and other island infrastructure, and
4. Contingencies plan in the event cyclone damage occurs.

Commitment 16: Cyclone Procedures Management

The proponent will implement the approved Cyclone Procedures Protocol.

Commitment 17: Fuel and Chemical Management

The proponent will prepare a Toxic and Hazardous Substances Management Protocol that will include:

1. Correct procedures for fuel and chemical storage,
2. Handling procedures and safety information regarding fuel and chemicals,
3. Best practice methodology to reduce fuel and chemical requirements in addition to handling and storage,
4. A fuel and/or chemical spill contingency plan, and
5. An extensive list of all emergency contacts.

Commitment 18: Fuel and Chemical Management

The proponent will implement the approved Toxic and Hazardous Substances Management Protocol (THSMP). A draft THSMP is presented in Appendix I.

Commitment 19: Staff and Stock Management

The proponent will prepare a Standard Operating Procedures (SOP) protocol for the purpose of staff training, education and induction and stock management that will include the requirements, obligations and procedures to be utilised in relation to:

1. The nursery facility,
2. The sea cage system,
3. Feeding and stock health,
4. Harvesting and transport,
5. Biosecurity measures,
6. Environmental monitoring,
7. Animal husbandry techniques,
8. Staff Occupational Health and Safety regulations (OH&S), and
9. Code of Conduct

Commitment 20: Staff and Stock Management

The proponent will implement the approved Standard Operating Procedures Protocol.

Commitment 21: Environmental Management System

The proponent will develop an Environmental Management System using the principles of ISO14001 – 2004 standards that incorporates:

1. An environmental policy,
2. Key objectives and targets,
3. An EMMP,
4. Regular reviews to ensure maintenance of best practice,
5. Auditing of processes and procedures, and
6. Reporting requirements and processes.

Commitment 22: Environmental Management System

The proponent will implement the approved Environmental Management System.

Commitment 23: Waste Management Plan

The proponent will develop a WMP that incorporates:

1. Waste minimisation, reduction, reuse and recycling principles,
2. Procedures and processes for waste disposal, and
3. Environmental best practice of waste disposal and management.

Commitment 24: Waste Management Plan

The proponent will implement the WMP. A draft WMP is given in Appendix J.

Commitment 25: Best Practice

The proponent will continue to undertake research and development into improving all aspects of the proposal operations including:

1. Annual analysis of industry wide research and development, practices and processes,
2. Research into the use and/or incorporation of improved and relevant techniques, equipment and processes, and
3. Communications, support and participation in industry based Research and Development projects (eg FRDC, Aquafin CRC, DoF, ABFA etc).

9. Conclusion

The investigations undertaken in the preparation of this PER have provided important information about the licence site and surrounding area including:

- The hydrodynamic features of the existing licence area and Cone Bay in general are ideal for sea cage aquaculture because of:
  - Required minimum depths within a well flushed area; and
  - Excellent flushing rates and circulatory patterns that have been shown to be able to support the proposed 1000 tonne production level.

- The hydrodynamic modelling provided positive information and predictions of the proposed deposition and settlement areas enabling MPC to effectively plan mooring systems and fallowing programs.

- The hydrodynamic modelling also demonstrated that there is no interaction of dissolved nutrients between the two adjacent 1,000T fish farms operating at full capacity. The results also indicated that the region as a whole is able to support a much larger production level than is currently being proposed (ie two 1,000T farms).

- The identification of BPPHs and investigations into the potential impact has shown that the existing communities have not been adversely impacted as a result of the existing sea cages. Further investigations and predictions have shown the potential impacts are expected to be minimal due to the ambient environmental conditions and the associated proposed management strategies.

- The Cone Bay EMMP has shown that the ambient environmental conditions of the area are highly variable particularly between wet and dry seasons and between any given sampling day and more often than not reference sites have higher levels of nutrients than the cage sites.

- The EMMP also demonstrated that the natural fluctuations in ambient conditions have a far greater impact on the environmental parameters measured than the sea cages, indicating that the region supports and assimilates much higher nutrient inputs than those proposed by the 1,000T fish farm on a regular basis.

- That the majority of potential impacts resulting from the proposed 1,000T Barramundi aquaculture venture identified in Section 4 can, and will, be avoided.

- For those impacts that cannot be avoided, such as dissolved and solid waste outputs and impacts to the benthic substrate below the cages, MPC is committed to minimising these impacts by the development and incorporation of effective management strategies that ensure environmental best practice.

Investigations into other sea cage culture operations have supported the Cone Bay data by also demonstrating that impacts from sea cage fish farming are not generally detectable over natural variation. (Glencross, 2002; Woods *et al*, 2004; Cheshire *et al*, 2005; Santulli, 2005; Loo *et al*, 2006a; Loo *et al*, 2006b; Tanner *et al*, 2006).

It has also been suggested that increases in nutrients can actually be beneficial to environments that are naturally nutrient-poor, such as the King Sound region (Rossi & Underwood, 2002) as mangrove communities readily take up and assimilate these extra nutrients. Rossi & Underwood (2002) went further to suggest that moderate increases in sediment nutrients have little effect on macrobenthic assemblages.

Results from the tuna industry in South Australia and the salmon industry in Tasmania have demonstrated that sea cage culture does have an impact on the sediment quality. However, this impact has only been observed directly beneath the cages and has shown to be confined to an area less than 40-50m from the cages (Woods *et al*, 2004; Loo M, *pers com*; Pavlineris, undated).

Benthic monitoring results from these industries have also shown that the majority of impacts to the environment, particularly in coastal areas, is a result of terrestrial runoff and not from the sea cage fish farming operations (Huon Estuary Study Team, 2000; Woods *et al*, 2004). These findings are supported by the results from the Cone Bay EMMP which have shown similar impacts from seasonal rainfall and subsequent terrestrial runoff (Appendix D).

Most importantly, the majority of other studies have shown that given appropriate management strategies, particularly effective fallowing programs, any changes to the benthic substrate have all been short term and that most areas show quick recovery and none have had any long term or permanent impacts (Hoskins & Underwood, 2001; Cheshire *et* al, 2005; Vita-Barberan & Marin, 2005;Santulli, 2005; Pavlineris, undated).

Information on sea cage operations in the tropics is limited, however results (eg Marine Harvest Barramundi Farm in the NT) have shown that even in environments considered to be more 'sensitive' to the effects from sea cage outputs, impacts have been minimal and are expected to be maintained by implementing appropriate management strategies (Cahill, 2005; Enesar Consulting, 2006).

The proposal also provides many positive outcomes, including environmental, economic and social benefits that work to ensure ecological sustainability and environmental best practice for both current and future generations. This includes the development of programs such as the IES, WMP, EMMP and overall EMS.

Thus, by effectively managing the potential short term impacts and ensuring the maintenance of environmental best practice through the EMMP and EMS, the Crawford Bay Sea Cage Aquaculture Proposal is not expected to cause any unacceptable, long term environmental impacts and in fact, is expected to result in many positive and improved outcomes for the Kimberley region.

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11. Appendices

APPENDIX A

RIDLEY AQUA-FEED MARINE 45/20 (SINKING) AND SKRETTING NOVA ME COMPOSITION AND SEA CAGE OPERATION DISCHARGE CALCULATIONS

RIDLEY AQUA-FEED
High Performance Aquatic Nutrition

Reference Guide

Marine 45/20

(Sinking)

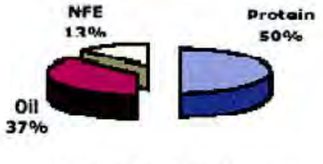
A Complete Diet for Barramundi, Kingfish and other marine species

For starter feed see Starter Feed data sheet

Barra 45/20	4mm
Barra 45/20	6mm
Barra 45/20	8mm
Barra 45/20	10mm
Barra 45/20	15mm

Packaging - 25kg. Bulk bags on request
(Minimum quantity applies)

Energy Distribution



(Values for 4.5mm - Digestible energy)

Store in a cool dry place. Protect from rain and direct sunlight
For guarantee of vitamin levels use within six months of manufacture date

Indicative Composition

Fish meal, oils of marine and vegetable origin, cereals, animal and vegetable protein meals, vitamins and minerals, amino acids, mould inhibitor, antioxidant (ethoxyquin)

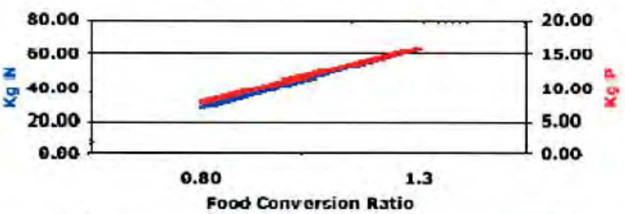
Nutritional Declaration

Crude Protein (%)[1]	45
Crude Fat (%)[1]	20
Nitrogen Free Extract (%)[2]	16
Fibre (%)[2]	2
Ash (%)[2]	11.2
Phosphorus (%)[2]	1.6
Gross Energy (MJ/Kg)[2]	21.29
Digestible Energy (MJ/Kg)[2]	18.44

1 Declared value
2 Due to natural variation in raw materials these are indicative values

Ecological Value

Nitrogen (N) & Phosphorus (P) discharge for 1000 kg fish produced



For pricing and other inquiries, please call Cathy or Lisa on 1000 260 200 or email aquafeed@ridley.com.au

Rev. 3 Issued: 30-Sept-2005

A division of:
Ridley AgriProducts Pty Ltd A.B.N. 94 006 544 145
12–18 Neon Street, Narangba, QLD 4504
(PO Box 187, Deception Bay, QLD 4508)
Telephone: (07) 3203 3422 Fax: (07) 3883 1618

Nova ME

SKRETTING

Nova ME is a high-performance sinking diet for marine fish. Formulated to Skretting global audited specifications, Nova ME provides optimal nutrition and complies with AminoBalance™ and LipoBalance™ principles. Nova ME is a high-quality medium energy feed that can provide good growth performance from fingerling to 5kg body weight. Nova ME is mammalian product free (MP-free) and is suitable for marine fish destined for export markets.

Our range now also includes Nova ME-L. Nova ME-L uses innovative extrusion technology to produce a large pellet with an elliptical profile better suited to the mouth gape of bigger fish. The unique shape results in an attractive sinking and tumbling motion that stimulates feeding activity.

Composition

	3/4	6/9/11 & L
Crude protein	50.0%	45.0%
Crude lipid	17.0%	20.0%
Carbohydrates	15.0%	18.0%
Moisture	8.0%	8.0%
Ash	10.0%	9.0%
Total Phosphorus	1.4%	1.4%
Avail. Phosphorus	0.9%	0.9%

Declared Energy

per kg of feed

	3/4	6/9/11 & L
Gross Energy	21.1MJ	21.7MJ
Digestible Energy	18.6MJ	18.9MJ

Ingredients

Fish meal, plant protein meal, poultry protein meals, wheat, fish oil, poultry oil, vitamins, minerals.

Environmental Impact

Maximum amount of discharge (kg) per 1,000 kg fish produced

Nitrogen (N)	FCR = 1.2	FCR = 1.5
Dissolved Waste	56.4	78.0
Solid Waste	9.6	12.0
Total Waste	66.0	90.0

Phosphorus (P)	FCR = 1.2	FCR = 1.5
Dissolved Waste	6.7	9.4
Solid Waste	6.0	7.5
Total Waste	12.7	16.9

Suggested Pellet Sizes

Pellet size	Barramundi weight	Yellowtail weight
3mm	10g	50g
4mm	60g	150g
6mm	150g	300g
9mm	250g	1000g
11mm	750g	1500g
L	1000g	3000g

LipoBalance™

Our LipoBalance™ concept at the foundation of our alternative oil formulations is based on extensive research, commercial production and testing. Through LipoBalance™, fish oils and alternatives are blended to maintain the consistently high level of Omega-3 (EPA and DHA) fatty acids required in the final product. The process improves our sourcing flexibility, long term sustainability and stabilises costs. LipoBalance™ provides a safe, healthy and proven path to meet final product quality needs without compromising growth, feed conversion or flesh attributes.

ISO 9001:2000 SGS

a nutreco company

www.skretting.com.au

Waste Output Calculator

Feed Type: Nova ME / Marine 45-20

Feed characteristics	*As fed (g/kg)*	*DM*	*Consumed*
Dry matter	920		
Crude protein	450	489	675.0
Crude fat	200	217	300.0
Gross Ash	60	65	90.0
Phosphorus	16	17	24.0
Nitrogen	72	78	108.0
NFE	210	228	315.0
Gross Energy	22.2	24.1	24.1

		FCR	Gain
Amount fed	1500	1.5	1,000
Amount eaten	1500	1380.0	

Feed losses		
Uneaten feed	0%	0
Dry matter leaching	0%	0

Fish Production	
Fish initial biomass	0
Fish final biomass	1000

Biological characteristics		
Nitrogen retention	33%	35.6
Phosphorus retention	40%	9.6
		output
Dry matter digestibility	85%	207.0
Nitrogen digestibility	90%	10.8
Phosphorus digestibility	50%	12.0

Waste Outputs	
Organics/Total solids	207.0
Nitrogen solids	10.8
Phosphorus solids	12.0
Nitrogen - soluble	61.6
Phosphorus - soluble	2.4
Total Nitrogen	72.4
Total Phosphorus	14.4

Appendix B

Hydrodynamic Studies of Cone Bay, Western Australia

Analysis and Results

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1. Executive Summary

1.1. Introduction

Hydrodynamic and Ecological Studies of Cone Bay were conducted in the year 2000 by environmental consultants Brown & Root. Sampling for the study was undertaken from January through to March 2000 and included hydrodynamic modelling of the bay and the submission of a detailed report describing the results. The study investigated a number of features within and surrounding the bay that are relevant to this proposal such as:

- Flushing rates within the bay;
- Circulation patterns within and at the opening of the bay;
- Predicted dispersion of neutrally buoyant particles within the bay;
- Base-line nutrient levels and distribution with the bay; and
- Tidal range and cycle.

The details and results obtained from this study are presented in Section 1.

The Brown and Root study did not incorporate the potential impacts that the presence of sea cages may have within the bay, or the potential for accumulated effects form the two fish farms in adjacent bays operating at full capacity. As a result, Asia-Pacific Applied Science Associates (APASA) undertook additional hydrodynamic modelling in 2006 with a focus on Cone Bay whilst taking in consideration the adjacent Crawford Bay operation. As the Brown and Root study was conducted during the wet season, the APASA models were carried out over both the wet and the dry seasons to investigate the potential seasonal differences. The objectives of this study were:

- Simulation of the circulation within the bays, based on the existing morphology and the introduction of the sea cages;
- Quantification of the flushing rates for the adjacent bays, based on the existing bottom friction conditions and after the inclusion of the sea cages/increased bottom friction;
- Simulation of the dispersion and settlement patterns of fish food and fish waste from the fish farm operation in Cone Bay; and
- Estimate the dispersion and accumulation of dissolved nutrients in the case of total production of the two adjacent fish farms once operating at full capacity.

The details and results obtained from this study are presented in Section 2.

1.2. Findings

1.2.1. Circulation Patterns

Hydrodynamic simulations were undertaken in order to estimate the exchange rate between Cone Bay and the open sea by Brown and Root in 2000 and later in 2006 by APASA whose particular focus was within and around licence site 1465.

Predicted bay wide circulation within Cone Bay over a 24 hour period during a spring tide in 2000 demonstrates that currents are largely running in an east-west direction, at an average speed of 0.30 m/s (maximum: 0.75 m/s). Current speeds varied considerably between locations and ranged between 0.20 m/s and 0.70 m/s during this sampling period (see Section 2.3.1.2).

APASA predicted that current speeds within the central section of the Cone Bay sea cage site (licence site 1465) were in the range of 0.20 to 0.45 m/s for both wet and dry seasons based on the existing seabed conditions. Current speeds were reduced to 0.10 to 0.25 m/s by the inclusion of sea cages, however no changes in current directions were indicated.

In addition, the results obtained implied that the retardation of current speeds would be greatest during peak springs (30-50% decreases in current speeds) and marginal or no change would occur during neap tides. The findings by Brown and Root were confirmed by APASA that current speeds west of Turtle Island out into the middle of Cone Bay are stronger (maximum: 0.80 m/s) and APASA predicted that current speeds in this area would not be affected by the inclusion of sea cages (see Section 2.4).

1.2.2. Flushing Rates

Whilst Brown and Root conducted conservative tracer simulations of six sites within Cone Bay to obtain flushing rates in different parts of the bay, APASA compared the flushing rates within aquaculture licence site 1465 in Cone Bay and the proposed aquaculture licence site in Crawford Bay to examine the effects of the sea cages on local water flushing times.

The Brown and Root findings established rapid flushing of water at all six locations within Cone Bay with all sites experiencing over 90% flushing within two hours (ie. 90% of water at the site is exchanged within 2 hours) during both spring and neap tides. However, bay wide tracer simulations demonstrated differences between transportation of particles in the eastern, central and western ends of Cone Bay. During both spring and neap tides the eastern zone flushes relatively quickly. Results obtained during a neap tide showed that approximately 10% of particles initially placed within the zone remain after only 8 hours and this time is reduced to 2 hours during a spring tide.

For the central and eastern zones, results indicate it may take several days to reduce the number of particles to 10% of their original numbers during a neap tide but again this time is reduced to within 12 hours during a spring tide (see Section 2.3.1.4). This is due to the influence that the incoming and outgoing tidal flow has on the particles. In a neap tide situation a large percentage of the particles are not transported the entire distance from the western zone to the open ocean during an outgoing tide and as a result remain within the bay to then be transported back within this zone during an incoming tide.

The study conducted by APASA utilised a mass-transport model (BFMASS), which calculates the transport and dispersion of material by water currents predicted by the BFHYDRO model. The model results suggested that for the existing morphology, the Cone Bay aquaculture licence site was completely flushed of introduced particles within two days during both spring and neap tides. The flushing rates were not greatly affected by introduction of the sea cages during a spring tide but were a little longer during neap tides (3 days). This is due to the retardation of the tidal flows, which in turn reduced the extent of flushing during outgoing tides (see Section 2.5).

1.2.3. Dispersion and Settlement of Waste Products

To examine the fate of fish waste and food pellets the waste material was simulated separately from within the sea cage area in Cone Bay for a 30 day period for the wet and dry seasons. As a result of other studies demonstrating faecal settlement velocities ranging between 2–5cm/sec (Timmons *et al*, 2001; Cromey *et* al, 2002; Corner *et al*, 2006; Cromey & Black, undated), the average settlement velocity of 3cm/sec has been utilised for the model in the 2006 APASA study.

The release of fish waste and food pellets at eight points was also engaged within the broader section of the aquaculture area in Crawford Bay to account for the possibility of faeces or food overlapping. The results of numerical experiments demonstrated a distinctive tendency for material to settle close to the release sites and along the general east-west tidal axis. The deposition of released waste was dependent on the tidal cycle with accumulation occurring to the east during the incoming tide and west during the outgoing tide. Concentrations were predicted to decrease exponentially with distance from the release points and the sedimentation footprints around neighbouring points of discharge showed some overlap.

Notably, no overlap of the sedimentation footprints from two fish farms was predicted. For the minimum threshold concentration of 0.01 g/m^2/day, settlement distance for fish waste was estimated as up to 250 m from a given discharge source strictly along the main tidal axis. For the fish pellets, this distance was reduced to approximately 130-140 m due to the quicker settling rate (APASA, 2006). Greater detail is provided in Section 2.6.

1.2.4. Dispersion and Accumulation of Nutrients from Two Adjacent Fish Farms

To estimate the dispersion and potential accumulation of dissolved nutrients, equal amounts of conservative and neutrally buoyant material were released from within each aquaculture licence site and simulated for a 30 day continuous release using generated currents for December 2005 and June 2006. Notably the ambient nutrient levels (Total Nitrogen and Total Phosphorous) obtained from the Brown and Root study and the Cone Bay EMMP, were reduced ten-fold for this model (from 130 µg/L to 30 µg/L) to determine if any interaction is a result of the fish farm operations. The model results indicated that the dissolved nutrient concentrations were strongly affected by tidal cycles within the bays. The concentrations increased within the licence area during the periods of slack tidal currents and decreased when the currents became stronger during either the flood or ebb events.

The time series comparisons also showed that the predicted concentrations at the western sector of the licence area were significantly less (maximum 0.01 g/m^3 (10 µg/L)) than that of the dissolved concentrations at the Cone Bay sea cage release site (maximum 0.015 g/m^3 (15 µg/L)), suggesting that any neutrally buoyant waste will be mixed rapidly due to the energetic nature of the surrounding waters. From the obtained model results there was no observed overlap of dissolved nutrient footprints from these two adjacent medium production fish farms at full production (APASA, 2006).

Results from the Brown and Root nutrient study demonstrate clear spatial differences within Cone Bay. During the sampling period of 12 weeks the eastern zone was characterised by elevated levels of phytoplankton, total suspended solids (TSS) and organic matter as demonstrated by higher total nitrogen (TN) and total phosphorous (TP) levels, whilst the western zone was not. During the January to March 2000 period, water quality was strongly influenced by rainfall, with levels of total suspended solids, organic matter (TN and TP) and phytoplankton increasing after heavy rainfall, and significant reductions after extended dry periods. Peaks in TSS, TN and phytoplankton coincided with coastal run-off following heavy rainfall (see Section 2.3.2.2 for rainfall and nutrient data). Data collected to date demonstrate nutrient levels in and surrounding Cone Bay are greatly influenced by factors such as tides and season and as a result great variability occurs between sites.

1.3. Conclusion

Overall both the studies demonstrated similar outcomes regardless of the year each study was undertaken, which provides an increased confidence and accuracy in interpreting the results and making predictions. The main conclusions that can be taken from both of these studies relevant to the proposed 1,000T Barramundi production proposal include:

- No changes to the circulation patterns of the bay will occur,
- Slight reduction of current speeds at the peak springs are expected to occur with the implementation of the cages,
- A slight decrease in the flushing rate may occur during the neap tides.
- Solid waste products from the fish farms may be deposited up to 250m from the sea cages, however at very low concentrations (0.01 – 0.05g/m^2/day) with the majority settling close to the sea cages (0.1 -0.5g/m^2/day).
- No interaction or potential accumulation of dissolved nutrients is expected to occur as a result of the two adjacent farms operating at full capacity.

2. Brown and Root Study – 2000

HYDRODYNAMIC AND ECOLOGICAL STUDIES IN CONE BAY, WESTERN AUSTRALIA

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July 2000

PN9090-GC-002, Rev.0

2.1. Summary

In 2000, a Hydrodynamic and Ecological Study was undertaken in Cone Bay by Brown and Root. A number of sites were selected within the bay (Figure B1) and predictive modelling and simulations of the results were carried out. The results from 6 sites demonstrated that there is wide circulation of water within Cone Bay over a 24 hour period. Current direction is predominately east-west and speed can be up to $0.6ms^{-2}$ (Brown & Root, 2000). Flushing rates were determined to be very high, with all sites in the study experiencing over 90% flushing within two hours and E-folding times less than one hour. This rapid flushing is to be expected with the high velocity currents experienced at these sites.

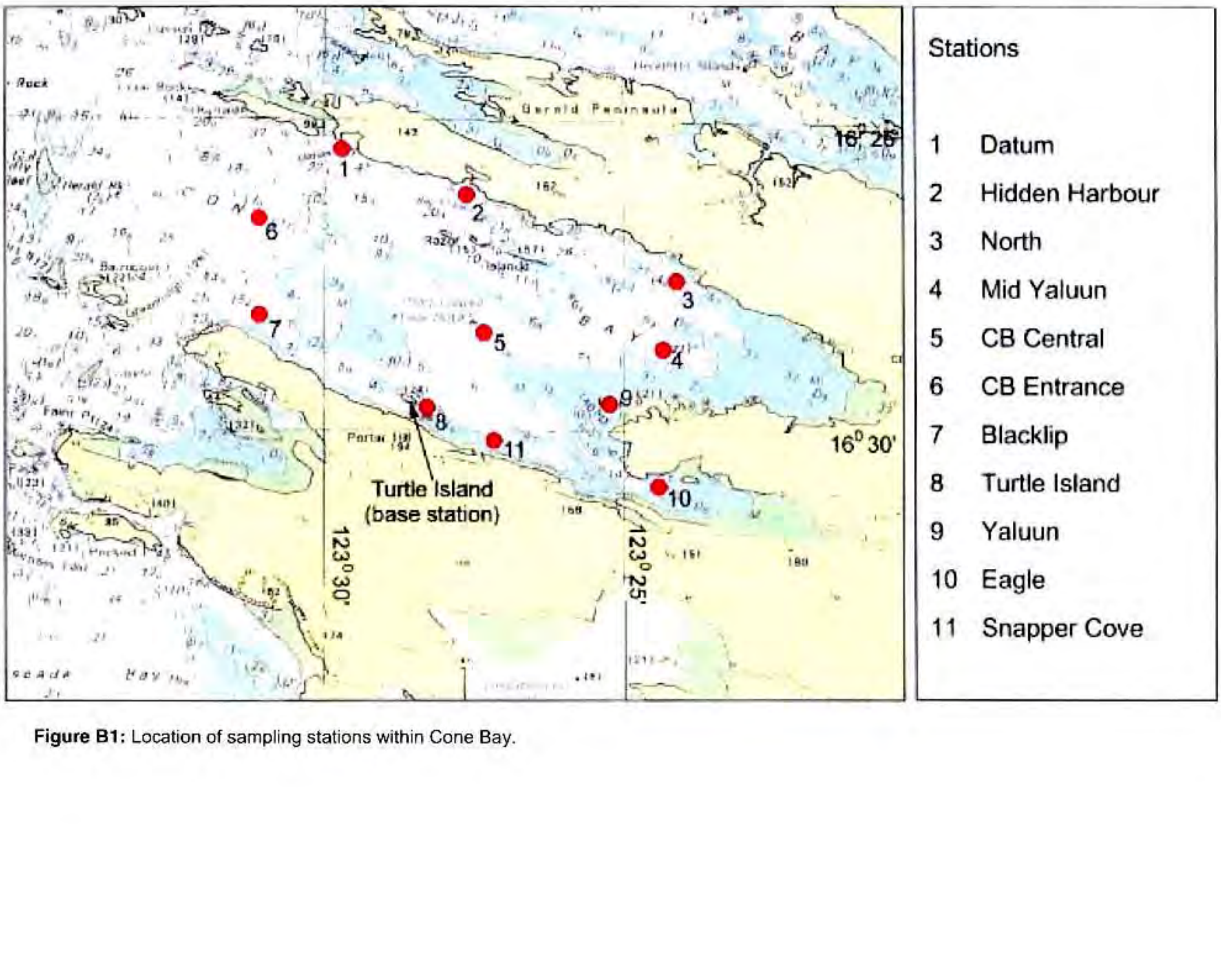


Figure B1: Location of sampling stations within Cone Bay.

2.2. Methodology

2.2.1. Biological Component

The original study was designed so that oyster health could be directly related to water quality information (nutrients, particulate organic matter, and phytoplankton levels) as well as hydrodynamic processes. The sampling period - January to March 2000 - coincides with a period of optimum pearl oyster growth, prior to the rest period for the shells, as winter approaches and water temperatures begin to drop in April (Brown and Root, 2000).

For this purpose, eleven sampling locations were chosen within Cone Bay (Figure B1; Table B1). At each of these locations a number of parameters were monitored over a three month period (Table B2):

- Water quality samples (nutrients, phytoplankton, suspended solids, suspended organic matter) were collected on a weekly basis for twelve weeks;
- In order to validate the hydrodynamic model, drogues were deployed at various locations within the bay during incoming and outgoing tides during spring tide, and their speed and direction were determined. In addition, bathymetric data, as well as tidal information, were collected during the field study.

Table B1: Details, Cone Bay sampling stations

Station	Location	Depth (m)*	Easterly	Northerly	Longitude	Latitude
1	Datum	31.4	553560	8184333	123° 30.100	16° 25.312
2	Hidden Harbour	14.2	557797	8183134	123° 32.483	16° 25.961
3	North	8.4	563940	8180229	123° 35.945	16° 27.531
4	Mid Yaluun	6.0	563817	8178009	123° 35.875	16° 28.728
5	CB Central	6.6	557770	8179065	123° 32.486	16° 28.185
6	CB Entrance	22.4	551571	8181833	123° 28.978	16° 26.658
7	Blacklip	8.6	551507	8178907	123° 28.943	16° 28.258
8	Turtle Island	3.3	556434	8176560	123° 31.674	16° 29.549
9	Yaluun	2.3	561731	8176846	123° 34.704	16° 29.353
10	Eagle	8.1	563253	8174066	123° 35.564	16° 30.862
11	Snapper Cove	1.3	558097	8175398	123° 32.748	16° 30.167

* Depth estimated from actual depth during sampling, and converted to depth at low tide during spring tide, based on Yampi Sound tide table (Dept of Defence, 1999). Note that low tide in Cone Bay during Spring tide is approximately 1 m less than at Yampi Sound.

Table B2: Sampling schedule and field activities

Week	Date	Water Quality*	Spat measurements	Water column profiling	Other activities
1	20 January	√ (High)	-	√	-
-	21 January	-		-	Drogues, bathymetry
-	22 January	-	√	-	Drogues, bathymetry
2	23 January	√ (Incoming)	-	√	-
3	29 January	√ (Outgoing)	-	-	-
4	6 February	√ (Low)	-	-	-
-	7 February	-	√	-	-
5	13 February	√ (Incoming)	-	-	-
6	20 February	√ (Low)		-	-
-	21 February	-	√	-	-
7	28 Feb	√ (Outgoing)	-	-	-
8	7 March	√ (High)	-	-	-
-	9 March	-	√	-	-
9	12 March	√ (Outgoing)	-	-	-
10	17 March	√ (High)	-	-	-
-	18 March	-	√	-	
11	23 March	√ (Incoming)	-	√	Tidal measurements
12	25 March	√ (Low)	-	√	Tidal measurements
-	26 March	-	-	-	Tidal measurements
-	28 March	-	√	-	

Tidal cycle during sampling in brackets

2.2.2. Desktop Hydrodynamic Modelling

The objective of desktop hydrodynamic modelling was to evaluate the rate of flushing of selected sections of the bay, the dilution of dissolved nutrients, as well as the transport of particulate matter that enters the Bay. This would give the answer to a number of basic questions:

- The rate of food dissipation in Cone Bay; and the rate of exchange of selected areas within the Bay with surrounding water;
- The exchange rate between the bay and the open sea was simulated.
- The trajectories of particulate (suspended organic and inorganic matter, including phytoplankton, resuspended substrate and detritus) and dissolved components (nutrients) as a function of tidal movements were modelled for six key locations within the bay.
- In addition, current strength and direction were determined at various tidal periods, as well as the rate of

exchange of the entire bay.

The above aspects are addressed by means of hydrodynamic and transport modelling, by monitoring the transport and dilution of conservative tracers (e.g. 'particles'; 'dye') released at selected locations within the bay as well as on the entrance into the bay. Therefore the modelling does not address any particular water quality variable but illustrates the effect of oceanographic features of the bay on transport and dilution of parameters (particulate organic matter; nutrients, phytoplankton) that either already exist at various locations or that they are adverted into the bay by ocean currents.

The model was verified against field data from two sources:

- Water velocities measured using drogues released at ten sites throughout the bay ('drogue studies');
- Changes in depth during tidal cycles, measured South of Turtle Island ('Tidal cycle').

2.2.3. Drogue Studies

In order to determine the rate of water exchange within the bay, drogue studies were undertaken during January (Table B2). Sub-surface (0.5 m depth) and mid-water (5 m depth) drogues (attached to surface floats) were deployed at various tidal phases and their movement traced over 30 – 60 minutes, depending on their speed. For this purpose, a small vessel located each drogue at regular intervals and its position was determined by means of a hand-held GPS. The distance covered was calculated from change in position, using triangulation, and the speed was calculated from the time interval.

2.2.4. Tidal Cycle

Changes in depth during tidal cycles were measured over a three day period in March (23 March, 6 PM, until 26 March, 6 AM). For this purpose, a Hydrolab Datasonde probe was deployed from a mooring, placed underneath one of the pontoons South of Turtle Island. The probe was attached to a concrete weight, and kept vertical by means of a sub-surface float. The distance between probe and weight was kept to a minimum (< 0.5 m from the substrate), to avoid vertical movement by tidal currents. The probe was programmed to record depth at 30 min intervals, and data were downloaded into Excel on completion of field measurements. Depth measurements were corrected by a constant factor, so that mean depth corresponded with that of Yampi Sound (5.8 m above datum). Cone Bay measurements were overlaid onto predicted tides for Yampi Sound and Derby (Department of Defence, 1999).

As part of hydrodynamic modelling, the tide was simulated using five major tidal constituents from Yampi Sound for the year 2000 (Table B3). These constituents also form the basis for the 2000 Yampi Sound tide calculations, as provided in the Australian tide tables (Dept of Defence, 1999). For the baywide circulation model (Appendix A1), this set of tidal constituents was applied over the whole model boundary.

Table B3: Tidal constituents for Yampi Sound

	Major tidal constituents				
	M2	S2	N2	K1	O1
Amplitude	2.741	1.642	0.429	0.294	0.176
Angle	322.0	30.4	289.3	303.5	282.7

Further refinements were later implemented as part of tracer simulations modelling by including other the tidal constituents (e.g. from Derby).

2.2.5. Bathymetry

Bathymetry of Cone Bay was derived from unpublished hydrographic surveys by the Royal Australian Navy (RAN), under license Number 0188SL of the Australian Hydrographic Office (signed: 6 December 1999). Six RAN charts formed the basis for bathymetry:

Fairsheets – V5/291 – (date 1975):

- Sheet 3565 – II SE – Tiffy Reef
- Sheet 3565 – II NW – High Island
- Sheet 3565 – II SW – Mermaid Island
- Sheet 3564 – IV NW– Kimbolton
- Sheet 3565 – IIISW – Cone Bay
- Sheet 3565 – IV SE – Touts Beach

Depth contours were digitised to provide geo-referenced depths, using 5 m contour intervals. These were imported into modelling software, and mean depths were assigned to cells of 250 by 250 m. To provide a better representation of the circulation in Cone Bay as a result of oceanic currents ('boundary conditions'), bathymetric data from the depth chart for Buccaneer Archipelago and King Sound (Chart Aus 733, Scale 1: 150 000; RAN, 1992) were also digitised and overlayed, together with the detailed survey data.

The bathymetry was then modified manually to facilitate and improve the model's computation of the circulation. The bathymetry used in the simulation is presented in Figure B2

2.2.6. Model Description

The model that is applied for this investigation is a three-dimensional numerical model called the Hamburg Shelf Ocean Model (HAMSOM), which was described by Backhaus (1985) and Stronach et al. (1993). The model was originally developed for oceanographic studies in the North Sea (Backhaus and Hainbucher 1986). However, it has been used at a number of locations around the world (Backhaus et al. 1987; Pohlmann 1986; Stronach et al. 1993).

Locally, the model has been successfully applied in the analysis of the hydrodynamic processes during the Perth Coastal Waters Study (Pattiaratchi and Knock 1995) and is currently being used in the Perth Long-term Ocean Outlet Monitoring programme (Kinhill 1997a, 1997b, 1998a, 1999). In the Cockburn Sound area, the model was verified and used to investigate the flushing of proposed harbour developments within the Sound for the Department of Environmental Protection (Kinhill 1998b, 1998c).

The simulation domain that was used for the modelling work in this study extends 30.5 km North–South and 43.5 km east–west. The computational grid was 250 m × 250 m, which gave 122 computational cells in the North–South direction and 174 cells in the east–west direction. The parameters used in the simulations are given in Table B4. No density effects were included in the simulations. The effects of Coriolis force, tides and the Leeuwin current were included in the simulations.

Table B4: Parameters used in the numerical simulations

Parameter	Baywide circulation (January 2000)	Tracer simulations (Jan & March 2000)
Number of cells N–S (horizontal plane)	122	122
Number of cells E–W (horizontal plane)	174	174
Number of layers (vertical plane)	4*	4*
Grid size in horizontal plane	250 m	250 m
Δt time step (seconds)	30	30
Fc bottom friction (-)	0.0025	0.0025
AH horizontal eddy viscosity (m2/s)	100	50
Boundary conditions at open boundaries	Orlanski condition	Orlanski condition

Note vertical layers: 5 m; 10 m; 15 m; ocean floor

2.2.7. Baywide Circulation

Initial baywide circulation hydrodynamic modelling ('Baywide circulation') was undertaken prior to field activities (Kinhill 2000), to assist in site selection. This work described broad scale circulation patterns within Cone Bay, and estimated current velocities at various tidal cycles, based on a typical day during Spring tide at the start of field activities (January 2000).

2.2.8. Tracer Simulations

Further hydrodynamic simulations ('Tracer simulations') were undertaken to estimate the flushing rate both for six sites within Cone Bay, and for the whole bay. Flushing rates were determined for each site by modelling the change in total mass over time of a conservative tracer released within the site. A conservative tracer is a parameter (particles, dye) which can be considered to be chemically inert (ie. no uptake by biota, not chemically active, and no adsorption by substrate) so that concentrations are only determined by the rate of dilution and/or dispersion. The results are compared using 'e-folding' time, defined as the time taken for the mass of tracer to be reduced to 1/e (or about 37 %) of its initial value.

The rate of flushing (e-folding time) was assumed to fit the exponential equation Ct = C0 e -t/T, where C0 is the initial concentration at t = 0, and T is the time constant. The flushing rate is defined as the time taken for the concentration Ct to drop 1/e of its original value, C0, so that the flushing time, t, equals the time constant T. A linear regression of ln C over time thus defines the slope of the line as (-1/T) and the intercept as ln C0. E-folding time can be calculated from the inverse of the slope of the linear fit.

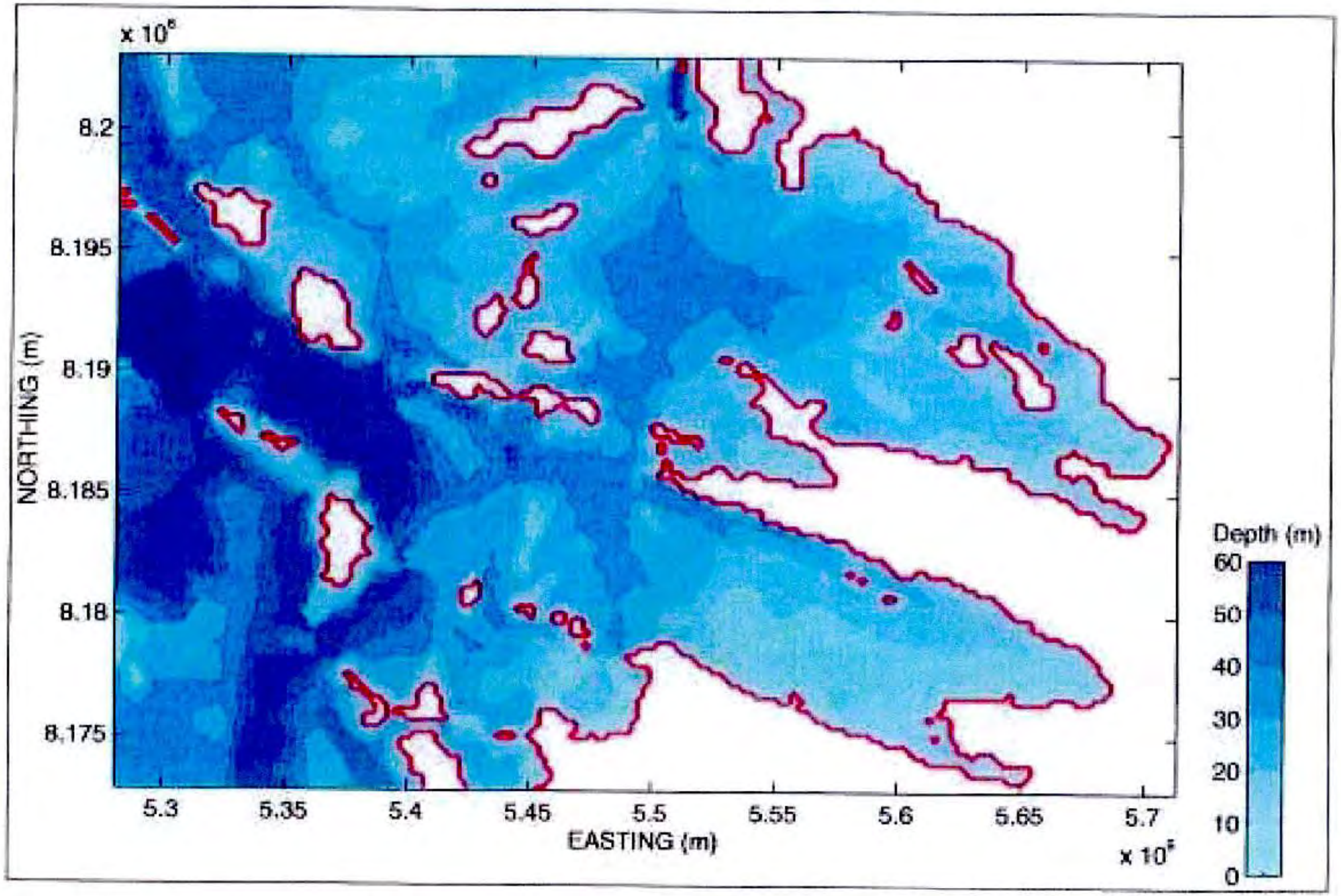


Figure B2: Bathymetry of Cone Bay used for hydrodynamic model simulation.

Tracer simulations for six sites within Cone Bay

The tracer simulations for the six sites were timed to coincide with the dates where field tidal data was available (23 to 28 March 2000). The tracer in the simulations was 'released' at known concentrations at each of the studied locations at midnight on 22 March 2000, and their change in concentration as a function of tidal movements was simulated over time. Each of the six modelled sites cover approximately a 1500 m x 1500 m area. The locations of the sites correspond to biological sampling stations and drogue release sites, as shown in Table B5.

Table B5: Relation between tracer simulation sites and biological sampling stations

Site in model	Station No	Station Name
1	1	Datum
2	2	Hidden Harbour
3	4	Mid Yaluun
4	5	CB Central
5	8	Turtle Island
6	10	Eagle

Bay-wide tracer simulations

The bay-wide tracer simulation was undertaken by simulating the travel of neutrally buoyant particles released at a depth of some 3 m below the water surface, at various locations in the bay. Based on their initial locations, the particles were divided into three groups, reflecting three zones within the bay: the entrance, the central and the eastern (interior) zone of the bay, as shown in Figure B3

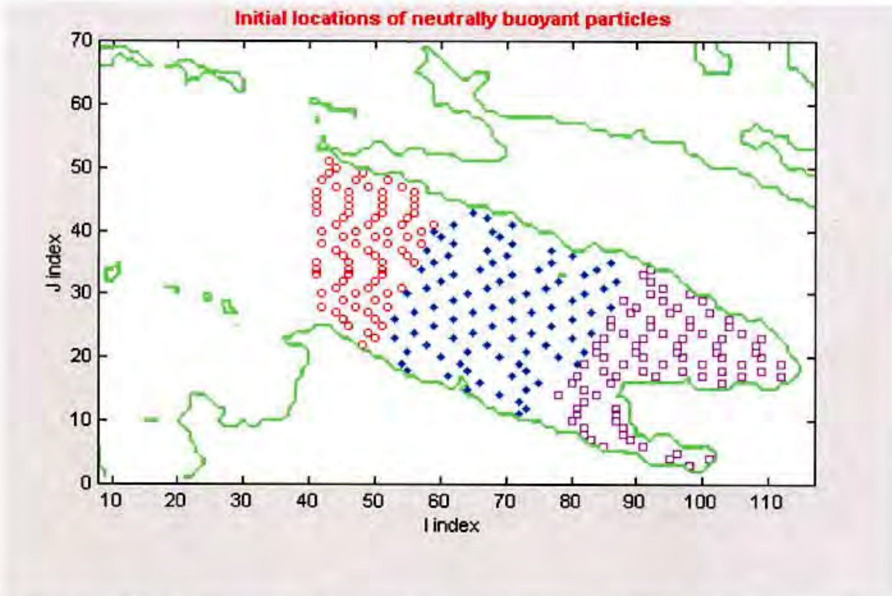


Figure B3: Tracer simulation: Initial locations of the neutrally buoyant particles, grouped into three zones, representing the entrance, the centre and the interior of the bay.

2.3. Findings

2.3.1. Hydrodynamic Modelling

2.3.1.1. Tidal Depth in Cone Bay

Depth as a function of tidal movement was measured at a fixed location in Cone Bay between 23 March and 26 March. This period coincided with spring tide, with a maximum tidal range of between 0.9 – 10.7 m (mean high tide: 10.2 m; mean low tide: 1.4 m). Cone Bay depths were corrected to Yampi Sound datum. During the same period, tides in Cone Bay ranged between 2.0 – 9.4 m (mean high tide: 9.4 m; mean low tide: 2.2 m). Thus, during spring tide the tidal range within Cone Bay is around 0.8 m less than the predicted tidal range in Yampi Sound. In addition, high tide is around 72 minutes behind Yampi Sound, while low tide is around 51 minutes behind that of Yampi Sound. Note that differences during neap tides are likely to be slightly different from those observed during spring tides, as reported above. There was good correspondence between measured tidal patterns and tidal changes predicted by the hydrodynamic model

2.3.1.2. Drogue Studies

Drogue studies were undertaken to provide a field validation of predicted current speeds and directions by the hydrodynamic modelling exercise. A total of 223 drogue measurements were undertaken between the 21st and 23rd January 2000 (spring tide). Each measurement was over an average of 10 minutes, during which an average of 218 m was covered by the drogues. Average current speed in Cone Bay during this period was 0.3 m s-1 (max: 0.75 m s^{-1}). Currents are expected to be less during neap tide.

Current speeds varied considerably between locations, with highest mean speeds of 0.6 m s^{-1} (but up to 0.7 m s^{-1} maximum) measured at Blacklip (Table B6). Strong currents were also measured at Datum and CB Entrance (both 0.5 m s^{-1}); Eagle (0.4 m s^{-1}); CB Central, Hidden Harbour and Razor Island east (all 0.3 m s^{-1}). Currents were less strong at Mid Yaluun and Snapper Cove (0.2 m s^{-1}). Currents at Station 3 (North) were measured just after low tide, and do not represent maximum currents.

Differences between surface currents and currents at 5 m depth were marginal (Table B6). All currents ran in a predominantly WNW during outgoing tide, and ESE direction during incoming tide, except at CB Central, where currents ran in a North-Southerly direction. Data further demonstrate that wind had little effect on currents within Cone Bay, as highest current speeds (at Blacklip) were measured during strong winds (>20 knots NW), in an opposite direction to prevailing currents at this location (Table B6). Observed currents correspond well with velocities predicted by baywide circulation modelling, which was undertaken prior to field measurements. The predicted models are demonstrated in Figures B4.1 – B4.8.

Table B6: Drogue study: results

Date	Time (hh:mm)	Predicted tide (Yampi Sound)	Location	Wind	Tide	Depth (m)	Mean speed ($m\ s^{-1}$)	Max speed ($m\ s^{-1}$)	Min speed ($m\ s^{-1}$)	Current direction	Number of measurements
21 Jan. '00	7:38 – 8:25	Low, 05:34 (1.5 m)	Mid Yaluun	NE, 5 – 12 knots	Outgoing	5	0.20	0.25	0.18	WNW	3 x 2
21 Jan. '00	7:38 – 8:25	Low, 05:34 (1.5 m)	Mid Yaluun	NE, 5 – 12 knots	Outgoing	0.5	0.21	0.25	0.18	WNW	3 x 2
21 Jan. '00	10:36 – 11:17	High, 11:39 (9.1 m)	Snapper Cove	NE, 5 – 12 knots	Incoming	5	0.16	0.20	0.11	ESE	2 x 3, 1 x 2
21 Jan. '00	10:36 – 11:17	High, 11:39 (9.1 m)	Snapper Cove	NE, 5 – 12 knots	Incoming	0.5	0.17	0.19	0.15	ESE	2 x 3, 1 x 2
21 Jan. '00	14:38 – 15:18	High, 11:39 (9.1 m)	Datum	W, 6 – 8 knots	Outgoing	5	0.50	0.55	0.46	WNW	3 x 4
21 Jan. '00	14:38 – 15:18	High, 11:39 (9.1 m)	Datum	W, 6 – 8 knots	Outgoing	0.5	0.47	0.51	0.42	WNW	3 x 4
21 Jan. '00	15:32 – 15:54	Low, 17:46 (2.2 m)	Hidden Harbour	W, 6 – 8 knots	Outgoing	5	0.27	0.29	0.24	WNW	3 x 3
21 Jan. '00	15:32 – 15:54	Low, 17:46 (2.2 m)	Hidden Harbour	W, 6 – 8 knots	Outgoing	0.5	0.27	0.28	0.27	WNW	3 x 3
22 Jan. '00	7:05 – 7:30	Low, 06:18 (1.1 m)	North Section	NE, 5 – 11 knots	Incoming/slack	5	0.07	0.08	0.06	ESE	1 x 3, 2 x 2
22Jan. '00	7:05 – 7:30	Low, 06:18 (1.1 m)	North Section	NE, 5 – 11 knots	Incoming/slack	0.5	0.09	0.11	0.07	ESE	1 x 3, 2 x 2
22 Jan. '00	10:13 – 10:46	Low, 06:18 (1.1 m)	Razor Island east	NNW, 12 knots	Incoming	5	0.31	0.45	0.22	ESE	3 x 3
22Jan. '00	10:13 – 10:46	Low, 06:18 (1.1 m)	Razor Island east	NNW, 12 knots	Incoming	0.5	0.28	0.45	0.16	ESE	3 x 3
22 Jan. '00	10:58 – 11:29	High, 12:22 (9.6 m)	CB Central	NNW, 12 knots	Incoming	5	0.32	0.35	0.31	ESE	1 x 3, 2 x 2
22Jan. '00	10:58 – 11:29	High, 12:22 (9.6 m)	CB Central	NNW, 12 knots	Incoming	0.5	0.34	0.36	0.31	ESE	2 x 3, 1 x 2
22 Jan. '00	15:37 – 15:50	Low, 18:31 (1.8 m)	CB Entrance	NW, 16 – 20 knots	Incoming	5	0.49	0.51	0.47	S	3 x 2
22Jan. '00	15:37 – 15:50	Low, 18:31(1.8 m)	CB Entrance	NW, 16 – 20 knots	Incoming	0.5	0.44	0.53	0.39	S	3 x 2
23 Jan. '00	10:46 – 11:32	High, 13:01 (9.9 m)	Eagle	NW, < 4 knots	Incoming	5	0.42	0.47	0.35	ESE	1 x 3, 2 x 4
23 Jan. '00	10:46 – 11:32	High, 13:01 (9.9 m)	Eagle	NW, < 4 knots	Incoming	0.5	0.44	0.50	0.35	ESE	3 x 4
23 Jan. '00	16:58 – 17:14	Low, 19:13 (1.6 m)	Blacklip	NW, > 20 knots	Outgoing	5	0.62	0.67	0.55	WNW	3 x 2
23 Jan. '00	16:58 – 17:14	Low, 19:13 (1.6 m)	Blacklip	NW, > 20 knots	Outgoing	0.5	0.61	0.67	0.53	WNW	3 x 2

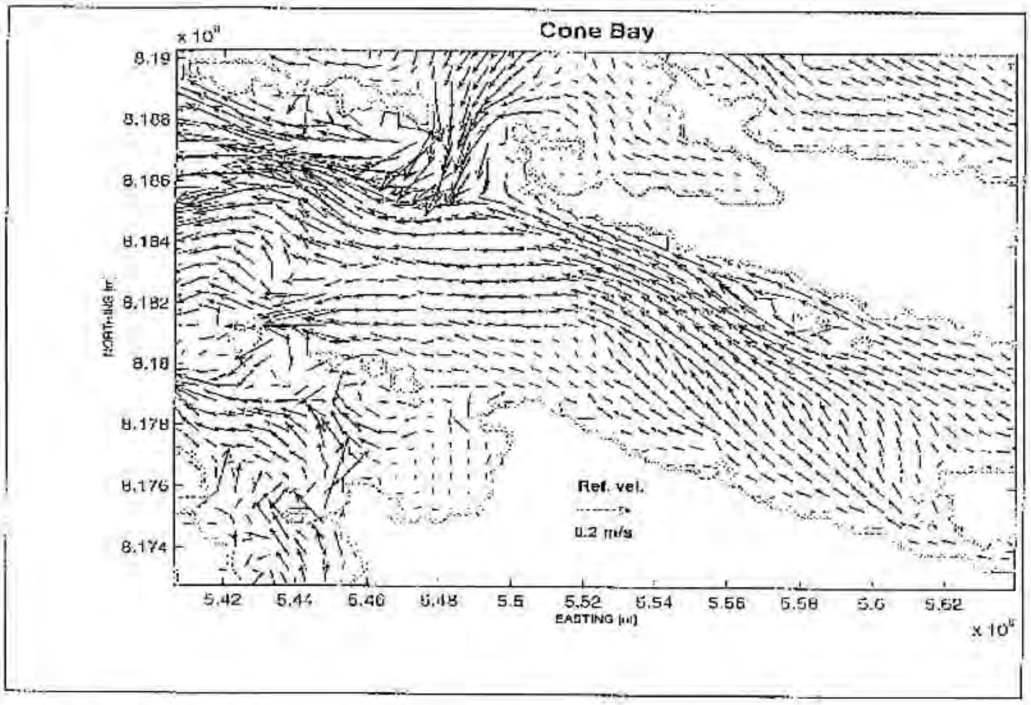


Figure B4.1: Computed circulation in Cone Bay at 12am – just after low tide (for corresponding elevations used in model runs refer to Figure 4)

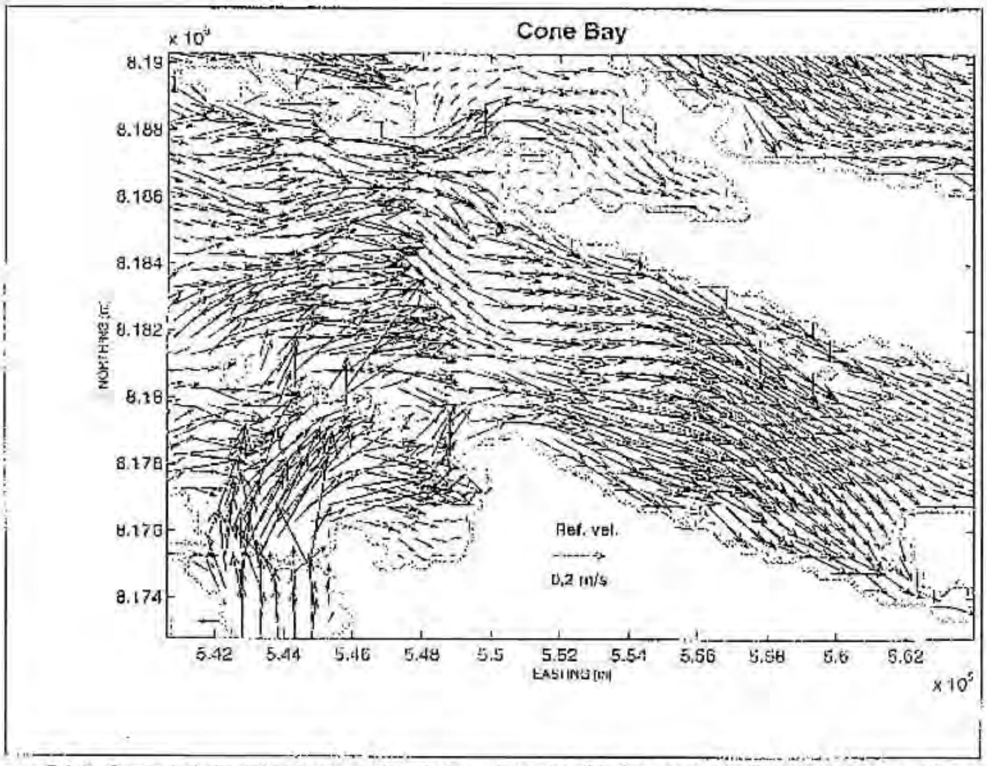


Figure B4.2: Computed circulation in Cone Bay at 3am – incoming tide (for corresponding elevations used in model runs refer to Figure 4)

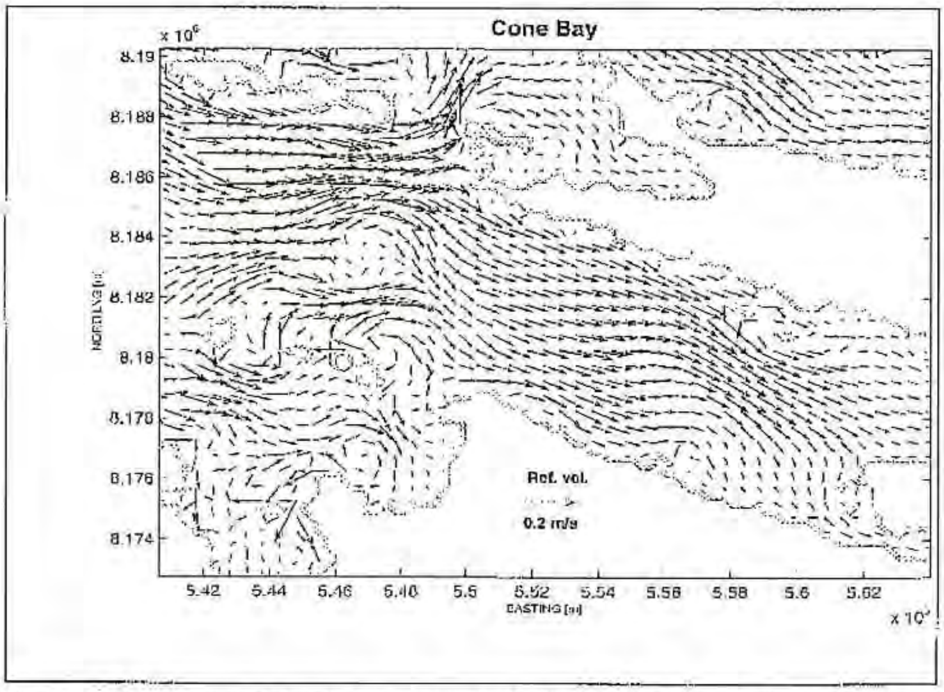


Figure 4.3: Computed circulation in Cone Bay at 6am – just before high tide (for corresponding elevations used in model runs refer to Figure 4)

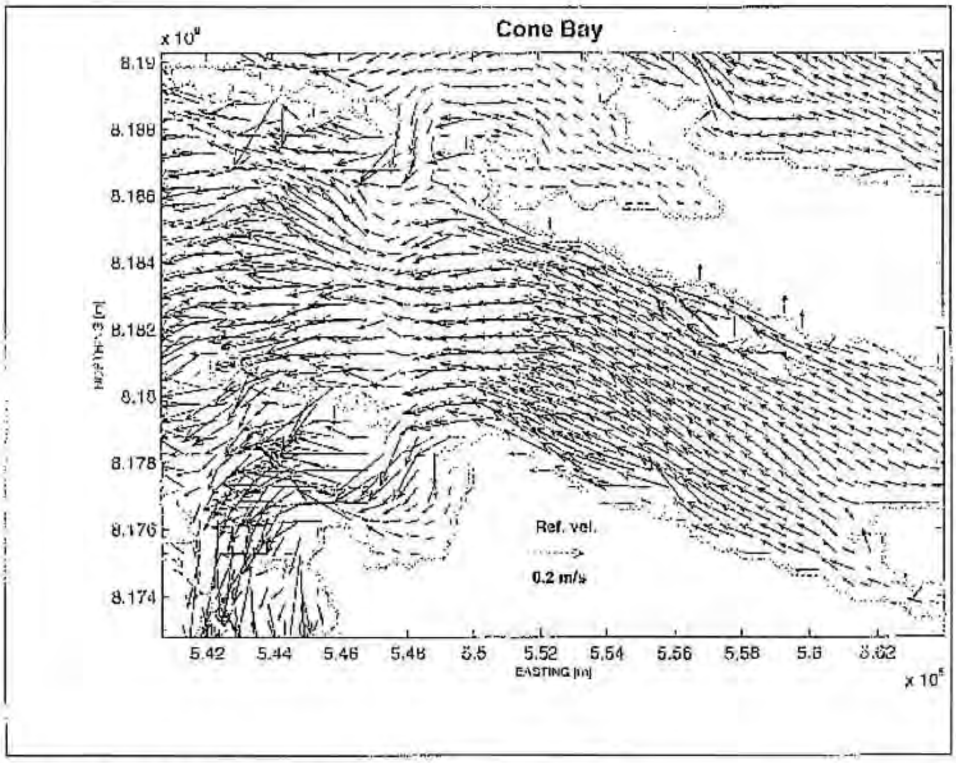


Figure B4.4: Computed circulation in Cone Bay at 9am - outgoing tide (for corresponding elevations used in model runs refer to Figure 4)

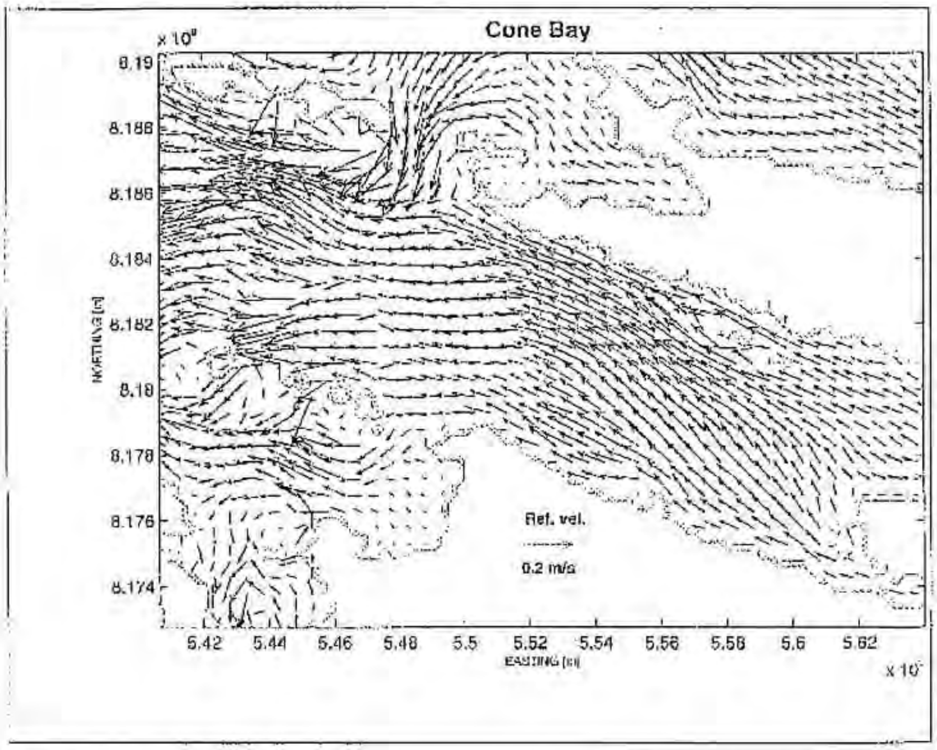


Figure B4.5: Computed circulation in Cone Bay at 12pm – just before low tide (for corresponding elevations used in model runs refer to Figure 4)

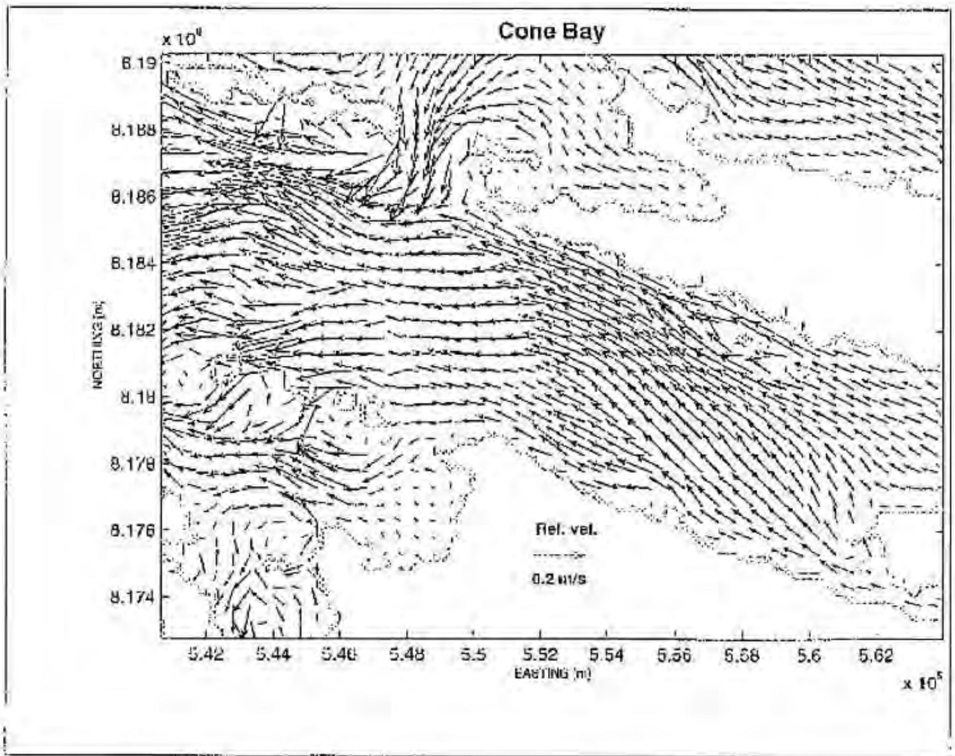


Figure B4.6: Computed circulation in Cone Bay at 3pm - incoming tide (for corresponding elevations used in model runs refer to Figure 4)

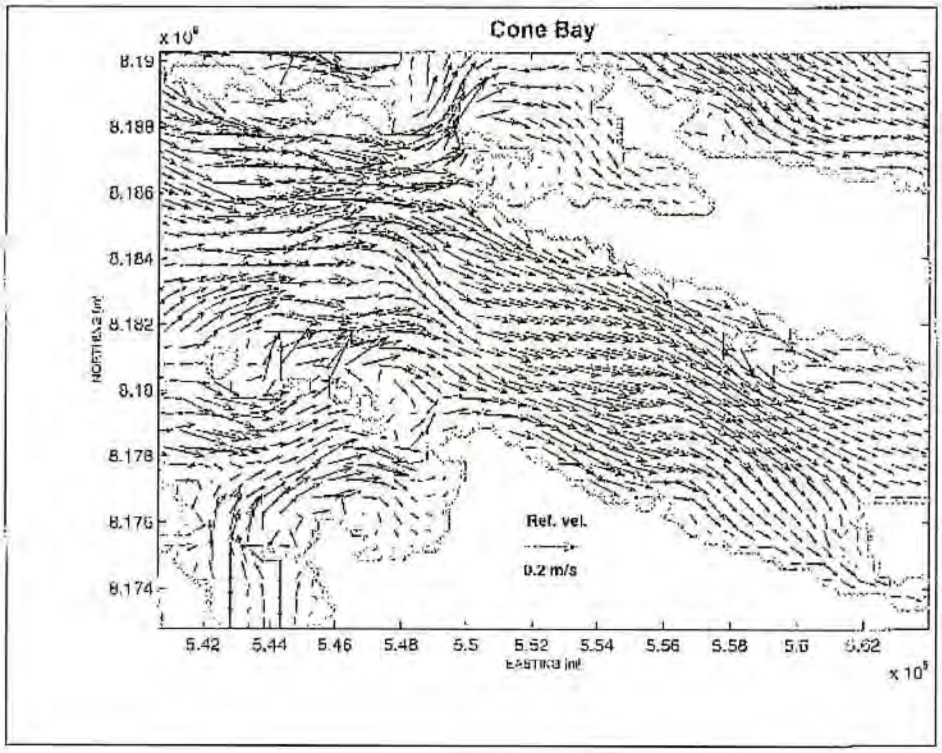


Figure B4.7: Computed circulation in Cone Bay at 6pm – just before high tide (for corresponding elevations used in model runs refer to Figure 4)

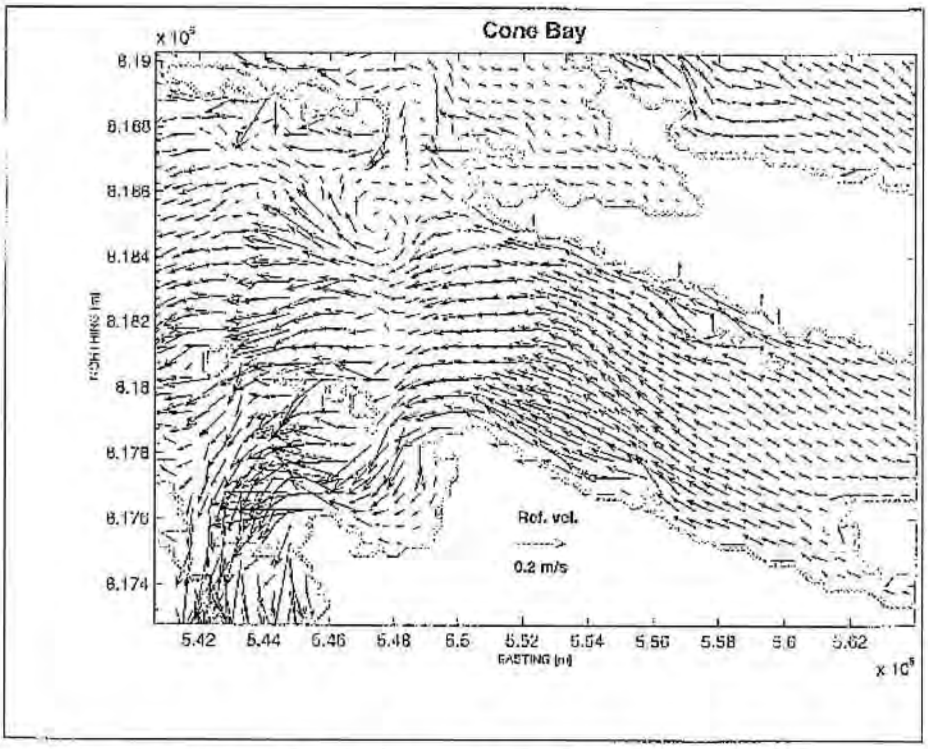


Figure B4.8: Computed circulation in Cone Bay at 9pm – just after high tide (for corresponding elevations used in model runs refer to Figure 4)

2.3.1.3. Baywide Circulation Modelling

Figure B4 presents the water levels in the middle of Cone Bay at a depth of 10 m, which formed the basis for baywide circulation modelling. The elevation range associated with this circulation is approximately 5.4 m. Predicted ocean current velocities over the Cone Bay area for a typical day (January 2000), as predicted by a baywide circulation modelling exercise, are provided in Appendix A1

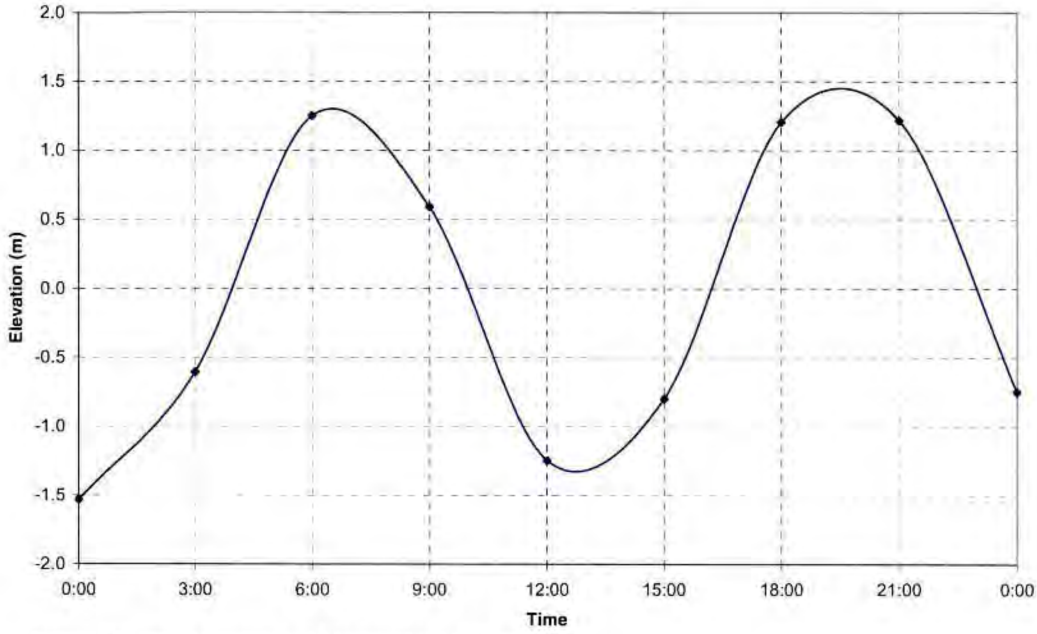


Figure B5: Model simulation of tide elevations in Cone Bay.

2.3.1.4. Tracer Simulation Modelling

Tracer simulations for six sites within Cone Bay

Figures B6.1 to B6.6 show the progressive flushing over time in each of the six sites of 1.5 by 1.5 km within Cone Bay, based on tidal data for 23 – 28 March 2000 (spring tide). These results demonstrate that the flushing rate (the e-folding time, during which the initial concentration drops by 1/e, to approximately 37%; Section 2.6.4) is generally less than 1 hour. The site is 95% flushed within 2 hours during the modelled period (ie. 95% of water resident at the site is exchanged within 2 hours). Flushing rates are somewhat lower during neap tide, although 95% flushing still takes place within a few hours.

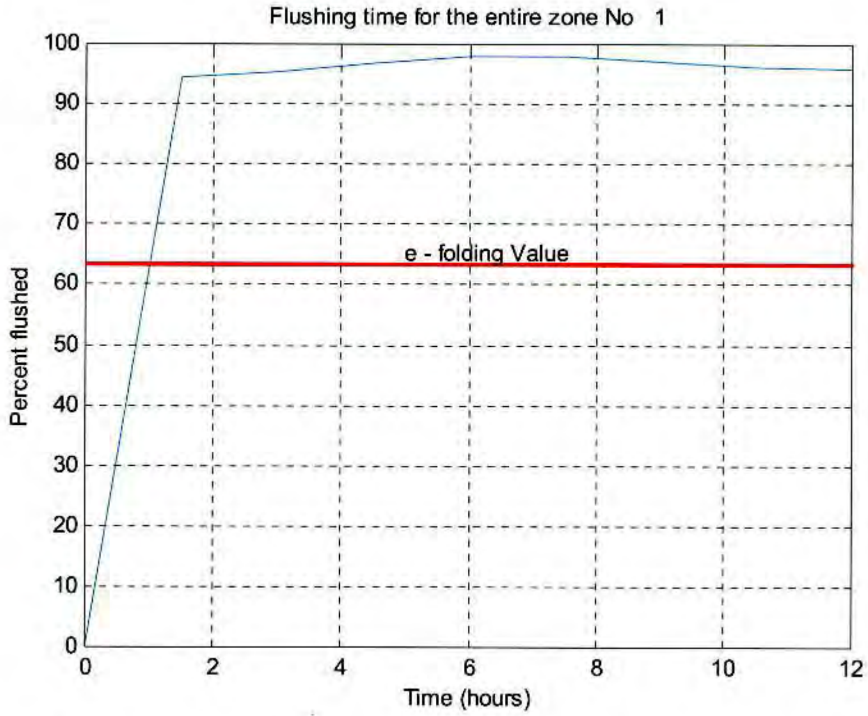


Figure B6.1: Simulated flushing time for Site 1: Datum (Station 1) for 22 March 2000 (spring tide)

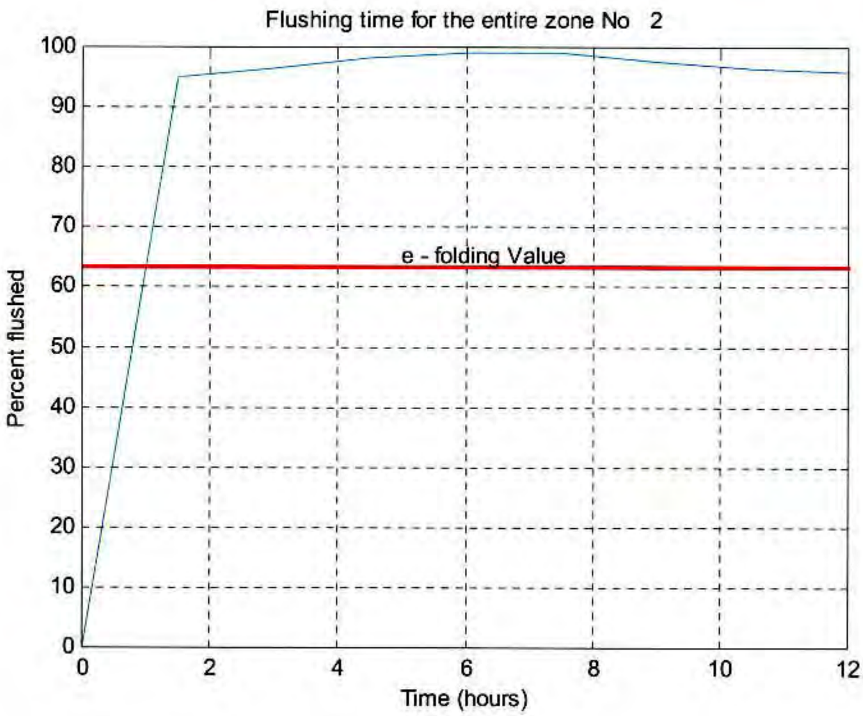


Figure B6.2: Simulated flushing time for Site 2: Hidden Harbour (Station 2) for 22 March 2000 (spring tide)

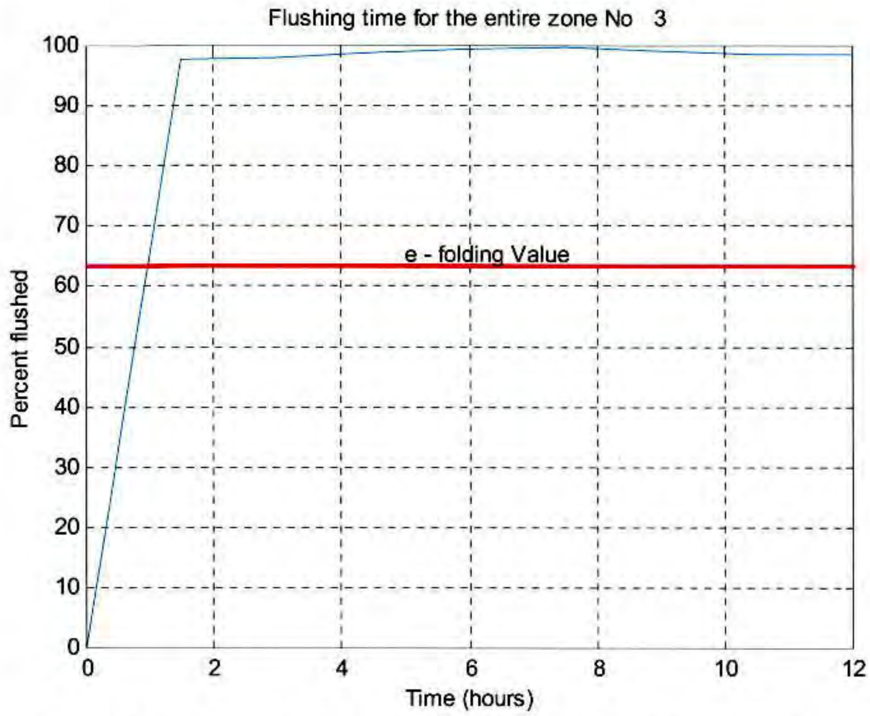


Figure B6.3: Simulated flushing time for Site 3: Mid Yaluun (Station 4) for 22 March 2000 (spring tide)

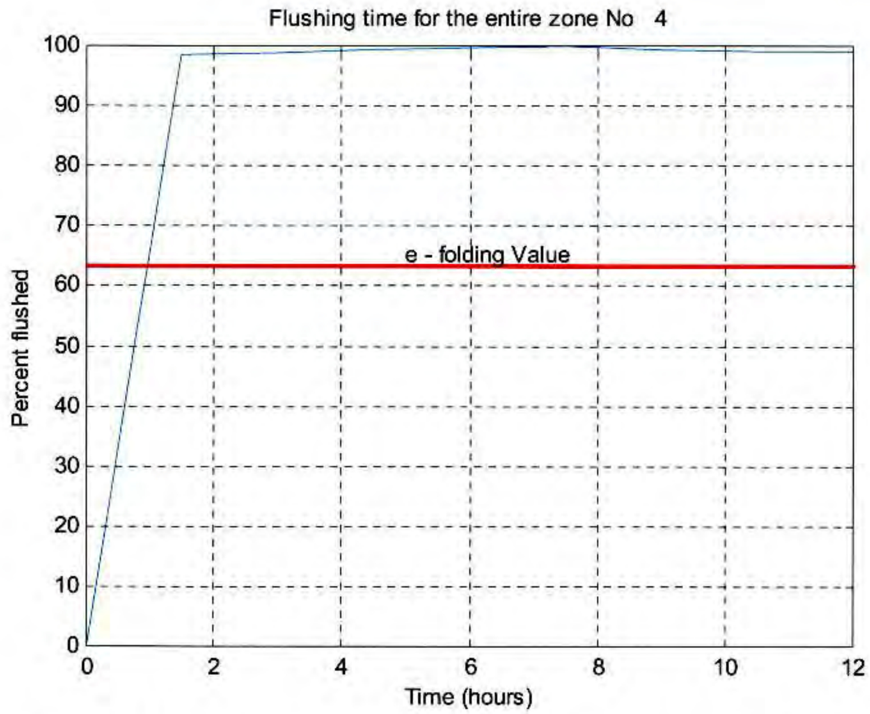


Figure B6.4: Simulated flushing time for Site 4: CB Central (Station 5) for 22 March 2000 (spring tide)

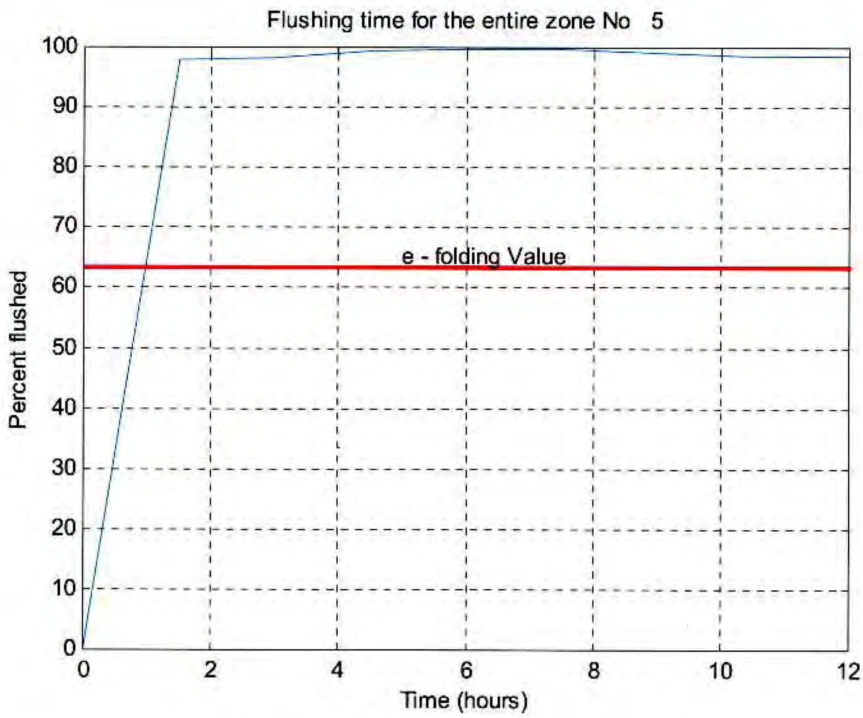


Figure B6.5: Simulated flushing time for Site 5: Turtle Island (Station 8) for 22 March 2000 (spring tide)

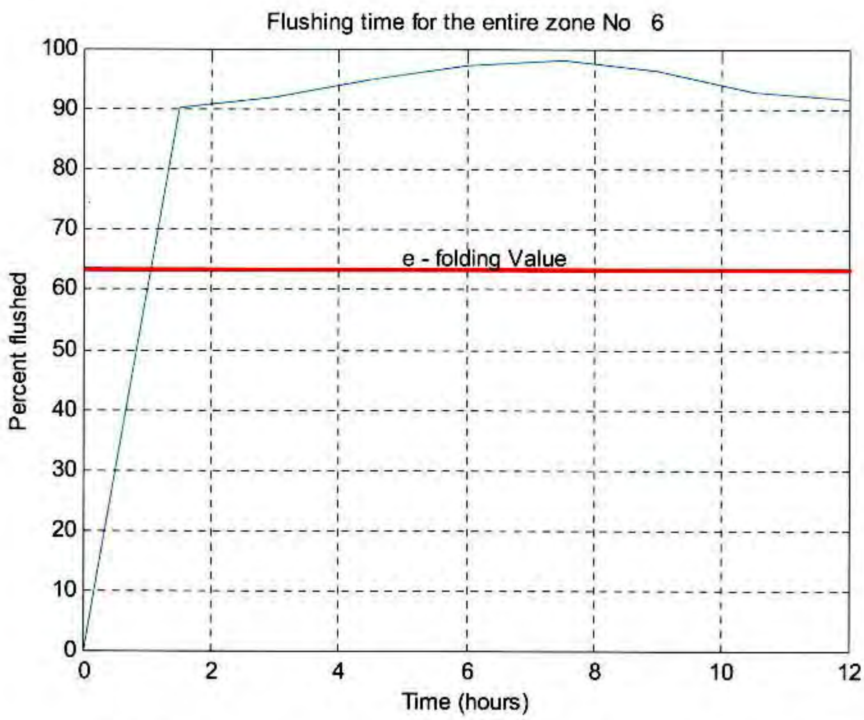


Figure B6.6: Simulated flushing time for Site 6: Eagle (Station 10) for 22 March 2000 (spring tide)

Bay-wide tracer simulations

Figures B7.1 and B7.2 show the rate of flushing for three zones within Cone Bay. Once released, the neutrally buoyant particles travelled throughout the bay and the open ocean, driven by tidally induced ocean currents. Their instantaneous locations were recorded and analysed to establish the number of particles present within selected zones during the period of the simulation. A reduction in the total number of particles initially placed within a particular zone (as a percentage of the initial number) reflects flushing of the zone by the tidal currents.

Two sets of baywide tracer simulations were undertaken, simulating the release and travel of the neutrally buoyant particles during neap and spring tide. The presented simulations reflect the neap tide, starting on 16th January 2000, and the spring tide starting on 23rd January 2000. The travel direction of the particles depends on their initial locations, the timing of their release relative to the tidal forcing (ie. incoming or outgoing tide, and tidal range) and the tidal forcing over the simulation period.

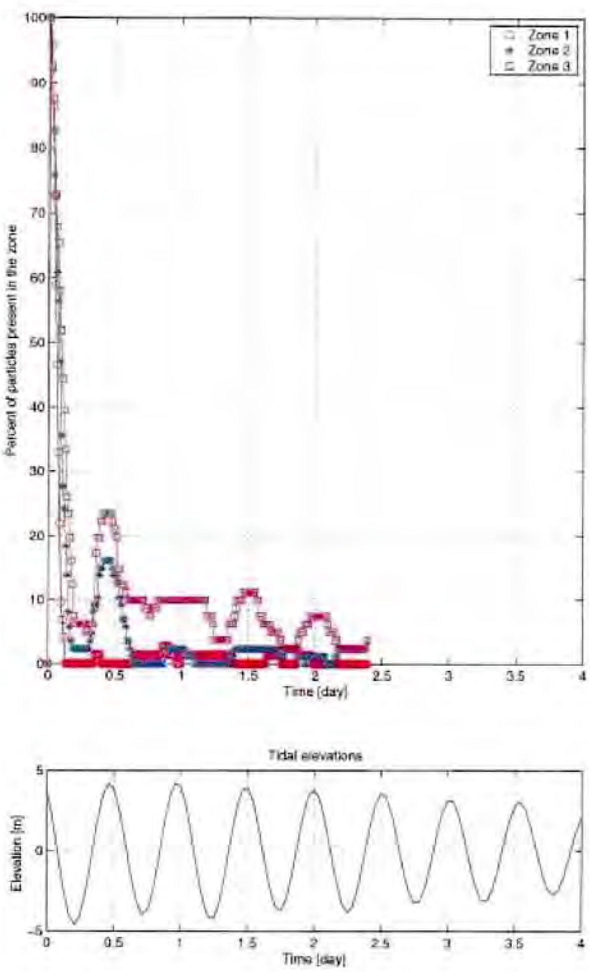


Figure B7.1 Simulated change in percent of particles initially placed within the selected zones, released during spring tide (23 January 2000)

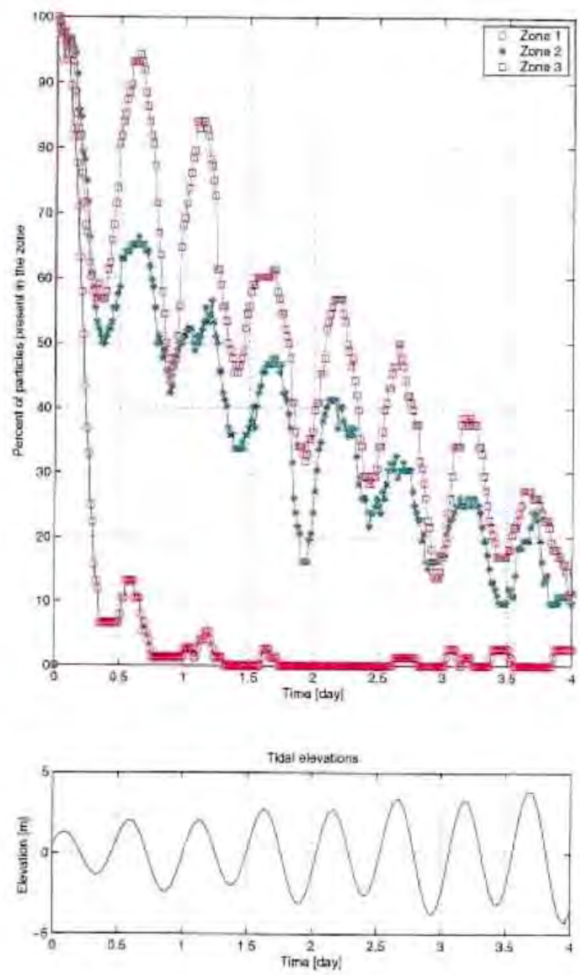


Figure B7.2 Simulated change in percent of particles initially placed within the selected zones, released during neap tide (23 January 2000)

The study ascertained the differences between 'areas' of Cone Bay, these being Western, Central and Eastern ends (also known as Zone 1, Zone 2 and Zone 3 respectively). All simulations demonstrated that the Western End (Zone 1) had extremely efficient flushing capacity with rapid flushing taking only a quarter of a day during neap tide (lowest water movement). The other areas demonstrated longer flushing rates with the Eastern End taking up to 3 days during a neap tide which is indicative of semi-enclosed bays. It was clear from the results that particles originating from Zone 1 tended to be flushed out of Cone Bay during the outgoing tide and taken away by oceanic currents within the King Sound.

2.3.2. Water Quality

2.3.2.1. Water Column Profiling

The water column at each of eleven stations within Cone Bay was profiled on four locations during water quality sampling (20 and 23 January; 23 and 25 March 2000). Data demonstrated that the water column is well mixed. Salinity was around 32 ppt, water temperature was around 30°C, while pH was around 8. Dissolved oxygen levels varied between 7 – 9 mg L^{-1}, except in surface layers. Elevated oxygen levels near the surface, which was observed at some locations, may be attributed to wave action.

2.3.2.2. Nutrient Levels in Cone Bay

The study demonstrated distinct spatial and temporal patterns in water column nutrient levels. The results demonstrated that there were distinct spatial patterns in nutrient levels within the bay. The findings showed that the levels of suspended solids, phytoplankton and dissolved nutrients were generally higher in the Eastern end of the bay (Zone 3) compared to the other two zones, the central and Western end of Cone Bay. Nutrient levels are given in Table B7.

Table B7: Mean nutrient levels in Cone Bay during twelve weeks between 20 January and 25 March 2000

Week (date)	TSS (mg/L)	LOI (%)	Ammonia (µg/L)	Ortho-P (µg/L)	NO_3+NO_2 (µg/L)	Total-P (µg/L)	Total-N (µg/L)	Chloro *a* (µg/L)	Chloro *b* (µg/L)	Chloro *c* (µg/L)
Means										
1 (20/1)	13.4	18.2	13.6	8.9	24.6	32.6	142.4	0.43	0.10	0.10
2 (23/1)	17.2	-	14.0	9.0	28.4	37.4	172.2	0.75	0.10	0.13
3 (29/1)	20.1	14.9	15.0	9.5	18.9	37.1	150.5	0.65	0.10	0.10
4 (6/2)	18.0	16.7	24.7	9.0	23.3	35.2	154.7	0.64	0.10	0.11
5 (13/2)	17.5	17.9	16.7	8.3	17.6	34.3	139.3	0.71	0.10	0.11
6 (20/2)	21.6	18.3	16.9	8.7	18.6	36.5	164.8	0.99	0.10	0.14
7 (28/2)	12.8	18.9	11.8	7.6	15.6	34.5	120.7	0.76	0.10	0.13
8 (7/3)	15.5	19.4	17.7	10.9	17.2	36.5	161.9	1.18	0.10	0.17
9 (12/3)	16.1	17.7	21.3	8.1	25.5	36.1	139.4	1.25	0.10	0.17
10 (17/3)	12.0	18.9	16.2	6.6	16.5	36.8	162.9	0.71	0.10	0.11
11 (23/3)	9.9	25.0	22.6	7.3	9.5	35.2	158.2	0.84	0.10	0.11
12 (25/3)	11.5	26.7	23.1	6.6	8.5	35.5	140.4	0.65	0.10	0.10
SE										
1 (20/1)	0.3	0.2	0.3	0.0	0.6	0.1	1.4	0.02	0.00	0.00
2 (23/1)	0.3	-	0.4	0.1	0.8	1.0	2.7	0.04	0.00	0.00
3 (29/1)	0.6	0.1	0.3	0.1	0.6	0.4	1.7	0.02	0.00	0.00
4 (6/2)	0.5	0.1	0.6	0.1	0.8	0.2	1.6	0.02	0.00	0.00
5 (13/2)	0.4	0.1	0.8	0.1	0.9	0.3	2.5	0.03	0.00	0.00
6 (20/2)	0.8	0.1	0.4	0.1	0.2	0.5	2.0	0.04	0.00	0.01
7 (28/2)	0.3	0.1	0.3	0.1	0.6	0.2	1.4	0.02	0.00	0.00
8 (7/3)	0.2	0.1	0.6	1.2	0.6	0.1	4.8	0.05	0.00	0.01
9 (12/3)	0.7	0.1	0.6	0.1	0.8	0.4	1.7	0.04	0.00	0.01
10 (17/3)	0.2	0.1	0.6	0.1	0.7	0.1	2.2	0.02	0.00	0.3
11 (23/3)	0.2	0.3	0.6	0.1	0.2	0.4	7.9	0.02	0.00	0.00
12 (25/3)	0.6	0.7	0.5	0.1	0.3	0.4	2.8	0.01	0.00	0.00

Total Suspended Solids

Mean levels of total suspended solids per station ranged between 2.6 and 39.9 mg L^{-1} (mean: 15.5 mg L^{-1}). Mean levels of TSS over twelve weeks were highest at Stations 10, 11, 4 and 5 (>18 mg L^{-1}; Figure B8). Lowest mean levels of TSS were measured at Stations 1, 2, and 7 (<12 mg L^{-1}). TSS levels varied considerably over time, with highest mean levels of TSS (21.6 mg L^{-1}) recorded during Week 6, followed by Week 3, 4 and 5 (>18 mg L^{-1}; Table B7). Lowest TSS levels (<12 mg L^{-1}) were recorded during Week 11, 12 and 10 (Table B7).

There was a good correspondence with rainfall (Figure B9). The highest absolute level of TSS (39.9 mg L^{-1}) was recorded at Station 11 (Snapper) during Week 6, which followed heavy rainfall of 81 mm between 19 and 20 February (Figure B10). The lowest absolute level of TSS (2.6 mg L^{-1}) was recorded at Station 1 (Datum) during Week 12, following several days of very low rainfall (5.6 mm over the four preceding days; Figures b9 and B10).

Table B8: TSS results of 2-way ANOVAs testing for differences among position in bay (Inshore, Middle, Entrance) and tide level (High, Incoming, Outgoing, Low)

Variable:	df	Sum of	Mean	F-Value	P-Value
TSS (Data used: Untransformed; Cochran's test: P<0.05)					
Position	2	218.773	109.387	15.697	0.0001
Tide	3	84.152	28.051	4.025	0.0155
Position * Tide	6	61.208	10.201	1.464	0.2219
Residual	32	223.000	6.969		

Particulate Organic Matter (Loss on Ignition)

Mean levels of particulate organic matter per station (measured as % Loss on Ignition, LOI, of TSS dry weight after ashing at 550°C) ranged between 13.9 and 30.9 % (mean: 19.3 %) (Figure B8). Mean levels of LOI over twelve weeks were highest at Stations 1 and 8 (20 - 21 %), while lowest mean levels of LOI were measured at Stations 10 and 6 (< 19 %). However, these LOI values are deceptive, as they become less reliable as the levels of TSS decrease, and should therefore be treated with considerable caution. No LOI values are available for Week 2 due to insufficient sample volumes, resulting in unacceptable analytical errors. Sample volumes were increased following Week 2. Highest mean levels of LOI were recorded during Week 12 and 11, while lowest mean LOI levels were recorded during Week 3 (Table B7). Highest absolute LOI levels (48.4 %) were recorded at Station 1 (Datum) during Week 12, while lowest absolute LOI levels (13.9 %) were recorded at Station 5 during Week 3.

Table B9: LOI results of 2-way ANOVAs testing for differences among position in bay (Inshore, Middle, Entrance) and tide level (High, Incoming, Outgoing, Low).

Variable:	df	Sum of	Mean	F-Value	P-Value
%LOI (Data used: Untransformed; Cochran's test: P<0.05.)					
Position	2	2.184	1.092	0.501	0.6108
Tide	3	119.690	39.897	18.295	0.0001
Position * Tide	6	37.280	6.213	2.849	0.0245
Residual	32	69.785	2.181		

Phytoplankton

Mean levels of Chlorophyll *a* by station ranged between 0.2 and 2.2 µg L^{-1} (mean: 0.8 µg L^{-1}; Figure B8). Mean levels of Chlorophyll *a* over twelve weeks were highest at Stations 10 and 11 (>1 mg L^{-1}). Lowest mean levels of Chlorophyll *a* were

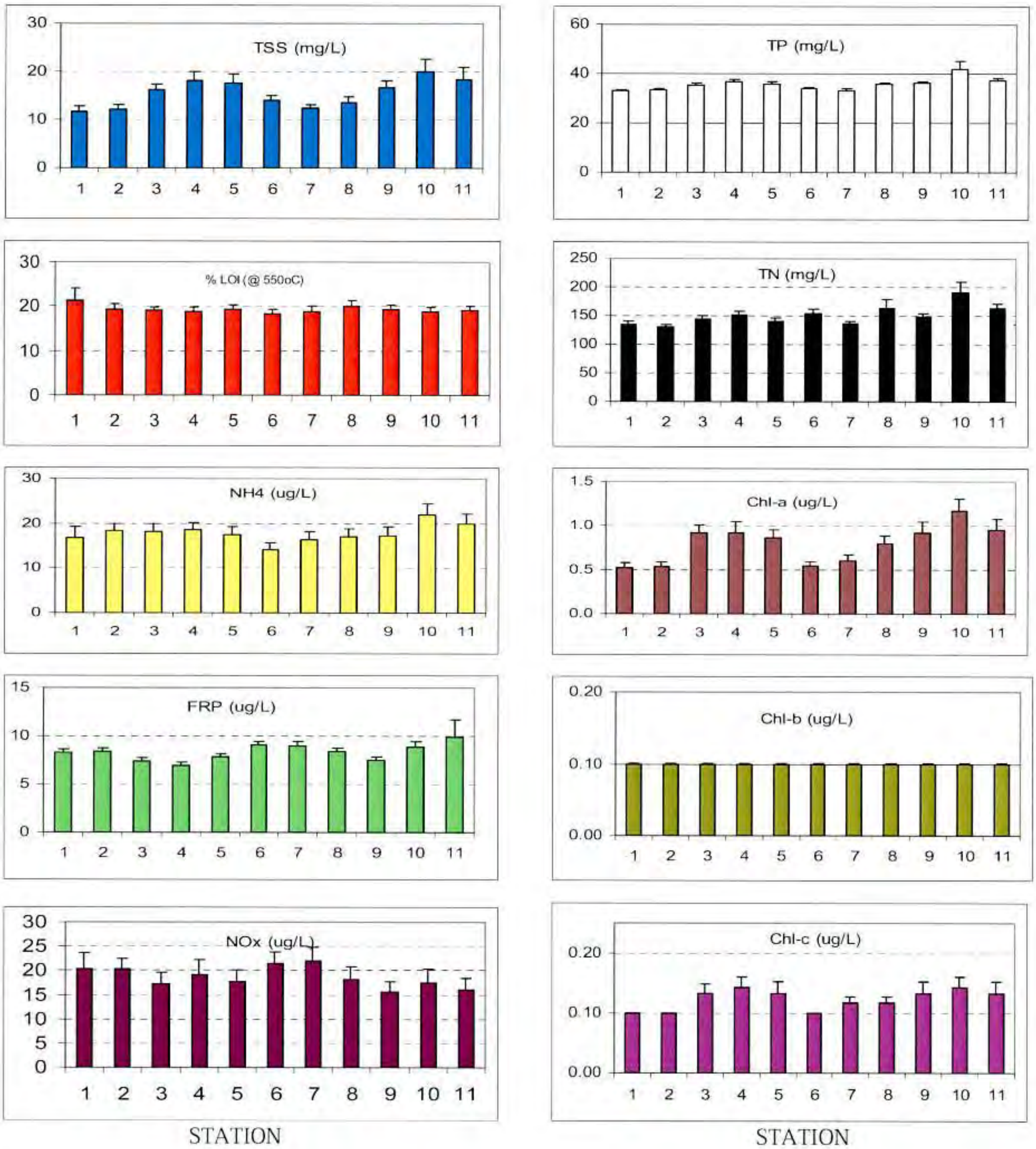


Figure B8: Mean Nutrient levels between 20 January and 25 March 2000, over all stations in Cone Bay (± SE) measured at Stations 1 and 2 (0.5 µg L^{-1}). Highest mean levels of Chlorophyll *a* were recorded during Weeks 9 and 8 (>1.2 µg L^{-1}), while lowest Chlorophyll *a* levels (<0.7 µg L^{-1}) were recorded during Week 1, 4 and 3 (Table B7). Chlorophyll *c* levels demonstrated similar patterns, while Chlorophyll *b* levels were consistently below detection limits (<0.1 µg L^{-1}).

There was a good correspondence with rainfall (Figure B9). The highest absolute level of Chlorophyll *a* (2.2 µg L^{-1}) was recorded at Station 10 (Eagle) during Week 9, which followed heavy rainfall resulting from cyclone 'Steve' (256 mm, Figure B10). The lowest absolute level of Chlorophyll *a* (0.2 µg L^{-1}) was recorded at Stations 1 and 2 during Week 1, following an extended period of low rainfall (Figure B10). Chlorophyll *c* showed similar patterns as chlorophyll *a*, although differences were less distinct, while chlorophyll *b* was at or below detection limit (0.1 µg L^{-1}) in all instances.

Table B10: Phytoplankton results of 2-way ANOVAs testing for differences among position in bay (Inshore, Middle, Entrance) and tide level (High, Incoming, Outgoing, Low).

Variable:	df	Sum of	Mean	F-Value	P-Value
Chloro 'a' (Data used: Untransformed; Cochran's test: P<0.05)					
Position	2	1.626	0.813	37.886	0.0001
Tide	3	.154	0.051	2.400	0.0861
Position * Tide	6	.262	0.044	2.034	0.0897
Residual	32	.687	0.021		
Chloro 'c' (Data used: Untransformed; Cochran's test: P<0.05)					
Position	2	.006	.003	2.263	.1205
Tide	3	.002	.001	.593	.6244
Position * Tide	6	.005	.001	.593	.7338
Residual	32	.045	.001		
Dependent: Chloro 'c'					

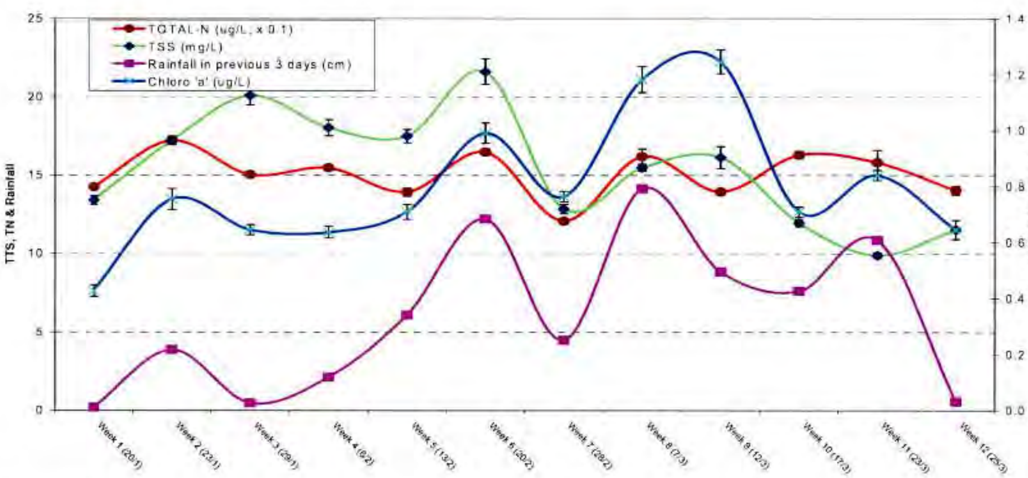


Figure B9: Levels of TSS and Cholorphyll-a against cumulative rainfall in preceding 3 days

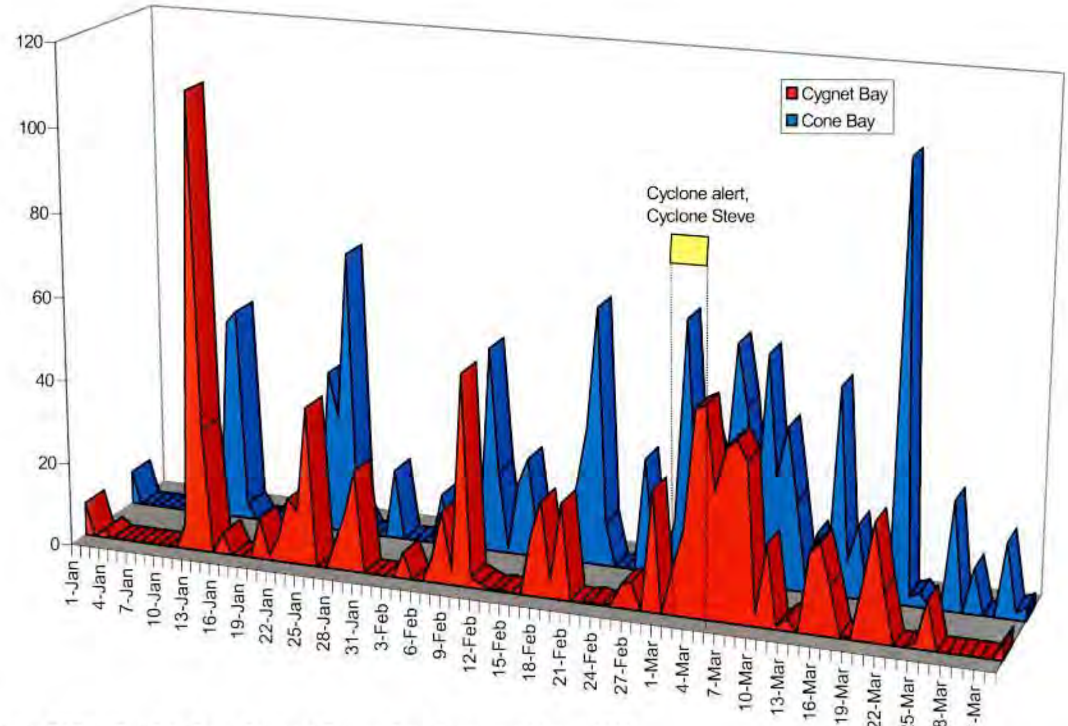


Figure B10: Rainfall: Cone Bay and Cygnet Bay; January – March 2000

<u>Dissolved and total nutrients (NH4, NO_x, TN, TP, FRP)</u>

Ammonia

Mean levels of ammonia per station ranged between 8 and 38 □g N L^{-1} (mean: 17.8 □g N L^{-1}; Figure B8). Mean levels of ammonia over twelve weeks were highest at Station 10 (21.8 mg N L^{-1}). Lowest mean levels of ammonia were measured at Station 6 (14.2 □g L^{-1}). High mean levels of ammonia were recorded during Week 4, 12, 11 and 9; lowest ammonia levels were recorded during Weeks 1 and 2 (Table B7). The lowest absolute level of ammonia (8 □g L^{-1}) was recorded at Station 1 during Week 1.

Nitrite and nitrate

Mean levels of NO_x per station ranged between 5 and 50 □g N L^{-1} (mean: 18.7 □g N L^{-1}). Mean levels of NO_x over twelve weeks were highest at Station 7, 6, 1 and 2 (all western stations) while lowest mean levels of NO_x were measured at Stations 9 and 11 (Figure B8). High mean levels of NO_x were recorded during Week 2, 10, 1 and 4 (>23 □g L^{-1}) lowest NO_x levels were recorded during Week 11 and 12 (<10 □g L^{-1}; Table B7). The lowest absolute level of NO_x (5 □g L^{-1}) was recorded at Stations 8 and 9 during Week 12.

Total Nitrogen

Mean levels of TN per station ranged between 97 and 381 □g N L^{-1} (mean: 18.7 □g N L^{-1}). Mean levels of TN over twelve weeks were highest at Station 10 (191 □g N L^{-1}), while lowest mean levels of TN (131 □g N L^{-1}) were measured at Station 2 (Figure B8). High mean levels of TN were recorded during Week 2, 6, 10 and 11 (>160 □g L^{-1}); lowest mean TN levels were recorded during Week 7 (121□g L^{-1}; Table B7). TN is the total of nitrite, nitrate, ammonia and organic nitrogen. Organic nitrogen makes up the majority of TN, and averaged 75 %

Total Phosphorus

Mean levels of TP per station ranged between 29 and 71 □g P L^{-1} (mean: 36 □g P L^{-1}). Mean levels of TP over twelve weeks were highest at Station 10 (42 □g P L^{-1}), while lowest mean levels of TP (33 □g P L^{-1}) were measured at Station 1 (Figure

B8). Highest mean levels of TP were recorded during Week 2 and 3 (>37 µg P L^{-1}); lowest mean TP levels were recorded during Week 7 (35 µg PL^{-1}; Table B7).

Filtrate reactive phosphorus

Mean levels of FRP per station ranged between 4 and 30 µg P L^{-1} (mean: 8.3 µg P L^{-1}). Mean levels of FRP over twelve weeks were highest at Station 11 (9.8 µg P L^{-1}), while lowest mean levels of FRP (7.3 µg P L^{-1}) were measured at Station 3 (Figure B8). Highest mean levels of FRP were recorded during Week 8 (10.9 µg P L^{-1}); lowest mean FRP levels were recorded during Week 12 (6.6 µg P L^{-1}; Table B7). The lowest absolute level of FRP (4 µg L^{-1}) was recorded at Stations 3 (Week 12) and 4 (Week 10); the highest (30 µg P L^{-1}) at Station 11 during Week 8

2.3.2.3. Spatial Patterns in Nutrient Parameters within Cone Bay

There were distinct spatial patterns in water column nutrient levels within Cone Bay (Figures B11.1 – B11.3). The eastern stations (North, Yaluun, Mid Yaluun and Eagle) demonstrated substantially higher phytoplankton, total suspended solids, total nitrogen (TN) and total phosphorus (TP) levels than the stations towards the bay entrance (Datum, Hidden Harbour, Blacklip, CB Entrance). Tidal cycles affected these levels only marginally at the eastern stations, while tidal influences were negligible at the stations towards the entrance of the bay. At the eastern stations, mean phytoplankton levels were highest during high and outgoing tides, and somewhat lower during low and incoming tides (Figure B11.3). TN and TP levels demonstrated an opposite pattern, and were highest during incoming tides. Note, however, that these observations were confounded by variable rainfall.

Table B11: Nutrients results of 2-way ANOVAs testing for differences among position in bay (Inshore, Middle, Entrance) and tide level (High, Incoming, Outgoing, Low).

Variable:	df	Sum of	Mean	F-Value	P-Value
AMMONIA (Data used: Untransformed; Cochran's test: NS)					
Position	2	52.907	26.454	2.642	0.0867
Tide	3	235.316	78.439	7.835	0.0005
Position * Tide	6	12.771	2.129	0.213	0.9701
Residual	32	320.356	10.011		
ORTHO-P (Data used: Untransformed; Cochran's test: P<0.05)					
Position	2	11.749	5.874	3.243	0.0522
Tide	3	3.386	1.129	0.623	0.6053
Position * Tide	6	11.636	1.939	1.071	0.4004
Residual	32	57.967	1.811		
NO3+N02 (Data used: Untransformed; Cochran's test: NS)					
Position	2	137.314	68.657	6.694	0.0037
Tide	3	52.750	17.583	1.714	0.1837
Position * Tide	6	144.460	24.077	2.347	0.0543
Residual	32	328.208	10.256		
TOTAL-P (Data used: Untransformed; Cochran's test: P<0.05)					
Position	2	178.726	89.363	8.386	0.0012
Tide	3	3.918	1.306	0.123	0.9461
Position * Tide	6	61.187	10.198	0.957	0.4694
Residual	32	340.991	10.656		
TOTAL-N (Data used: Untransformed; Cochran's test: P<0.05)					
Position	2	3596.272	1798.136	3.418	0.0451
Tide	3	2814.379	938.126	1.783	0.1702
Position * Tide	6	3693.214	615.536	1.170	0.3466
Residual	32	16833.243	526.039		

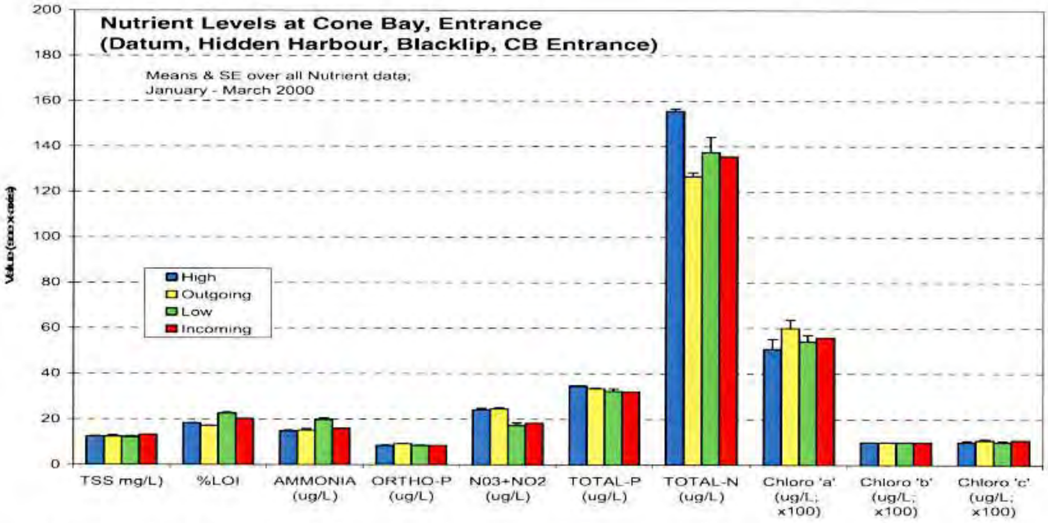


Figure B11.1: Mean Nutrient levels in Cone Bay Entrance sites during four tidal cycles

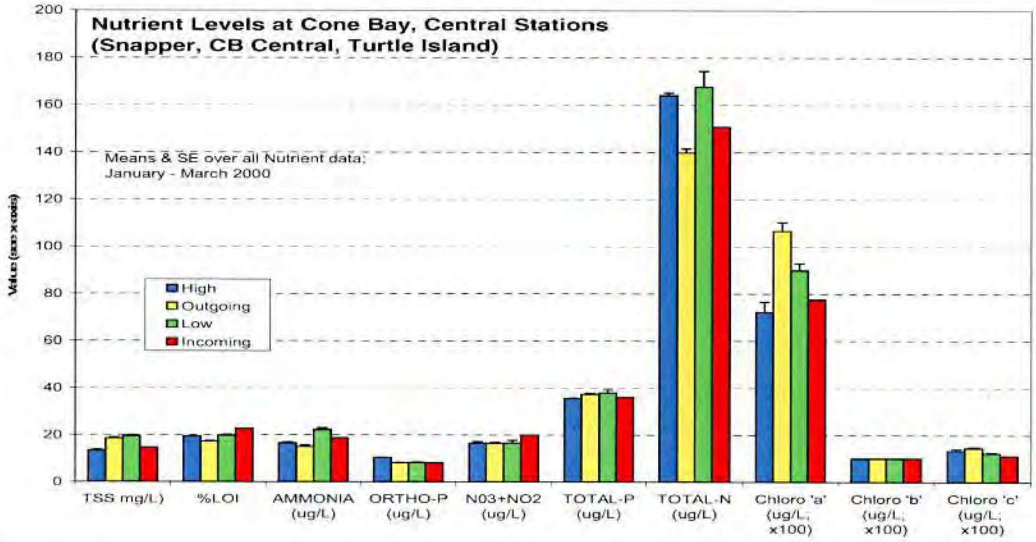


Figure B11.2: Mean Nutrient levels in Cone Bay central sites during four tidal cycles

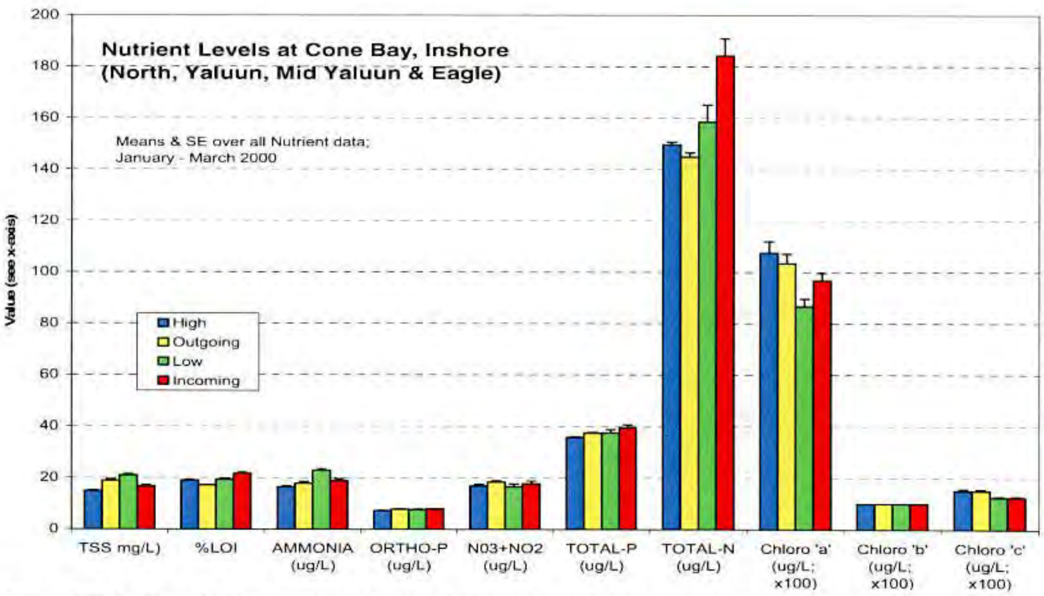


Figure B11.3: Mean Nutrient levels in Cone Bay Inshore sites during four tidal cycles

Surprisingly, % loss on ignition did not demonstrate such spatial patterns, possibly due to this parameter not being sufficiently sensitive. TN and TP are perhaps better indicators for levels of particulate organic matter in the water column (Figures B11.1 – B11.3). The central section of Cone Bay (Stations 11, 5 and 8; Figure B11.2) demonstrated intermediate levels of phytoplankton, TSS, TN and TP.

The western and central stations generally demonstrated lower levels of suspended solids (TSS), organic nutrients (LOI, TN, TP), and phytoplankton, than the eastern stations. However, a number of these stations (especially Stations 1, 2 and 11, which are near the shoreline) were susceptible to coastal run-off following heavy rain. Mean levels of TSS were lowest at Station 1 (11.7 mg L^{-1}; Figure B7). Local TSS levels increased substantially following heavy rain, and exceeded 15 mg L^{-1} at Station 1 during Weeks 2, 3, 6 and 8 (Figure B12a). Similarly, total nitrogen levels at Station 1 exceeded 150 mg L^{-1} during Weeks 2, 3 and 8 (Figure B12c), while chlorophyll-*a* levels exceeded 1.5 mg L^{-1} at stations 11 and 8 during Week 9 (Figure B12b). Station 10 (Snapper) had mean TSS levels of 19.9 mg L^{-1}, but levels exceeded 35 mg L^{-1} during Week 6.

Table B12: Correlations between nutrient parameters

Parameter*	TSS	%LOI	NH_4	FRP	NO_x	TP	TN	Chl. *a*	Chl. *b*	Chl. *c*
TSS	1.00									
%LOI	-0.48	1.00								
AMMONIA	0.17	0.11	1.00							
ORTHO-P	0.16	-0.26	0.15	1.00						
N03+NO2	0.21	-0.44	0.19	0.21	1.00					
TOTAL-P	0.46	-0.17	0.24	0.14	-0.02	1.00				
TOTAL-N	0.22	0.01	0.24	0.18	0.10	0.52	1.00			
Chloro 'a'	0.35	-0.01	0.20	0.01	-0.13	0.44	0.28	1.00		
Chloro 'b'	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	
Chloro 'c'	0.23	-0.06	0.11	0.18	-0.01	0.23	0.18	0.76	0.00	1.00

* Correlations between nutrient parameters which are shaded are highly significant ($p<0.001$)

There is a high correlation between TSS and TP, and between TSS and chlorophyll *a* (Table B12). TP levels were highly correlated with TN and chlorophyll *a*, while TN and TP were also strongly correlated, as were chlorophyll *a* and *c* (Table B12).

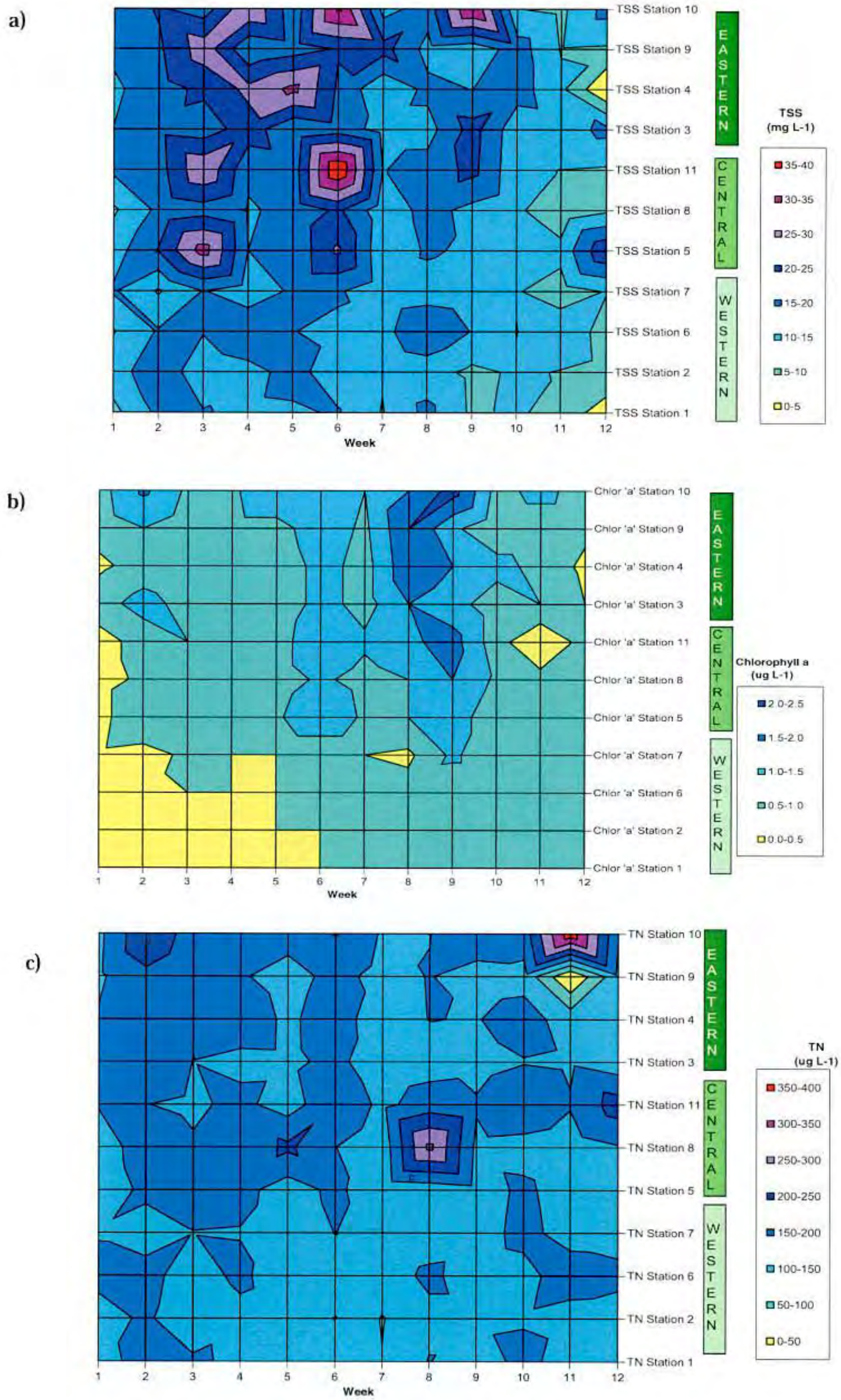
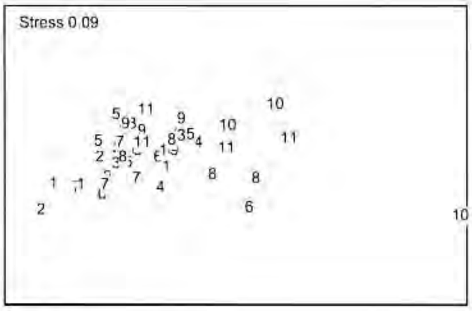


Figure B12: Spatial Patterns in nutrient levels at all stations including a) TSS ; b) Chlorophyll a ; c) Total Nitrogen.

2.3.2.4. Multivariate Analysis: Water Quality

Nonmetric multidimensional scaling (NMDS) ordination was used to examine multivariate patterns in water quality. Input data for this analysis were untransformed mean values for each Station at each Tide position (giving 4 values for each station—one for each Tide). Ordinations were based on Bray-Curtis similarity values, and analysis was done using the PRIMER 4.0 multivariate statistics software. Ordinations were constructed in 2 dimensions.

The stress value for the ordination was 0.09, indicating that a 2-dimensional plot was able to give a reasonable accurate representation of relative similarities among stations. The ordination showed clear trends related to Position in bay (Figure B13a & b) and Tide (Figure B13c). Generally, the ordination shows a gradient in water quality from the entrance of the bay to the inshore area (Figure B13b). One outlier in the plot was an inshore station (Station 10) characterised by high levels of Total P and Total N. Trends related to Tide (Figure B13c) were also present: the main pattern is the trend for points representing outgoing tides to cluster in the left of the plot.



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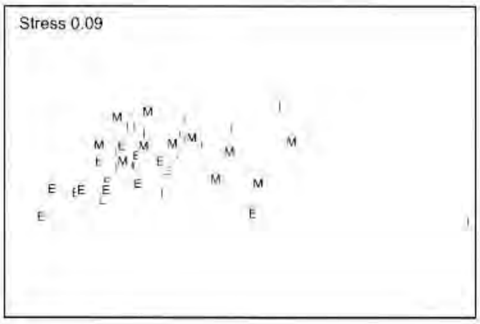

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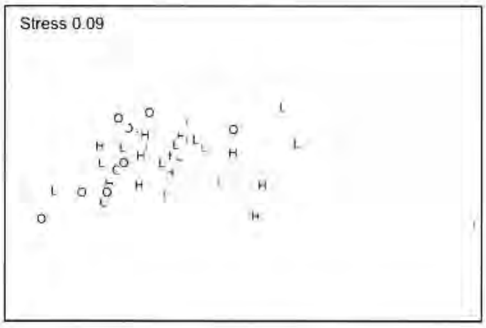


C

Figure B13: NMDS based on mean water quality data for each station at each tide (means calculated from 3 measurements). Symbols represent (a) Station, (b) Position in bay [Inshore, Middle, Entrance], (c) Tide [High, Low, Incoming, Outgoing].

2.4. Discussion

2.4.1. Hydrodynamic Modelling

Hydrodynamic simulations were undertaken for typical summer meteorological conditions (without density effects) in order to estimate the exchange rate between Cone Bay and the open sea. Predicted bay-wide circulation within Cone Bay over a 24 hour period demonstrates that currents are largely running in an east-west direction, and may be up to 0.6 m s^{-1} in the deep channel running along the Northern end of the bay (Datum, Hidden Harbour). Conservative tracer simulations of six sites within Cone Bay confirm rapid flushing at these locations. All of the sites experienced over 90% flushing within two hours. E-folding times were less than one hour in all sites. The short flushing time is to be expected resulting from the high current velocities in Cone Bay.

Bay-wide tracer simulations demonstrated differences in flushing between the eastern and western ends of Cone Bay. Both during spring and neap tide the entrance zone flushes relatively quickly. During neap tide, only about 10% of the particles initially placed within the zone are still present after only 8 hrs following the release. During spring tide, the flushing is even more efficient (tidal amplitudes are almost 100% higher than during neap tide). Here, the number of particles is reduced to less then 10% of the initial numbers in less than 2 hrs.

The results for the central and the inshore zones of the bay (ie Zone 2 and 3) indicate it may take several days to reduce the number of particles to 10 % of their original numbers during neap tide (see computer animations – Appendix B). During the spring tide, flushing in these zones is much more efficient and the particles were reduced to about 10 % of their initial numbers within about 12 hrs. The results clearly demonstrate that the flushing efficiency reduces towards the eastern end of the bay. This result is a common feature for semi-enclosed bays and estuaries.

The flushing rate (e-folding time) for the western end of Cone Bay was around a quarter of a day during neap tide and several hours at most during spring tide. However, for the eastern end of the bay, flushing rate was around half a day during Spring tide, and around 3 days during neap tide. Bay-wide tracer simulations further demonstrated that particles originating from the eastern end of the bay may move a considerable distance towards the western side of the bay during outgoing tides, but are largely taken back into the bay during incoming tides. Particles originating from the western side of the bay, on the other hand, tend to flush out of Cone Bay during an outgoing tide, and are then largely taken away by oceanic currents.

At any given time, the percent of particles remaining within the central zone (Zone 2) is lower than at the zone nearest to the entrance, and higher than the percent of remaining particles at the inshore zone (Zone 3). This indicates that for any given water quality variable, a gradient in concentrations exists throughout the bay, with smaller concentrations towards the entrance of the bay.
These observations correspond well with field observations, and may partly explain the existence of a nutrient and phytoplankton gradient within Cone Bay. However, desktop modelling is based on conservative tracers, and does not take into consideration the nutrient inputs originating from coastal run-off during the wet season, nor does it take into consideration any phytoplankton production, which presumably is considerable within this region.

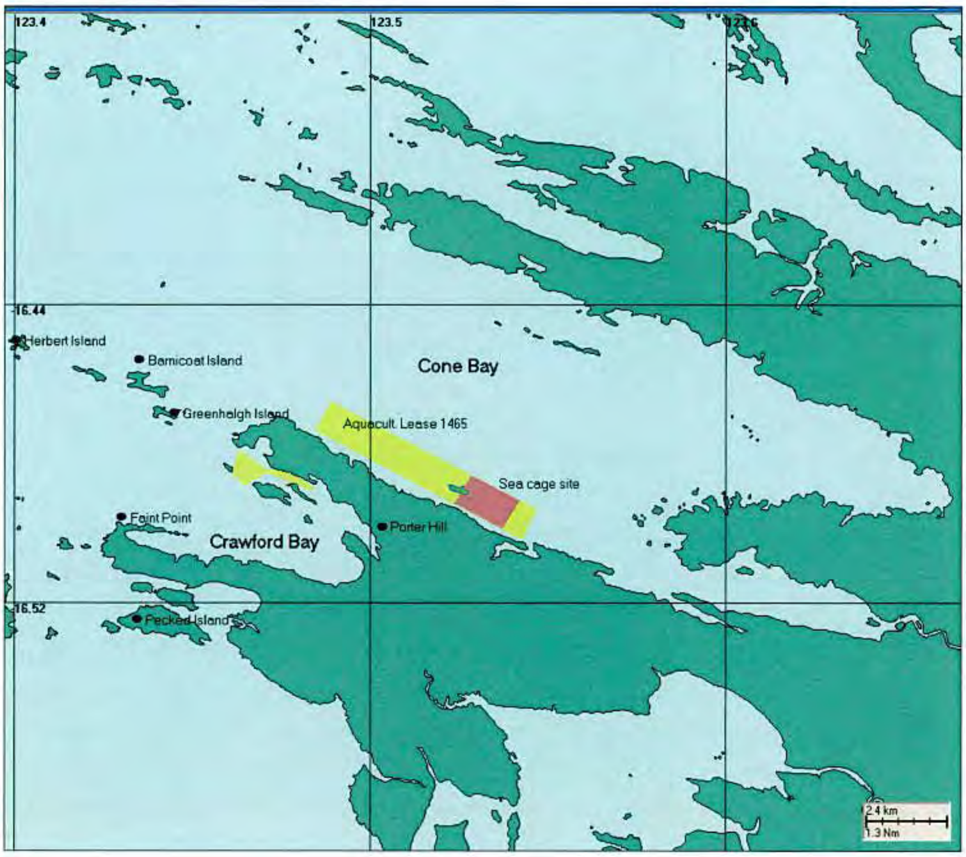
2.4.2. Water Quality

In summary, the results have demonstrated that there are clear spatial differences of nutrients within Cone Bay. The eastern part of the bay is characterised by elevated phytoplankton levels, high TSS levels, elevated organic matter and higher levels of dissolved nutrients. This is likely to be due to several reasons, including differences in flushing characteristics, in combination with the presence of mangroves, nutrient and organic inputs at the eastern end of the bay (especially so during the wet season), and coastal run-off. In addition, phytoplankton production rates are likely to be higher at the eastern end of the bay, resulting from elevated nutrient availability and better access to light in these shallower waters. The western part of the bay was characterised by predominately lower levels of the above-mentioned nutrients, although was seen to have the highest nitrite and nitrate levels. This is likely to be due to a combination of rapid breakdown of organic materials, and outgoing flows predominantly leaving the bay through the deep channel along stations 1 and 2, as well as along stations 6 (CB Entrance) and 7 (Blacklip).

Water quality was strongly influenced by rainfall in the period January – March 2000, with levels of total suspended solids, organic matter and phytoplankton increasing after heavy rainfall, and dropping back after extended dry periods (Figure B9). Peaks in TSS, TN and Chlorophyll *a* were observed during periods of strong rainfall (Figure B9). Also high during the rainy season is the particulate organic matter and phytoplankton levels in the eastern part of Cone Bay. In addition, concentrations of these parameters appear largely driven by coastal run-off following heavy rainfall. This is further supported by the results of the EMMP which indicate that nutrient levels in Cone Bay are dramatically affected by rainfall.

3. APASA Study – 2006

A NUMERICAL MODELLING STUDY OF THE PROPOSED INCREASE IN BARRAMUNDI PRODUCTION IN CONE BAY, WESTERN AUSTRALIA



December 2006

Prepared for: Maxima Pearling Company Pty Ltd

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Document control form

Document draft	*Originated by*	*Edit & review*	*Authorized for release by*	*Date*
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Final release for client review		*Dr Sasha Zigic* *Dr Oleg Makarynskyy*	Dr Sasha Zigic	12th December 2006
Final report with minor edits		*Dr Sasha Zigic*	*Dr Sasha Zigic*	25th January 2007

APASA Project Manager: Dr Sasha Zigic

Document Title: Cone_numerical modelling_Final.doc

APASA Project Number: N026

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3.1. Executive Summary

Maxima Pearling Company Pty Ltd (MPC) propose to increase production of the existing Barramundi aquaculture licence 1465 in Cone Bay, Western Australia from 150 to 1000 tonne/annum. To fulfil the requirements of the Environmental Protection Authority (EPA), and as a part of the environmental assessment process supporting the application, MPC commissioned APASA to perform a numerical modelling study with a focus on Cone Bay, although taking into consideration the adjacent Crawford Bay operation. The objectives of this study were:

1) Simulation of the circulation within the bays, based on the existing morphology and the introduction of the Barramundi sea-cages;
2) Quantification of the flushing rates for the adjacent bays, based on the existing bottom friction conditions and after the inclusion of the sea cages/increased bottom friction; and
3) Simulation of the dispersion and settlement patterns of fish food and fish waste from the fish farm operation in Cone Bay;
4) Estimate the dispersion and accumulation of dissolved nutrients in the case of total porduction operation of the two adjacent fish farms.

A two-dimensional version of hydrodynamic model (BFHYDRO) was set-up for the existing morphology of Cone Bay and Crawford Bay in order to complete the first objective. This hydrodynamic model was forced by locally-observed wind data and tides over two seasons: wet (December 2005-January 2006) and dry (June-July 2006), and a spatially-uniform bottom roughness representative of a rocky seafloor. After fine tuning of the model to satisfy the tidal range observed in the region and drogue validation tests, a modified version of the model was produced. This version was to represent the resistance to flow introduced by the sea cages, by increasing the seabed drag coefficient five-fold in the proposed location of the sea cages. Next a comparison was carried between the two hydrodynamic simulations using identical tidal conditions and samples of December-January and June - July winds to evaluate any changes in the local currents induced by the sea cages.

Based on the existing seabed conditions, the predicted current speeds within the central section of the Cone Bay sea cage sites (east of Turtle Island) were in the range from 0.20 to 0.45 m/s for both wet and dry seasons. Current speeds were reduced to 0.10-0.25 m/s by the inclusion of the sea cages. No changes in current directions were however indicated. Obtained results implied that the retardation of current speeds will be greatest for periods of faster tide flows, with 30-50% decreases in current speeds during peak springs and marginal or no change during neap tides. It should be noted that the predicted currents speeds west of Turtle Island and out into Cone Bay were much stronger (up to 0.8 m/s) and unaffected by the inclusion of the sea cages. The main reason that the currents are much weaker within the Cone Bay sea cage site, is due to the Island land mass creating a sheltering affect.

To quantify the flushing rates for the study area, a 30-day side-by side numerical dye-flushing comparison was carried out for Cone Bay and Crawford Bay with two distributed sources of dye cells located over the fish farm facilities to examine the effects of the sea cages on local water flushing times using the mass-transport model (BFMASS). The model results suggested that flushing times were not greatly affected by introduction of the sea cages during a spring tide for either a single dye source (Cone Bay licence only) or both. For the existing morphology, the Cone Bay licence area was completely flushed within 2-days during both December strong spring currents and June weak neap currents. By introducing the sea cages the estimated flushing times were predicted the same under December strong spring currents, although, were longer during neap tides. Flushing took approximately one day longer (3 days) due to the retardation of the tidal flows, which inturn reduced the extent of flushing during ebbing tides.

To examine the fate of fish waste and food pellets the waste material was simulated separately from within the sea cage area in Cone Bay for a 30 day period for the wet and dry seasons. The release of fish waste and food pellets at eight points was also engaged within the broader section of the aquaculture area in Crawford Bay to account for the possibility of waste/food overlapping. The results of numerical experiments demonstrated a distinctive tendency for material to settle close to the release sites and along the general east-west tidal axis. The deposition of released waste was dependent on the tidal cycle with accumulation occurring to the east during the flood and west during ebb. Concentrations were predicted to decrease exponentially with distance from the release points and the sedimentation footprints around neighbouring points of discharge showed some overlap. Notably, no overlap of the sedimentation footprints from two fish farms was predicted. For the minimum threshold concentration of 0.01 g/m^2/day, settlement distance for fish waste was estimated as up to 250 m from a given discharge source strictly along the main tidal axis. For the fish pellets, this distance was reduced to approximately 130-140 m due to the quicker settling rate.

To estimate the dispersion and potential accumulation of dissolved nutrients equal amounts of conservative and neutrally buoyant material were released from within each aquaculture licence and simulated for a 30 day continuous release using generated currents for December 2005 and June 2006. The model results indicated that the dissolved nutrient concentrations was strongly affected by tidal cycles within the bays. The concentrations increased within the licence area during the periods of slack tidal currents and decreased when the currents became stronger during either the flood or ebb events. The time series comparisons also showed that the predicted concentrations at the western sector of the licence area were significantly less (maximum 0.01 g/m^3 (10 µg/L)) than that of the dissolved concentrations at the Cone Bay sea cage release site (maximum 0.015 g/m^3 (15 µg/L)), suggesting that any neutrally buoyant waste will be mixed rapidly due to the energetic nature of the surrounding waters. From the obtained model results there was no observed overlap of dissolved nutrient footprints from these two adjacent medium production fish farms at full production.

3.2. Introduction

Maxima Pearling Company Pty Ltd (MPC) proposed to increase production of the existing Barramundi aquaculture in Cone Bay, Western Australia from 150 to 1000 tonne/annum. Cone Bay is approximately 21.0 km long and 6.2 km wide near its west facing opening (see Figure B14). The proposed aquaculture site in this bay would cover approximately 699.41 hectares along the south-west shore.

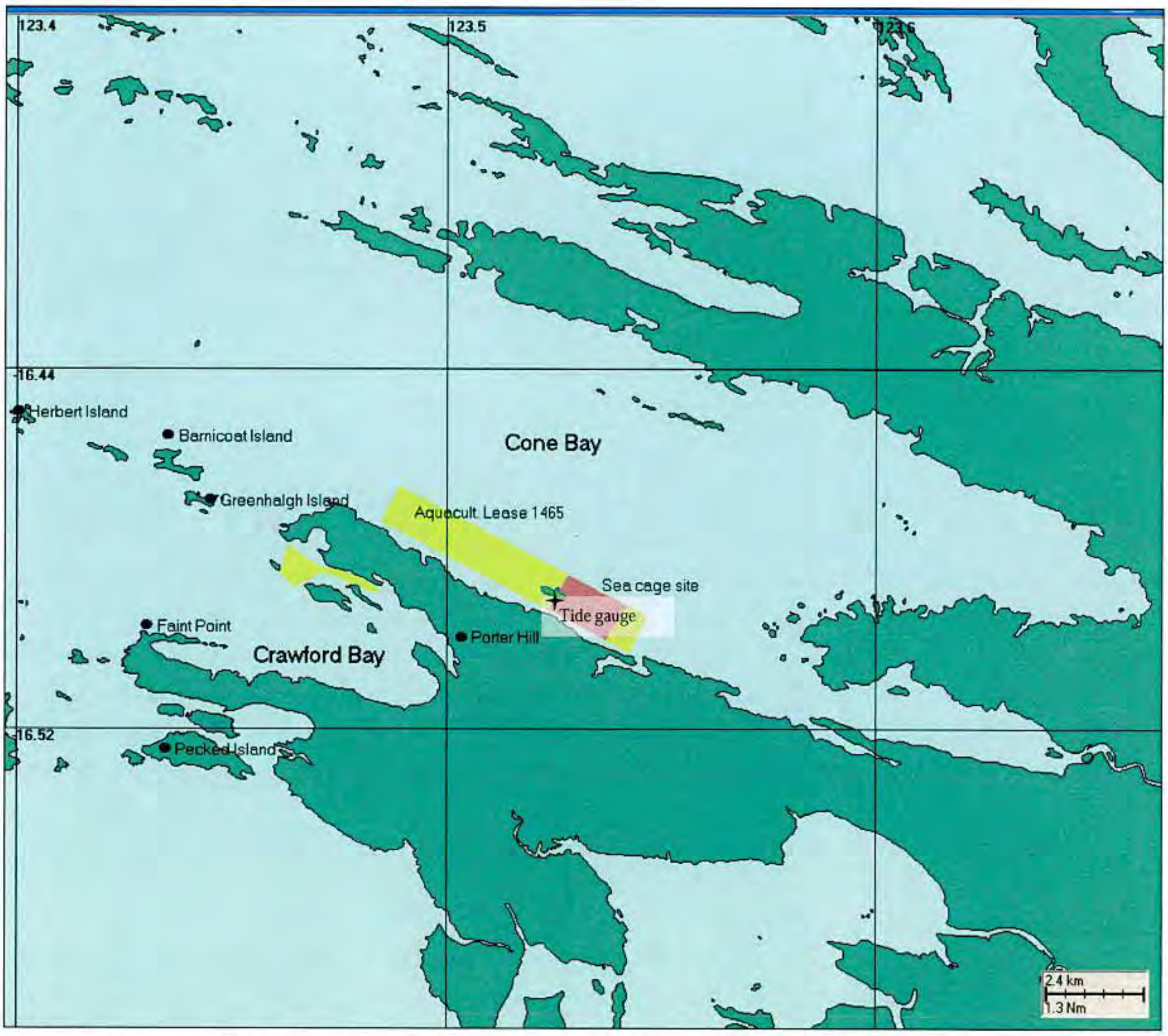


Figure B14: Location of the proposed Barramundi aquaculture sites in Crawford Bay and existing site in Cone Bay (highlighted in yellow), Yampi Sound, Western Australia. Note the Cone Bay sea cage sites (highlighted in pink) and tide gauge (✚).

As part of the environmental assessment proposal, MPC commissioned Asia-Pacific ASA (APASA) to carry out a numerical modelling study with a focus on Cone Bay, although taking into consideration the adjacent Crawford Bay operation, in order to quantify the following:

1. Circulation within Cone Bay and Crawford Bay, based on the existing environment and with the introduction of the proposed sea cages;
2. Flushing rates for water in Cone Bay and Crawford Bay, based on the existing environment and with the introduction of the sea cage system;
3. Dispersion and settlement patterns of food waste and fish waste released from the sea cages in Cone Bay; and
4. Dispersion and accumulation of dissolved Nitrogen and Phosphorous from two fish farms in the adjacent bays.

The first task involved set-up of a two-dimensional hydrodynamic model (BFHYDRO) for the existing morphology of the two adjacent bays. This hydrodynamic model was forced by locally-observed wind data and specifications for local tidal influences. Tidal elevations predicted by the model were validated against a tide gauge (Figure B14) deployed within Cone Bay south of Turtle Island (Brown & Root, 2000).

Circulation patterns simulated by the model were validated against drogue experiments conducted within Crawford Bay under different conditions. Having satisfied the validation tests, a modified version of the model was made with increased seabed drag in the proposed location of the sea-cages, to represent increased resistance to flow. The hydrodynamic models were then operated in a side-by side comparison using identical samples of December-January and June-July wind conditions (60 day samples of observed wind-data in each case), to determine any changes in the direction and speed of local currents introduced by the sea cages.

Flushing simulations were used to quantify effects of the cages on flushing rates for Cone Bay and Crawford Bay. Patterns of dispersion and settlement of waste materials, as well as neutrally buoyant dissolved nutrients released from the sea cage locations were also modelled. Simulations were carried out for different combinations of wind and tide conditions during the wet (December-January) and dry (June-July) seasons to ensure that results were robust.

3.3. Hydrodynamic Model (BFHYDRO)

Circulation within Cone and Crawford Bays was simulated using a two-dimensional (depth-averaged) variant of a hydrodynamic model (BFHYDRO). BFHYDRO is employed to generate tidal elevations, current velocities, salinity and temperature distributions in estuarine, coastal sea and continental shelf waters. This model has a long history of development (over 20 years) and application world-wide for simulation of hydrodynamic circulation (e.g. Huang & Spaulding 1995, Peene *et al.* 1997, Mathison *et al.* 1989, Mendelsohn *et. al.* 1999, Yassuda *et. al.* 1999, Kim & Swanson 2001, Ward & Spaulding 2001, Zigic *et al.* 2005b, Zigic, 2005a) and the model algorithms have been extensively peer-reviewed and developed over this time. BFHYDRO is a general, curvilinear, boundary-fitted model that forms the hydrodynamic model within the WQMAP (Water Quality Mapping Analysis Program) general water quality and circulation model.

BFHYDRO solves the conservation of mass, momentum, salt and temperature on a non-orthogonal, boundary-fitted, curvilinear grid-system (Muin & Spaulding 1996, 1997; Spaulding et al., 1999; Sankaranarayanan & Spaulding 2003). This gridding scheme allows the grid boundaries closely match the geometry of the water body while maximizing spatial resolution. The boundary-fitted gridding technique was proved to be advantageous to this study, due to the geometrically complex nature of the water body. Since the barotropic (tides and wind) circulation is of primary importance, baroclinic (density) effects are neglected.

The reader is referred to Muin & Spaulding (1997) and Swanson (1986) for detailed presentation of the governing equations and other test cases of the BFHYDRO model.

3.3.1. Hydrodynamic Grid Setup

Simulations were performed using an irregularly-spaced, boundary-conforming grid that covered both bays and extended 3-4 km seaward (Figure B15). The grid consisted of 25,613 active computational water-cells. The size and shape of these grids were varied over the domain. A fine (<50m) grid resolution was defined within the aquaculture region in Cone Bay, to capture the effect of the grow-out and nursery cages. A coarser grid cell resolution (between 100 m and 200 m) was applied over the wider bay. This approach optimized model resolution around the aquaculture site while maintaining model efficiency and stability, important to allow sufficiently long simulations to be carried out. The cells consisted of quadrilaterals with variable

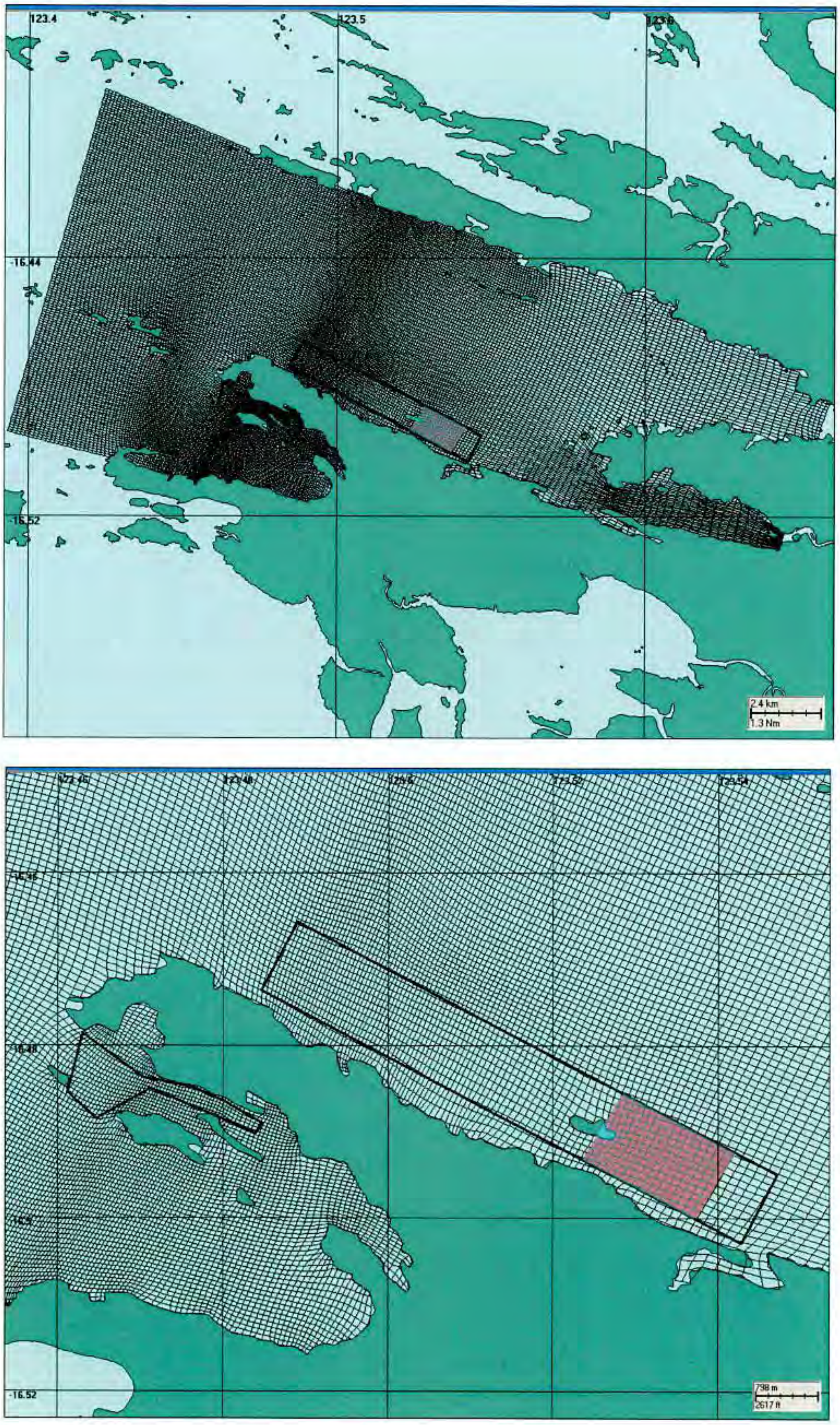


Figure B15: Extent of the boundary-fitted grid covering Cone Bay and Crawford Bay (top panel); and zoomed-in view of the fine grid resolution adjacent to the aquaculture sites (bottom panel).

shapes that were conformed as closely as possible to the local coastline. Particular attention was paid to conforming grid boundaries to the coastline of the three adjacent islands and the headland that could have local impact on circulation and flushing.

Bathymetric data used to describe the shape of the seabed within the study area was generated from a composite of Geoscience Australia gridded depth data, measured depth soundings supplied by MFF for the previous Crawford Bay study and digitising from admiralty charts. The Geoscience dataset has a nominal resolution of approximately 250m, with good data coverage over waters >10-15 m, but lacked detail in shallower waters.

Depth soundings were taken for the Crawford Bay aquaculture site by MFF and post-processed to correct for tidal level. However, depth soundings were not required for the Cone Bay aquaculture site as more recent and accurate data is available on admiralty charts. Features of the study region that were not resolved by the Geoscience data or field-soundings were digitised from admiralty charts. Spot-depth data from all sources were spatially interpolated to form a seamless interpretation of the bathymetry (see Figure B16).

3.3.2. Model Parameters and Forcing

Tidal heights at the open boundaries of the model were calculated for real times using the latest Topex Poseidon global tidal set (TPX051; source: NOAA), which is a gridded set of tidal constituents derived from satellite altimetry. Tidal elevations at all open boundary cells were calculated at each time step in the model using the 5 largest tidal constituents for the area (O1, K1, N2, M2 and S2). The model then calculated sea heights and resulting tidal currents for locations within the region by propagation of constant water mass over the three-dimensional shape of the region.

To scale the frictional drag between the seabed layer and the seabed, a spatially-uniform bottom roughness coefficient of 0.016, representative of a rocky seafloor, was applied.

Water surface elevations in Cone Bay were measured over a three day period in March 2000 (23 March, 6 PM, until 26 March, 6 AM) as part of a previous hydrodynamic study conducted by Brown & Root. For this purpose, a Hydrolab Datasonde probe was deployed from a mooring, placed underneath one of the pontoons south of Turtle Island (Figure B14). The probe was attached to a concrete weight, and kept vertical by means of a sub-surface float. The distance between probe and weight was kept to a minimum (< 0.5 m from the substrate), to avoid vertical movement by tidal currents. The probe was programmed to record depth at 30 minute intervals. Depth measurements were corrected to mean sea level for Yampi Sound (5.8 m above datum).

Figure B17 shows a comparison between surface-elevations from these measurements and as predicted by the BFHYDRO model, using the TPX0.5 gridded tidal data at the boundaries of the computational domain. The model predictions closely reproduced the measured phase and amplitudes, demonstrating the reliability and accuracy of the model for predicting the propagation of tidal currents over the bathymetric grid for the study area.

Both Cone and Crawford Bays are relatively shallow, therefore circulation in the bays is expected to be affected by wind patterns. Thus, estimates of wind-induced shear acting on the free water surface were included in the hydrodynamic model. Due to the remoteness of meteorological stations, estimates for local wind data were derived from the output of a numerical atmospheric model (the NCEP/NCAR model reanalysis) provided by the NOAA-CIRES Climate Diagnostics Centre in Boulder, Colorado, from their Web site at http://www.cdc.noaa.gov. Data from the closest grid station was downloaded for sample periods spanning December 2005, January, June and July 2006. Figure B18 shows monthly wind roses for these data. The wind roses indicate that winds over Cone and Crawford Bays during the wet period (December 2005-January 2006)

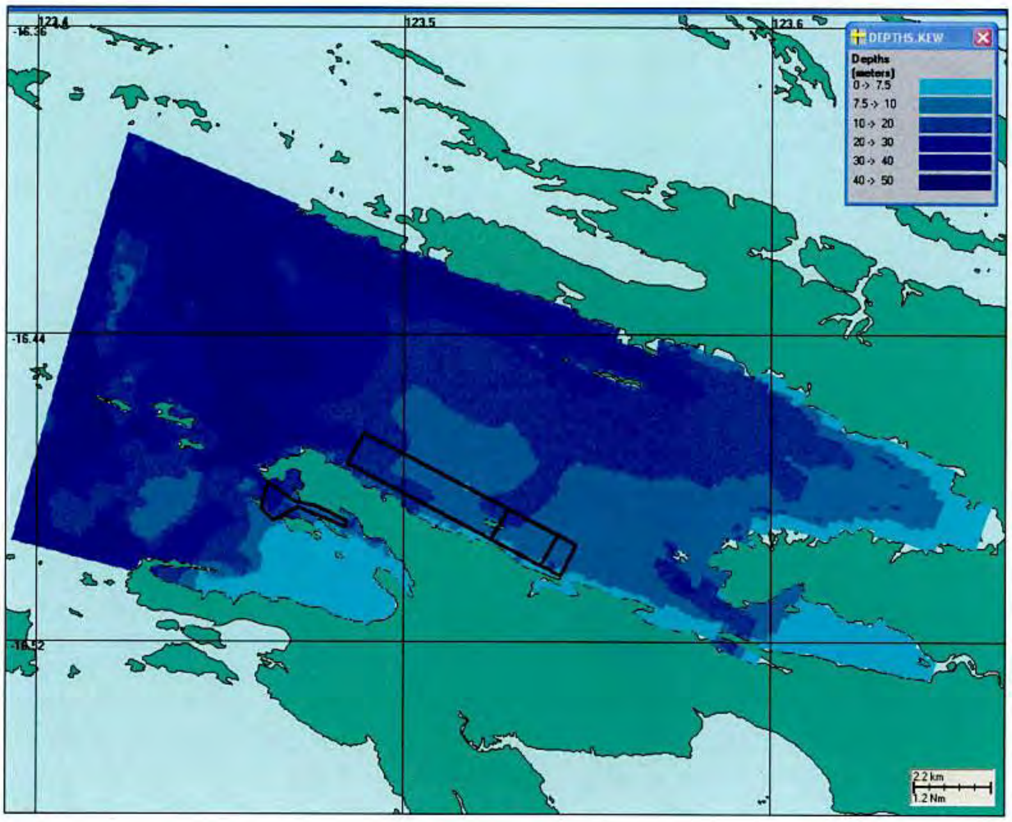


Figure B16: Details of the bathymetric grid defining the model domain.

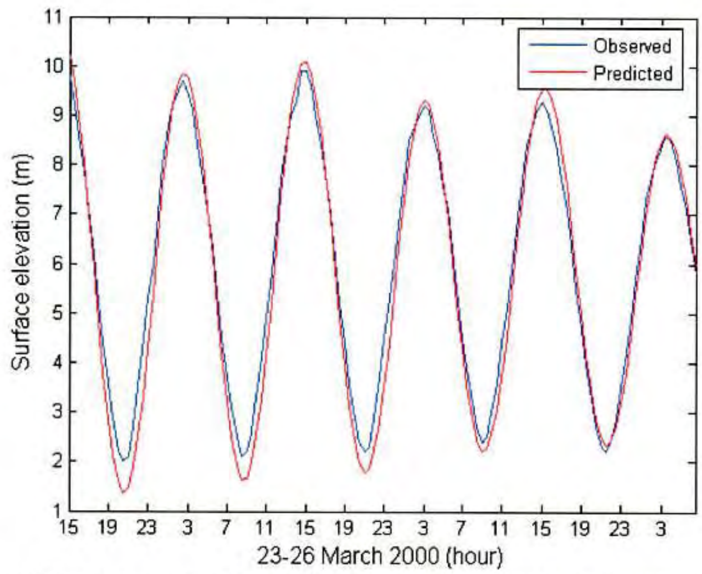


Figure B17: Comparison of observed and predicted surface elevations within Cone Bay during 23– 26 March 2000.

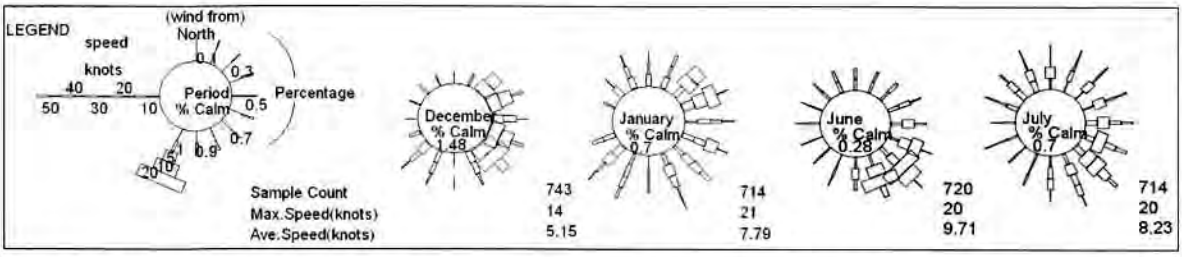


Figure B18: December 2005, January, June and July 2006 monthly wind rose diagrams. Axes indicates the direction the wind blew from.

had a mean of 6.5 knots and a maximum of 21 knots, while during the dry season (June-July 2006) a mean of 9 knots and a maximum of 20 knots were observed. During December, the winds were predominately from the south-eastern/north-eastern quarter; during June they were predominately from the south-east. Wind directions during January and July were more variable.

A wind-drag coefficient of 0.0014 was applied to account for the stress on the water surface (Kowalik and Murty, 1993).

3.3.3. Drogue Validation Study

Maxima Fish Farms Pty Ltd conducted drogue studies within Crawford Bay during June and July 2006, which were used to validate the hydrodynamic model. The drogue studies were carried out at random times and under varying environmental conditions on the 2nd, 6th, 30th June and 11th July 2006. The drogues were deployed at 5 m below the water surface at three locations within the proposed aquaculture site and their positions tracked over time.

To simulate the trajectories of each drogue, BFHYDRO predicted currents were used as input to a particle-trajectory model. The model also included allowances for sub-grid scale turbulence and diffusion, specified as a horizontal diffusion coefficient value of 10 m^2/s representative of coastal waters with strong tidal flows.

Figures B19 - B22 show comparisons of the observed start and end points for the drogues and the model-predicted trajectories. It can be observed from these figures that the model simulated trajectories show a consistently good agreement with the field observations, especially those within the aquaculture site in Crawford Bay, indicating that the model settings are appropriate.

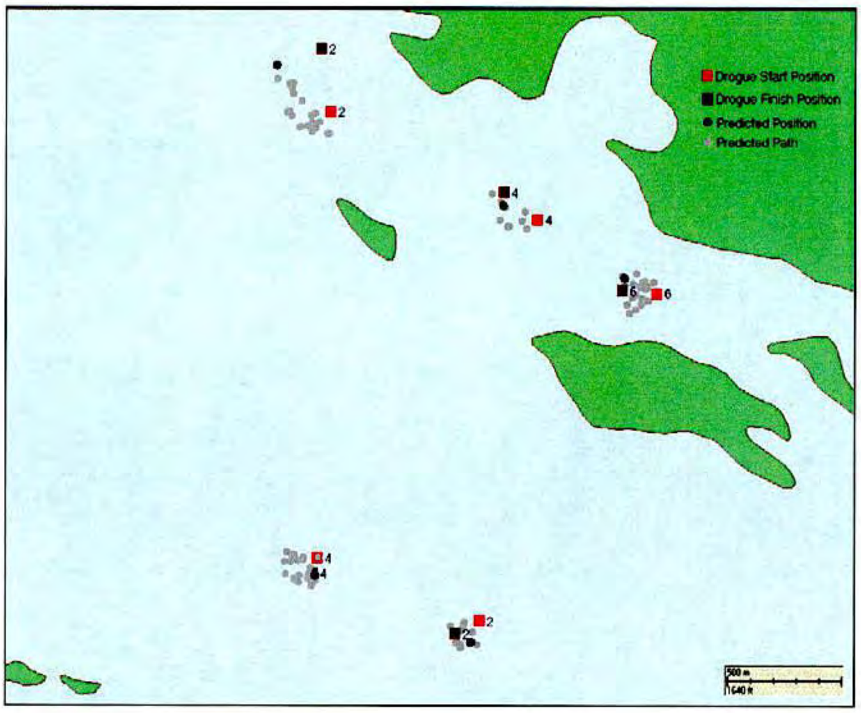


Figure B19: Measured and simulated (black circle) drogue trajectories for the 2nd June 2006 in Crawford Bay.

Figure B20: Measured and simulated (black circle) drogue trajectories for the 6th June 2006 in Crawford Bay.

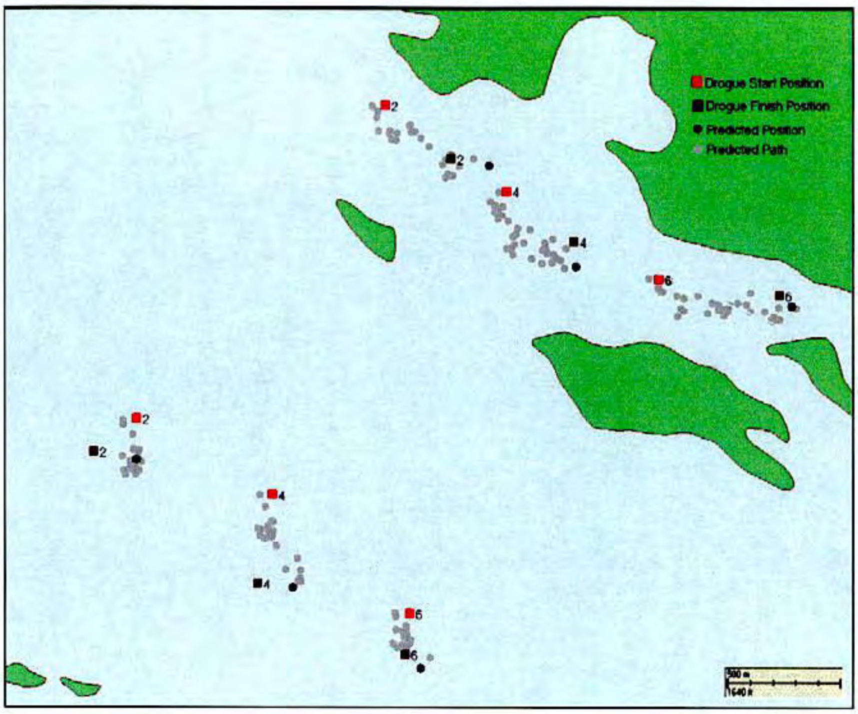


Figure B21: Measured and simulated (black circle) drogue trajectories for the 30th June 2006 in Crawford Bay.

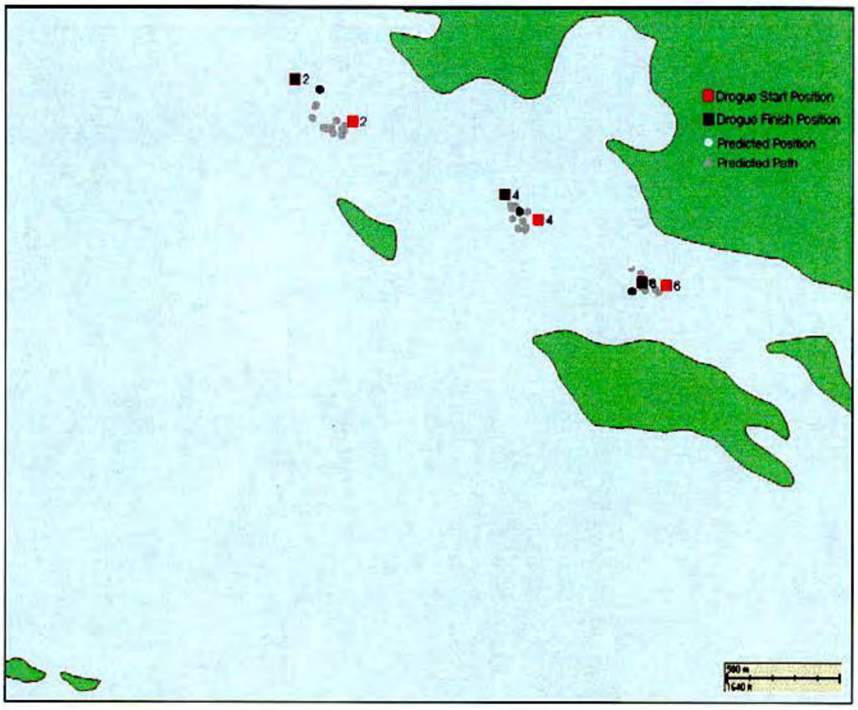


Figure B22: Measured and simulated (black circle) drogue trajectories for the 11th July 2006 in Crawford Bay.

3.4. Circulation Within Cone Bay and Crawford Bay

Following the validation stage, the hydrodynamic model was run for two 60-day periods under December 2005-January 2006 and June-July 2006 wind and tide conditions, respectively. A second set of hydrodynamic simulations was also performed to include the flow-retardation imposed by the sea-cages. The seabed drag coefficient was increased fivefold from 0.016 to 0.08 in the cells where the cage-clusters would be positioned, following recommendations by Grant and Bacher (2001) based on current measurements around suspended sea cages.

Figures B23 – B24 (wet season wind) and B25 –B26 (dry season wind) show a comparison of the predicted circulation patterns during peak flood and ebb tide flows, respectively. Currents are displayed for the same time with and without sea-cage drag. Figure B27 shows comparisons of the predicted current speeds over time at a central site within the aquaculture licence with and without sea-cage drag. Results indicate that similar circulation patterns occur through the aquaculture licence and within the wider study area irrespective of the sea cages. Current speeds through the immediate location of the cages would however be reduced during peak flood and ebb flow. Peak current speeds at the centre of the aquaculture area were estimated to reach 0.45 m/s without the sea cages and 0.25 m/s with the installation of the sea cages. Greater retardation of current speeds was indicated for periods of faster tide flows because drag effects would increase exponentially with higher flow rates. Retardation was marginal during neap tides.

It should be noted that the predicted currents speeds west of Turtle Island and out into Cone Bay were much stronger (up to 0.8 m/s) and unaffected by the inclusion of the sea cages. The main reason that the currents are much weaker within the Cone Bay sea cage site, is due to the Island land mass creating a sheltering effect.

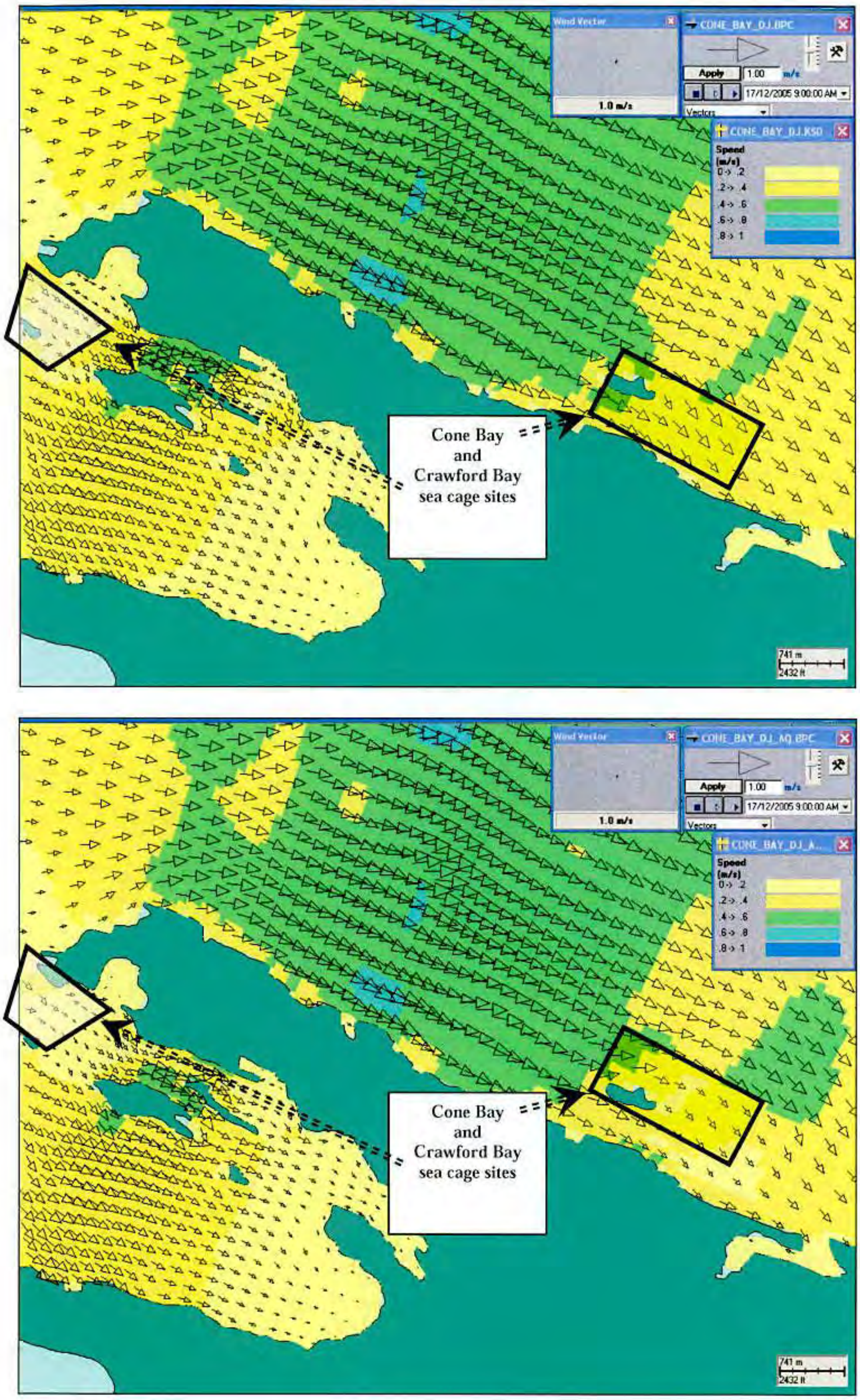


Figure B23: Comparison of circulation patterns during a flood tide event for the existing environment (top) and with introduction of additional drag to represent the sea cages (bottom), December 2005. Colour coding and arrow lengths indicate the relative magnitude of current speeds.

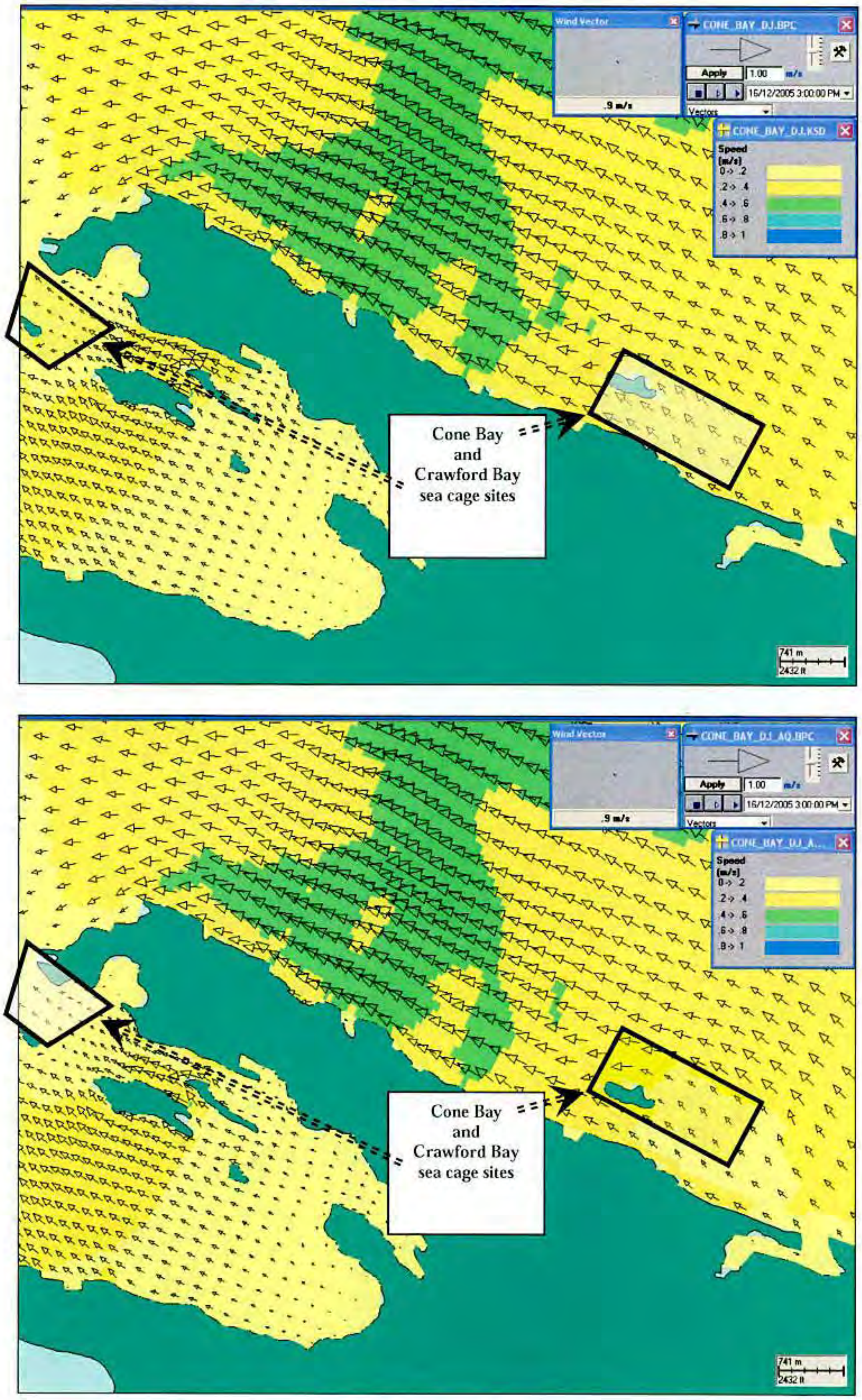
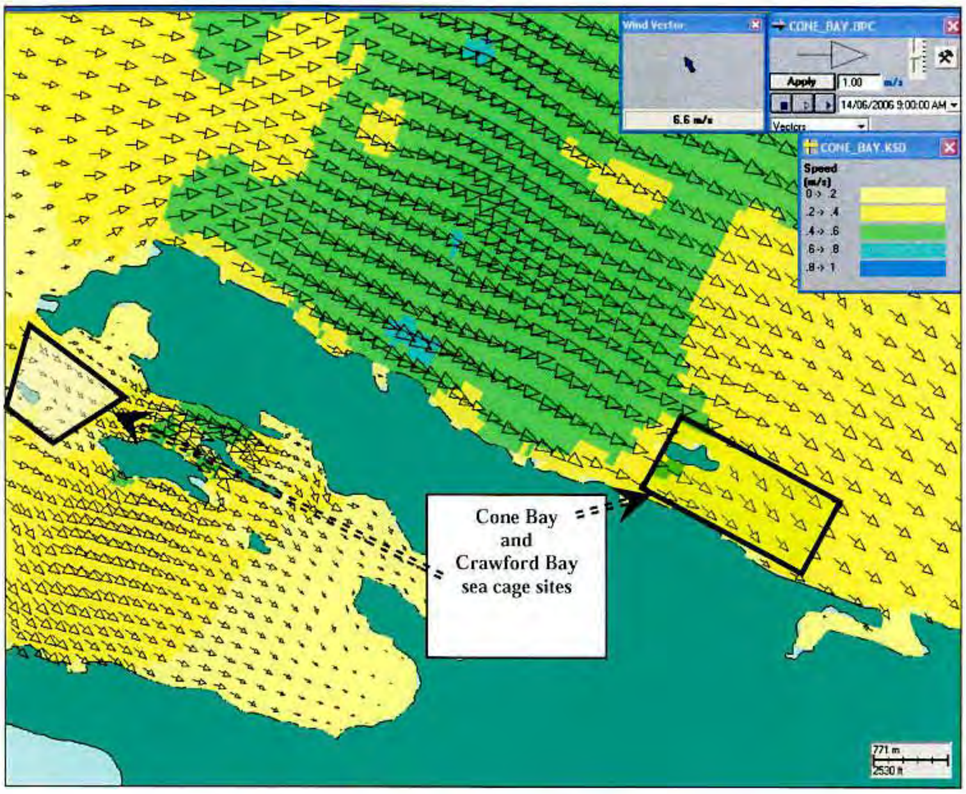


Figure B24: Comparison of circulation patterns during an ebb tide event for the existing environment (top) and with introduction of additional drag to represent the sea cages (bottom), December 2005. Colour coding and arrow lengths indicate the relative magnitude of current speeds.



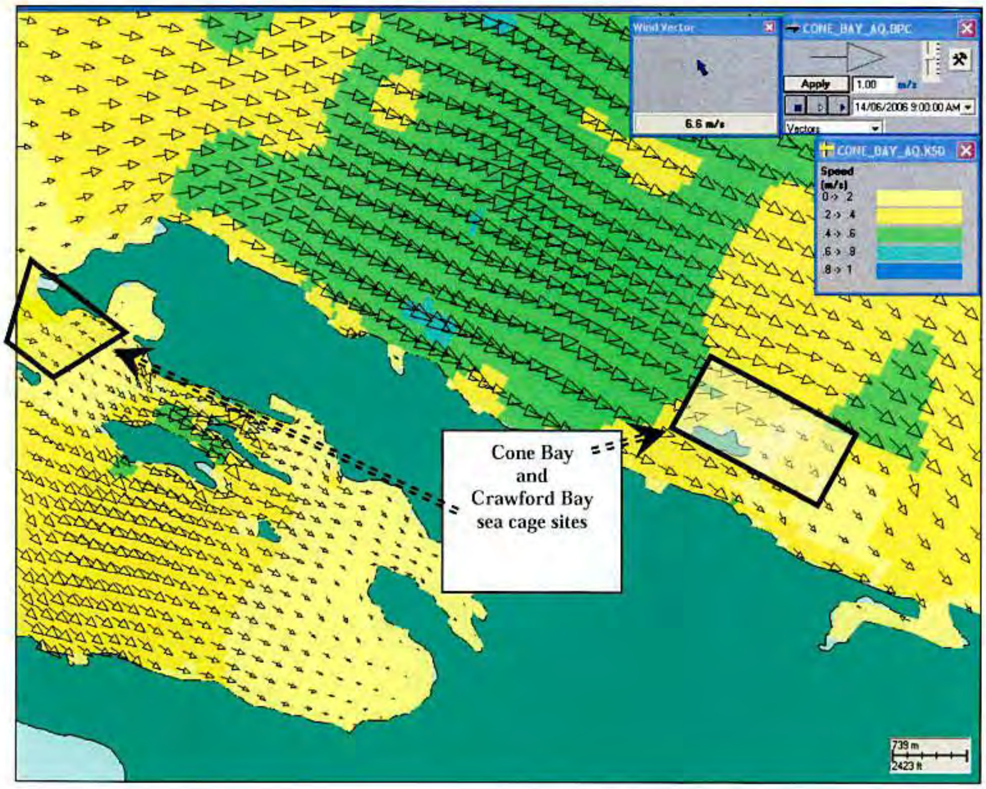
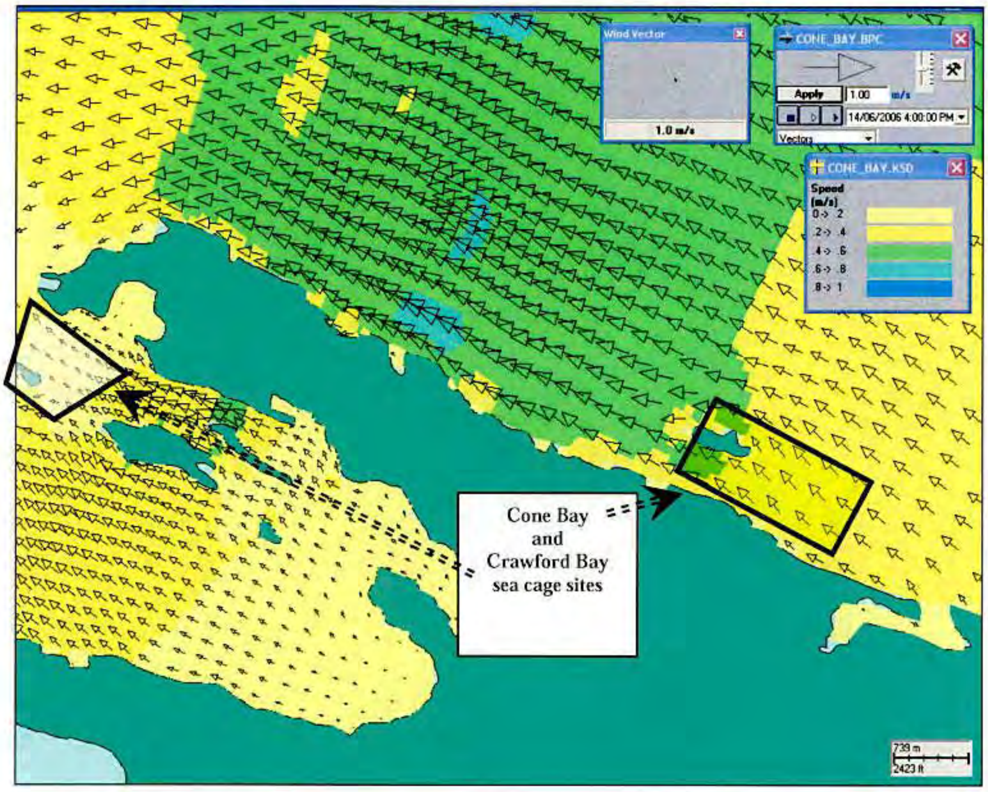


Figure B25: Comparison of circulation patterns during a flood tide event for the existing environment (top) and with introduction of additional drag to represent the sea cages (bottom), June 2006. Colour coding and arrow lengths indicate the relative magnitude of current speeds.



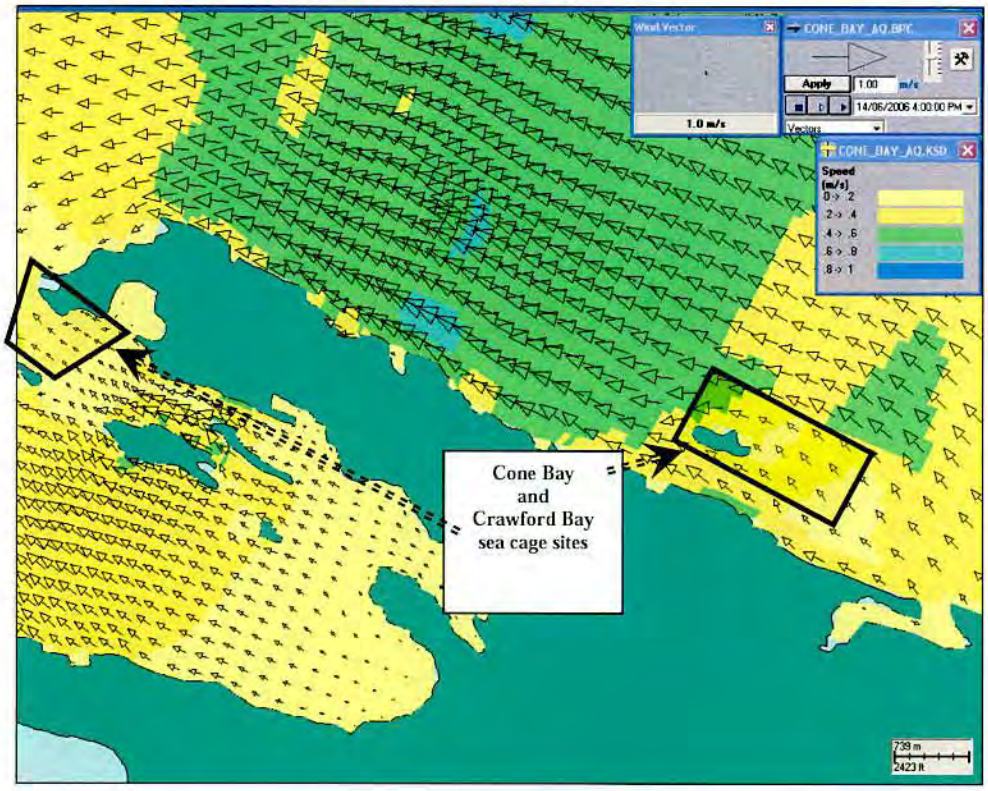


Figure B26: Comparison of circulation patterns during an ebb tide event for the existing environment (top) and with introduction of additional drag to represent the sea cages (bottom), June 2006. Colour coding and arrow lengths indicate the relative magnitude of current speeds.

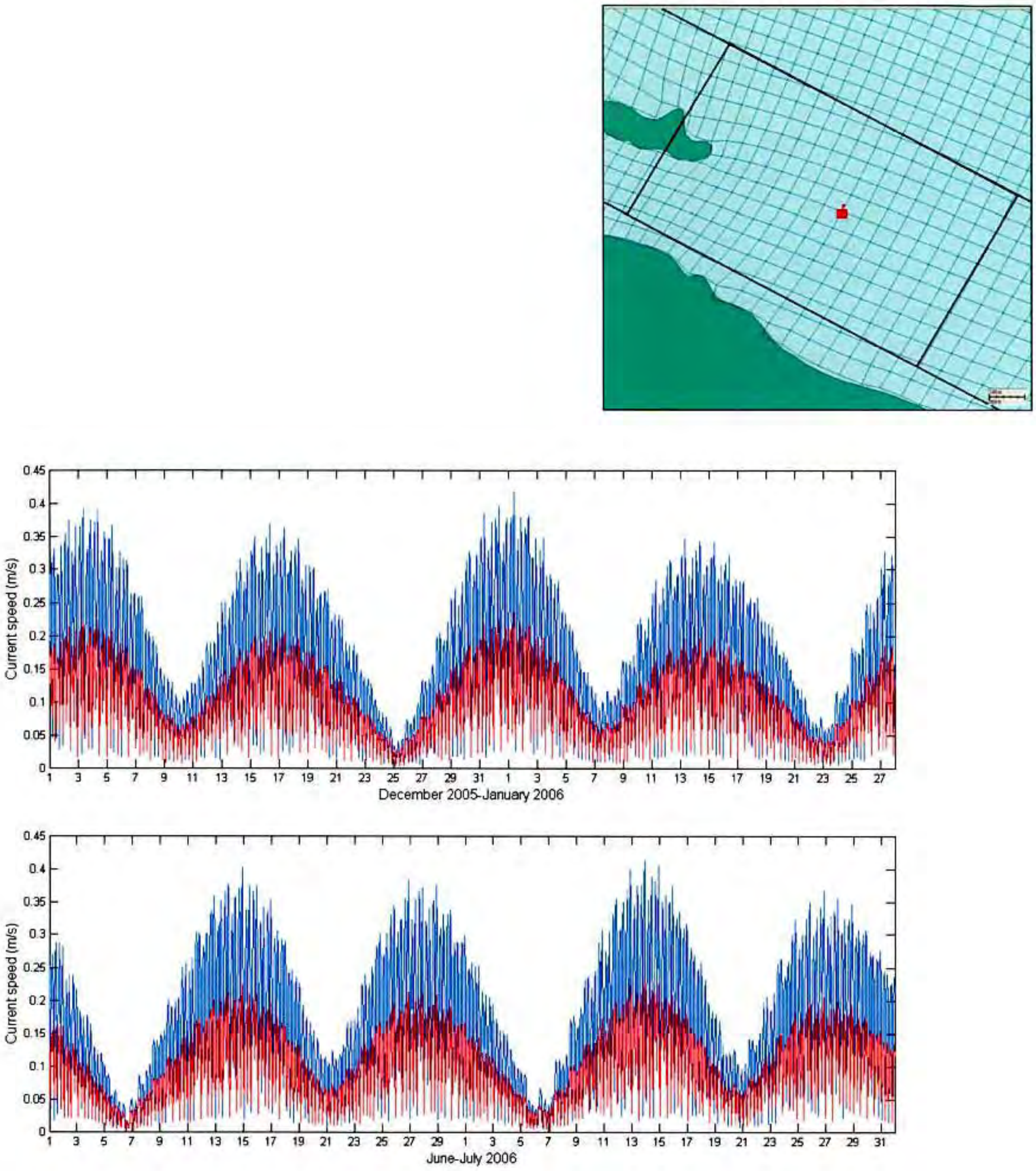


Figure B27: Comparison of the hourly variations in current speeds at a central point within the Cone Bay (top panel) predicted for the existing environment and with introduction of sea cages aquaculture licence for the wet (middle panel) and dry (bottom panel) seasons.

3.5. Effects of Sea Cages on Flushing

To examine the effects of the sea cages on local water flushing times a numerical dye-flushing simulation was carried out for both Cone and Crawford Bays. The study used a mass-transport model (BFMASS), which calculates the transport and dispersion of material by water-currents predicted by the BFHYDRO model. To investigate the flushing times, a uniform dye concentration was defined within two polygons limited by the aquaculture licences in Cone Bay and Crawford Bay (Figure B28). Multiple numerical simulations were carried out for different samples of circulation to estimate the time required for concentrations to flush to below threshold levels with and without the sea cages. Samples were taken from the 30-day circulation data for wet and for dry seasons in the presence of one (left panel in Figure B28) or both (right panel in Figure B28) fish farms. Flushing time was calculated as the time required for concentrations to drop below 37% of the initial concentration (the e-folding time). The tracer was treated as neutrally buoyant and non-reactive so that changes in the tracer concentrations were solely affected by advection of the currents.

Figures B29 – B35 show graphical comparisons of flushed states after elapsed times for both the existing morphology and with the introduction of the sea cages in Cone Bay or Cone and Crawford Bays as in Figure B28.

Figure B36 shows the comparison of the predicted flushing states for the existing environment and introduction of sea cages at a central point within Cone Bay licence site for December spring tide currents and June neap tide currents.

The model results suggested that flushing times were not greatly affected by introduction of the sea cages during a spring tide for either a single dye source (Cone Bay licence only) or both. For the existing morphology, the Cone Bay licence area was completely flushed within 2-days during both December strong spring currents and June weak neap currents.

By introducing the sea cages the estimated flushing times were predicted the same under December strong spring currents, although, were longer during neap tides. Flushing took approximately one day longer (3 days) due to the retardation of the tidal flows, which in turn reduced the extent of flushing during ebbing tides.

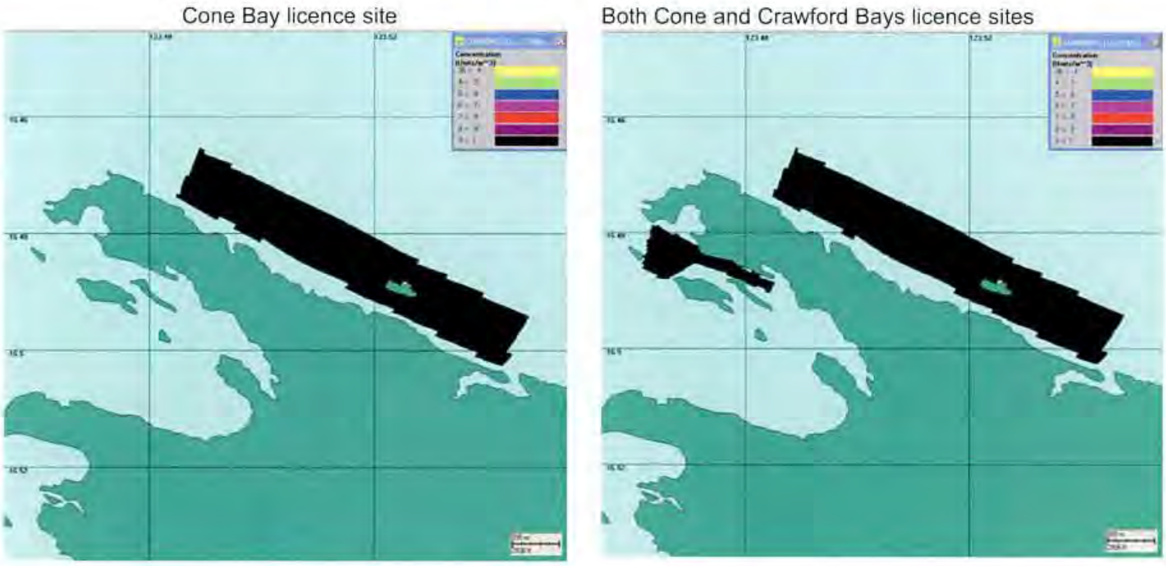


Figure B28: Distributed sources of tracers for flushing studies.

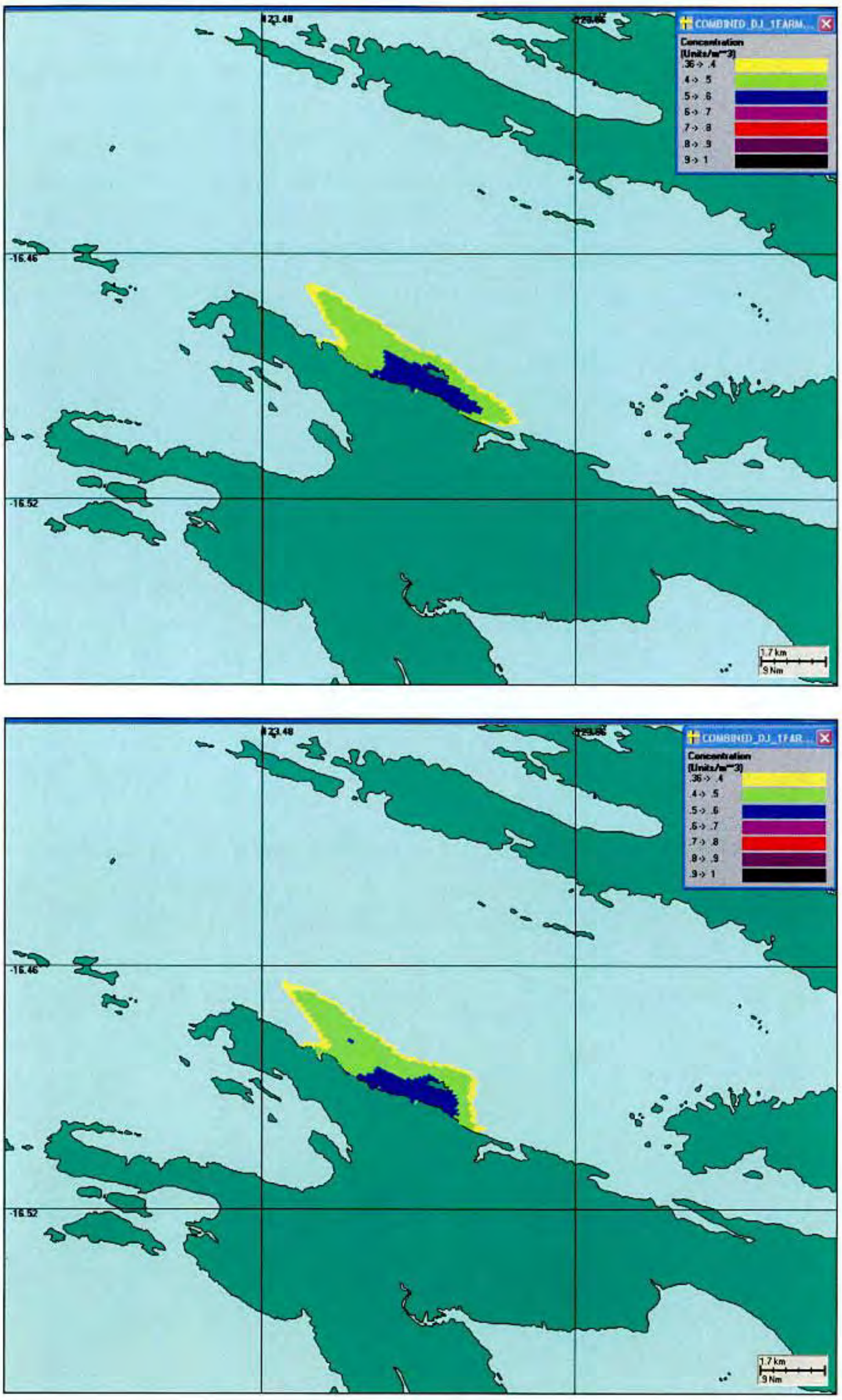


Figure B29: Comparison of flushed states after one day for the Cone Bay licence site. Top panel shows the existing environment; bottom panel shows the introduction of the sea cages (December 2005 spring tide currents).

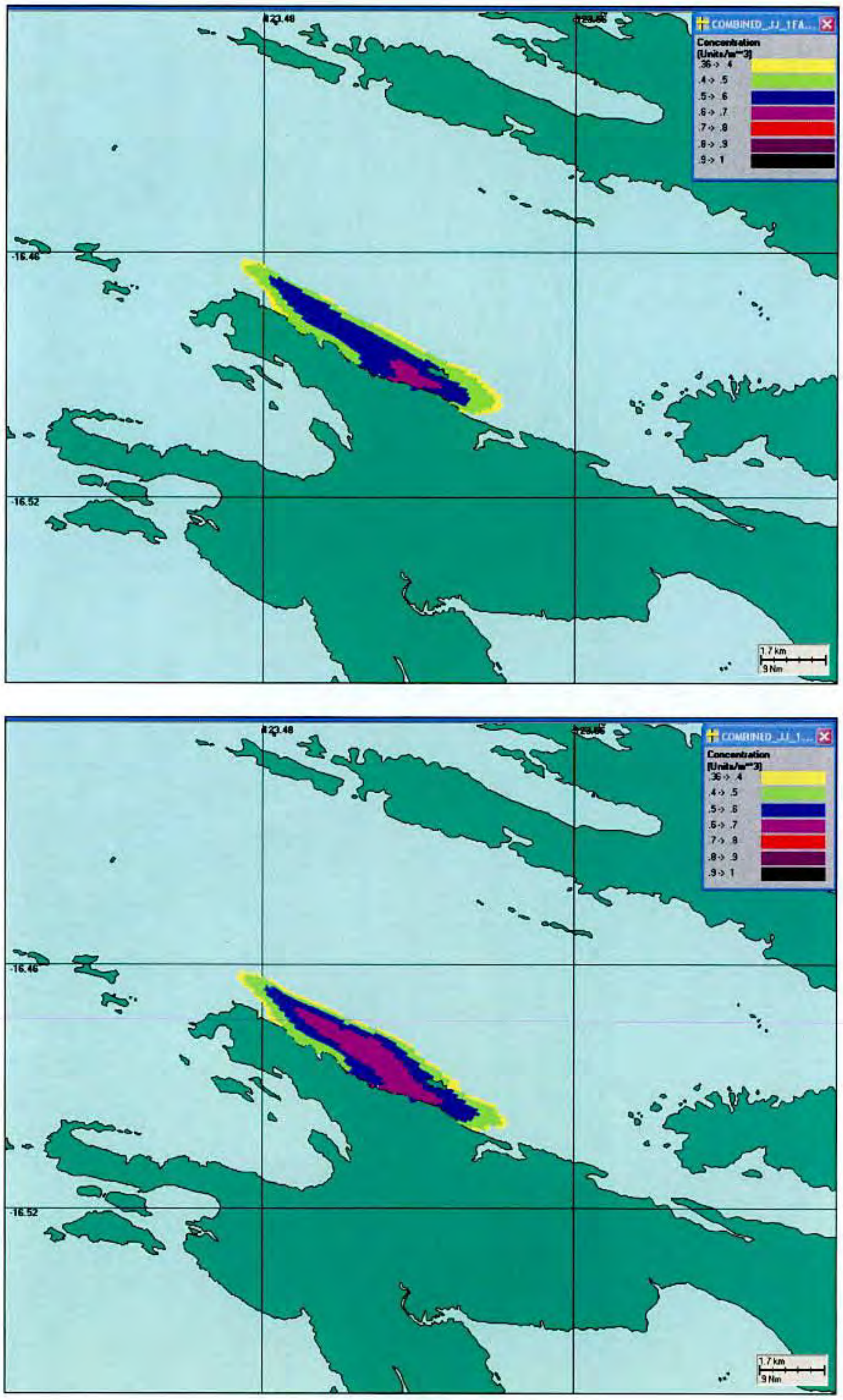


Figure B30: Comparison of flushed states after one day for the Cone Bay licence site. Top panel is for the existing environment; bottom panel is with the introduction of the sea cages (June 2006 neap tide currents).

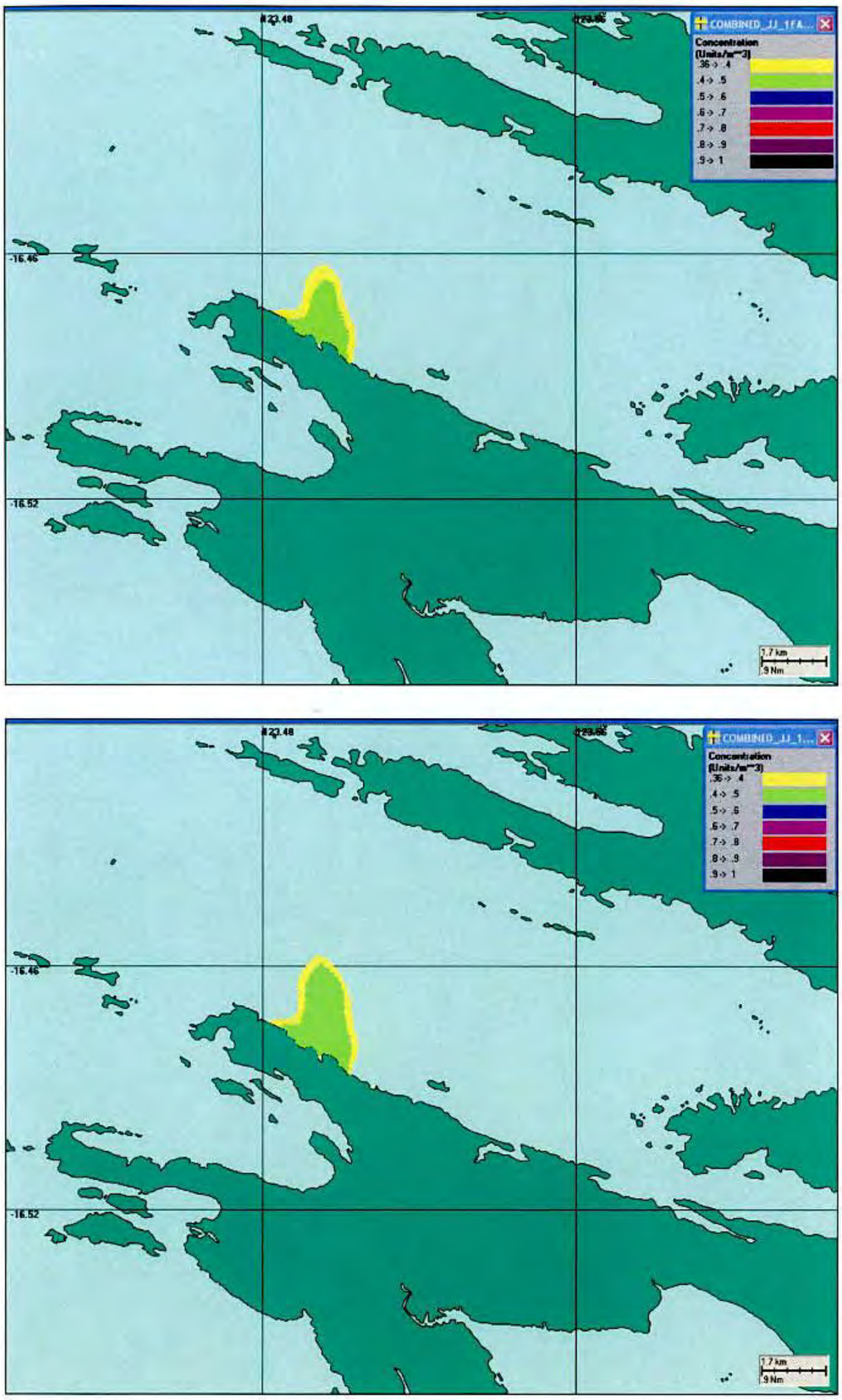


Figure B31: Comparison of flushed states after 5 days for the Cone Bay licence site. Top panel is for the existing environment; bottom panel is with the introduction of the sea cages (June 2006 neap tide currents).

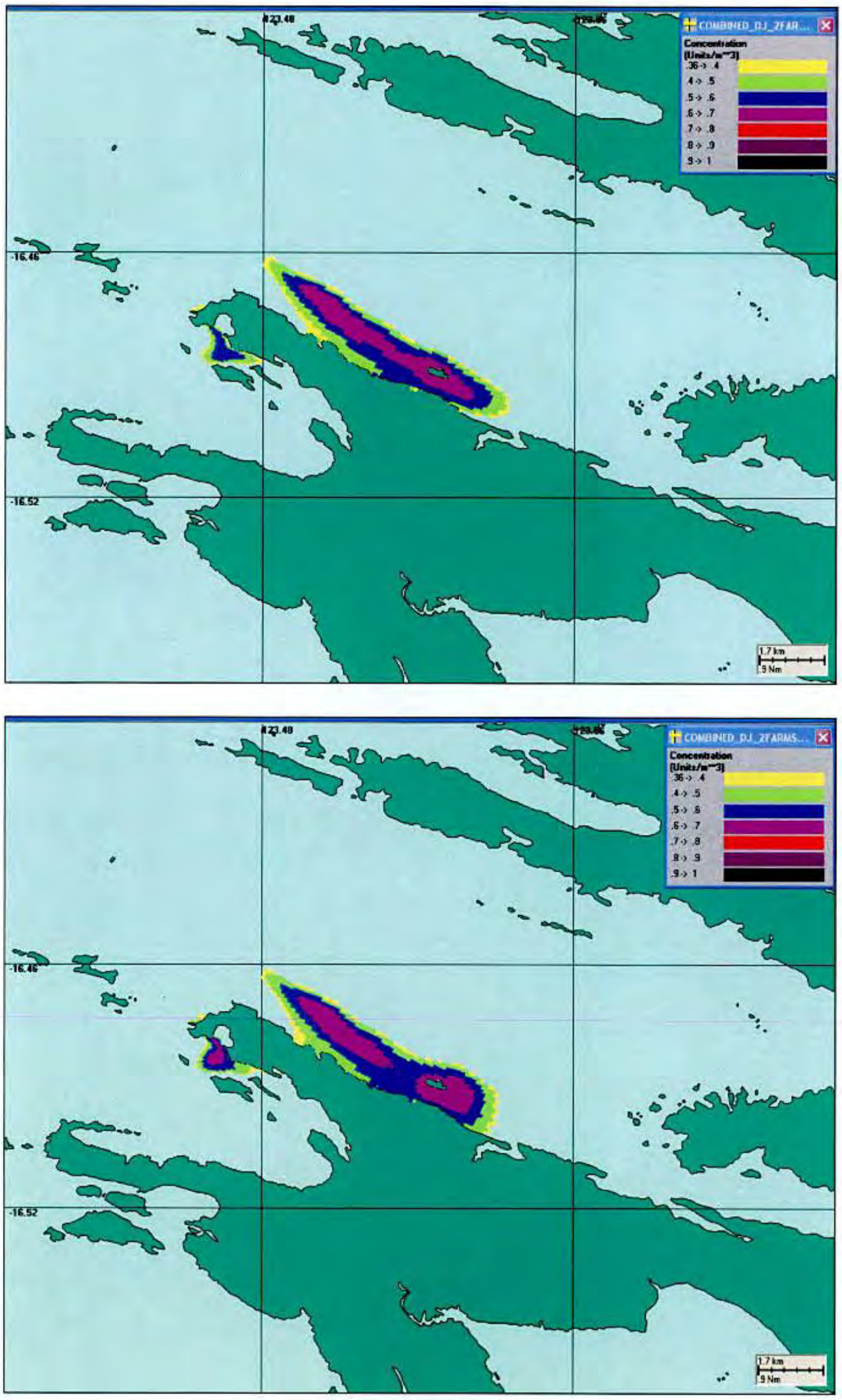


Figure B32: Comparison of flushed states after 12-hours for both (Cone Bay and Crawford Bay) licence sites. Top panel shows the existing environment; bottom panel shows introduction of the sea cages (December 2005 spring tide currents).

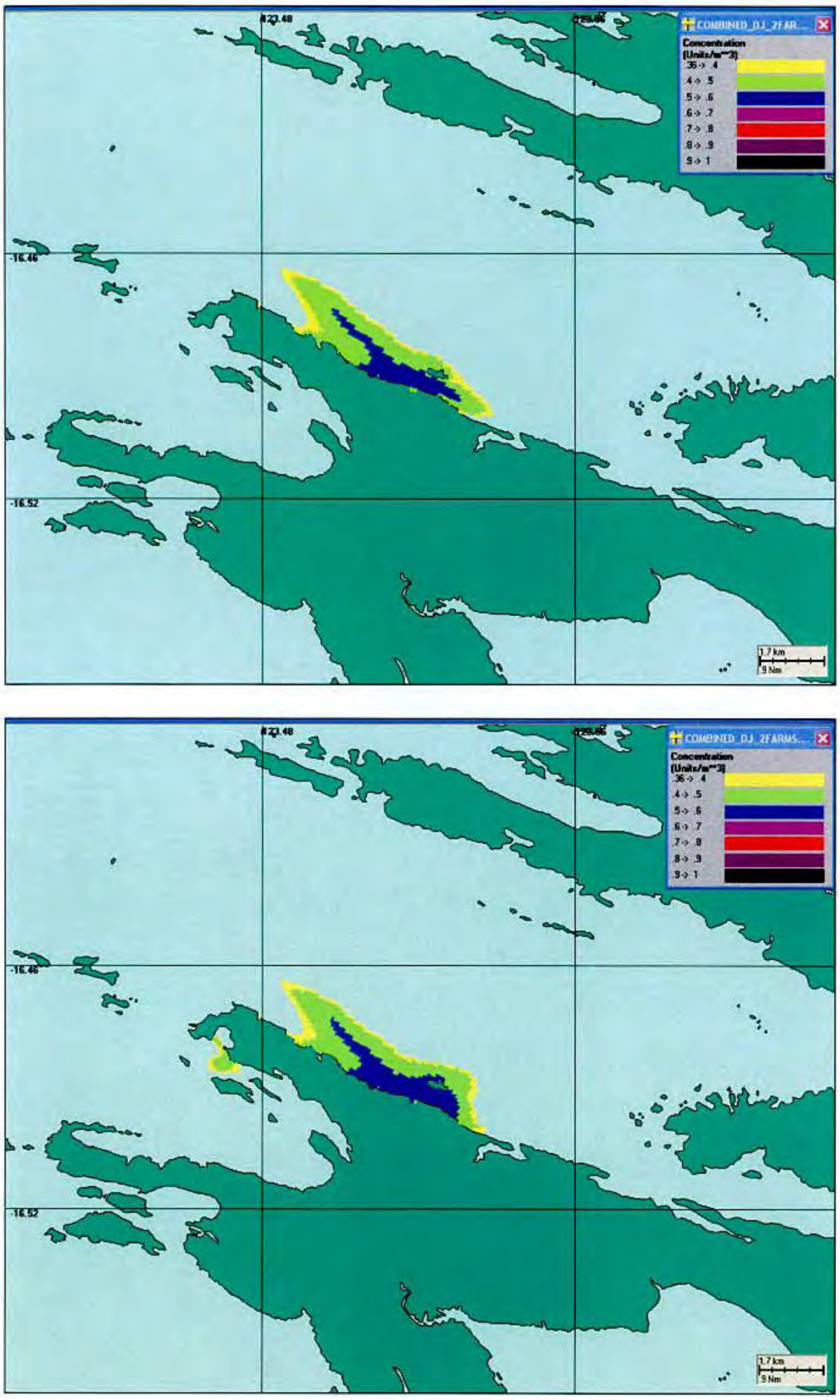


Figure B33: Comparison of flushed states after one day for both (Cone Bay and Crawford Bay) licence sites. Top panel shows the existing environment; bottom panel shows the introduction of the sea cages (December 2005 spring tide currents).

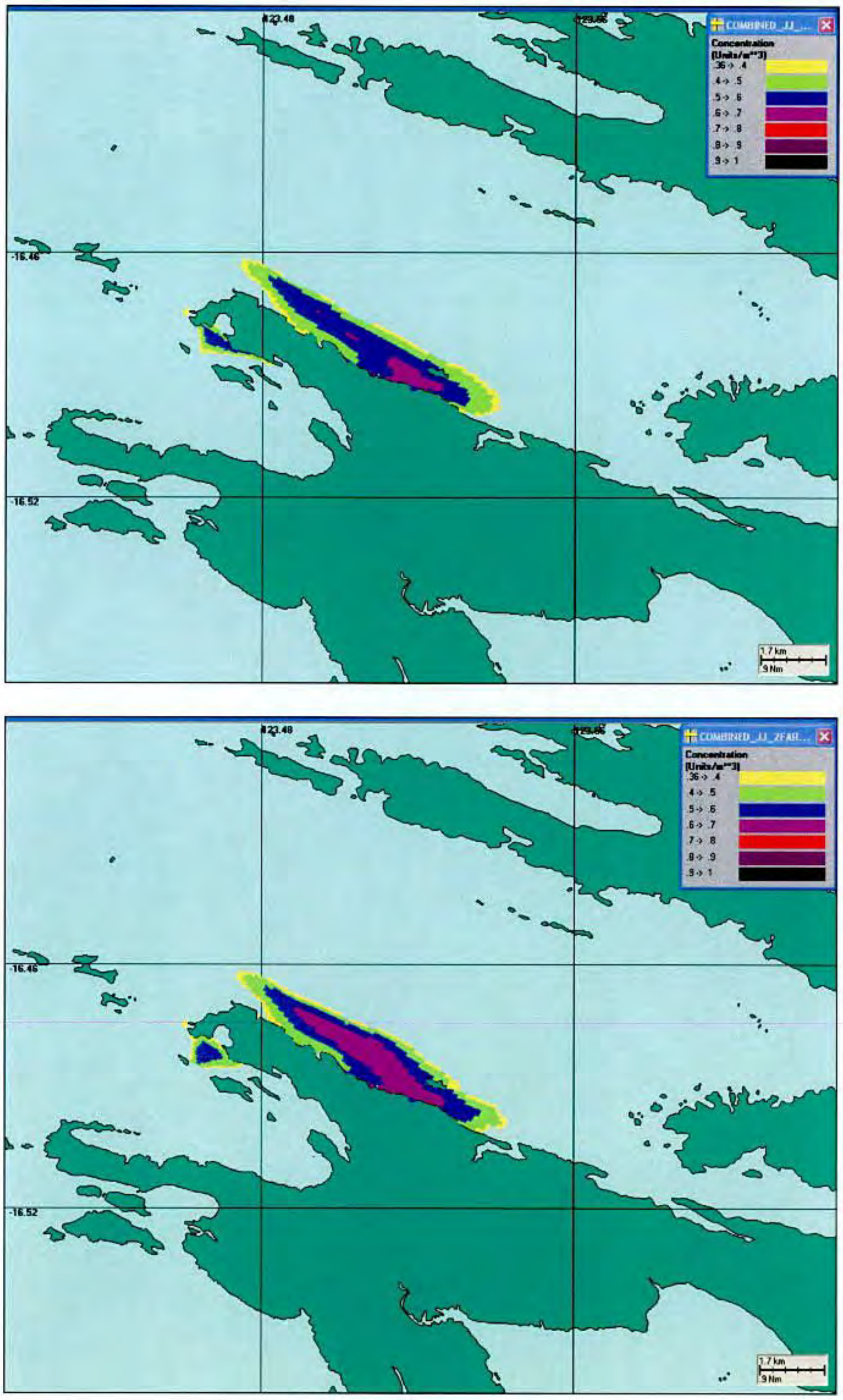


Figure B34: Comparison of flushed states after one day for both (Cone Bay and Crawford Bay) licence sites. Top panel is for the existing environment; bottom panel is with the introduction of the sea cages (June 2006 neap tide currents).

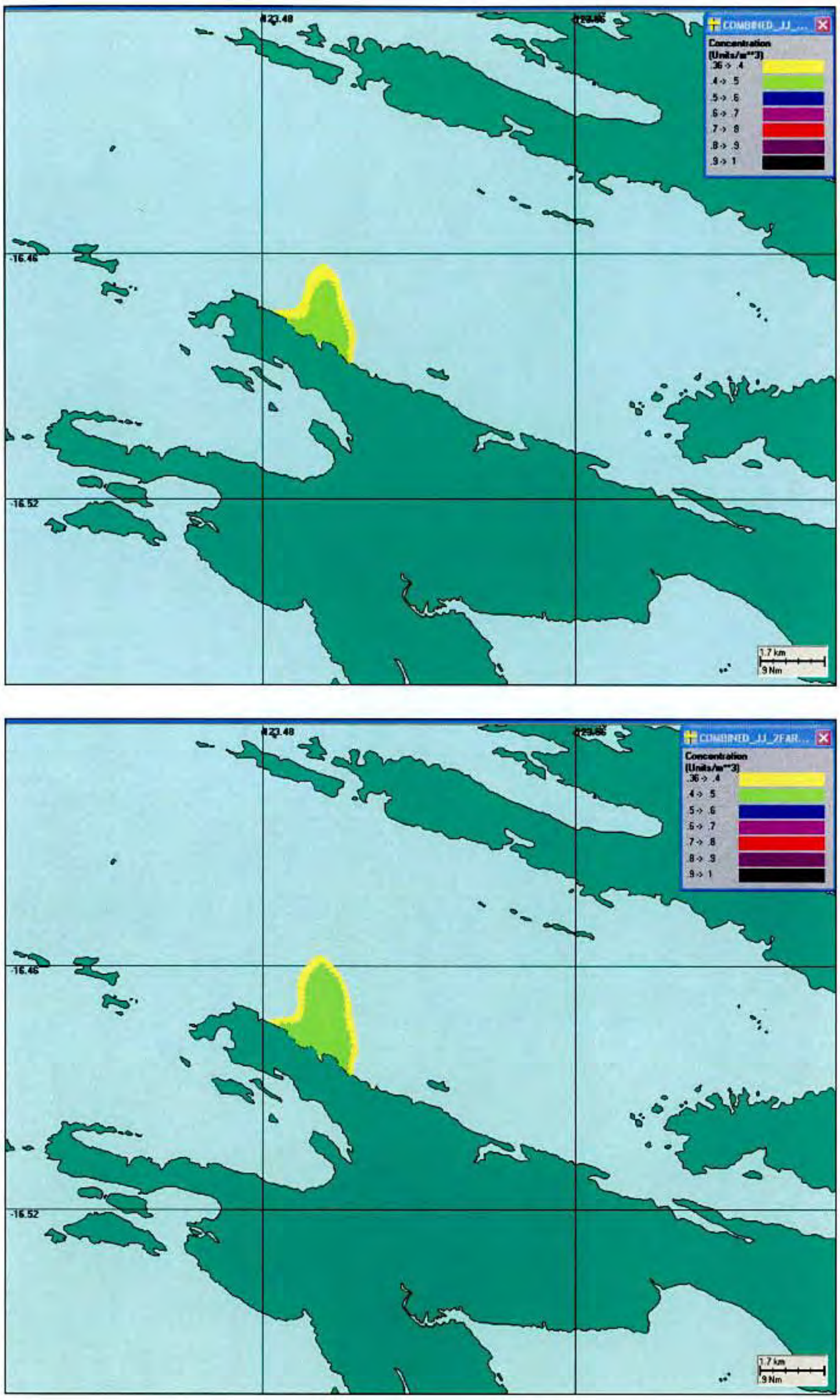


Figure B35: Comparison of flushed states after 5 days for both (Cone Bay and Crawford Bay) licence sites. Top panel is for the existing environment; bottom panel is with the introduction of the sea cages (June 2006 neap tide currents).

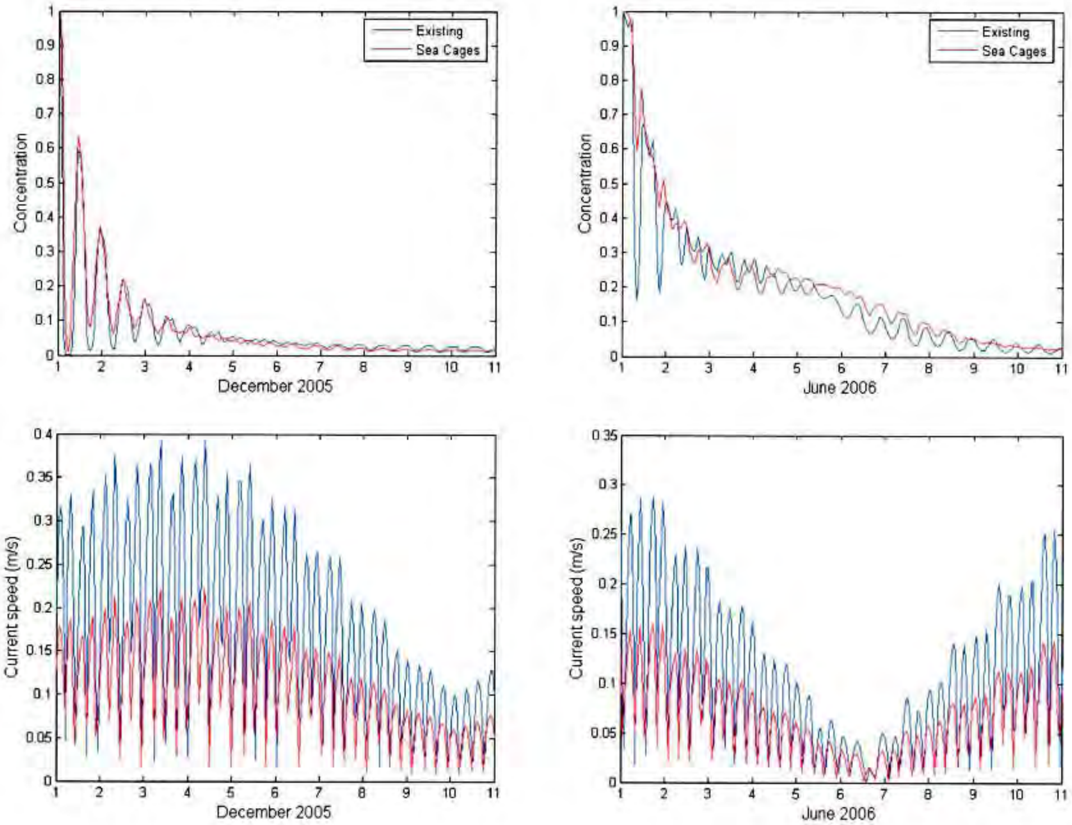


Figure B36: Comparison of the predicted flushing states for the existing environment and introduction of sea cages at a central point within Cone Bay licence site for spring tide currents during the wet (left panels) and neap tide currents during dry (right panels) seasons, respectively; tracers released from both Cone Bay and Crawford Bay distributed sources.

3.6. Modelling the Dispersion and Settlement of Waste Products

MPC have indicated that waste products from the Barramundi operation will be in the form of fish waste and/or lost fish food pellets. With regards to the fish waste it is estimated the amount of solid wastes will be approximately 53.4 kg/day, which will have an average sinking rate of 3 cm/sec (Timmons *et al*, 2001; Cromely *et al*, 2002; Corner *et al*, 2006; Cromely and Black, undated). For the loss of fish food, MPC anticipated that, due to the planned feeding method, only 0.5% of the 1500 T/annum (approximately 20 kg/day) of fish food will be lost. MPC anticipate that four pellet sizes will be used to feed the Barramundi (4 mm, 6 mm, 8 mm and 10 mm), with the 10 mm pellet making up 70 – 80 % of the feed and the rest being mostly 8 mm. (Table B13).

Sinking rates for the various pellet sizes were obtained from the food producers and are shown in Table B13. Fall velocities for the range of fish pellet sizes are very similar so as a conservative approach modelling was carried using the settling rate for the pellet size that has slowest settling velocity (10 mm) and, therefore, would travel the furthest.

Table B13: Fish pellet sizes, distribution and average settling velocities

Pellet size (mm)	% Distribution (by volume)	Average Settling velocity (cm/s)
4	3	11.1
6	3	11.1
8	14	10.5
10	80	10.4

The transport and deposition of the fish waste and lost fish food was simulated using BFMASS. This model is suitable for a single constituent contaminant that is conservative, settles, decays, or grows. The simulation did not include subsequent re-suspension or digestion of the food waste. Moreover, total deposition over time will be a product of the duration of supply. Thus estimates of deposition have been presented in terms of daily-deposition rates ($g/m^2/day$) to indicate the magnitude of the supply of food material to specific locations. In addition to simulating the transport and sinking of food pellets and fish waste, the model calculated dispersion by water turbulence. A horizontal diffusion parameter of 10 m^2/s (representative of energetic coastal waters) and a vertical diffusion coefficient of 0.001 m^2/s (typical for a well mixed water column) were applied.

The fates of fish waste and food pellets were simulated separately for two 30 day release periods using currents for December 2005 and June 2006. The waste products were released from 20 points within the Cone Bay aquaculture licence (Figures B14 and B37) as well as eight points within the broader section of the Crawford Bay aquaculture area.

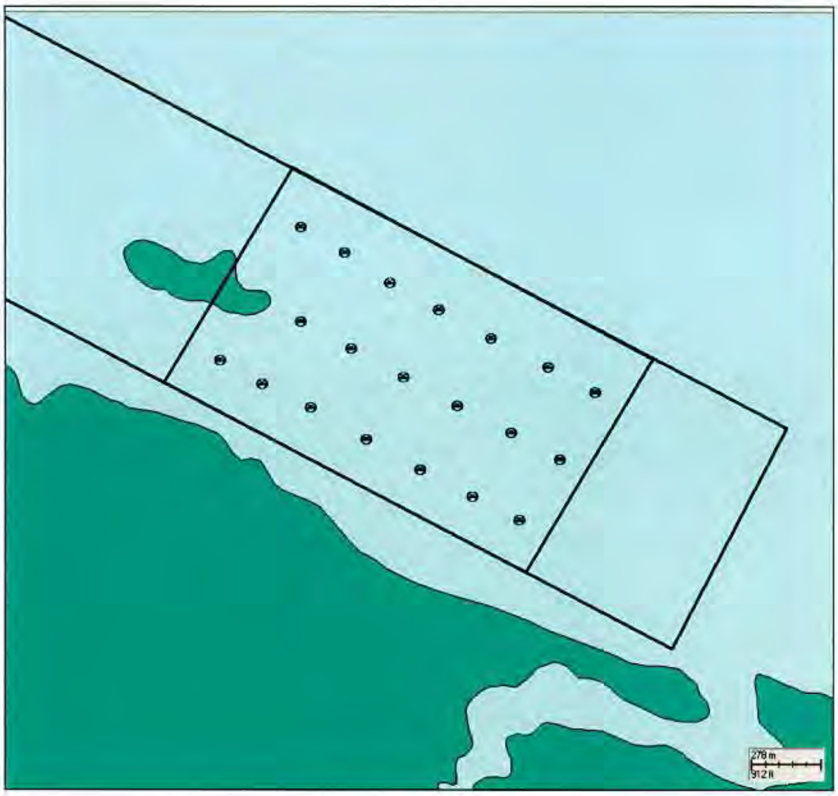


Figure B37: Location of the 20 point source release sites used to simulate the release of fish waste and food waste within licence site 1465.

Figures B38 and B39 show the predicted deposition rates for the fish waste and food waste, respectively, under the sample conditions in Cone Bay. The corresponding results for December 2005 and June 2006 were virtually identical thus demonstrating the dominance of settling velocities and tidal processes over variations in wind between the wet and dry seasons. Another common result for all simulations is the tendency for material to settle close to the release sites and along the general east-west tidal axis. The deposition of released waste depends on the tidal cycle: accumulation occurs to the east during the flood and west during ebb. Concentrations were predicted to decrease exponentially with distance from the release points and the sedimentation footprints around neighbouring points of discharge showed overlap. For the minimum threshold concentration of 0.01 $g/m^2/day$, settlement distance for fish waste was estimated as up to 250 m from a given discharge source along the main tidal axis. For the fish pellets, this distance was reduced to approximately 130-140 m. These distances provide a guide to the distance that cages should be away from the licence boundaries to minimise escape of fish waste and fish food from the aquaculture licence.

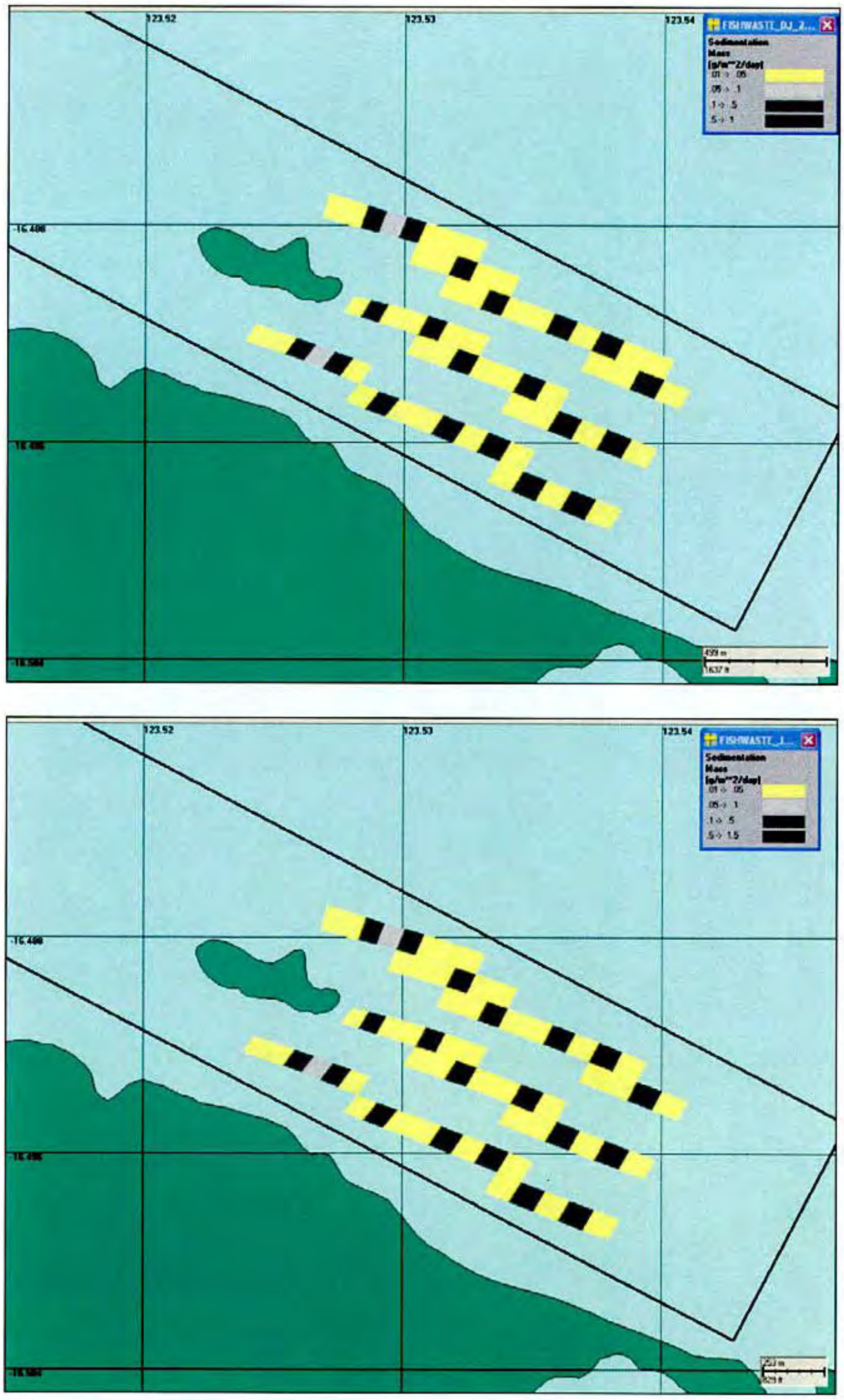


Figure B38: Predicted average deposition rate (g/m^2/day) over a 30 day continuous release of fish waste under December 2005 (top panel) and June 2006 (bottom panel) conditions.

Figure B39: Predicted average deposition rate (g/m^2/day) over a 30 day continuous release of fish pellets under December 2005 (top panel) and June 2006 (bottom panel) conditions.

3.7. Estimated Accumulation of Outputs From Two Adjacent Medium Production Fish Farms

The BFMASS model was used to estimate the dispersion and potential for accumulation of dissolved nutrients when released from the two adjacent medium production fish farms at full operation. MPC have indicated that the maximum total dissolved waste from the production of 1000 tonne of fish would equate to 87400kg per annum, or 239.5kg per day composed of 213.7kg of Nitrogen and 25.8kg of Phosphorous.

As part of the study BFMASS was used as a conservative tracer (no reaction or decay) and neutrally buoyant constituting a "worst case" scenario. The same horizontal (10 m^2/s) and vertical (0.001 m^2/s) diffusion coefficients were as in modelling the dispersion and settlement of waste products. Equal amounts of dissolved waste was released from 4 points in Cone and Crawford Bay aquaculture licences (see Figure B40). The releases were simulated for two 30 day continuous release periods using currents for December 2005 and June 2006. Please note, based on baseline studies, the background Total Nitrogen and Total Phosphorus were estimated at approximately 130 µg/L (~ 0.130 g/m^3), however as part of this modelling study the background concentrations values were set at 10 µg/L (~ 0. 010 g/m^3), to assess **if any** accumulation or interaction takes place between the two adjacent medium production farms, since this would be a worst case situation.

The model results indicated that the dissolved nutrient concentrations were strongly affected by tidal cycles within the bays. The concentrations increased within the licence area during the periods of slack tidal currents and decreased when the currents became stronger during either the flood or ebb events. This is evident from Figure B41, which shows a comparison of the predicted dissolved nutrient concentrations in the western sector and central point of the Cone Bay licence during December 2005 and June 2006 current conditions. The time series graphs show that the predicted concentrations at the western sector were 50% less than that of the dissolved concentrations at the Cone Bay sea cage release site.

Figures B42 – B44 showing the predicted concentration of dissolved nutrient concentrations during 3 distinctive observed stages: (a) initially noticeable accumulation reaching and exceeding the level of 0.01 g/m^3 (10 µg/L) after 7 days in December 2005 and after 3 days in June 2006 (Figure B42); (b) the maximum accumulation of up to 0.02 g/m^3 (20 µg/L) occurring during neap tides (Figure B43) with a consequent significant dilution during spring tides (Figure B44). From the obtained results there was no observed overlap of dissolved nutrient footprints from these two adjacent medium production fish farms even during the two 30 day simulations.

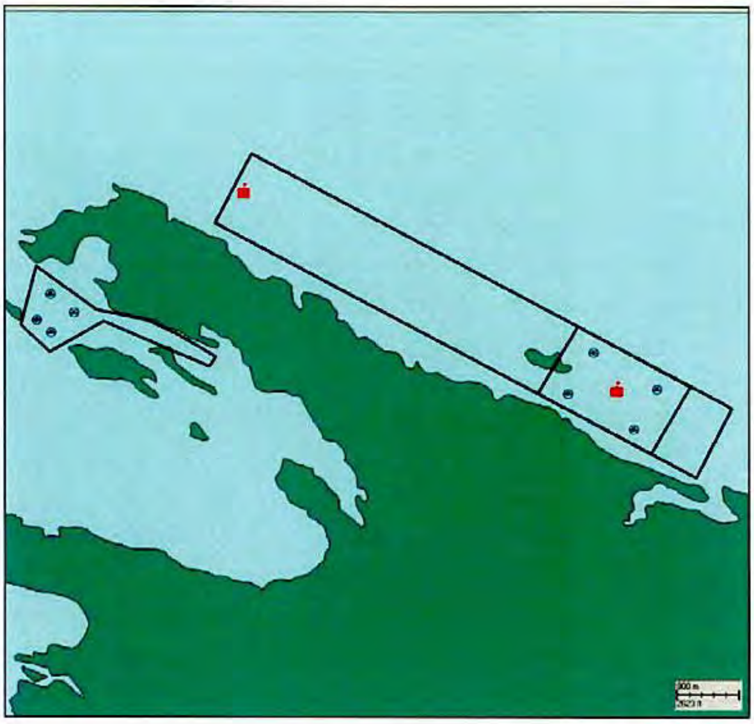


Figure B40: Location of the 8 point source release sites used to simulate the N&P concentration within Cone and Crawford Bays, as well as time series sites at the tip and in the central point of the Cone Bay licence.

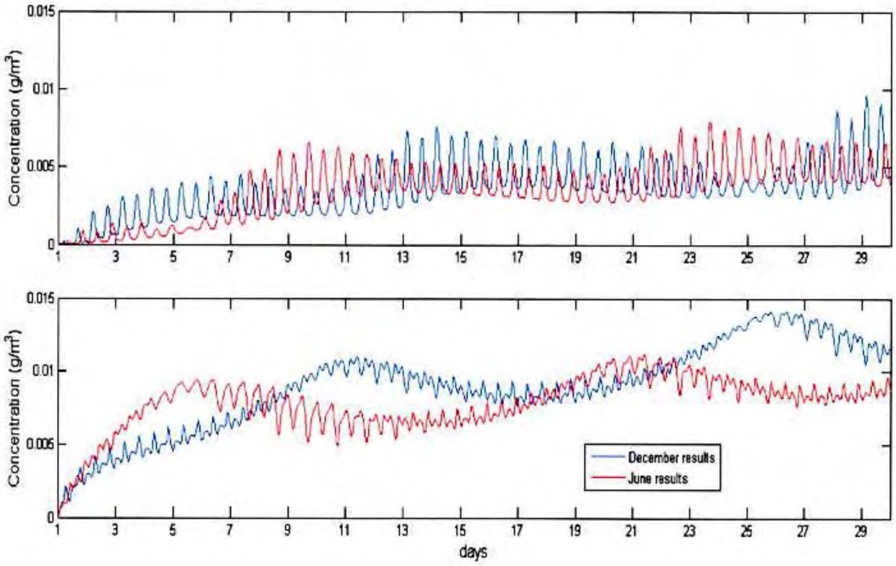


Figure B41: Predicted concentrations of dissolved nutrients at the tip (top panel) and in the central point (bottom panel) of the Cone Bay licence for December 2005 and June 2006

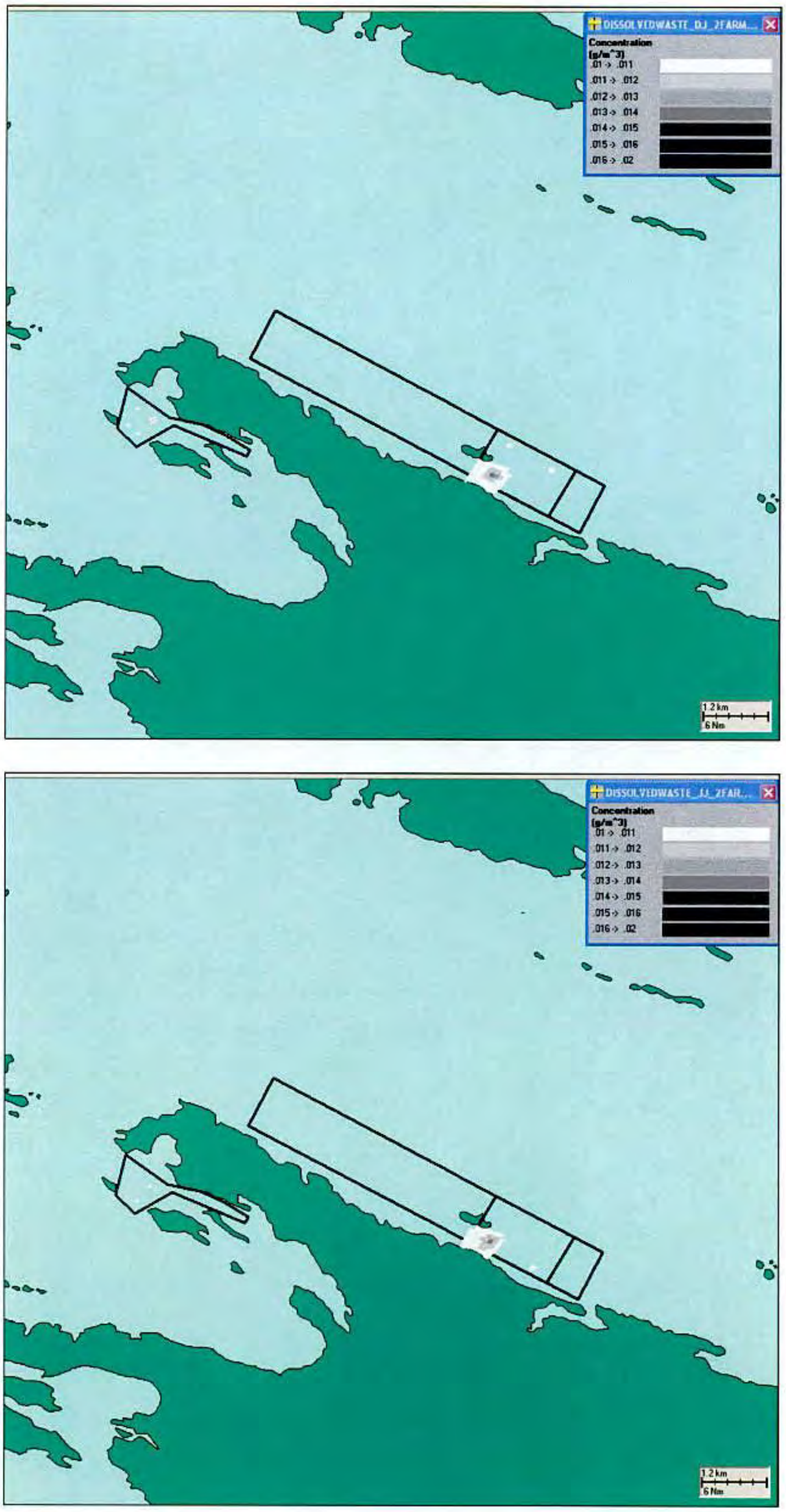


Figure B42: Predicted dissolved nutrient concentrations (g/m^3) after a 7 days continuous release in December 2005 (top panel) and a 3 days continuous release in June 2006 (bottom panel) conditions.

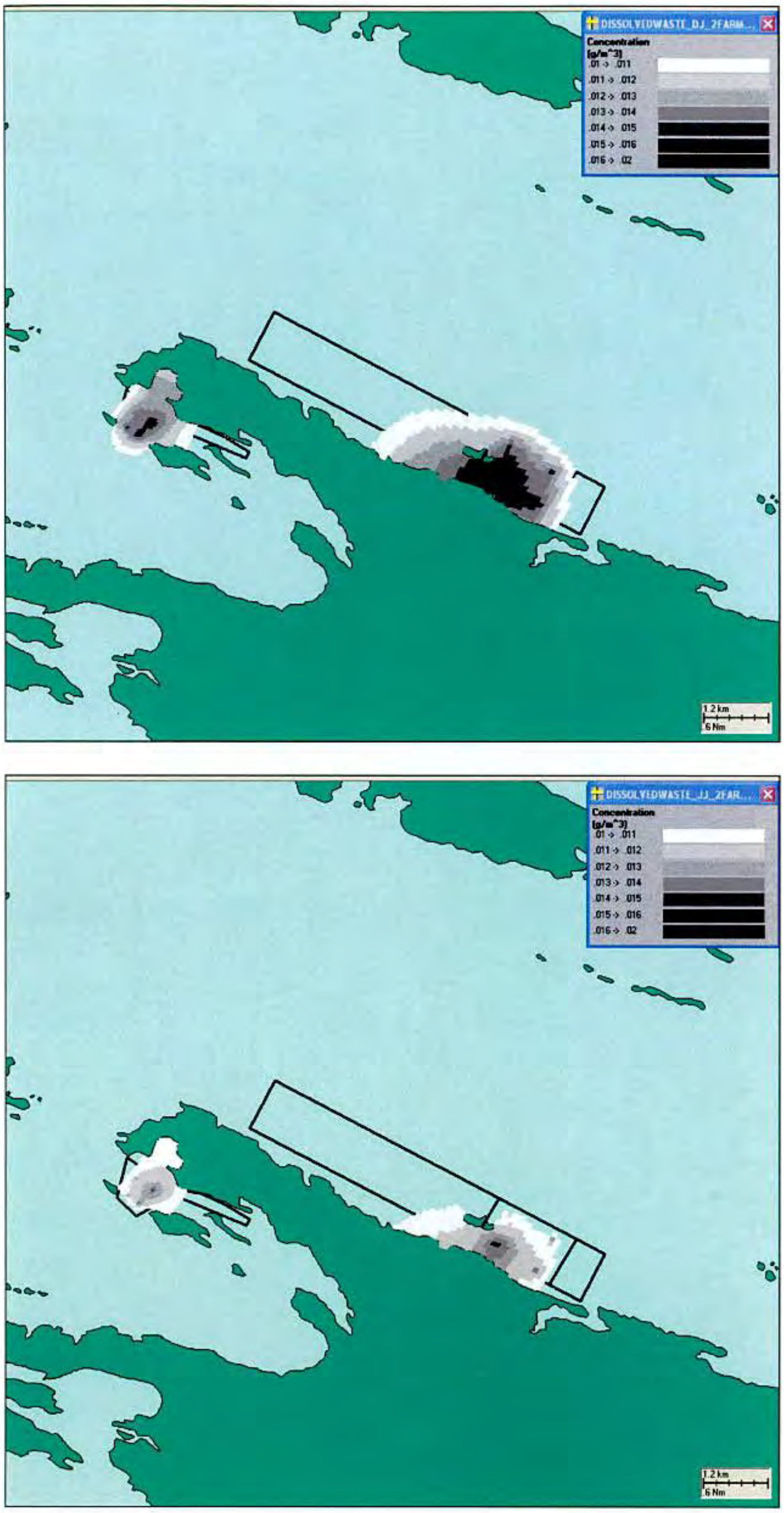


Figure B43: Predicted dissolved nutrient concentrations (g/m^3) for neap tide in December 2005 (after a 25 days continuous release, top panel) and in June 2006 (after a 20 days continuous release, bottom panel).

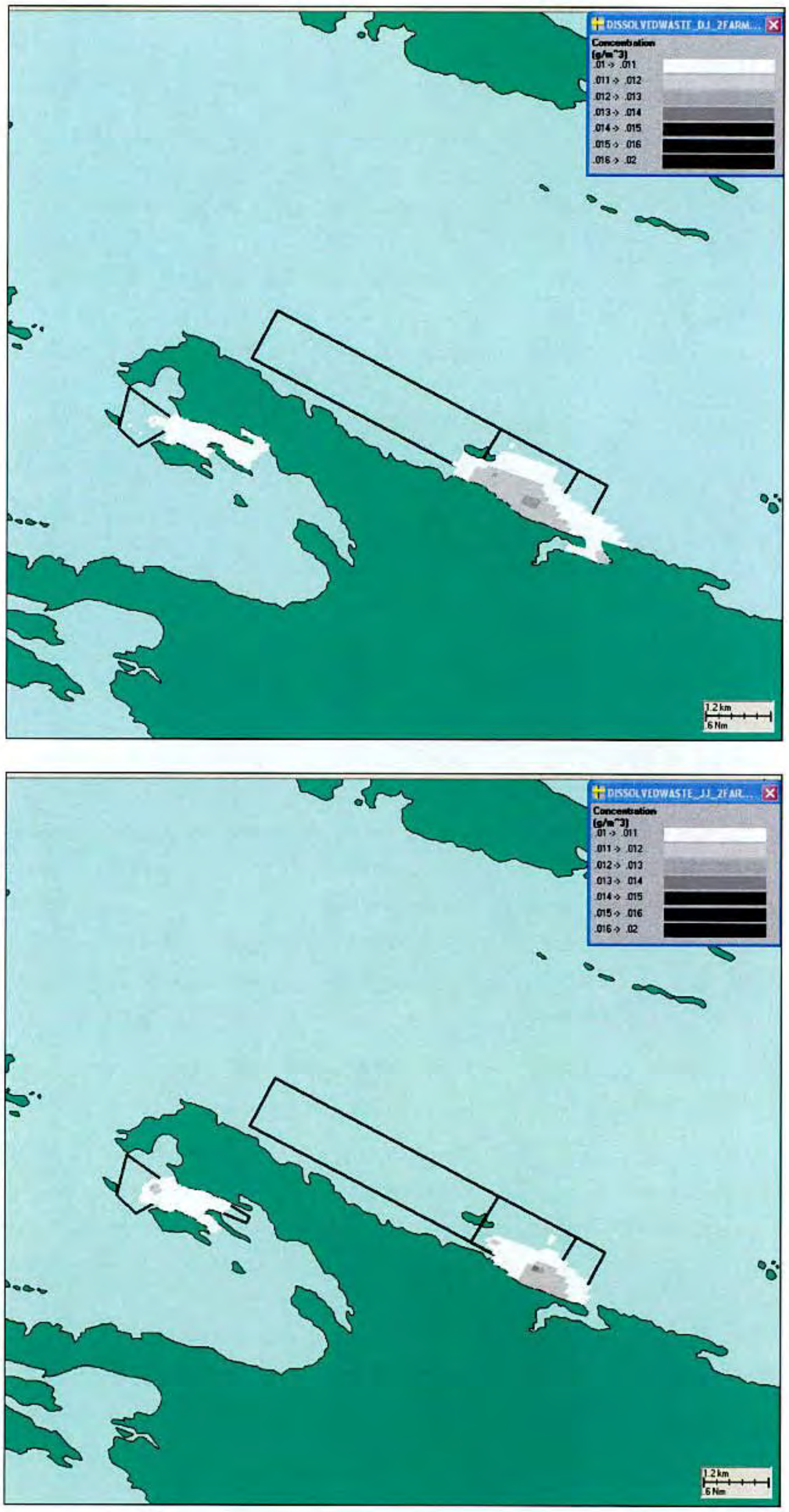


Figure B44: Predicted N & P concentrations (g/m^3) after a 30 days continuous release for spring tide in December 2005 (top panel) and in June 2006 (bottom panel).

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APPENDIX C

LIST OF THREATENED AND MIGRATORY SPECIES

List of Threatened and Migratory Species (Source: Department of Environment & Heritage website: *Species of National Environmental Significance Database.*).

Threatened Species	Status	Type of Presence
Birds		
Erythrotriorchis radiatus * Red Goshawk	Vulnerable	Species or species habitat likely to occur within area
Erythrura gouldiae * Gouldian Finch	Endangered	Species or species habitat may occur within area
*Geophaps smithii blaauwi** Partridge Pigeon (western)	Vulnerable	Species or species habitat likely to occur within area
Rostratula australis * Australian Painted Snipe	Vulnerable	Species or species habitat may occur within area
Mammals		
Dasyurus hallucatus * Northern Quoll	Endangered	Species or species habitat may occur within area
Balaenoptera musculus * Blue Whale	Endangered	Species or species habitat likely to occur within area
Megaptera novaeangliae * Humpback Whale	Vulnerable	Breeding known to occur within area
Reptiles		
Caretta caretta * Loggerhead Turtle	Endangered	Species or species habitat may occur within area
Chelonia mydas * Green Turtle	Vulnerable	Species or species habitat may occur within area
Dermochelys coriacea * Leathery Turtle, Leatherback Turtle, Luth	Vulnerable	Species or species habitat may occur within area
Eretmochelys imbricata * Hawksbill Turtle	Vulnerable	Species or species habitat may occur within area
Natator depressus * Flatback Turtle	Vulnerable	Species or species habitat may occur within area
Sharks		
Pristis microdon * Freshwater Sawfish	Vulnerable	Species or species habitat likely to occur within area
Rhincodon typus * Whale Shark	Vulnerable	Species or species habitat may occur within area

Migratory Species	Status	Type of Presence
Migratory Terrestrial Species		
Birds		
Erythrura gouldiae Gouldian Finch	Migratory	Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle	Migratory	Species or species habitat likely to occur within area
Hirundo rustica Barn Swallow	Migratory	Species or species habitat may occur within area
Petrophassa smithii blaauwi Western Partridge Pigeon	Migratory	Species or species habitat likely to occur within area
Poecilodryas superciliosa cerviniventris Derby White-browed Robin	Migratory	Species or species habitat likely to occur within area
Migratory Wetland Species		
Birds		
Charadrius veredus Oriental Plover, Oriental Dotterel	Migratory	Species or species habitat may occur within area
Glareola maldivarum Oriental Pratincole	Migratory	Species or species habitat may occur within area
Numenius minutus Little Curlew, Little Whimbrel	Migratory	Species or species habitat may occur within area
Rostratula benghalensis s. lat. Painted Snipe	Migratory	Species or species habitat may occur within area
Migratory Marine Species **Mammals**		
Balaenoptera edeni Bryde's Whale	Migratory	Species or species habitat may occur within area
Balaenoptera musculus * Blue Whale	Migratory	Species or species habitat likely to occur within area
Dugong dugon Dugong	Migratory	Species or species habitat likely to occur within area
Megaptera novaeangliae * Humpback Whale	Migratory	Breeding known to occur within area
Orcaella brevirostris Irrawaddy Dolphin	Migratory	Species or species habitat may occur within area
Orcinus orca Killer Whale, Orca	Migratory	Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin	Migratory	Species or species habitat may occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations)	Migratory	Species or species habitat likely to occur within area

Reptiles		
Caretta caretta * Loggerhead Turtle	Migratory	Species or species habitat may occur within area
Chelonia mydas * Green Turtle	Migratory	Species or species habitat may occur within area
Crocodylus porosus Estuarine Crocodile, Salt-water Crocodile	Migratory	Species or species habitat likely to occur within area
Dermochelys coriacea * Leathery Turtle, Leatherback Turtle, Luth	Migratory	Species or species habitat may occur within area
Eretmochelys imbricata * Hawksbill Turtle	Migratory	Species or species habitat may occur within area
Natator depressus * Flatback Turtle	Migratory	Species or species habitat may occur within area
Sharks		
Rhincodon typus Whale Shark	Migratory	Species or species habitat may occur within area

GPS position used: 16° 28' S, 123° 29' E

Figure C1: Diagram representing the GPS position used in establishing threatened and migratory species within the vicinity of Cone Bay.

APPENDIX D

CONE BAY ENVIRONMENTAL MONITORING AND MANAGEMENT PROGRAM – RESULTS AND ANALYSIS

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1. Introduction

An environmental monitoring and management plan (EMMP) was developed for the existing sea cage operation in Cone Bay in 2005 (Cahill Co, 2005) and was approved by the Environmental Protection Authority (EPA) and the Department of Environment and Conservation (DEC), formerly known as the Department of Environment (DoE) and implemented in early 2006. The current EMMP was developed from studies that were previously conducted to form baseline environmental parameters in Cone Bay by Brown and Root in early 2000.

Although, an EMMP was only formally incorporated into the current Barramundi project in 2006, water quality data and biota records have been collected for the Cone Bay area since 2004 coinciding with the introduction of the pilot project and thus the first sea cage. Since then the overall biomass of fish has increased over time to a total of 2.5 tonne (@3.4kg/m^3) by the end of 2004, 15 tonne (@ 12.8kg/m^3) by the end of 2005 and is currently estimated at 110-120 tonne upon the submission of this PER in 2007. It is important to note that sediment quality data, benthic infauna assemblages, mangrove monitoring and coral reef monitoring were not introduced into the Cone Bay EMMP until February 2006 and as a result the data presented for these parameters in this section is not as extensive as for water quality.

The original EMMP was developed using much of the information obtained from hydrodynamic studies conducted in Cone Bay by Brown & Root (formerly Kinhill) in early 2000. These studies were undertaken for the pearling venture in existence at the time, however provides the basic information of the bay and sample sites that was incorporated into the Cone Bay EMMP.

The following section presents all data collected as a part of the Cone Bay EMMP since early 2004 up until early –mid 2007. Data collection for the Cone Bay EMMP has been undertaken as described in the revised Cone Bay EMMP described in Appendix F. The results have been extracted from the annual DEC (formerly DoE) reports that MFF is required to submit as a part of the licence conditions, the Brown and Root study conducted in 2000 and includes all recent results from the 2006 and 2007 monitoring program.

2. Investigations

Six sites were originally selected for the EMMP, three being sample sites and three being reference sites to which the sample sites could be compared and to enable the identification of any natural variability occurring. The reference sites were selected as a result of the Brown and Root study conducted in 2000 which looked at the nutrient levels and hydrodynamic studies. Another site has been incorporated into the revised EMMP as a result of a recent application for an aquaculture licence in Crawford Bay (Figure D1). Data has been collected from this seventh site since mid-2006 and thus results are limited. The original Crawford Bay sample site will continue to be included as a reference site for both the Cone Bay and Crawford Bay EMMPs until the inception of the Crawford Bay aquaculture venture. The site names and locations are given in Table D1 and are represented diagrammatically in Figure D1. The sampling schedule is given in Table D2

Table D1: Cone Bay EMMP site names and locations

Site No.	Local Name	Latitude	Longitude
1	Crawford Lease site	123°28.098'E	16° 29.029'S
2	Mid Crawford	123°27.760'E	16°28.759'S
3	Gerald Bay	123°26.393'E	16° 30.210'S
4	S.E. Pearl Lease	123°33.914'E	16° 28.658'S

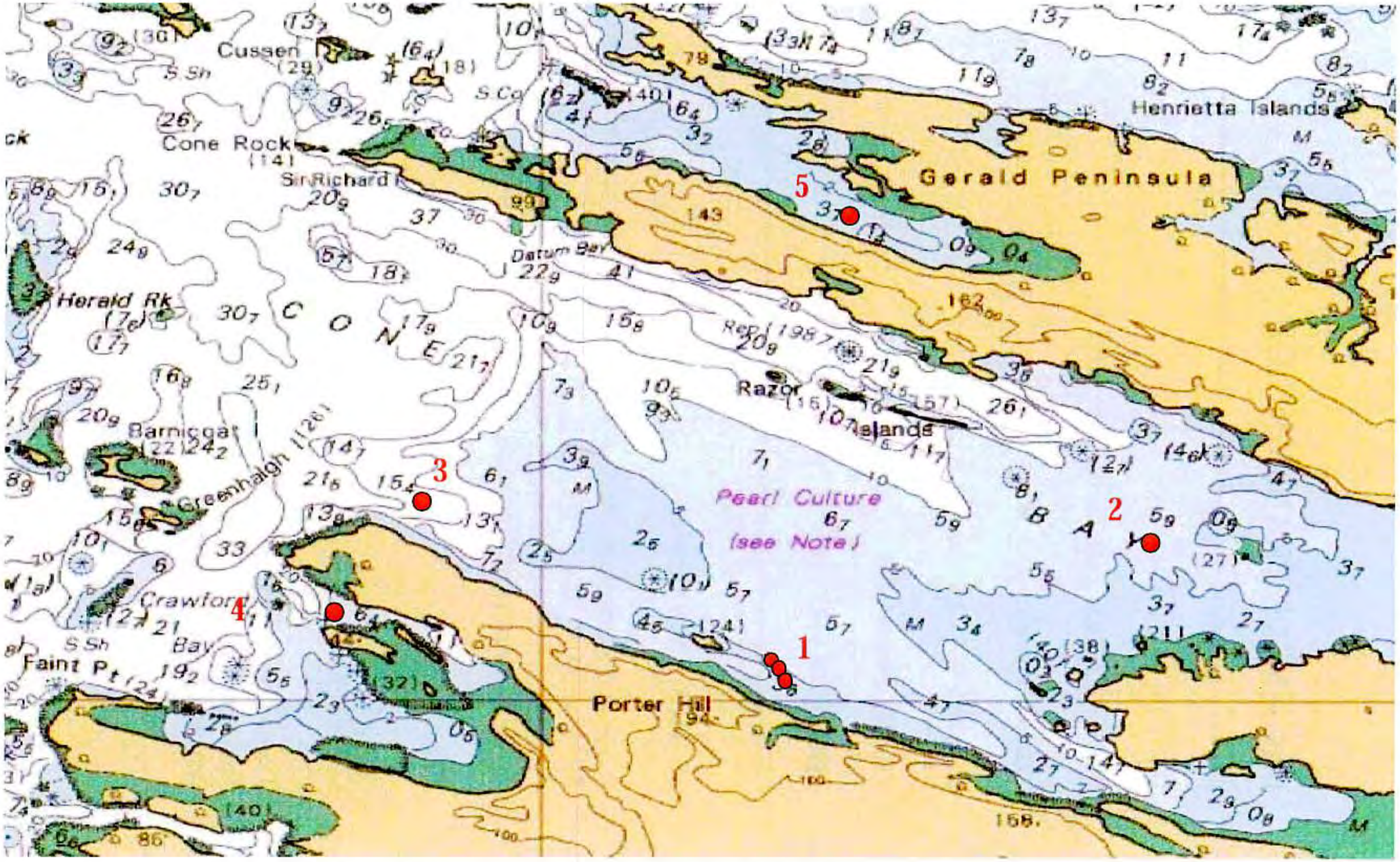

Figure D1: Location of Sites for the Cone Bay EMMP. Site 1 represents the three existing cages. Site 4 will become a sample site for the Crawford Bay Aquaculture licence at the onset of the proposed aquaculture application. Site 5 is the new reference site to replace Site 4.

Samples for the EMMP were collected according to the 2006 and 2007 monitoring schedule and included observations and sampling of the following parameters:

- Water Quality
- Benthic/Sediment Quality
- Benthic Infauna
- Mangrove Areas
- Coral Reef Areas
- Biota

Table D2: Cone Bay 2006 and 2007 Monitoring Program Schedule. A red 'X' indicates the parameters that have been sampled on the associated dates and a blue 'X' indicates proposed future sampling dates.

Sampling Dates	Cone Bay EMMP				
	Water quality	Benthic analysis	Benthic Infauna	Mangrove assessment	Coral Reef assessment
2006					
14-Feb	X				
31-March	X				
14-May	X				
30-June	X				
11-July			X	X	X
18-August	X	X			
26-September	X		X		
10-October		X			
7-November	X				
12-December				X	X
19-December	X	X			
2007					
30-January	X				
9-March	X				
		X			
19-April	X		X		
31-May	X	X		X	X
12-July	X				
23-August	X	X			
4-October	X		X		
15-November	X	X		X	X
27-December	X				

3. Water Quality

3.1. Introduction and Methodology

Water quality can be an important part of any monitoring program due to the propensity for nutrient enrichment. Nutrient enrichment refers to the increase in phytoplankton/algae growth resulting from an increased availability of nutrients (particularly Nitrogen) discharged from the proposed sea cages. The subsequent effect of increased phytoplankton growth is the reduction in light attenuation and therefore a reduction in underwater photosynthesis by Benthic Primary Producers (BPPs) such as seagrass beds, mangroves and coral reefs (Sim & Masini, 2004).

Water samples were collected using a submersible pump lowered to the required depth (3m) in the water column. The entire system is flushed for approximately one minute before sampling commences. At each station, a minimum of five litres of unfiltered seawater is decanted into polyethylene storage containers and stored on ice in the dark until return to the laboratory. Samples are then processed, frozen and air-freighted to Perth for analysis. The following water parameters are measured as a part of the existing EMMP:

Nutrients, Phytoplankton and Total Suspended Solids

Water quality samples are collected on a six weekly basis and analysed for total nitrogen (TN) and total phosphorous (TP), phytoplankton in the form of chlorophyll *a* (chl-a) and total suspended solids (TSS).

A more detailed description of the sampling methodology and analysis for water quality nutrients is given in Appendix F.

Physico-chemical parameters

Data on the physico-chemical parameters are also collected on a six weekly basis at the same time as the water samples discussed above. The Brown & Root study in Cone Bay (Brown & Root, 2000) assumed that a thorough mixing of the water body occurs because of the considerable tidal movements and considerable level of mixing with oceanic water. These assumptions were confirmed by means of water column profiling of dissolved oxygen (DO), pH, temperature and salinity. Depth profiling of temperature, salinity, DO and pH was conducted at all sites in the Brown and Root study.

All water quality results up until submission of this PER have been included.

3.2. Results

Depth Profiling

Depth profiling of 11 sites sampled in the Brown and Root study in 2000 demonstrated that the water body was well mixed. The results for the relevant sites in the Cone Bay EMMP have been extracted from the 2000 study and presented in Figures D2 to D4.

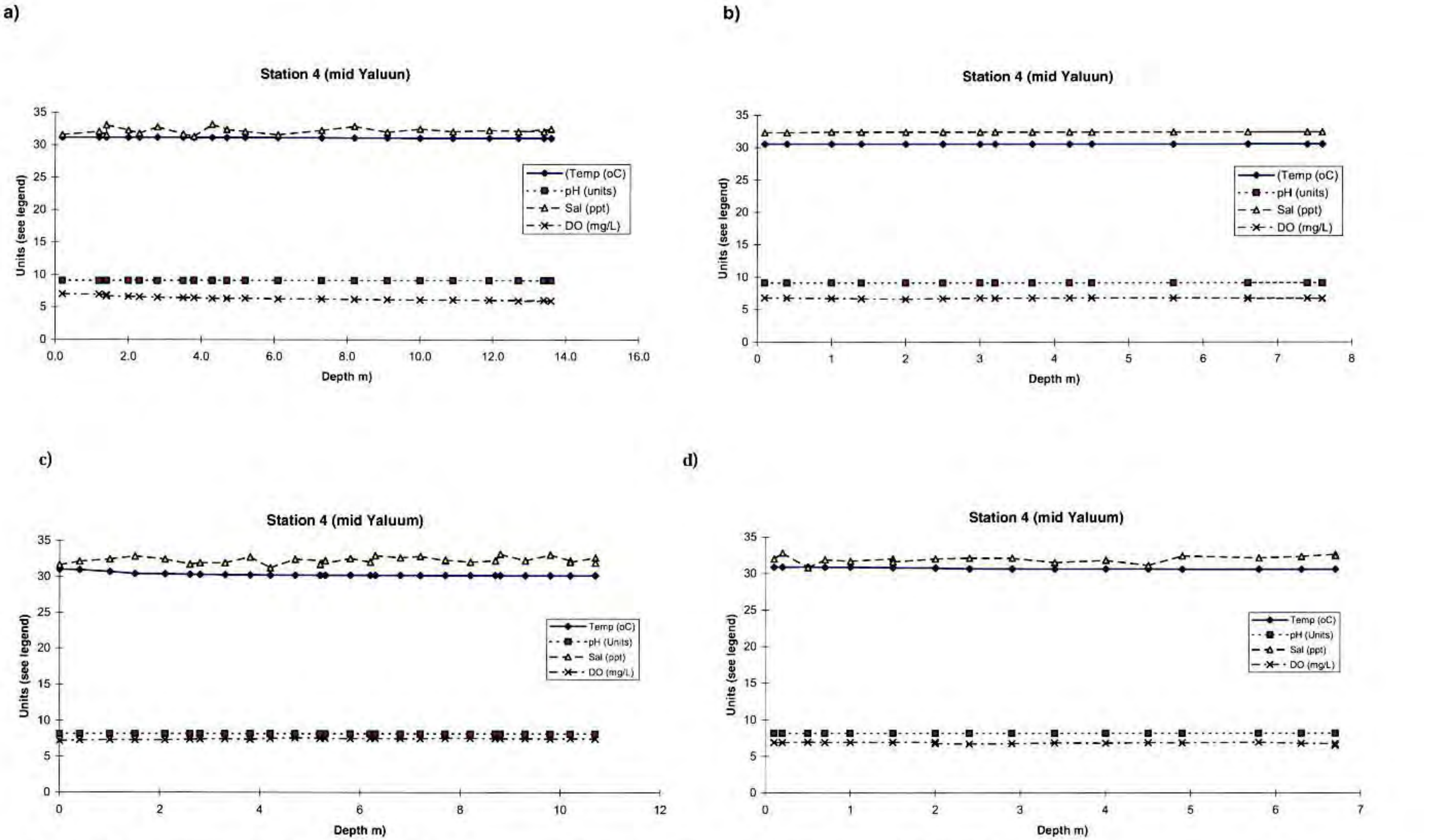

Figure D2: Water column profiles, Station 4 (Yaluun/SE Pearl Lease) on a) 20 January, b) 23 January, c) 23 March, and d) 25 March 2000

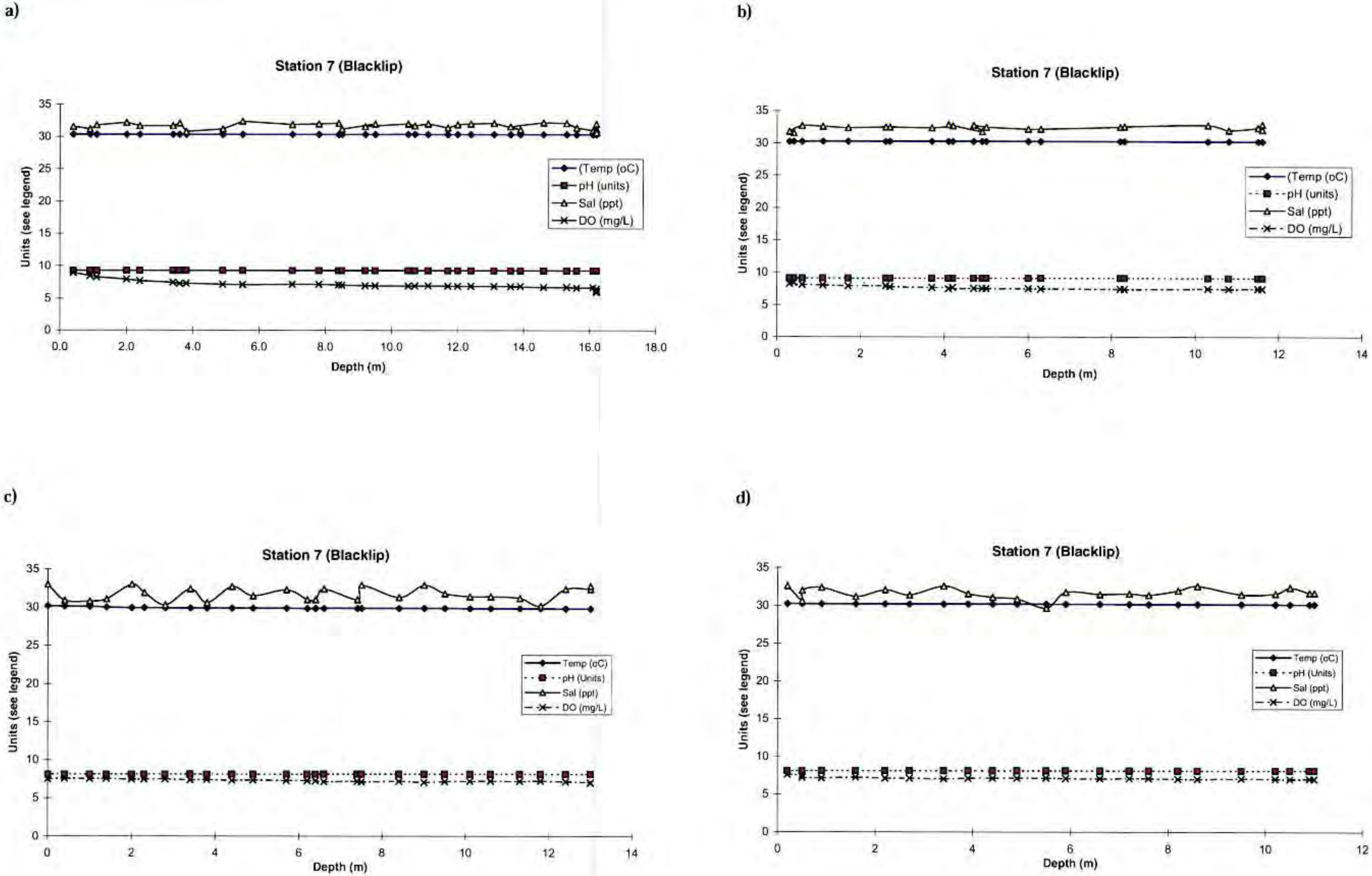

Figure D3: Water column profiles, Station 7 (Blacklip/SW Cone Bay) on a) 20 January, b) 23 January, c) 23 March, and d) 25 March 2000

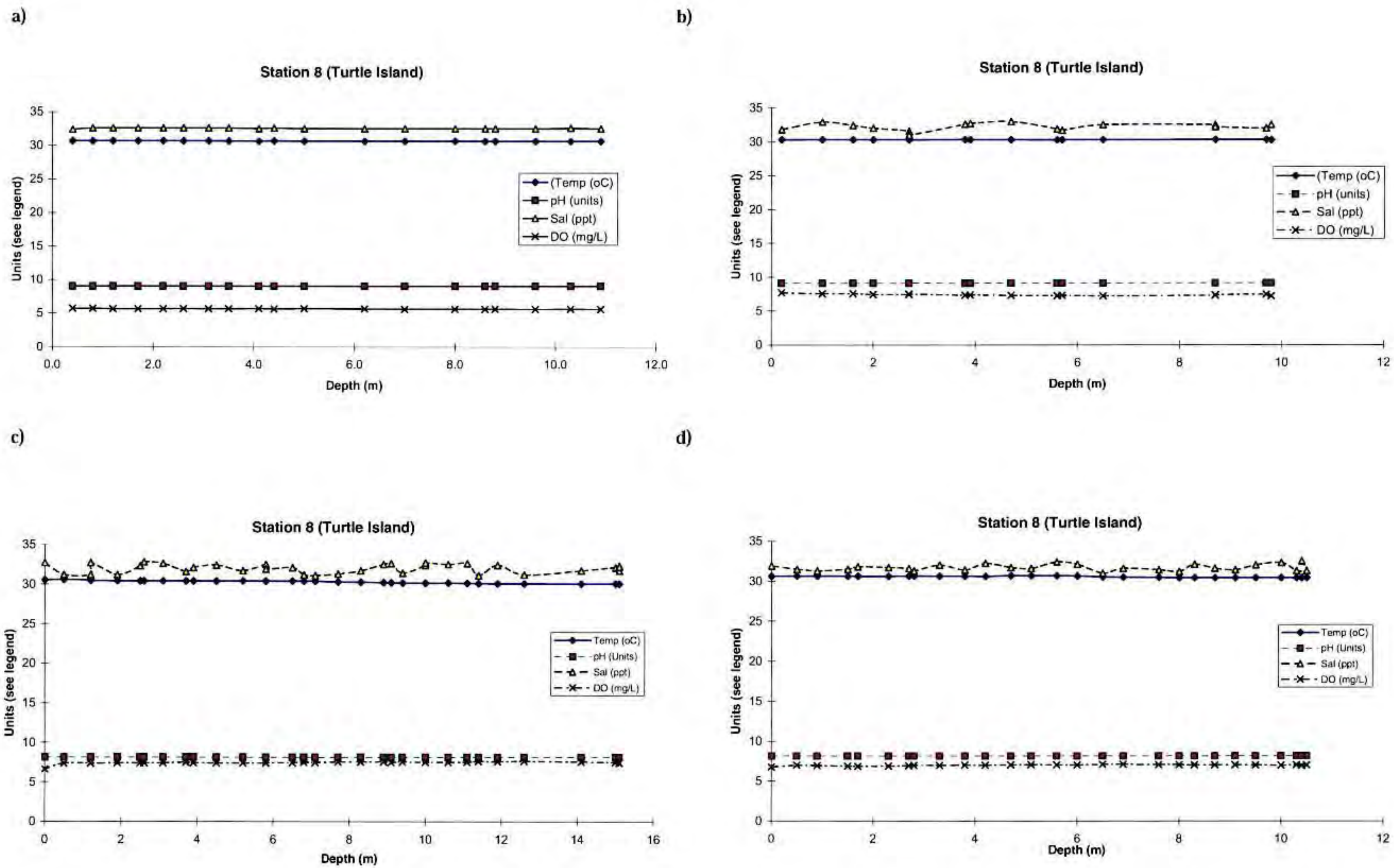

Figure D4: Water column profiles, Station 8 (Turtle Island/Sea Cage #1) on a) 20 January, b) 23 January, c) 23 March, and d) 25 March 2000

Temperature

Water temperature shows a distinct seasonal pattern with lower temperatures observed during the 'dry' season and higher temperatures during the 'wet' which is characteristic of tropical environments. The last 3 years has shown a range of temperatures between 24.0°C (SW Cone Bay August 2006) and 32.3°C (S.E. Pearl Lease February 2006), indicating distinct seasonal patterns. However, it is important to note that temperature was relatively constant between sites on each sampling day including the reference site in Crawford Bay. Temperature results are demonstrated in Figure D5.

Salinity

Salinity was measured at sites within Cone Bay and Crawford Bay over the last 3 years, with readings ranging between 32.8‰ (Sea Cage #1 June 2004) and 36.7‰ (S.E. Pearl Lease Dec 2003). Salinity levels showed little variation between sites on any sampling date, with all sites showing similar trends over time. Salinity results are demonstrated in Figure D6.

pH

pH levels did not vary significantly between sites on any given sampling date and were relatively stable throughout the period, ranging from 7.34 (Gerald Bay August 2006) – 9.92 (S.E. Pearl Lease December 2004). Although the meter is serviced once a year, the lower than expected and variable results seen in October 2005 and August 2006 were more likely due to calibration issues with the meter. pH results are demonstrated in Figure D7.

Dissolved Oxygen (DO)

DO levels show very little variation at any given sampling date, however a slight seasonal pattern is evident with levels generally increasing as water temperatures decrease. The sea cage site did not produce significantly different DO levels than reference sites which is consistent with the low stocking densities of the cages and the high tidal energy characteristic of the region. Some readings were omitted due to procedural issues in measuring DO on a monthly basis. DO results are demonstrated in Figure D8.

Chlorophyll a (Chl-a)

Chlorophyll *a* levels are generally low, but show a strong correlation to season, with lower levels recorded during the dry season and higher levels in the wet season. The higher than normal results seen in February 2006 have been attributed to a high rainfall season resulting in large amounts of terrestrial run-off. Being that the coastline is characteristically steep rocky cliffs, these effects are to be expected. Overall, results appear consistent with the expected seasonal cycles in algal productivity. Due to the large tidal ranges, high flushing rates and high variability in ambient conditions experienced in the area, it is difficult to draw conclusions on the differences in readings between sample sites on any sample date, particularly given that in many cases reference sites show higher levels of chl-a than sea cage sites. Chl-a results are demonstrated in Figure D9.

Total Suspended Solids (TSS)

Levels of TSS ranged between 8mg/L (SW Cone Bay - December 2003) and 23.0mg/L (Sea cage #2 – September 2006) over the 3 years. TSS levels do not appear to be significantly affected by season, although slight increasing trends are associated with the 'wet' season, possibly resulting from the terrestrial run-off from rain. Recordings for the Sea Cage sites are very similar to those from the reference sites so it does not appear that the presence of fish within the bay is impacting on the TSS value. Although Sea Cage #2 demonstrated a higher level of TSS than any other site in the September 2006 sampling, the other two sea cage sites were seen to have similar levels as the reference sites, thus the higher result was considered to be an anomaly. This was further demonstrated in the results of the November and December sampling where TSS levels at Sea Cage #2 were once again similar to all other sites. It is important to note that SW Cone Bay shows consistently higher levels of TSS, which is expected due to its location near the entrance of the bay and the large tidal dynamics and flushing of Cone Bay and adjacent waters of the King Sound. TSS results are demonstrated in Figure D10.

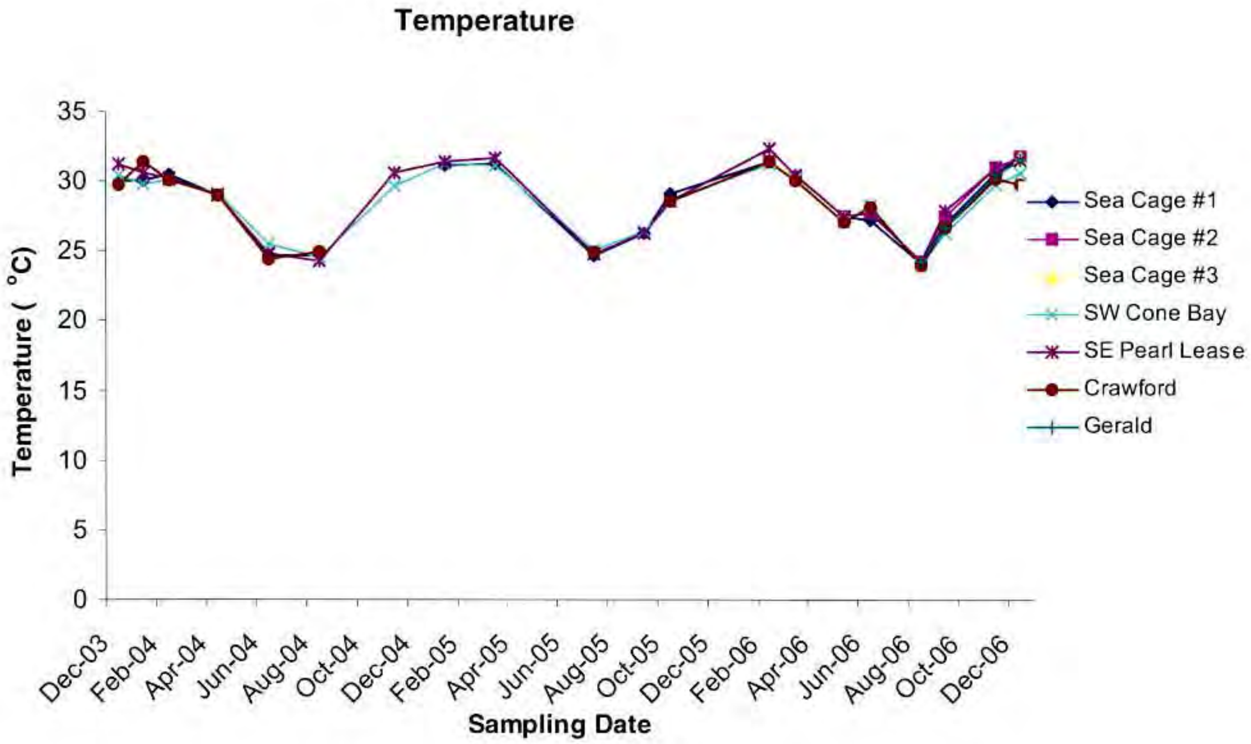

Figure D5: Water Temperature during the period December 2003 – December 2006.

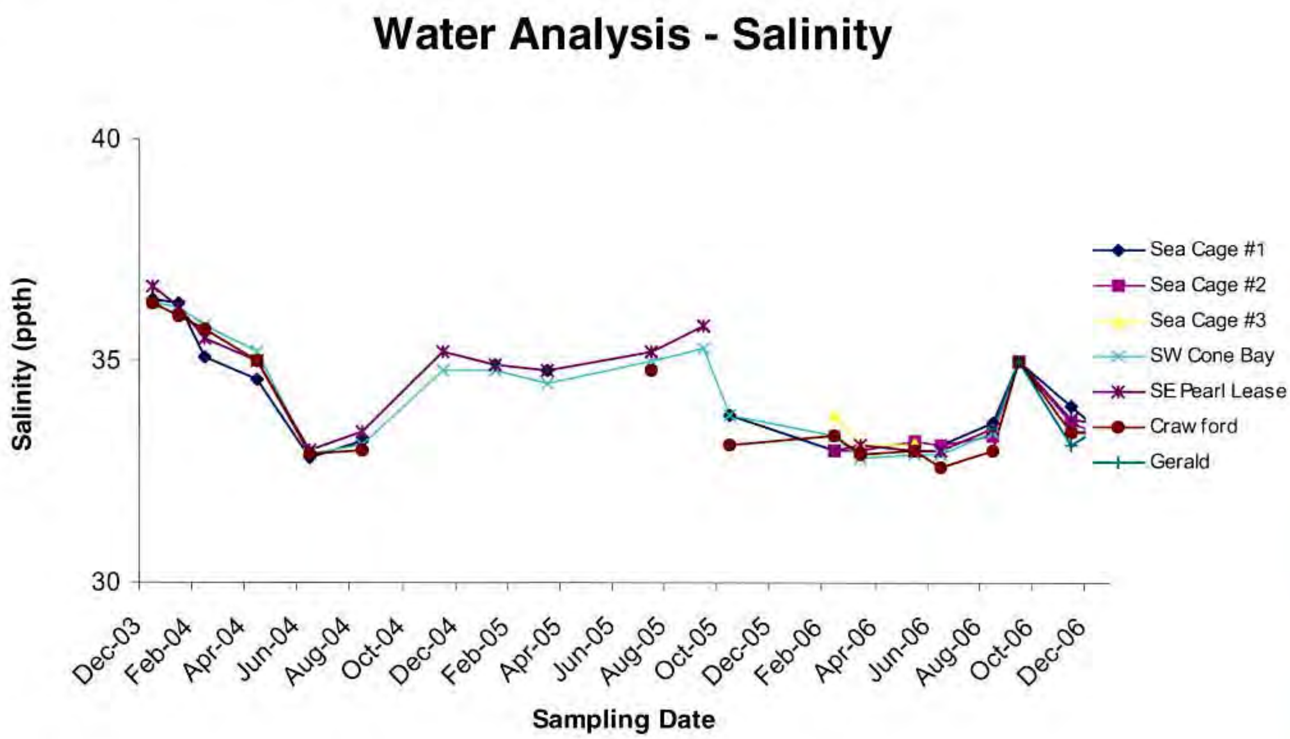

Figure D6: Salinity measurements during the period December 2003 – December 2006.

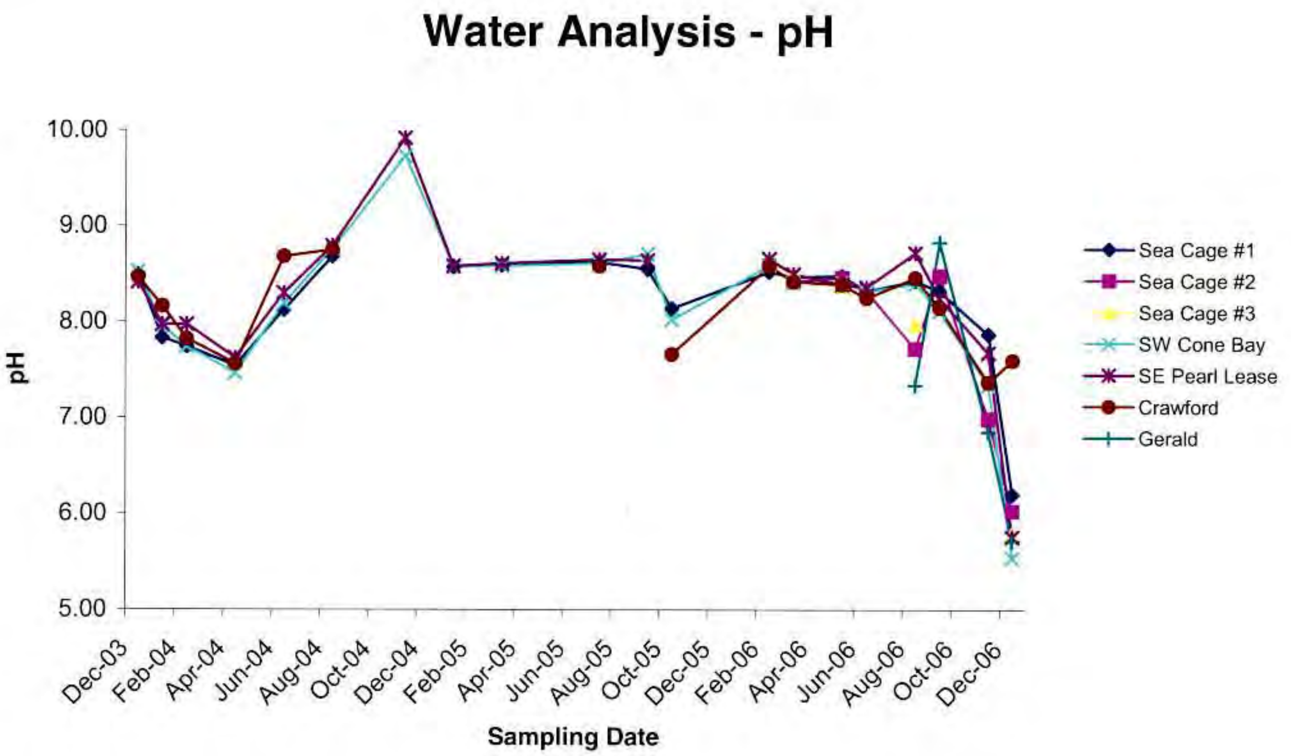

Figure D7: pH measurements during the period December 2003 – December 2006.

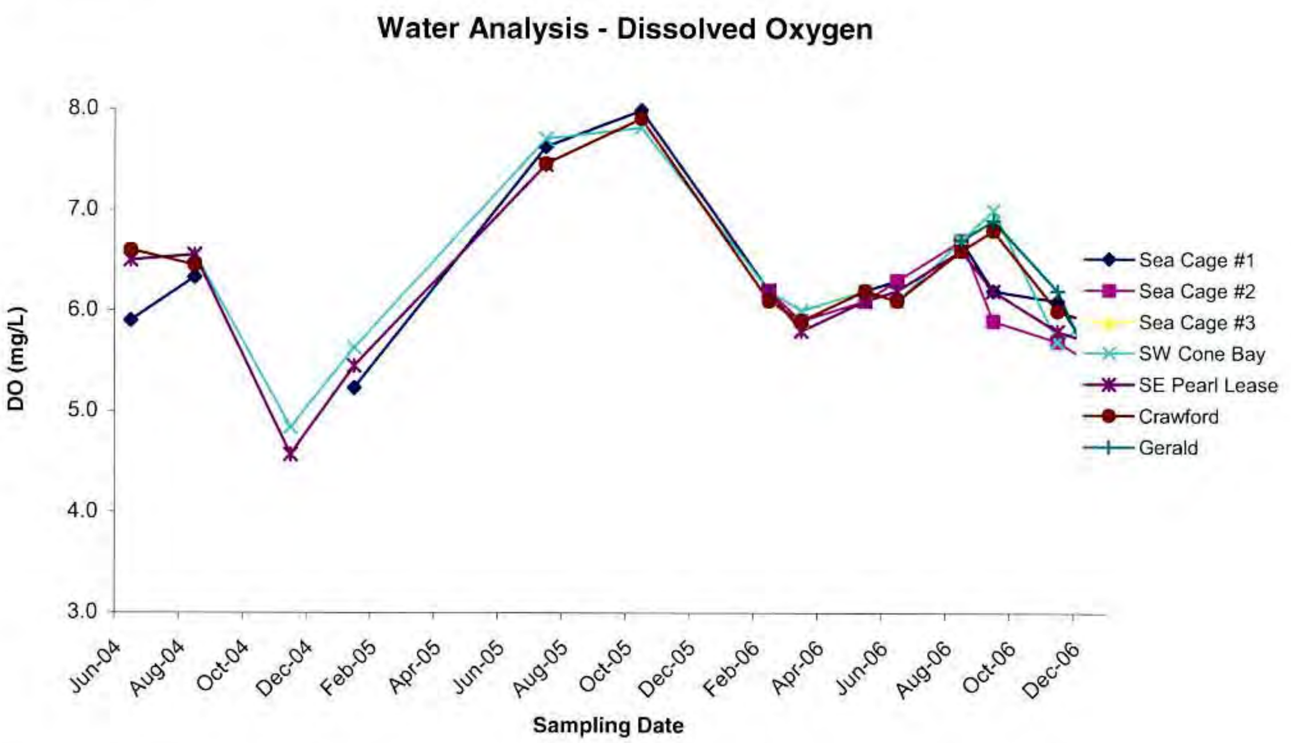

Figure D8: Dissolved Oxygen levels measured from June 2004 – December 2006.

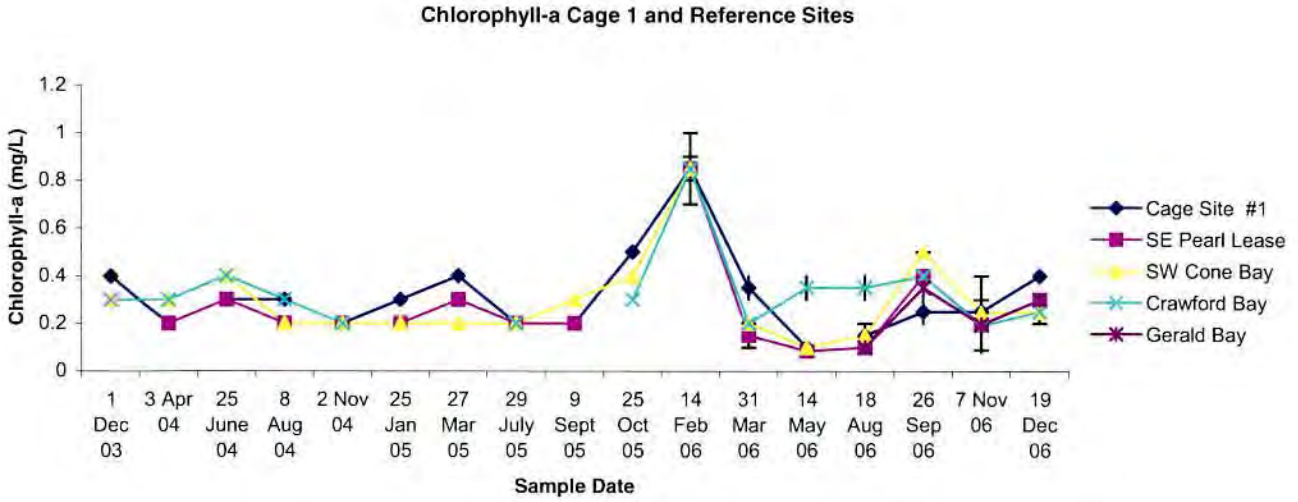

Figure D9 (a): Chlorophyll-a levels measured for Cage 1 and Reference sites from December 2003 – December 2006.

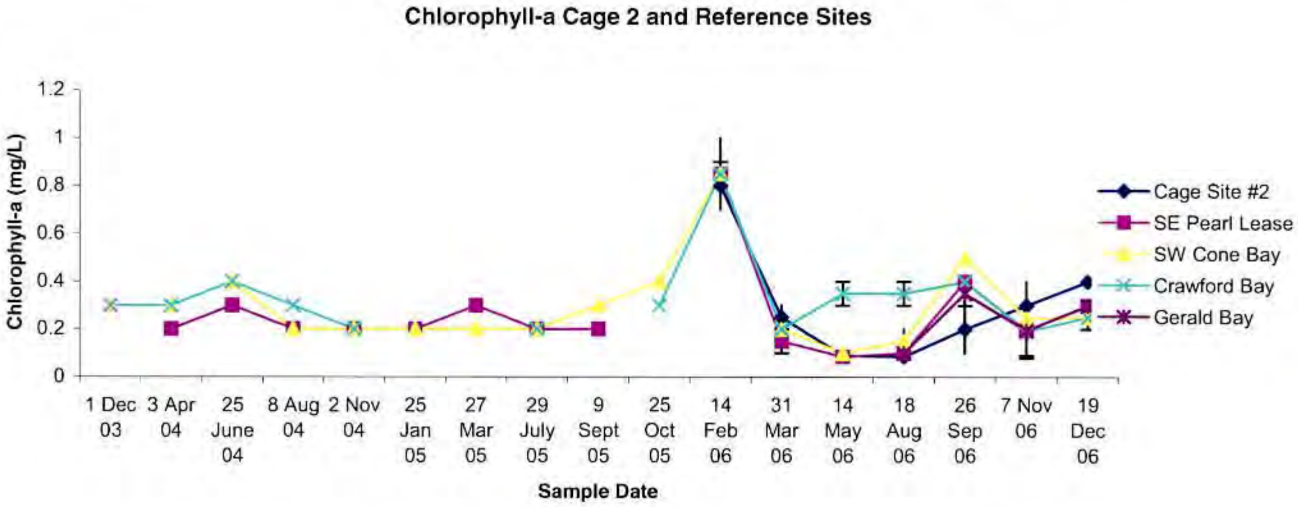

Figure D9 (b): Chlorophyll-a levels measured for Cage 2 and Reference sites from December 2003 – December 2006.

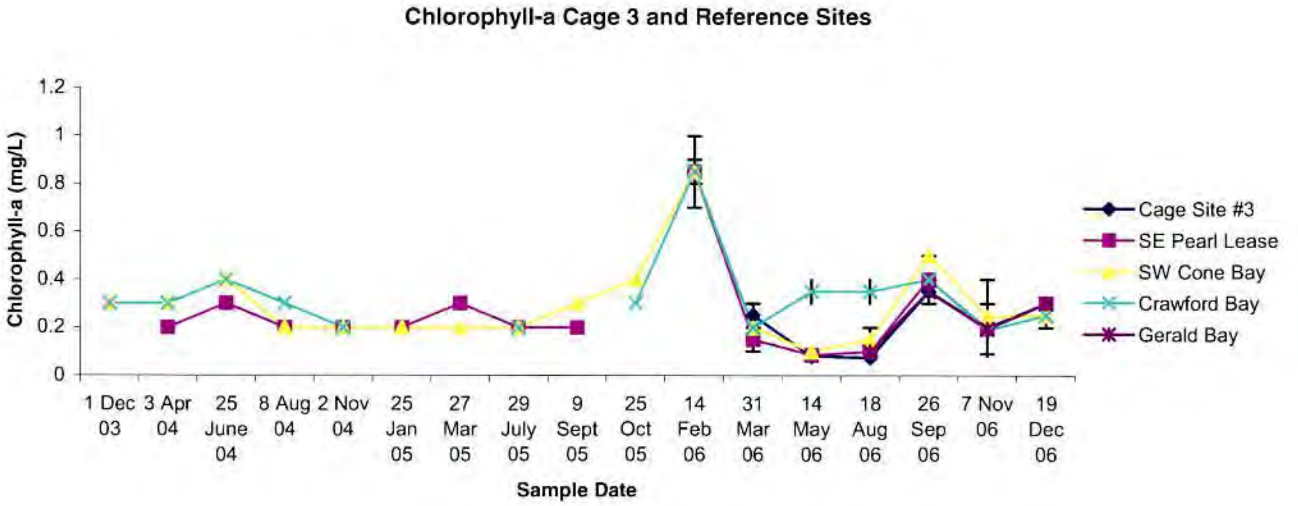

Figure D9 (c): Chlorophyll-a levels measured for Cage 3 and Reference sites from December 2003 – December 2006.

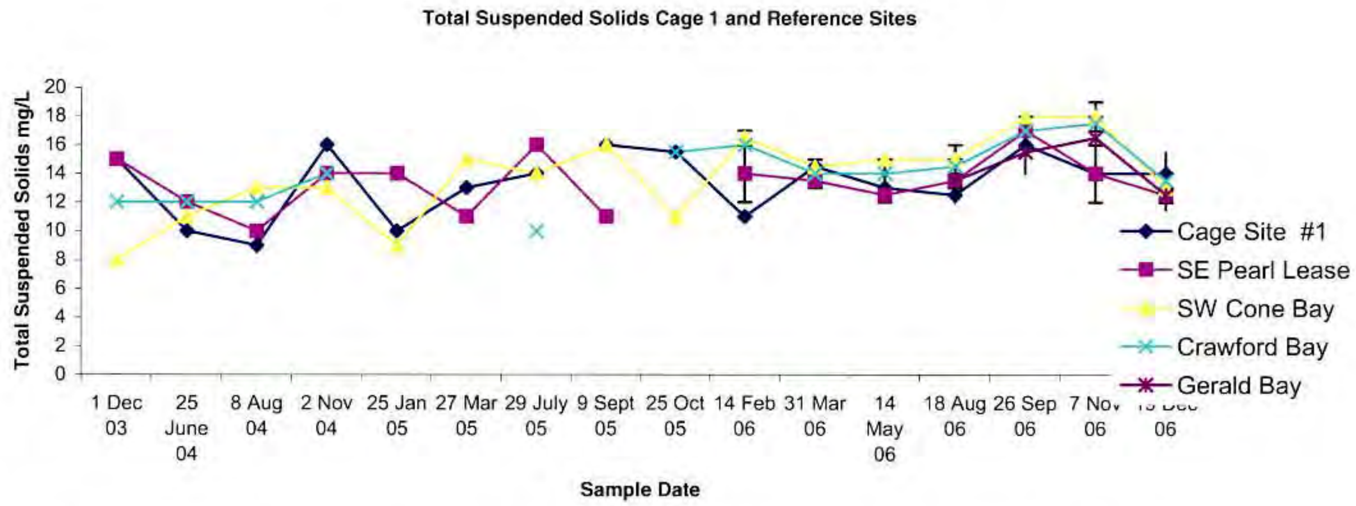

Figure D10 (a): Total Suspended Solids measured for Cage 1 and Reference sites from December 2003 – December 2006.

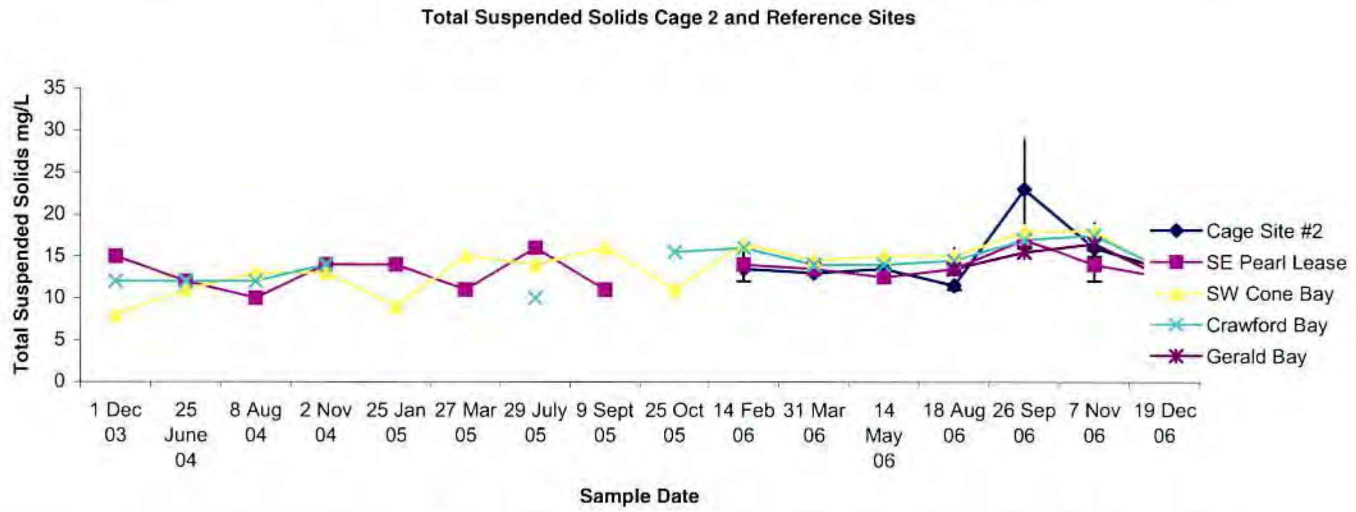

Figure D10 (b): Total Suspended Solids measured for Cage 2 and Reference sites from December 2003 – December 2006.

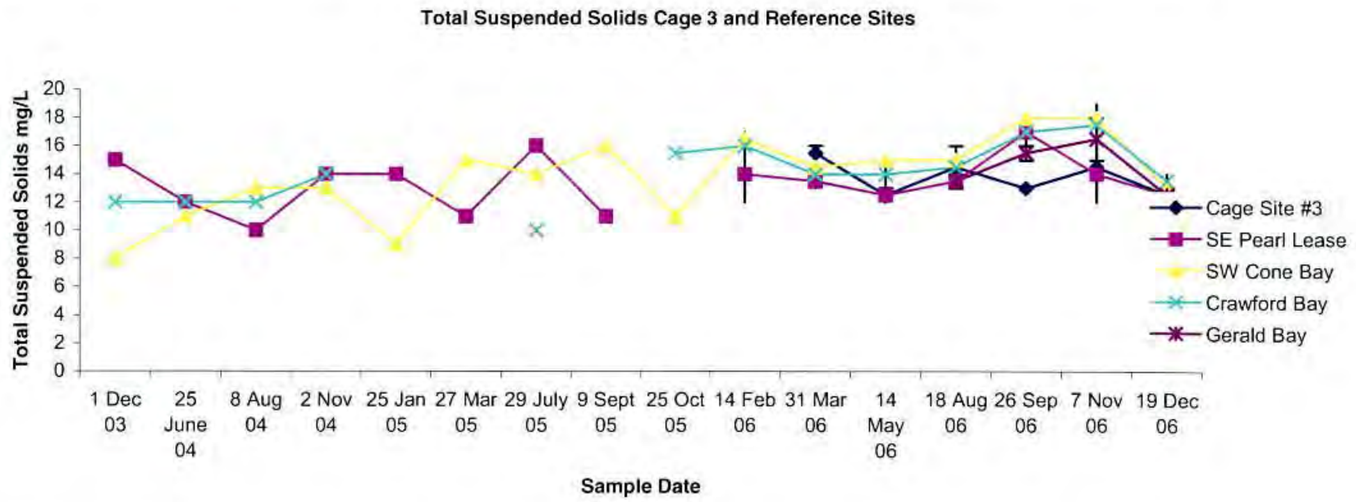

Figure D10 (c): Total Suspended Solids measured for Cage 3 and Reference sites from December 2003 – December 2006.

Total Nitrogen (TN)

TN was initially only recorded at two sites: Sea Cage #1 and Crawford Bay. Upon implementation of the Cone Bay EMMP in 2006, all sites were measured for TN levels so as to obtain a reasonable sample number for the EQCs developed. Recorded levels of TN do not vary significantly between the sampling sites, but does show a slight increase during the period between October and December 2004 and then very high readings at both sites in October 2005. Levels then showed a decline from February through to June 2006. These readings are difficult to explain, but could be attributed to seasonal effects and with tides in the area creating a consistent movement of water out of the region, it is unlikely to be the effects of the fish farming operation as sea cage results have been similar or lower than many of the reference sites. The falling levels seen from February through to June associated with the relatively constant levels observed between sites at each sampling day are indicative of natural environmental variation. TN levels ranged between 0.05mg/L (Sea cage #1 - early and mid 2005) and 1.4mg/L (Crawford Bay – October 2005). TN results are demonstrated in Figure D11.

Total Phosphorous (TP)

Prior to implementation of the Cone Bay EMMP in February 2006, TP was also only sampled at two sites (Sea Cage #1 and Crawford Bay). Although measurements for TP levels are incomplete for 2005, there appears to have been a significant reduction in TP since August 2004, and all results show little variation between sampling sites. With the implementation of the EMMP, TP has shown to be relatively consistent between all sites at any given sampling day. Over the 3 year period levels have ranged between 0.009mg/L (Sea cage 1 & 2 – March 2006) and 0.09mg/L (Crawford Bay – August 2004), however the highest levels are not associated with the increasing biomass of fish (ie highest biomass of fish is in mid 2006). TP results are demonstrated in Figure D12.

Turbidity

Turbidity is a measure of the water clarity and is highly correlated with phytoplankton blooms, TSS, tidal movement and seasonal rainfall. Over the 3 year period, water clarity has ranged between 2.0m and 7.5m. Turbidity was shown to be variable both on temporal and seasonal scale and therefore is not considered to be an accurate indicator of impacts resulting from the fish farm. The variability observed between sites on any given sampling day can be attributed more to site conditions (ie tidal movement, current speeds, rainfall and runoff etc) than to effects of the fish farm operations, particularly when the reference sites predominantly showed higher turbidity levels than the sea cage sites. Turbidity results are demonstrated in Figure D13.

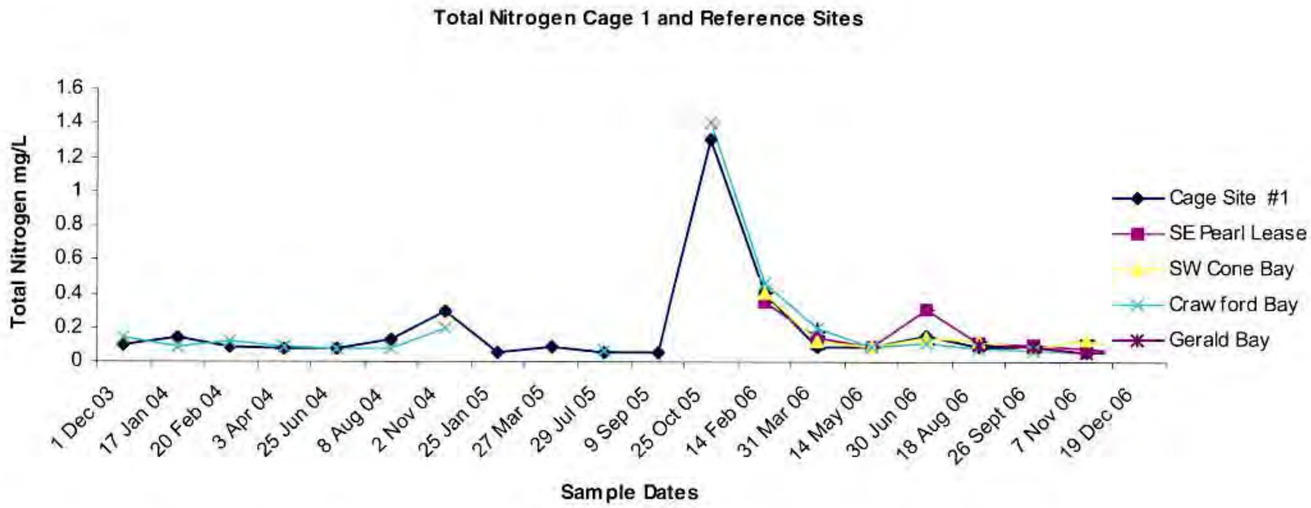

Figure D11 (a): Total Nitrogen levels for Cage 1 and Reference sites from December 2003 – December 2006.

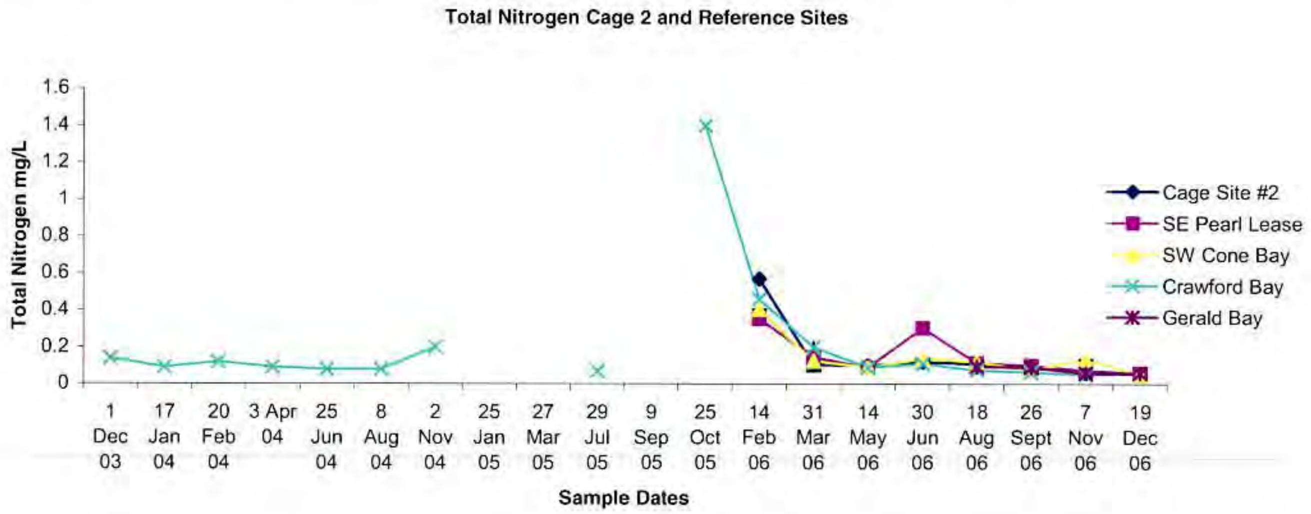

Figure D11 (b): Total Nitrogen levels for Cage 2 and Reference sites from December 2003 – December 2006.

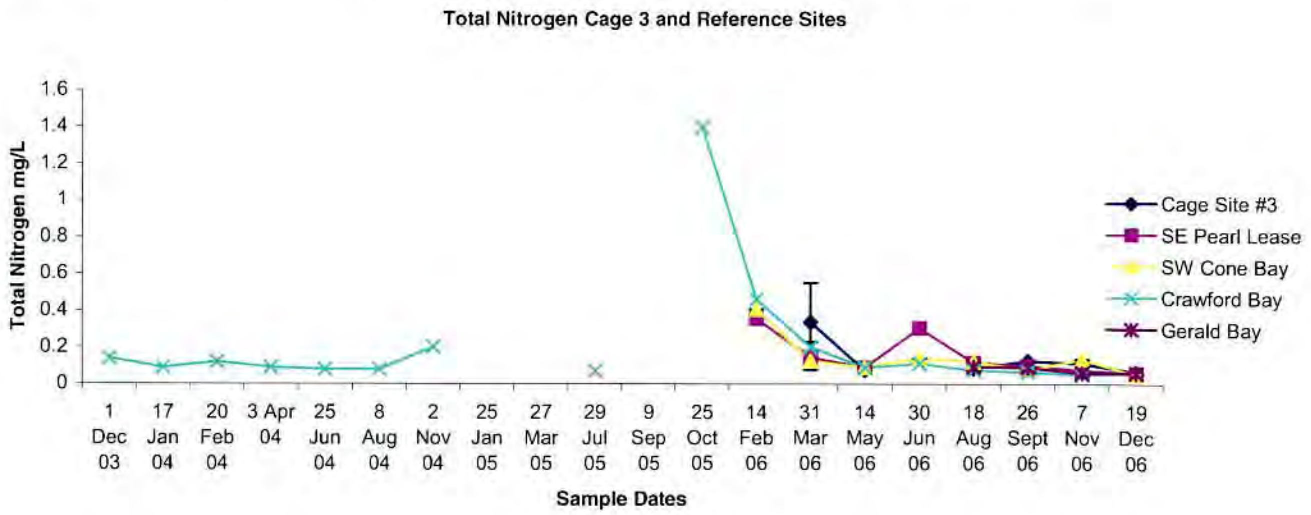

Figure D11 (c): Total Nitrogen levels for Cage 3 and Reference sites from December 2003 – December 2006.

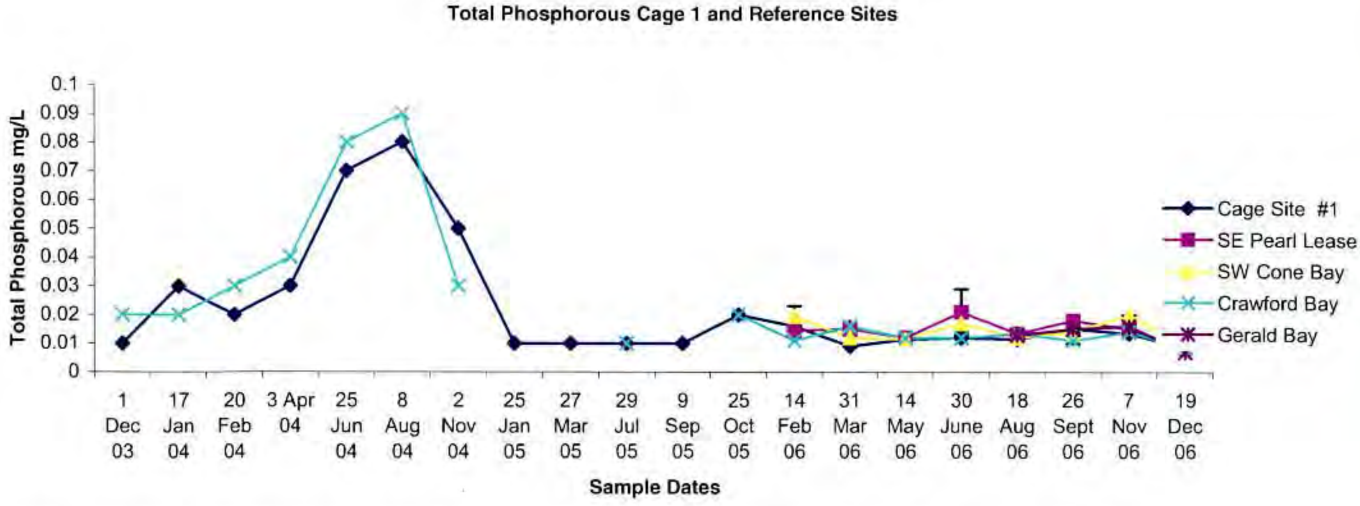

Figure D12 (a): Total Phosphorous levels for Cage 1 and Reference sites from December 2003 – December 2006.

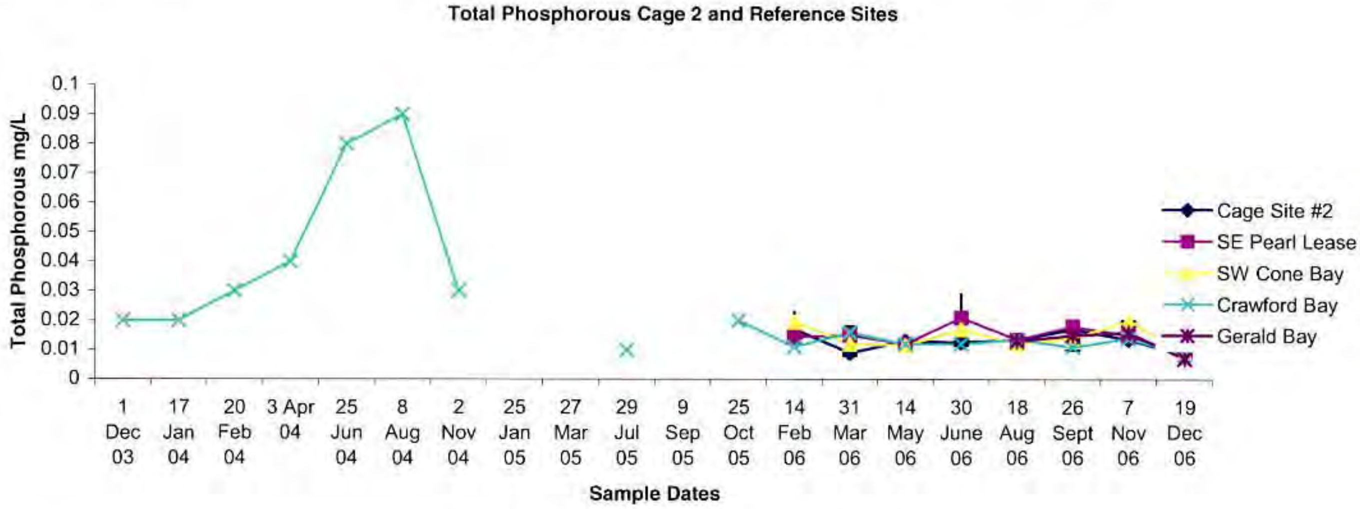

Figure D12 (b): Total Phosphorous levels for Cage 2 and Reference sites from December 2003 – December 2006.

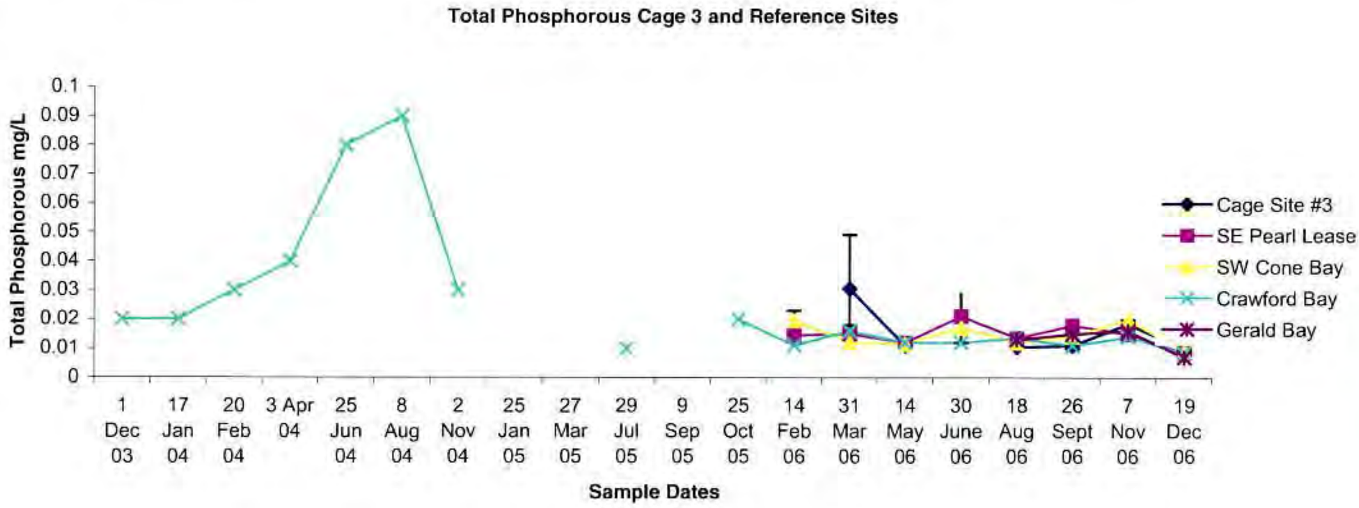

Figure D12 (c): Total Phosphorous levels for Cage 3 and Reference sites from December 2003 – December 2006.

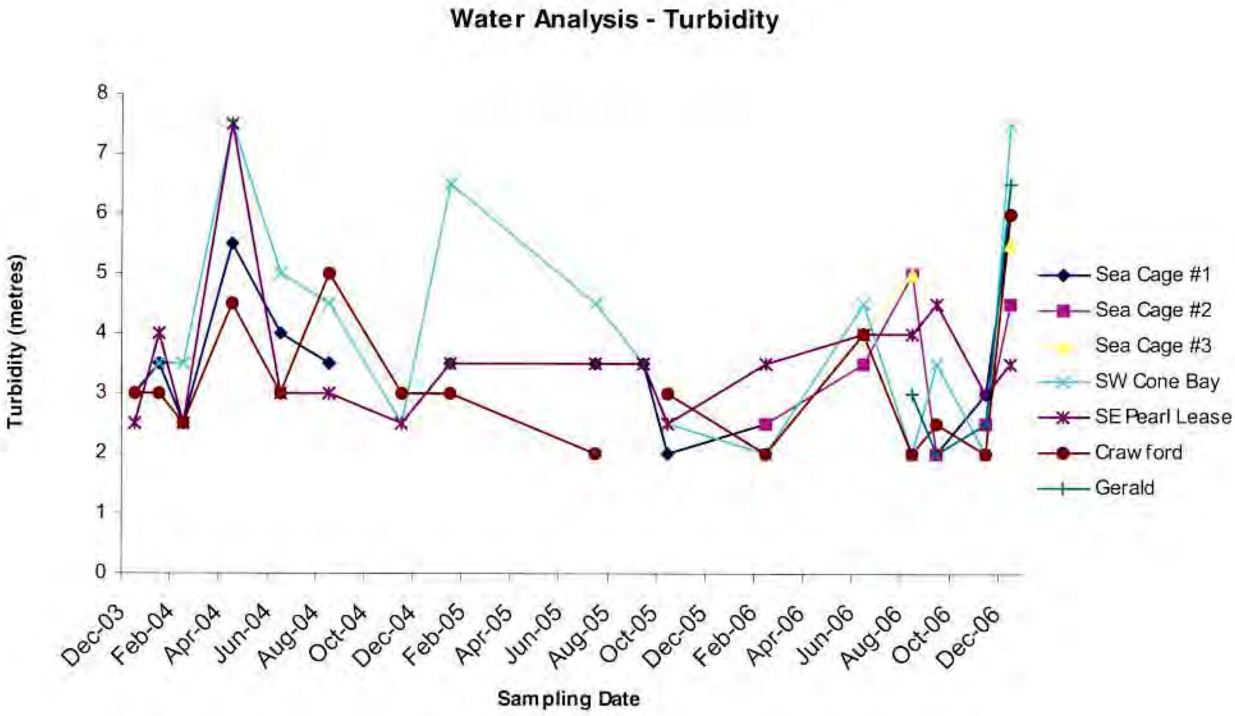

Figure D13: Turbidity levels from December 2003 – December 2006.

3.3. Discussion

Depth profiling demonstrated that the water quality parameters measured were relatively consistent with depth at each site. It also showed that results were consistent over all sites. Thus, the depth profiling data confirmed the assumption that the regions water body is well mixed and therefore sampling is conducted at one depth, this being 3m.

The EMMP results demonstrate that all parameters except turbidity are relatively consistent between sites on any given sampling day. The Cone Bay EMMP has shown that some water quality parameters demonstrate seasonal patterns, particularly TSS, chl-a, TN, TP, temperature and DO. Generally peak levels of TSS, chl-a, TN and TP during the higher rainfall periods occur, as with peak levels of temperature and salinity which are to be expected as environmental conditions enter the hot, humid wet season. Peak levels of DO have been observed to occur during the cooler dry season, however this is to be expected as oxygen levels will increase with decreasing water temperature.

Turbidity is highly dependant on tidal and current states and environmental conditions, thus is seen to be highly variable over time (and between sites) with no distinct patterns being elucidated. pH is relatively constant both over time and between sites, however some sampling dates have demonstrated variable results which have been attributed to procedural problems with the pH meter in the field.

Overall, the results of the Cone Bay EMMP have shown that water quality is relatively consistent between sites on any given sampling date and that for some parameters, such as temperature, chl-a (and to some extent TSS), salinity and DO, distinct seasonal patterns have been observed. Other parameters such as TN, TP and turbidity have not shown distinct seasonal patterns, however do show variability over time that may possibly be attributed to the ambient environmental conditions at that sampling time (eg spring or neap tide, large amount of terrestrial run-off etc). In general the results from Cone Bay have clearly shown that ambient environmental conditions, such as rainfall, cyclones and other seasonal conditions cause greater fluctuations in water quality than do the outputs from the cages.

4. Benthic/Sediment Quality

4.1. Introduction and Methodology

Benthic or 'sediment' quality is also considered to be an important part of a monitoring program due to the propensity for organic enrichment. Organic enrichment refers to the reduction in health of the sediments and/or the increase in suspended organic material (ie TSS) resulting from the discharge and dispersion of undissolved/particulate matter from the sea cages (eg uneaten food & faeces). The subsequent effects is accumulation of organic matter in the sediments which act to reduce oxygen levels causing anaerobic conditions or in extreme situations, anoxic conditions in which the required natural ecological processes of nutrient cycling/recycling and natural biodiversity of the sediments cannot be supported (Sim & Masini, 2004). Other effects include the reduction in light attenuation as in nutrient enrichment, resulting from the presence of sea cages.

Sediment samples are collected from the same stations utilised for water sampling but after water samples are taken to avoid water contamination. A number of sub-stations (3) within each site are sampled to investigate intra-site spatial variation. A more detailed explanation of the methodology is described in the Cone Bay Sea Cage Aquaculture Environmental Monitoring and Management Program (Cone Bay EMMP) in Appendix F.

Sediment sampling was only incorporated into the EMMP in early 2006 however due to procedural problems was not implemented until July 2006. Sediment samples are collected on a three monthly basis and sent to an NATA registered laboratory for analysis. The results to early 2007 are included in this PER.

4.2. Results

Sediment quality parameters analysed include total nitrogen (TN), total kjeldahl nitrogen (TKN), particulate organic matter (loss on ignition (LOI)), total phosphorous (TP) and red-ox potential. Although a couple of previous sediment samples were conducted in August 2004 and January 2005, these were prior to the development of the EMMP and only incorporated two sites: Sea cage #1 and S.E. Pearl Lease. The sediment quality results are presented in Table D3 and Figures D14 to D18.

Table D3: Benthic Quality Analysis, Cone Bay EMMP

Date	Station	Location	Location	Sample #	Sample ID	Spatial location	Sub-sample #	TN (mg/kg)	TP (mg/kg)	TKN (mg/kg)	LOI (%w/w)	Redox (mV)
								MCM 6.1.2.3/4.12/ 4.13	MCM 6.1.3.5/4.8	MCM 6.1.2.3	MCM 6.1.2.4	
26-Aug-04	1	Cage 1	0 mtrs	4	1.1.1	N	5	470	300	470	8.47	299
					1.1.2	E	5					
					1.1.3	S	5					
					1.1.4	W	5					
	4	S.E. Pearl Lease		3	4.1.1	12m	5	530	400	530	7.95	231
					4.1.2	12m	5					
					4.1.3	12m	5					
	7	Eagles		3	5.1.1	12m	5	600	380	600	11.4	262
					5.1.2	12m	5					
					5.1.3	12m	5					
18-Jan-05	1	Cage 1	0 mtrs	4	1.1.1	N	5	380	110	380	7.76	488
					1.1.2	E	5					
					1.1.3	S	5					
					1.1.4	W	5					
	4	S.E. Pearl Lease		3	4.1.1	12m	5	610	1000	610	8.8	410
					4.1.2	12m	5					
					4.1.3	12m	5					

	7	Eagles		3	5.1.1	12m	5	470	12	470	8.45	442
					5.1.2	12m	5					
					5.1.3	12m	5					
18-Aug-06	1	Cage 1	0 mtrs	4	1.1.1	N	5	520	217	520	9.45	76
					1.1.2	E	5	420	195	420	6.34	79
					1.1.3	S	5	540	171	540	11.5	78
					1.1.4	W	5	340	172	340	6.51	78
						Average		455	188.75	455	8.45	77.75
			50 mtrs west	3	1.2.1	12m	5	550	218	550	10.1	81
					1.2.2	12m	5	530	230	530	7.74	82
					1.2.3	12m	5	410	163	410	7.68	82
						Average		496.6667	203.6667	496.6	8.506	81.66
			200 mtrs west	3	1.3.1	12m	5	460	325	460	9.74	82
					1.3.2	12m	5	570	272	570	8.45	81
					1.3.3	12m	5	580	226	580	6.81	80
						Average		536.6667	274.3333	536.667	8.333	81
	2	Cage 2	0 mtrs	4	2.1.1	N	5	460	226	460	6.44	80
					2.1.2	E	5	440	251	440	7.21	77
					2.1.3	S	5	45	335	45	4.61	81
					2.1.4	W	5	400	401	400	3.42	81
						Average		336.25	303.25	336.25	5.42	79.75
			50 mtrs west	3	2.2.1	12m	5	610	246	610	7.63	80
					2.2.2	12m	5	380	256	380	5.41	80
					2.2.3	12m	5	320	364	320	7.13	82
						Average		436.6667	288.6667	436.66	6.7233	80.666
			200 mtrs west	3	2.3.1	12m	5	230	258	230	6.32	83
					2.3.1	12m	5	540	233	540	11.2	81
					2.3.3	12m	5	200	330	200	7.86	87
						Average		323.3333	273.6667	323.333	8.46	83.666
	3	Cage 3	0 mtrs	4	3.1.1	N	5	260	134	260	7.11	88
					3.1.2	E	5					
					3.1.3	S	5	180	337	180	7.07	87
					3.1.4	W	5	210	213	210	6.84	86
						Average		216.6667	228	216.66	7.0066	87
			50 mtrs west	3	3.2.1	12m	5	170	217	170	5.32	87
					3.2.2	12m	5	450	217	450	9.03	87
					3.2.3	12m	5	600	243	600	7.34	87
						Average		406.6667	225.6667	406.666	7.23	87
			200 mtrs west	3	3.3.1	12m	5	380	190	380	4.53	94
					3.3.2	12m	5	420	216	420	4.8	90
					3.3.3	12m	5	560	240	560	6.87	90
						Average		453.3333	215.3333	453.33	5.4	91.333
	4	S.E. Pearl Lease		3	4.1.1	12m	5	620	272	620	11.9	90
					4.1.2	12m	5	650	280	650	11.2	91
					4.1.3	12m	5	700	276	700	11.7	92
						Average		656.6667	276	656.666	11.6	91
	5	S.W. Cone Bay		3	5.1.1	12m	5	290	173	290	6.22	272
					5.1.2	12m	5	290	172	290	8.12	83
					5.1.3	12m	5	380	179	380	10.2	83
						Average		320	174.6667	320	8.18	146
	6	Crawford Bay		3	6.1.1	12m	5	190	314	190	7.62	94
					6.1.2	12m	5	180	273	180	6.04	90
					6.1.3	12m	5	290	201	290	8.2	89
						Average		220	262.6667	220	7.2867	91
10-Oct-	1	Cage 1	0 mtrs	4	1.1.1	N	5	420	263	420	6.39	155
					1.1.2	E	5	220	238	220	4.29	152

06					1.1.3	S	5	90	108	90	1.54	152
					1.1.4	W	5	530	252	530	6.69	154
						Average		315	215.25	315	4.7275	153.25
			50 mtrs west	3	1.2.1	12m	5	150	81	150	2.79	151
					1.2.2	12m	5	150	141	150	1.7	157
					1.2.3	12m	5	180	230	180	2.01	147
						Average		160	150.6667	160	2.1666	151.66
			200 mtrs west	3	1.3.1	12m	5	220	370	220	1.9	141
					1.3.2	12m	5	330	236	330	3.74	145
					1.3.3	12m	5	40	236	40	4	142
						Average		196.6667	280.6667	196.666	3.2133	142.66
	2	Cage 2	0 mtrs	4	2.1.1	N	5	220	239	220	6.25	141
					2.1.2	E	5	290	315	290	6.36	183
					2.1.3	S	5	400	238	400	7.72	-60
					2.1.4	W	5	470	273	470	7.53	164
						Average		345	266.25	345	6.965	107
			50 mtrs west	3	2.2.1	12m	5	410	354	410	9.36	-70
					2.2.2	12m	5	390	318	390	7.26	163
					2.2.3	12m	5	220	210	220	7.48	56
						Average		340	294	340	8.0333	49.666
			200 mtrs west	3	2.3.1	12m	5	200	249	200	7.08	166
					2.3.1	12m	5	260	288	260	6.3	-68
					2.3.3	12m	5	200	364	200	5.35	165
						Average		220	300.3333	220	6.2433	87.666
	3	Cage 3	0 mtrs	4	3.1.1	N	5	270	157	270	4.57	-68
					3.1.2	E	5	320	325	320	5.49	167
					3.1.3	S	5	260	144	260	5.13	-69
					3.1.4	W	5	260	350	260	6	163
						Average		277.5	244	277.5	5.2975	48.25
			50 mtrs west	3	3.2.1	12m	5	310	252	310	8.46	-74
					3.2.2	12m	5	410	282	410	9.23	158
					3.2.3	12m	5	240	238	240	7.87	170
						Average		320	257.3333	320	8.52	84.666
			200 mtrs west	3	3.3.1	12m	5	480	228	480	7.49	160
					3.3.2	12m	5	490	190	490	7.89	167
					3.3.3	12m	5	600	319	600	8.79	162
						Average		523.3333	245.6667	523.333	8.0566	164.5
	4	S.E. Pearl Lease		3	4.1.1	12m	5	600	298	600	10.7	157
					4.1.2	12m	5	650	238	650	10.9	154
					4.1.3	12m	5	300	148	300	9.38	155
						Average		516.6667	228	516.666	10.326	155.33
	5	S.W. Cone Bay		3	5.1.1	12m	5	380	200	380	8.01	160
					5.1.2	12m	5	410	294	410	7.4	157
					5.1.3	12m	5	360	498	360	7.65	157
						Average		383.3333	330.6667	383.333	7.6866	158
	6	Crawford Bay		3	6.1.1	12m	5	440	223	440	7.23	188
					6.1.2	12m	5	240	271	240	6.73	168
					6.1.3	12m	5	370	257	370	6.42	160
						Average		350	250.3333	350	6.7933	172
19-Dec-06	1	Cage 1	0 mtrs	4	1.1.1	N	5	110	301	110	7.65	364
					1.1.2	E	5	240	263	240	8	330
					1.1.3	S	5	130	240	130	6.91	376
					1.1.4	W	5	160	284	160	8.38	302
						Average		160	272	160	7.735	343
			50 mtrs west	3	1.2.1	12m	5	200	233	200	8.58	319
					1.2.2	12m	5	120	278	120	8.83	303

				1.2.3	12m	5	350	219	350	8.24	301
				Average			223.3333	243.3333	223.333	8.55	307.66
		200 mtrs west	3	1.3.1	12m	5	130	264	130	9.42	313
				1.3.2	12m	5	710	295	710	8.97	298
				1.3.3	12m	5	100	202	100	8.03	299
				Average			313.3333	253.6667	313.333	8.8066	303.33
2	Cage 2	0 mtrs	4	2.1.1	N	5	300	243	300	5.29	294
				2.1.2	E	5	190	238	190	4.96	301
				2.1.3	S	5	120	314	120	4.63	293
				2.1.4	W	5	290	283	290	4.05	295
				Average			225	269.5	225	4.7325	295.75
		50 mtrs west	3	2.2.1	12m	5	300	265	300	8.59	296
				2.2.2	12m	5	350	278	350	7.23	289
				2.2.3	12m	5	300	286	300	6.95	279
				Average			316.6667	276.3333	316.666	7.59	288
		200 mtrs west	3	2.3.1	12m	5	420	203	420	7.48	292
				2.3.1	12m	5	270	208	270	7.04	294
				2.3.3	12m	5	280	251	280	6.78	320
				Average			323.3333	220.6667	323.333	7.1	302
3	Cage 3	0 mtrs	4	3.1.1	N	5	430	257	430	6.16	308
				3.1.2	E	5	280	379	280	4.19	299
				3.1.3	S	5	330	382	330	4.64	306
				3.1.4	W	5	1020	393	1020	5.14	287
				Average			515	352.75	515	5.0325	300
		50 mtrs west	3	3.2.1	12m	5	300	238	300	2.64	282
				3.2.2	12m	5	370	817	370	4.19	299
				3.2.3	12m	5	280	247	280	4.54	279
				Average			316.6667	434	316.666	3.79	286.66
		200 mtrs west	3	3.3.1	12m	5	290	215	290	3.7	288
				3.3.2	12m	5	220	817	220	4.24	281
				3.3.3	12m	5	60	247	60	2.71	348
				Average			190	426.3333	190	3.55	305.66
4	S.E. Pearl Lease		3	4.1.1	12m	5	700	315	700	9.99	303
				4.1.2	12m	5	550	294	550	13.3	304
				4.1.3	12m	5	240	358	240	7.79	301
				Average			496.6667	322.3333	496.666	10.36	302.66
5	S.W. Cone Bay		3	5.1.1	12m	5	450	283	450	6.34	303
				5.1.2	12m	5	360	279	360	6.34	337
				5.1.3	12m	5	310	223	310	4.49	314
				Average			373.3333	261.6667	373.333	5.7233	318
6	Crawford Bay		3	6.1.1	12m	5	290	227	290	5.96	304
				6.1.2	12m	5	400	205	400	5.47	305
				6.1.3	12m	5	520	303	520	4.43	301
				Average			403.3333	245	403.333	5.2866	303.33
7	Gerald Bay		3	6.1.4	12m	5	540	290	540	9.63	304
				6.1.5	12m	5	410	276	410	14.1	303
				6.1.6	12m	5	700	306	700	6.14	299
				Average			550	290.6667	550	9.9566	302

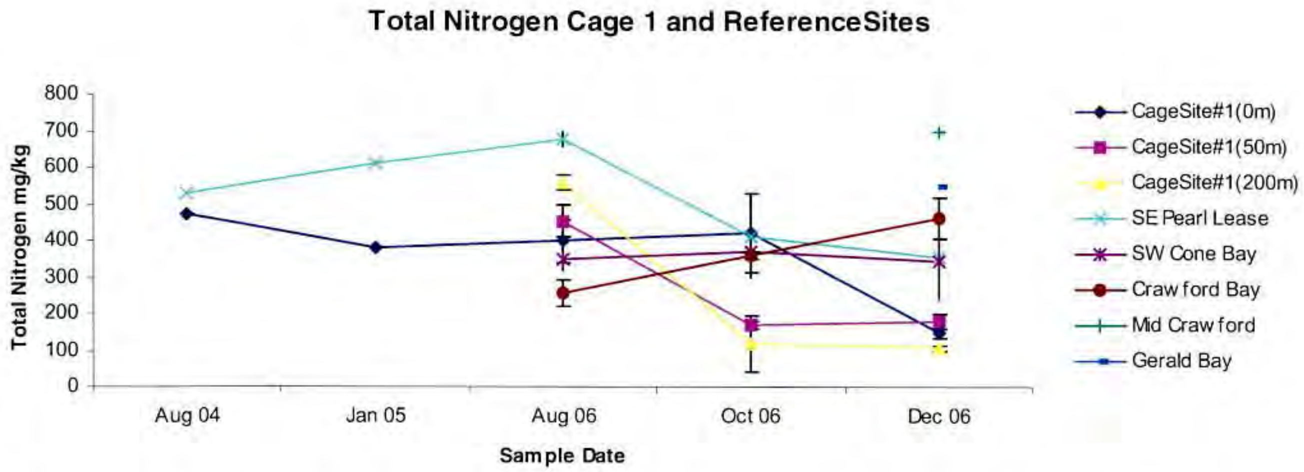

Figure D14 (a): Benthic sediment Total Nitrogen levels for Cage 1 and Reference sites from August 2004 to December 2006.

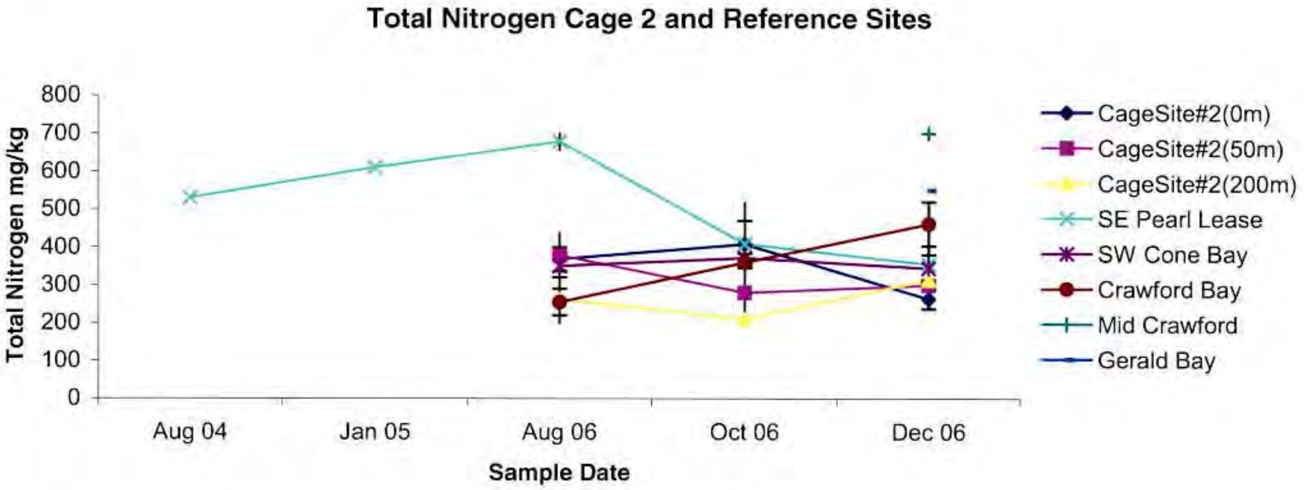

Figure D14 (b): Benthic sediment Total Nitrogen levels for Cage 2 and Reference sites from August 2004 to December 2006.

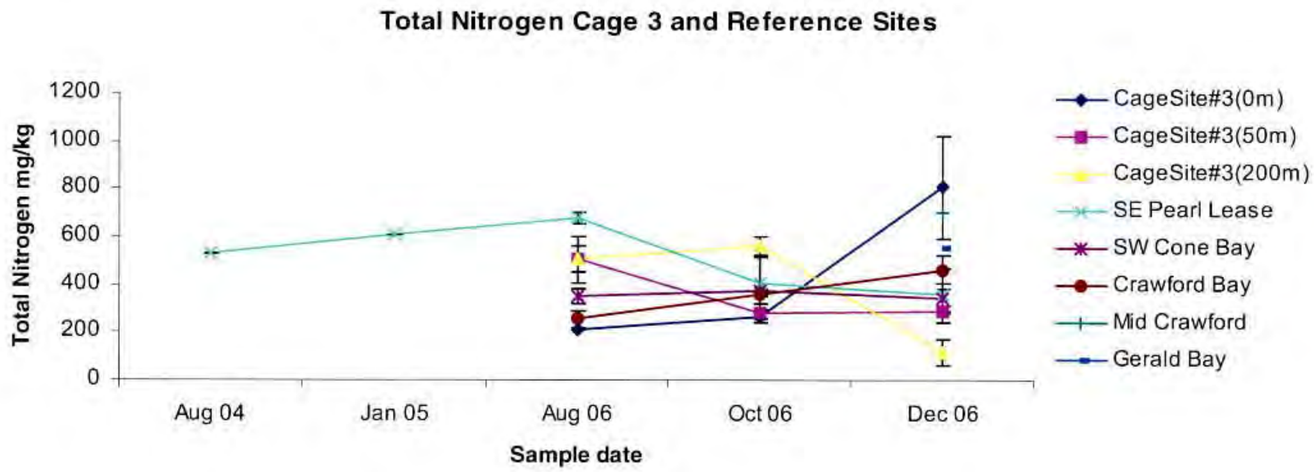

Figure D14 (c): Benthic sediment Total Nitrogen levels for Cage 3 and Reference sites from August 2004 to December 2006.

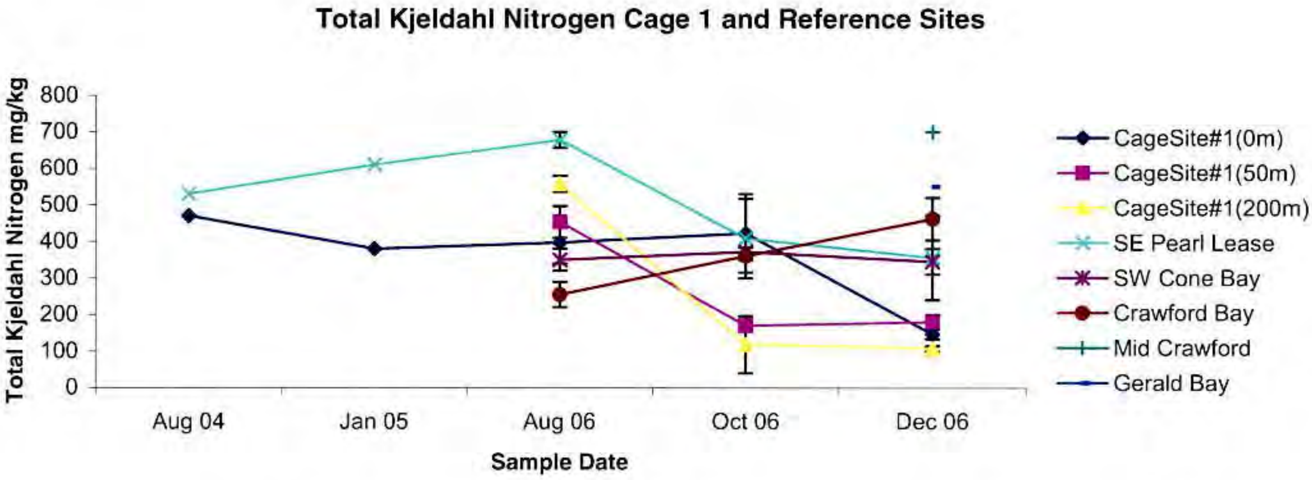

Figure D15 (a): Benthic sediment Total Kjeldahl Nitrogen levels for Cage 1 and Reference sites from August 2004 through to December 2006.

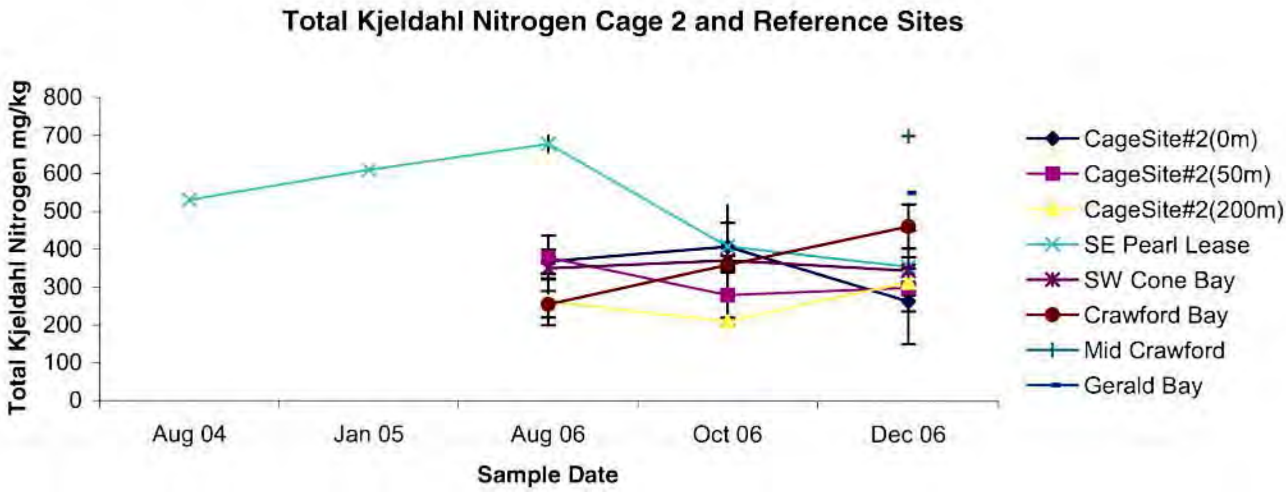

Figure D15 (b): Benthic sediment Total Kjeldahl Nitrogen levels for Cage 2 and Reference sites from August 2004 through to December 2006.

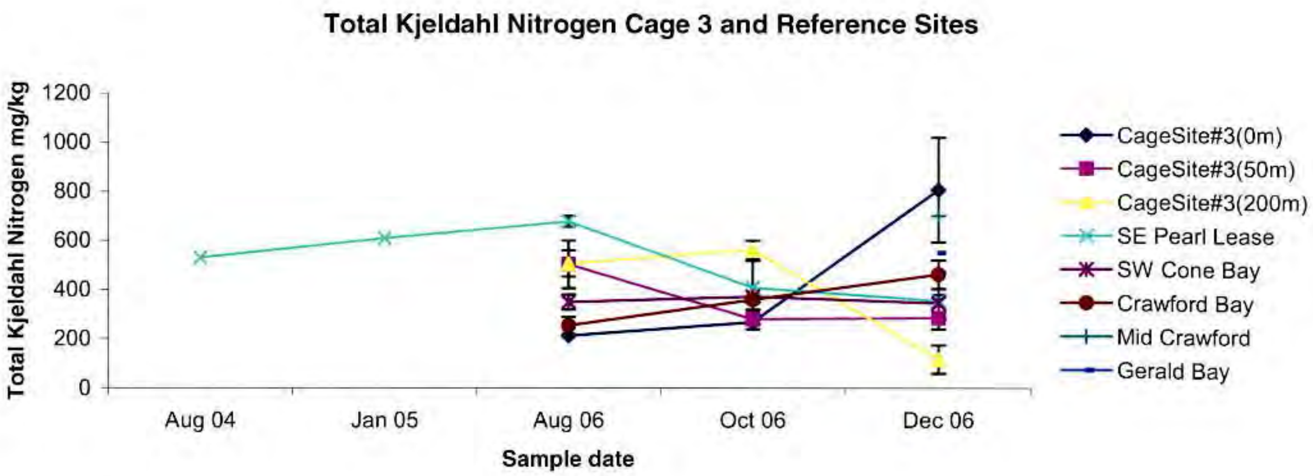

Figure D15 (c): Benthic sediment Total Kjeldahl Nitrogen levels for Cage 3 and Reference sites from August 2004 through to December 2006.

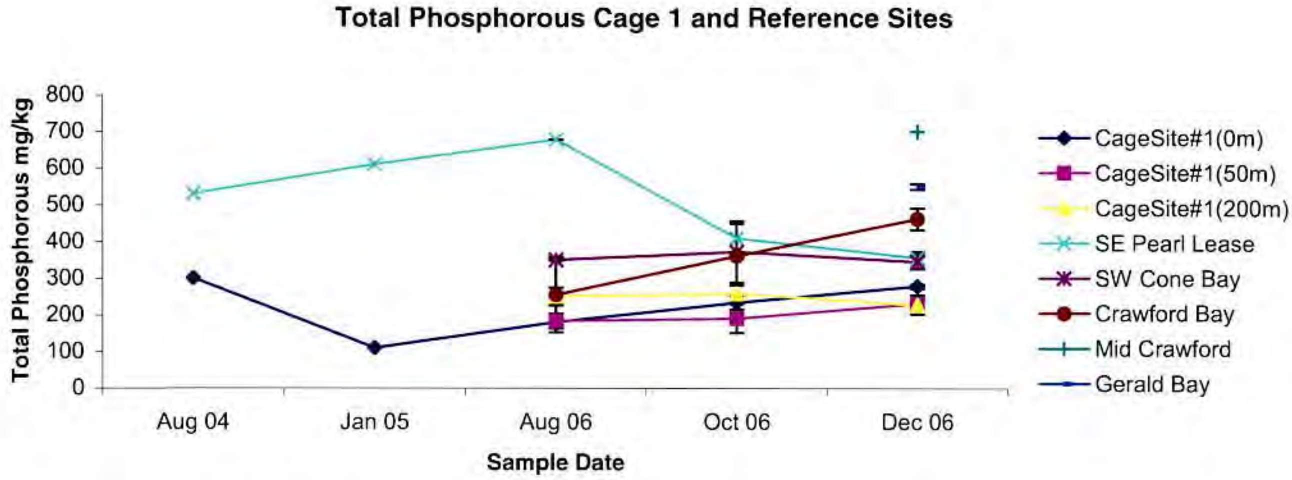

Figure D16 (a): Benthic sediment Total Phosphorous levels for Cage 1 and Reference sites from August 2004 through to December 2006.

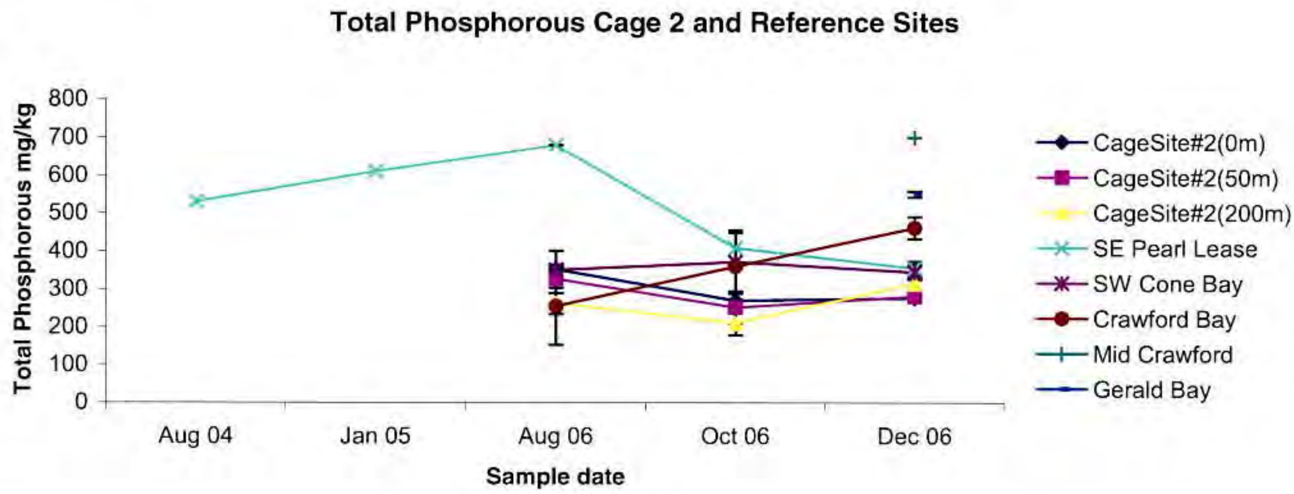

Figure D16 (b): Benthic sediment Total Phosphorous levels for Cage 2 and Reference sites from August 2004 through to December 2006.

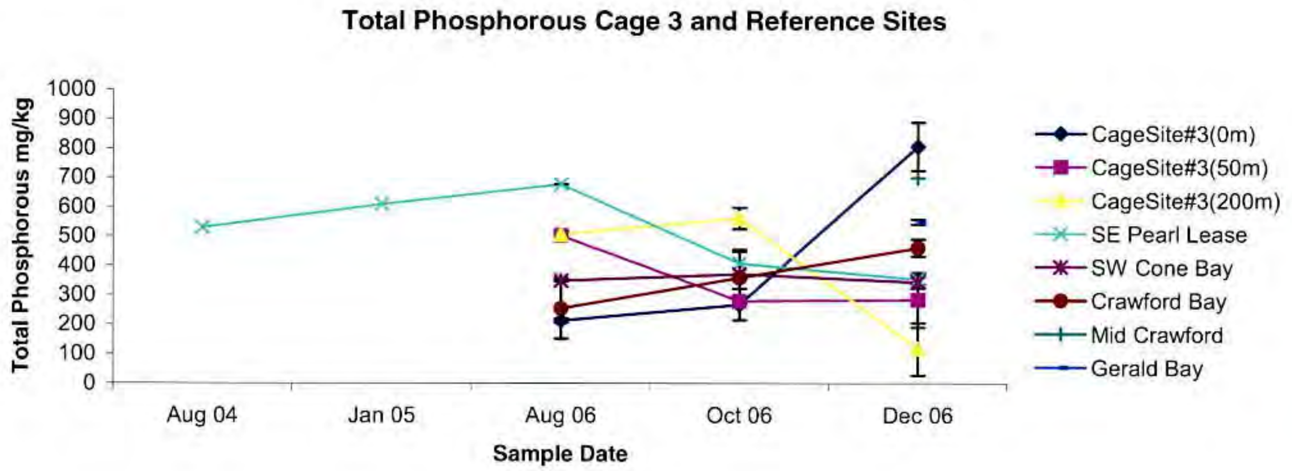

Figure D16 (c): Benthic sediment Total Phosphorous levels for Cage 3 and Reference sites from August 2004 through to December 2006.

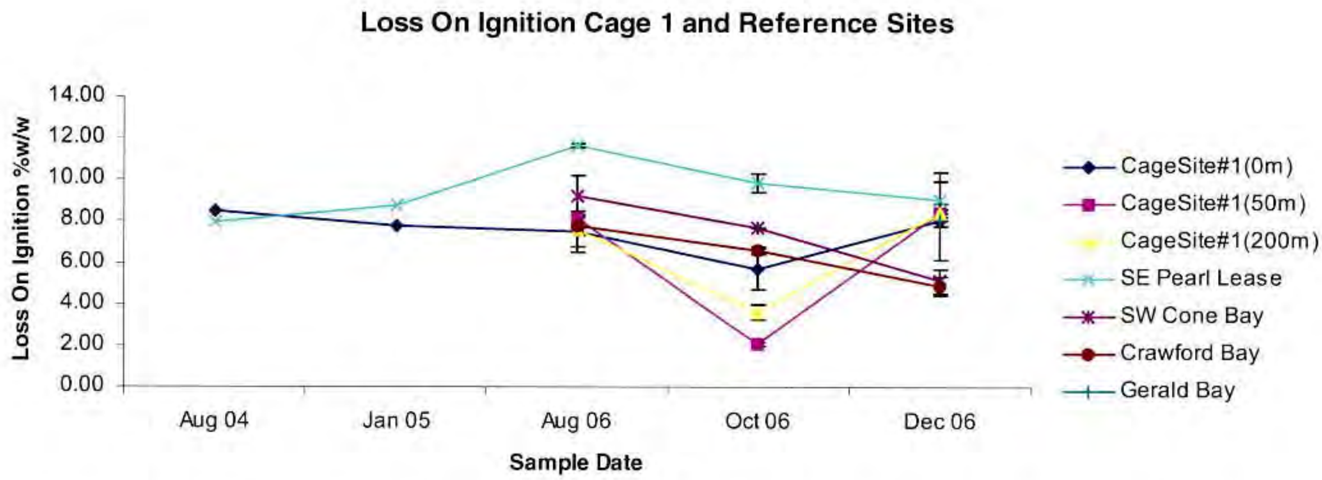

Figure D17 (a): Benthic sediment Total Organic Matter (LOI) levels for Cage 1 and Reference sites from August 2004 through to December 2006.

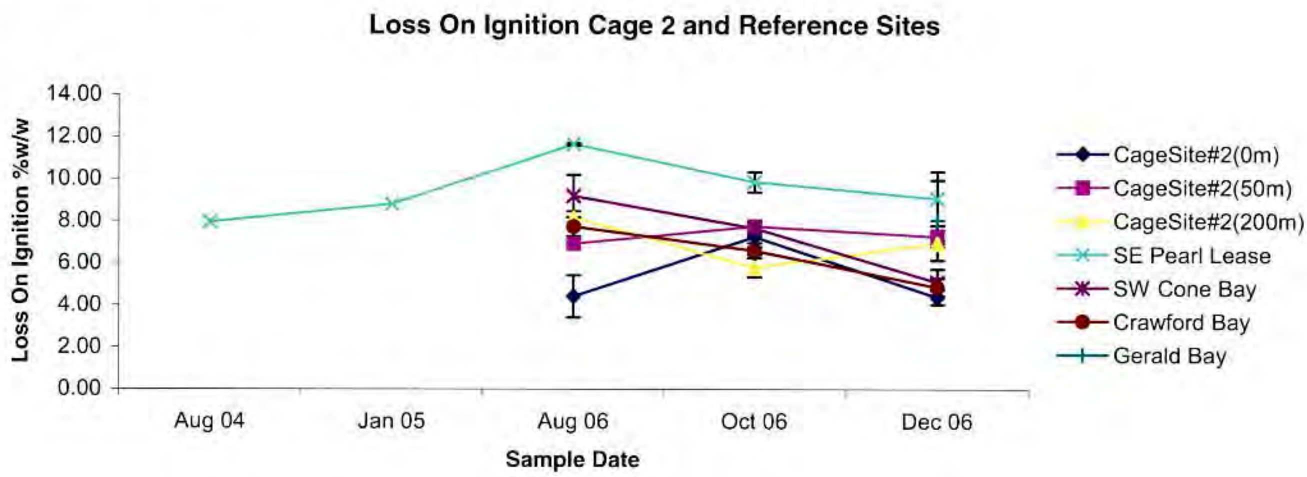

Figure D17 (b): Benthic sediment Total Organic Matter (LOI) levels for Cage 2 and Reference sites from August 2004 through to December 2006.

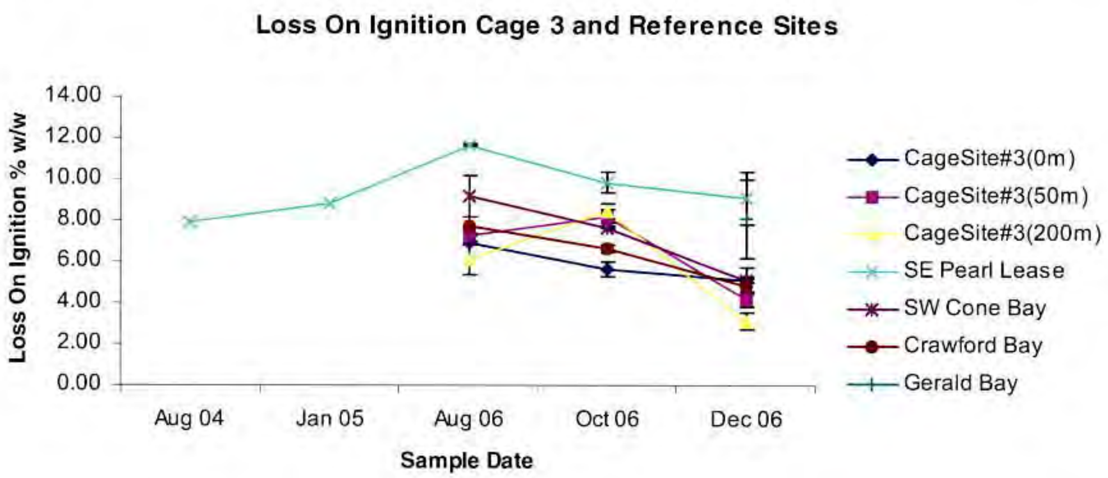

Figure D17 (c): Benthic sediment Total Organic Matter (LOI) levels for Cage 3 and Reference sites from August 2004 through to December 2006.

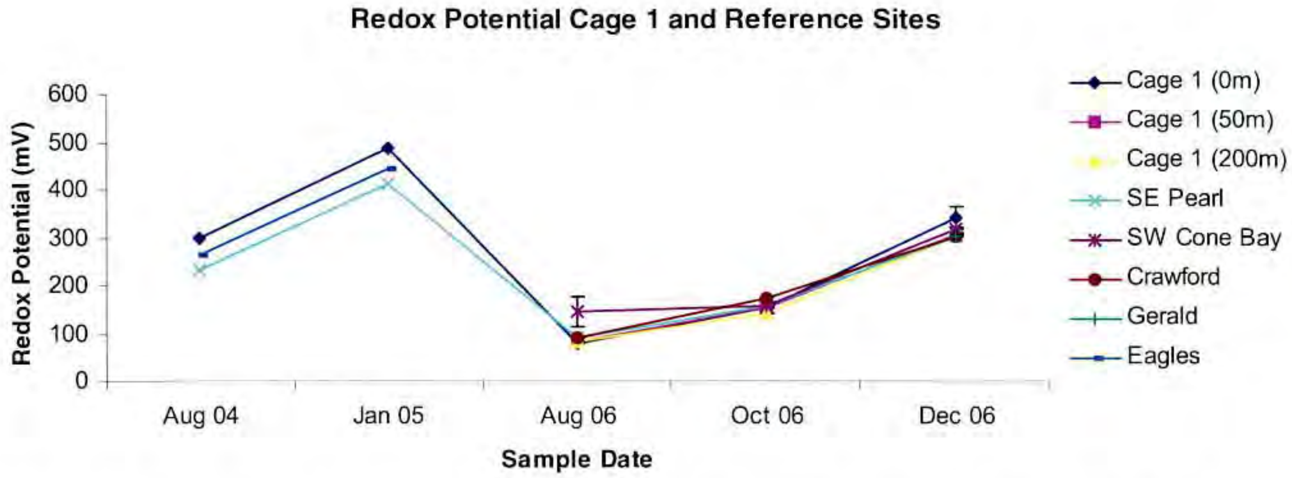

Figure D18 (a): Benthic sediment Redox Potential levels for Cage 1 and Reference sites from August 2004 through to December 2006.

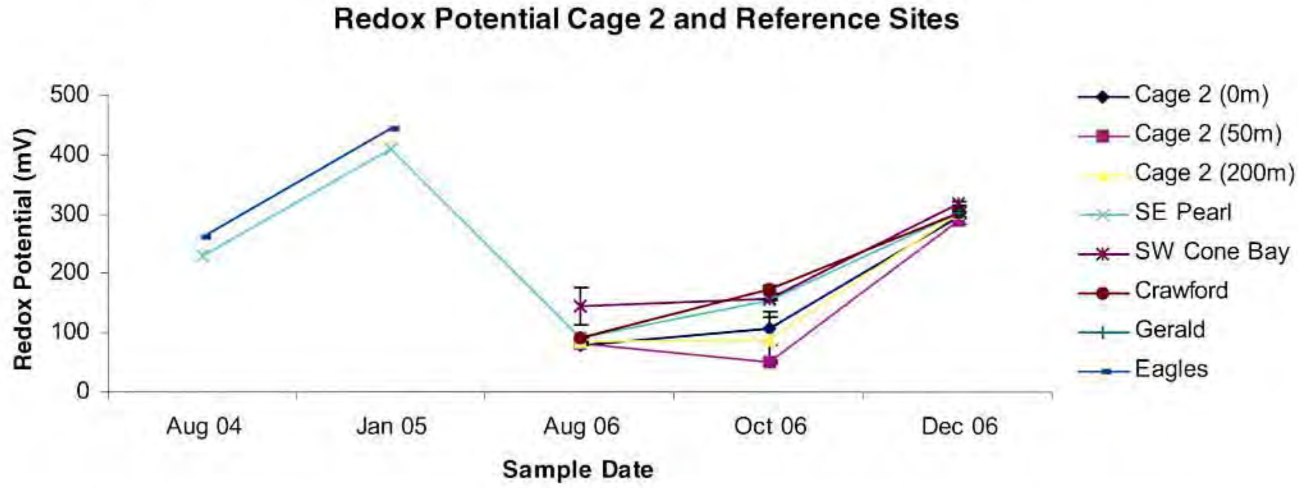

Figure D18 (b): Benthic sediment Redox Potential levels for Cage 2 and Reference sites from August 2004 through to December 2006.

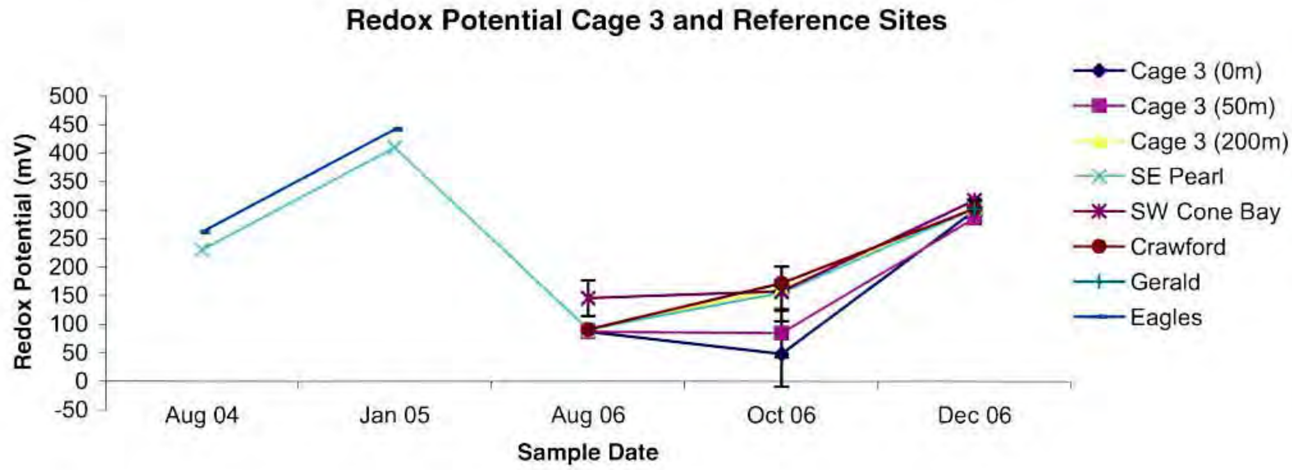

Figure D18 (c): Benthic sediment Redox Potential levels for Cage 3 and Reference sites from August 2004 through to December 2006.

The Cone Bay EMMP results show that TKN makes up the total nitrogen value, indicating that the nitrogen found in the sediments of the region are predominantly organic and that the inorganic component is below detectable levels. Intra-site samples were averaged to obtain one value for each site. Benthic nitrogen levels ranged between 160 and 863mg/kg and were seen to be higher at the reference sites than at the sea cage sites for the 2004 and 2005 sampling periods, however this is to be expected due to the low biomass and stocking densities maintained during these years. The October and December 2006 results showed a decline in benthic TN levels at all sites, however, sea cage #1 was comparable to previous years and interestingly, the reference sites demonstrated higher levels of TN than the cage sites.

TP ranged between 108 and 1000 mg/kg, however the high reading seen at S.E. Pearl Lease in January 2005 could be construed as an anomaly due to the large difference to all other readings obtained on any other sampling date. With the introduction of the EMMP the results show that although there is some variability, the sea cages are showing similar values of benthic phosphorous as the reference sites and in some cases even lower. Overall, excluding the surprisingly high reading in January 2005, TP ranged between 108 and 400 mg/kg.

Loss on ignition (LOI), a test for organic content of the sediment, ranged between 5.4 and 11.6%w/w. The readings showed that there was little difference between Sea Cage #1 and S.E. Pearl Lease in 2004 and 2005, however there was a greater variability seen in the readings between reference sites in the 2006 sampling dates although no distinct patterns can be detected except that S.E. Pearl Lease consistently demonstrates the highest levels.

Redox potential was not measured on a regular basis prior to the development of the EMMP, however results obtained show that redox potential is relatively consistent between sites on any sampling date, although highly variable over time. The results have demonstrated much lower readings in August and October 2006 than previous results in both 2004 and 2005, with levels then increasing again in December 2006 to be comparable to those in 2004 and 2005.

4.3. Discussion

As benthic samples are only collected on a 3 monthly basis the data for sediment quality is therefore somewhat limited, however it does show that overall inter- & intra-site variability is high and any comparisons and conclusions need to be undertaken with this variability in mind.

The Cone Bay EMMP has also shown that where water quality is relatively consistent, the sediment quality was shown to be highly variable, both within and between sites. However, these results did determine that little inorganic nitrogen exists in the sediments and that no unacceptable impacts to sediment chemistry have occurred to date. Although visual reports have noted that sediment looks to be getting a "darker surface layer", this is very thin and not considered 'toxic'. Most importantly, the Cone Bay EMMP has demonstrated that no EQCs have been exceeded and that no unacceptable changes to sediment quality has occurred as a result of the sea cage Barramundi venture.

Furthermore, although visual observations of the sediment by staff has demonstrated small changes to the benthic sediment directly below the cages, no discernible or obvious changes have been detected during laboratory analysis and no reports of a hydrogen sulphide smell have occurred, thus indicating that the environment is able to support and in fact assimilate the nutrient output from the sea cages to a certain degree. Although impacts to the sediment directly below the cages is expected to occur, the development of an effective fallowing plan will ensure that there continues to be no permanent impacts to the benthos or unacceptable impacts to the surrounding environment.

5. Benthic Infauna

5.1. Introduction and Methodology

The diversity and abundance of benthic macro invertebrates to the Family level was assessed at four sampling sites. An extra 500mL sample was collected when sediment samples were collected using the corer from each site. These samples were preserved in 10% formalin seawater solution, refrigerated and dispatched to a NATA registered laboratory for analysis and identification. Samples were then sieved, stained, sorted and identified to family level once received by the laboratory.

5.2. Results

The benthic infaunal assemblages of three reference sites and the Sea Cage #1 were sampled and identified to family level. Benthic infaunal studies were undertaken twice as results from the first round of sampling on the 11th July were considered to be inaccurate. The first round of samples taken from all sites resulted in very low abundance and diversity. At two sites no benthic organisms were detected and a total of only three individuals and species identified at all other sites. Results from the first round of sampling are given in Figure D19. As a result, a second round of sampling for benthic organisms was undertaken on the 26th September 2006 in order to either confirm or repudiate the initial results. The results of the second Benthic Infuanal analysis is given in Figure D20. Table D4 provides a summary of the results including the sample site and number for the corresponding laboratory reference number used in the figures.

Table D4: Benthic Infauna Assemblages of the Cone Bay Licence and Surrounding Areas

Date Sampled	Laboratory No.	Sample Site	Diversity (No. of species)	Abundance (Total no. of individuals in sample)	Phylum Represented
11th July 2006	0622421	Crawford Lease Site	1	1	Crustacea
	0622422	Mid Crawford	1	1	Annelida
	0622423	Gerald Bay	0	0	
	0622424	SE Pearl Lease	1	1	Annelida
	0622425	Sea Cage 1	1	1	Mollusca
	0622426	SW Cone Bay	0	0	
26th Sept 2006	0634358M	Crawford Bay Lease Sample #1	1	1	Crustacea
	0634359M	Crawford Bay Lease Sample #2	0	0	
	0634360M	Crawford Bay Lease Sample #3	1	1	Sipuncula
	0634361M	Mid Crawford Sample #1	1	1	Crustacea
	0634362M	Mid Crawford Sample #2	1	1	Crustacea
	0634363M	Mid Crawford Sample #3	1	1	Annelida
	0634364M	Gerald Bay Sample #1	12	17	Crustacea (x5 spp), Echinodermata (x1), Cnidaria (x1), Annelida (x5 spp)
	0634365M	Gerald Bay Sample #2	2	2	Crustacea (x1), Annelida (x1)
	0634366M	SE Pearl Lease Sample #1	1	1	Mollusca (bivalve)
	0634367M	SE Pearl Lease Sample #2	2	2	Annelida (x2)
	0634368M	SE Pearl Lease Sample #3	1	1	Annelida
	0634369M	Sea Cage 1 Sample #1	5	5	Crustacea (x2 spp), Annelida (x3 spp)
	0634370M	Sea Cage 1 Sample #2	1	1	Annelida
	0634371M	Sea Cage 1 Sample #3	2	2	Crustacea (x1), Annelida (x1)

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Date 4/9/06

Results of taxonomic identification of samples from Microserve

Sample Code: MIC06-71

Please Note: There were 2 samples that did not contain any organisms that were derived from previously living material, *i.e.* 0622423 and 0622426.

Phylum	Family	Taxa	Code	0622421	0622422	0622424	0622425
Crustacea	Alpheidae	Alpheid sp. 1	CAl1	0	0	1	0
Annelida	Sternaspidae	Sternaspid sp 1	PSt1	0	0	0	1
Annelida	Orbinidae	Orbinid sp. 1	POr1	0	1	0	0
Mollusca	Veneridae	Venerid sp. 1	MVe1	1	0	0	0

Your Sincerely

Michael Travers

Figure D19: First round of taxonomic identification results of benthic infauna at the Cone Bay environmental monitoring sites

Marine and Freshwater Research Laboratory
Environmental Science

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INFAUNA DATA

Customer: Microserve
Address:181 Claisbrook Road, Perth WA 6000

Date of Issue: 4/1/2007
Our Reference: MIC06-108

Phylum	Class	Order	Family	Genus	Taxa	Code	4358	4360	4361	4362	4363	4364	4365	4366	4367	4368	4369	4370	4371
Crustacea	Maxillopoda	Calanoida			Calanoid sp. 1	CCal1	0	0	0	0	0	1	0	0	0	0	0	0	0
Crustacea	Ostracoda				Ostracod sp. 1	COs1	0	0	0	0	0	3	0	0	0	0	0	0	0
Crustacea	Malacostraca	Cumacea			Cumacean sp. 1	CCu1	0	0	0	0	0	1	0	0	0	0	0	0	0
Crustacea	Malacostraca	Tanaidacea			Tanaid sp. 1	CTa1	0	0	0	1	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda	Ampeliscidae		Ampeliscid sp. 1	CAAm1	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda	Ampeliscidae		Ampeliscid sp. 2	CAAm2	0	0	1	0	0	0	0	0	0	0	0	0	1
Crustacea	Malacostraca	Amphipoda			Amphipod sp. 1	CA1	0	0	0	0	0	0	1	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda			Amphipod sp. 2	CA2	0	0	0	0	0	0	0	0	0	0	1	0	0
Crustacea	Malacostraca	Amphipoda			Amphipod sp. 3	CA3	0	0	0	0	0	3	0	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda			Amphipod sp. 4	CA4	0	0	0	0	0	1	0	0	0	0	0	0	0
Crustacea	Malacostraca	Amphipoda			Amphipod sp. 5	CA5	1	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Decapoda				Brachyuran sp. 1	CBr1	0	0	0	0	0	0	0	0	0	0	1	0	0
Echinodermata	Ophiuroidea				Ophiuroid sp. 1	EO1	0	0	0	0	0	1	0	0	0	0	0	0	0
Mollusca	Bivalvia				Bivalve sp. 1	BUn1	0	0	0	0	0	0	0	1	0	0	0	0	0
Cnidaria					Cnidarian sp. 1	Cn1	0	0	0	0	0	1	0	0	0	0	0	0	0
Sipuncula			Phascolionidae		Phascolionid sp. 1	SPh1	0	1	0	0	0	0	0	0	0	0	0	0	0
Annelida	Polychaeta	Scolecida	Capitellidae	Capitella	Capitella sp.	PC1	0	0	0	0	1	0	0	0	0	0	1	0	0
Annelida	Polychaeta	Scolecida	Capitellidae		Capitellid sp.	PC2	0	0	0	0	0	1	0	0	0	0	0	0	1
Annelida	Polychaeta	Terebellida	Terebellidae		Terebellid sp. 1	PTe1	0	0	0	0	0	1	0	0	0	0	0	0	0
Annelida	Polychaeta	Terebellida	Terebellidae		Terebellid sp. 2	PTe2	0	0	0	0	0	1	0	0	0	0	0	0	0
Annelida	Polychaeta	Phyllodocida	Nereididae		Nereidid sp.	PN1	0	0	0	0	0	2	0	0	1	0	0	0	0
Annelida	Polychaeta	Phyllodocida	Syllidae		Syllid sp. 1	PSy1	0	0	0	0	0	1	0	0	0	0	0	0	0
Annelida	Polychaeta	Phyllodocida	Syllidae		Syllid sp. 2	PSy2	0	0	0	0	0	0	0	0	0	1	0	0	0
Annelida	Polychaeta	Terebellida	Cirratulidae		Cirratulid sp.	PCi1	0	0	0	0	0	0	1	0	0	0	1	0	0
Annelida	Polychaeta	Terebellida	Sternaspidae		Sternaspid sp.	PSt1	0	0	0	0	0	0	0	0	1	0	0	0	0
Annelida	Polychaeta	Phyllodocida	Nephtydae		Nephtyd sp.	PNp1	0	0	0	0	0	0	0	0	0	0	1	0	0
Annelida	Polychaeta	Scolecida	Lumbrineridae		Lumbrinerid sp.	PLu1	0	0	0	0	0	0	0	0	0	0	0	1	0

Note: This not covered under the scope of NATA accreditation

Signatory: [signature]
Date: 4/1/07

All test items tested as received. Spare test items will be held for two months unless otherwise requested.

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Figure D20: Second round of taxonomic identification results of benthic infauna for the Cone Bay EMMP.

5.3. Discussion

The results from the both rounds of benthic sampling show that infaunal assemblage species diversity and abundance is very low. Only one individual was found in most of the samples and therefore a number of sites. The second round of sampling demonstrated that the first round was only slightly inaccurate, however did not have enough samples per site. Gerald Bay demonstrated the highest diversity and abundance with 12 taxa being represented and a total of 17 individuals in total. Only 5 samples (3 sites) were observed to have more than one taxa represented. Only one sample in the second round of sampling (at Crawford Bay Lease) did not contain any organisms derived from living materials.

Also clearly evident by the Gerald Bay results is that the results are highly variable. It is interesting to note that Sea Cage #1 demonstrates a higher species diversity and abundance than all other sites excepting Gerald Bay. One theory for this is that the nutrient output from the cages is actually having a positive effect on the benthic organisms by providing nutrients in an environment that is predominantly lacking in nutrients. However, further sampling needs to be conducted to ascertain this. Hoskin & Underwood (2001), in a study of the benthic macro-invertebrates living directly under the sea cages of a commercial snapper farm in Providence Bay, NSW also observed increased diversity in one of the sample sites, indicating.

Other studies on the benthic and sediment organisms in the King Sound have also demonstrated that the benthic substrate of the entire area does not support a wide variety or number of organisms (CALM, 1994; Pearson *et al*, 1998; Bellanger, 2004). Further more, other studies of the benthic organisms below fin-fish sea cages have demonstrated evidence that changes do occur, however the majority of the changes observed were subtle and were expected to recover quickly once production in that area ceases, such as a fallowing program or similar activity (Hoskin & Underwood, 2001; Woods *et al*, 2004; Cheshire *et al*, 2005; Loo *et al*, 2006b).

Consequently, using changes in benthic infaunal species diversity and abundance as a key indicator of impacts from the sea cages may not be an effective tool. Further research into DNA assaying and data collection will be required to ascertain the effectiveness of utilising benthic infaunal analysis as a monitoring tool. Thus, MFF will continue to undertake this component of the EMMP as well as undertake further research into other more effective monitoring tools as a part of improving and reviewing the environmental management system (EMS). It will be important in future comparisons to take into consideration the initial low species diversity and abundance and thus should not automatically attribute any future changes in diversity and abundance to sea cage outputs.

6. Mangrove Communities

6.1. Introduction and Methodology

Two mangrove communities in Cone Bay have been selected for the EMMP. These sites were selected due to their proximity to the proposed lease area and are considered the most likely to be impacted by the proposed Barramundi Aquaculture Farm.

When site selection was being conducted it was noted that the mangrove areas would be very difficult to reach during low tides due to the large mud flats that were exposed in each embayment. This associated with the risk of crocodile interactions and staff safety issues led to the decision to conduct sampling of the mangrove communities at mid to high tides. As a consequence, in order to move the boat close enough for the close-up photographic records the mangroves were partially submerged. Results from other mangrove monitoring programs (by Aquanel for Marine Harvest, NT, 2003) have shown that no changes to the epiphytic growth on the roots of mangroves monitored are attributable to the inception of Barramundi sea cages in Port Hurd, Darwin, NT in 2000. Photographic results at low tides are only undertaken if samplers consider it safe to do so.

At each site, two positions were chosen to photographically record the communities. One position was close to mangroves, focusing on a small number of trees and the other position was from a distance, focusing on the community as a whole. Both positions will provide a comparative tool to which the status and health of each community over time can be monitored as a part of the ongoing EMMP. At both positions in each sampling site, the GPS points were recorded and a series of photographs were taken to provide visual comparison at a later date. At each sampling site, general visual observations of the health of the communities were recorded including comments on the presence of dead trees if any, faunal observations and where possible, species identification.

Site selection and initial sampling took place on the 30th May with the second round of sampling occurring on 12th December. All photographs of the mangroves are presented in Appendix E

6.2. Results

<u>Mangrove Site 1 – Snapper Cove, Cone Bay</u>

The first mangrove sampling site in Cone Bay is situated in Snapper Cove on the southern side of the bay (see Figure D21).

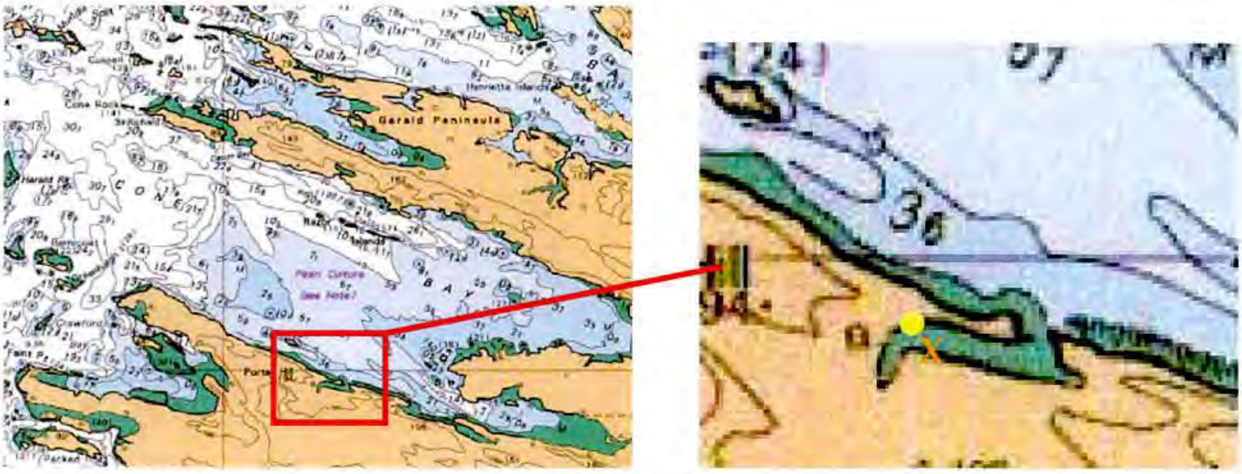


Figure D21: Mangrove sampling site 1, Cone Bay (Snapper Cove) – GPS position of the 'close-up' position is within the area indicated by the yellow circle, position of the 'distant' location is indicated by the orange 'X').

The GPS positions of the sample sites in Snapper Cove are as follows:

	Latitude	Longitude
Close-up location	16° 30.230' S	123° 32.239' E
Distant location	16° 30.345' S	123° 32.304' E

This mangrove community occupies a very large area that extends around most of Snapper cove and is one of the largest communities in Cone Bay (after the communities found at the back of the bay) covering an approximate area of 1500m^2. Most of the cove is exposed mudflats during spring low tides with the mangroves hugging the coastline with some areas extending up to 30-40m off the mainland. The entire edge of Snapper Cove is characterised by sheer cliff faces and very steep rocky banks rising abruptly out of the water except the very end of the cove (southeast corner). This area has a much gentler gradient than the rest of the bay, however can be very difficult to reach and is home to at least one known resident crocodile.

The species present within Snapper Cove and Cone Bay in general, are predominantly *Avicenna marina* and *Rhizophora sp.* The *Rhizophora sp.* is assumed to be *Rhizophora stylosa* as this was the only *Rhizophora* present in the King Sound area described in the *Survey of the Marine Biota of the Southern Kimberley Islands, Western Australia* (Wells *et al*, 1995) which was conducted by the Western Australian Museum in November 1994. *A. marina* is the tree with the grey coloured foliage and the *Rhizophora sp.* has the green foliage. The *Rhizophora sp* is also characterised by a high and numerous stilt root system that are obvious during low tide.

In the mangrove area photographed three trees were noted to have bare 'dead-looking' branches, however all three possessed one or two other branches that had an obvious covering of leaves (Appendix E). There were no dead trees and no obvious branches lacking foliage. As a community the area is considered to be in an undisturbed and healthy condition.

The ongoing monitoring results from the December sampling show that there has been no loss of community, however some individual trees were observed to have a number of dead branches, however no signs of increased mortality was observed. Overall there were no obvious changes to the mangrove community when compared to the May 2006 results.

No low tide analysis was undertaken due to the extent of the exposed mudflats and the safety risk associated with the known resident crocodile.

Mangrove Site 2 – Crawford Bay

The second mangrove sampling site is situated further west from the first sampling site, but still on the southern side of Cone Bay towards the western end of the licence (see Figure D22).

The GPS positions of the close-up and distant sampling positions are as follows:

	Latitude	Longitude
Close-up location	16° 28.951′ S	123° 29.670′ E
Distant location	16° 28.858′ S	123° 29.695′ E

The species present within Sampling Site 2 are predominantly *Avicenna marina* and *Rhizophora sp.* Just as in Snapper Cove, the *Rhizophora sp.* is assumed to be *Rhizophora stylosa* as this was the only *Rhizophora* present in the King Sound area described in the *Survey of the Marine Biota of the Southern Kimberley Islands, Western Australia* (Wells *et al*, 1995) which was conducted by the Western Australian Museum in November 1994.

The mangrove community in this inlet is very small in comparison to the community in Snapper Cove and covers an approximate area of $60m^2$. The mangrove community is situated on rock substrate with very little mud (see Appendix E). This community faces in northerly direction and as it is near the entrance of the bay, receives a lot more natural disturbance as a result of strong currents, wind and wave action. The proximity of this site to the aquaculture lease makes this community an ideal sample site.

In this community, it was observed that the mangroves in the front row are not in as good a condition as those directly behind them (See Appendix E). The mangroves on the right-hand side of the inlet are also in better condition. This is most likely a result of the direction the mangroves face with the front ones receiving the majority of impacts from natural disturbances (ie wind and wave action). The community on a whole is considered to be in a healthy condition with naturally adverse environmental effects causing the disturbances observed at this time.

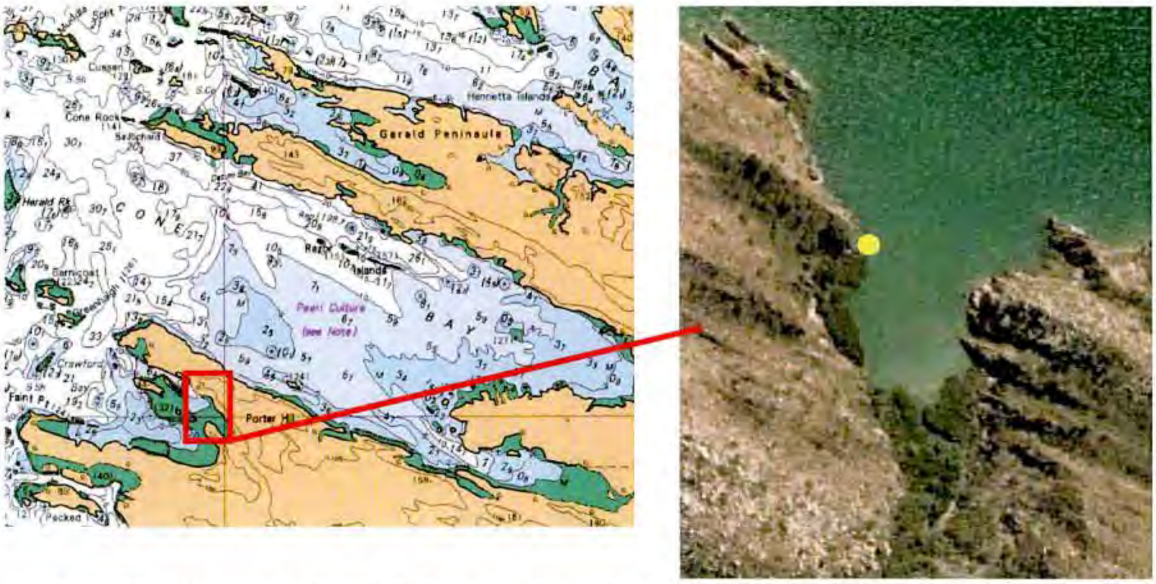


Figure D22: Mangrove sampling site 2, Cone Bay – the position of the mangrove sample area is within the area indicated by the yellow circle.

The ongoing monitoring results showed that the amount of dead and dying trees in the front row had not noticeably increased from the May sampling results. The close-up photographs demonstrated that the same individual trees were in very good health and no loss of size was evident. The community as a whole has shown not signs of receding or loss in size and is considered to be in a healthy condition with naturally occurring environmental conditions (eg wind and tidal impacts) causing the disturbances noted.

Low tide analysis demonstrated that the sediment is primarily sand and rocky coastline as opposed to the deep mud sediment observed in Snapper Cove. Also obvious at low tide is that the large proportion of the community is submerged at high tides and the presence of new mangrove trees growing near the foot of the larger trees

6.3. Discussion

Typically mangroves support a large diversity of marine flora and fauna and act as sediment and nutrient sinks by taking up nutrients from the water, sediments and terrestrial run-off. Mangroves play an important role in the marine environment and as a result impacts to mangrove communities can result in detrimental impacts to the marine environment (information from the ozestuaries website: www.ozestuaries.org). The proposal is not expected to impact on the nearby mangrove communities and it has been suggested that due to naturally variable and nutrient poor conditions associated with the region and the capacity for mangrove communities to recycle nutrients, that any potential increases in nutrients will quickly and efficiently be utilised by the mangroves. This in effect can result in positive impacts such as increased biomass, more habitat provision and generally a more productive micro-environment for the marine flora and fauna reliant on these communities.

7. Coral Reef Communities

7.1. Introduction and Methodology

One coral reef community has been selected in Cone Bay as a part of the EMMP. This site was selected as a result of it being the only known coral reef in the bay. The site will be monitored on a six monthly basis to detect any unacceptable impacts arising from the outputs of the proposal. Comparisons over time will enable detection of any changes and if required further monitoring will allow the source of the changes to be determined.

Sampling was conducted during a neap tide in an attempt to minimise the danger to the diver. The risks associated with diving in the King Sound (including Crawford Bay and surrounding areas) are many and are not eliminated during a neap tide, only reduced. These risks include: strong current flow and high turbidity making it very difficult for the diver to see anything or stay stationary in order to photograph an area. The presence of crocodiles and sharks in the area also increase with increasing turbidity and current flow as these predators are more likely to attack in these conditions using the cover provided to surprise their prey.

All future coral reef assessments will be undertaken during a neap tide and as accurately as possible the same area will be photographed. It is obvious in the photographs provided in the initial sampling periods that regardless of providing a GPS point to return to, the turbidity and high current flow of the area will make it very difficult to photograph the same 'quadrant'. As a result, future comparisons will need to be made on 'general health' observations obtained from both the photographs and the divers comments. As much as possible, the same diver will be conducting the sampling so continuity in that regard will exist.

At each sampling site, a GPS point was still recorded to enable the return to as close as possible the same position. Landmarks were also recorded as they provide a far easier method of locating the position, after which the GPS point enables further accuracy. General observations of the reef area were recorded along with any biota observed. As coral identification is highly specialised, identification to family level was attempted where possible.

It is important to note that a similar aquaculture venture is being proposed in Crawford Bay, adjacent to Cone Bay, by Maxima Fish Farms Pty Ltd. As a part of that proposal, two coral reef sampling sites have been chosen for monitoring purposes and will be used as a comparison for the Cone Bay coral reef sampling site. The results of the Crawford Bay coral reef monitoring sites are presented in this section as well.

Site selection and initial sampling took place on the 30th May 2006 with the second round of sampling occurring on 12th December 2006. All photographs of coral and other reef inhabiting organisms are presented in Appendix E.

7.2. Results

Sir Richard's Pass coral reef – Cone Bay

The coral reef sampling site selected is Sir Richards Pass in Cone Bay and is situated on the north-western side of the bay (Figure D23). The GPS position of the sample site is:

Latitude:	16° 24.918′ S
Longitude:	123° 30.175′ E

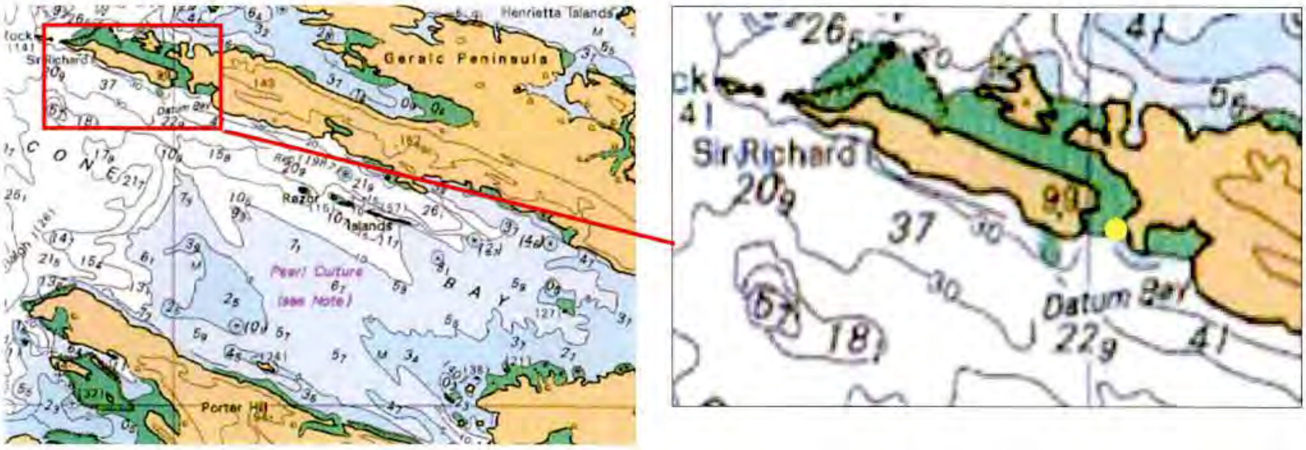


Figure D23: Coral reef sampling site, Cone Bay – GPS position of sample site is within the area indicated by the yellow circle.

The general state of the coral reef sample site is considered to be in good health and in an undisturbed state, however, a small amount of evidence of natural disturbance (ie broken coral) was observed. Photographic archives of the area are presented in Appendix E. Visibility is highly variable depending on tidal state and ambient environmental conditions, however generally visibility is low as a result of the high current velocity. The area surrounding the sample site is situated in a very high energy environment with rapid current velocity and low visibility occurring most of the time. Visibility was substantially better during the December sampling than in the May sampling period.

Corals present are predominantly hard corals, including those from the families Faviidae (brain corals), Acropora (staghorn and plate corals) and Poritidae (stony corals), although varieties from other Scleractinia (reef-building) families are present as well eg Fungiidae, Pectiniidae, Pocilloporidae, Agariciidae and Mussidae. A variety of soft corals also exist including gorgonian sea fans (Subergorgiedae), sea rods (Plexauridae) and other families including Alcyoniidae and Nephtheidae. Sponges observed are thought to be from the families Haplosclerida and Dictyoceratida.

Other reef inhabiting organisms observed on all sampling dates included sea urchins (Echinoidea – Diadematidae), starfish (Asteroidea), sea slugs (Holothuriidae), Bryozoans, shells and snails (Gastropods), bivalves, nudibranchs (Nudibranchia), worms (Polychaetes) and many crustaceans including barnacles, shrimps and crabs. Many reef fish were observed, both small and large, including butterfly fish, angel fish, dottybacks, anemone fish, gobys, groupers, cods, parrotfish, bream etc

The ongoing monitoring results showed that the coral reef is still considered to be in pristine and healthy condition. A small amount of damage was observed from natural environmental conditions (eg tide and wave action).

Coral Reef Site 1 – Crawford Bay

Coral Reef sampling site 1 is situated at the point of the northernmost side of the Crawford Bay (see Figure D24). The GPS position of the sample site is:

Latitude:	16° 28.499′ S
Longitude:	123° 27.532′ E

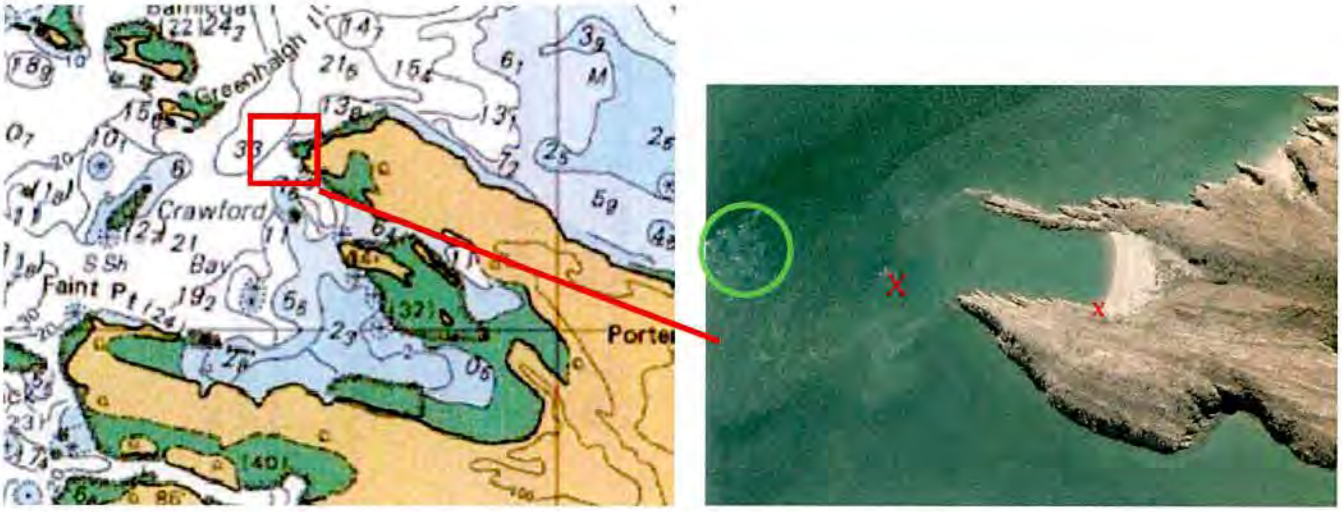


Figure D24: Coral reef sampling site No. 1 – Aerial view (GPS position of sample site is within the area indicated by the green circle)

The general state of the coral reef at sample site 1 is considered to be in good health. Corals present are predominantly hard corals, including those from the families Faviidae (brain corals), Acropora (staghorn and plate corals) and Poritidae (stony corals), although varieties from other Scleractinia (reef-building) families are present as well eg Fungiidae, Pectiniidae and Mussidae. A variety of sponges and soft corals also exist along with many invertebrate species including crustaceans, molluscs and echinoderms.

The reef is also considered to be in an undisturbed state, however, a small amount of evidence of natural disturbance (ie broken coral) was observed. Some photographs of the coral reef existing at the GPS position are presented in Appendix E. Visibility is low due to the high current velocity even though the sample site was dived on at the onset of neap tides. The area surrounding the sample site is situated in a very high energy environment with rapid current velocity and low visibility occurring most of the time.

The ongoing monitoring results showed that the coral reef is still considered to be in pristine and healthy condition. A small amount of damage was observed from natural environmental conditions (eg tide and wave action). However, this reef is relatively small and its location at the entrance of the bay results in ambient environmental conditions shaping the structure and diversity of the reef. Visibility was substantially better during the December sampling than in the May sampling period.

Other reef inhabiting organisms observed included sea urchins (Echinoidea), Featherstars (Crinoidea) and anemones (Family Stichodactylidae, possibly *Heteractis sp*) and some molluscs (bivalves) and few crustaceans (barnacles and crabs). Only a small number of reef fish were observed.

Coral Reef Site 2 – Crawford Bay

Coral Reef sampling site 2 is situated off the western-most island on the northern side of Crawford Bay (see Figure D25). The GPS position of the sample site is:

Latitude:	16° 28.977′ S
Longitude:	123° 27.539′ E

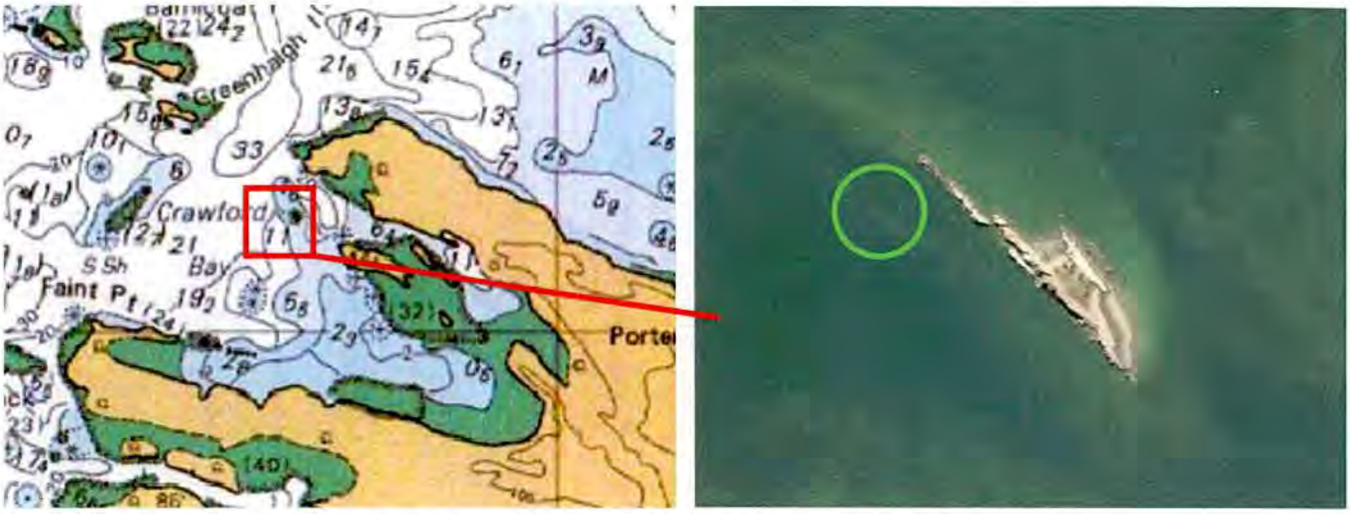


Figure D25: Coral reef sampling site No. 2 – Aerial view (GPS position of sample site is within the area indicated by the green circle)

The general state of the coral reef at sample site 2 is considered to be in good health. Corals present are predominantly hard corals, including those from the families Acropora (staghorn and plate corals) and Poritidae (stony corals), although there appears to be more of a variety of coral types in sample site 2 than observed in sample site 1. Other types of coral seen included other Scleractinia (reef-building) families such as Fungiidae, Faviidae, Pectiniidae and Mussidae. A larger variety of soft corals were observed and sponges were abundant as well.

The reef is also considered to be in an undisturbed state, however, a small amount of evidence of natural disturbance (ie broken coral and fallen rocks) was observed.

Some photographs of the coral reef existing at the GPS position are presented in Appendix E. Once again, visibility is low due to the high current velocity even though the sample site was dived on at the onset of neap tides. The area surrounding the sample site is also situated in a very high energy environment with rapid current velocity and low visibility occurring most of the time similar to the conditions experienced at sample site 1.

Ongoing monitoring demonstrated that no loss of coral or adverse impacts were observed and the reef is still considered to be in a healthy and pristine condition. Due to the shallow nature of this reef, some patches of dead coral were observed, however these are small and few in number. This reef is slightly more protected than site 1 and was observed to possess a higher diversity than the other site within the small area sampled with a larger number and diversity of reef fish and invertebrates.

Invertebrate species observed include Featherstars (Crinoidea), anemones (Stichodactylidae), molluscs including nudibranchs (Nudibranchia), snails (Gastropods) and bivalves. A number of crustaceans were also observed including barnacles, many shrimps and crabs. Soft coral species observed included Gorgonian fan and other Plexauridae spp. Sponges were also observed and thought to be from the Haplosclerida, Dysidea and/or Axinellida families.

Hard Coral species observed included staghorn (Acroporidae), Plate coral (Agariciidae), Brain and flat corals (Fungiidae and Faviidae spp). Ascidians were also thought to be identified, however it is difficult to determine if they were in fact sponges or ascidians. A number of species were not identified due to the difficulty in determining whether they were hard/soft corals or sponges.

7.3. Discussion

Sir Richards Pass is a large and extensive coral reef situated in the north-western part of Cone Bay and is considered to be in a natural pristine and undisturbed state. This reef also supports a large diversity and abundance of marine life including many invertebrate and vertebrate species, both reef dwelling and pelagic. The Crawford Bay coral reef monitoring sites are also considered to be in a natural and undisturbed state, demonstrating similar characteristics as Sir Richards Pass, however neither are anywhere near as large as the coral reef area in Cone Bay.

Continued monitoring of the coral reef will be undertaken as per the Cone Bay EMMP, in order to maintain the ecological value of this important BBPH. However due to the physical difficulties associated with this (ie water clarity and current velocities discussed earlier) the main focus of monitoring will be assessing the "general" health of the community rather than specific GPS transects. Future monitoring methods may include ROV transect video monitoring, however further investigations need to be undertaken prior to these methods being implemented into the EMMP.

8. Marine Biota

8.1. Introduction and Methodology

Marine biota (including mammals, fish, birds and reptiles) observations around the sea cages are recorded on a daily basis during feeding as a part of the Standard Operating Procedures (SOP) and the EMMP. The notes detail the species (common names) and approximate number of any visible mammals, birds, reptiles and/or fish fauna in close proximity to the sea cages (<200m). Comments on behaviour are incorporated if considered different to normal behaviour.

8.2. Results

Recordings of the presence of marine fauna around the sea cages from February 2004 through to March 2007 are presented in Table D5. Days that no fauna were observed are not included in the table.

Table D5: Marine Biota Observations – Cone Bay Sea Cage Aquaculture EMMP.

Date	Sea Cage #	Common Name	Number of Each Species	Approximate distance to cage (m)	Comments
19/02/2004	1				Batch 02-11 transferred into sea cage #1.
12/03/2004	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
16/03/2004	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
22/03/2004	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
23/03/2004	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
12/06/2004	1				Batch 03-11 transferred into sea cage #1.
25/06/2004	1	Black tip reef shark	1	20	Eating stray pellets that float from the cage.
	1	Yellow tail tuna	1	10	Circling outside of cage.
8/08/2004	1	Spanish mackerel	1	10	Circling outside of cage.
	1	Cobia	1	10	Circling outside of cage.
22/08/2004	1	Giant trevalley	2	10	Circling outside of cage.
	1	Cobia	1	10	Circling outside of cage.
23/08/2004	1	Giant trevalley	2	10	Consuming bait fish on the outside of the cage.
23/08/2004	1	Giant trevalley	2	10	Consuming bait fish on the outside of the

					cage.
10/09/2004	1	Spanish mackerel	1	10	Circling outside of cage.
	1	Cobia	1	10	Circling outside of cage.
	1	Black tip reef shark	1	20	Eating stray pellets that float from the cage.
	1	Osprey	1	0	Perched on hand rail when boat approached.
7/11/2004	1	Spanish mackerel	1	10	Circling outside of cage.
	1	Black tip reef shark	2	20	Eating stray pellets that float from the cage.
	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
30/11/2004	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
12/12/2004	1	Swimmer crab	1	0	Climbing onto wire mesh.
12/01/2005	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
14/01/2005	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
20/01/2005	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
11/02/2005	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
20/02/2005	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
22/02/2005	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
23/02/2005	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
8/03/2005	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
10/03/2005	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
11/03/2005	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
12/03/2005	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
13/03/2005	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
22/06/2005	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
	1	Triple tail	1	10	Circling outside of cage.
12/07/2005	1	Crocodile	1	100	
13/07/2005	1	Crocodile	1	100	
17/07/2005	1	Crocodile	1	100	
18/07/2005	1	Spanish mackerel	1	10	Circling outside of cage.
	1	Giant trevalley	1	10	Circling outside of cage.
26/07/2005	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
8/08/2005	1	Giant trevalley	1	10	Circling outside of cage.
	1	Cobia	1	10	Circling outside of cage.
9/08/2005	1	Osprey	2	0	Perched on hand rail when boat approached.
17/08/2005	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
	1	Reef heron	2	0	Perched on hand rail when boat approached.
18/08/2005	1	Triple tail	1	10	Circling outside of cage.
	1	Dolphin	2	200	Swimming by.
20/08/2005	1	Triple tail	1	10	Circling outside of cage.
24/08/2005	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
27/08/2005	1	Triple tail	1	10	Circling outside of cage.
	1	Giant trevalley	2	10	Circling outside of cage.
	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
6/09/2005	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
8/09/2005	1	Sea Eagle	1	0	Perched on hand rail when boat approached.

	1	Black tip reef shark	1	50	Only 1m in length.
9/09/2005	1	Sea Eagle	1	0	Perched on hand rail when boat approached.
	1	Black tip reef shark	1	30	Only 1m in length.
	1	Spanish mackerel	1	10	Circling outside of cage.
10/09/2005	1	Black tip reef shark	1	30	Eating stray pellets that float from the cage.
11/09/2005	1	Reef heron	1	0	Perched on hand rail when boat approached.
12/09/2005	1	Reef heron	1	0	1 grey stork, 1 mackerel.
	1	Spanish mackerel	1	10	Circling outside of cage.
4-May 2006	2	Baitfish	school	0	all around cage
	3	Baitfish	school	0	all around cage
	3	Lemon Shark	1	1	Stayed close to cage
5-May	2	Baitfish	school	0	all around cage
	3	Garfish	100	0	
	3	Lemon Shark	1	1	Stayed close to cage
6-May	2	Baitfish	school	0	all around cage
	3	Garfish	school	0	all around cage
	3	Baitfish	school	0	all around cage
	2	Small Trevally	2	2	Around boat
7-May	1	Tropical Reef Fish	6	1	Angel fish- stayed close to cage
	2	Baitfish	school	1	all around cage
	3	Garfish	school	1	all around cage
	3	Garfish	school	1	all around cage
	2	Lemon Shark	1	3	Around boat
8-May	all	Baitfish	school	1	all around cage
	all	Garfish	school	1	all around cage
9-May	all	Baitfish	school	1	all around cage
	3	Lemon Shark	1	1	Swam around cage
	3	Mackerel	1	1	Swam past twice
	2	Baitfish	school	2	all around cage
	2	Bat Fish	school	1	Stayed close to cage
	1	Baitfish	school	1	all around cage
	1	Lemon Shark	1	1	Along side the boat
10-May	3	Giant Trevally	1	4	Along side the boat
	3	Lemon Shark	1	1	Off the side of boat
	3	Giant Trevally	2	15	Swam around cage
	3	Reef Shark	1	2	Swam around boat
	2	Lemon Shark	1	3	Swam past boat
11-May	3	Giant Trevally	1	2	Swam around cage
	3	Garfish	school	2	all around cage
	3	Baitfish	school	2	all around cage
11-May	2	Garfish	school	1	all around cage
	2	Baitfish	school	1	all around cage
	2	Baitfish	school	1-2	all around cage
	2	Bat Fish	10-15	1-2	all around cage
	2	Tropical Reef Fish	school	2	all around cage
	3	Giant Trevally	2	2	Swam around cage
	3	Baitfish	school	1	all around cage
	3	Garfish	school	1	all around cage
12-May	3	Garfish	school	1	
	3	Small Trevally	school	1	
	3	Bat Fish	10-15	2	
	3	Baitfish	school	2	
12-May	2	Garfish	school	2	

	2	Bat Fish	10-20	2-3	
	2	Small Trevally	school	1-2	
12-May	3	Baitfish	lge school	1	all around and in cage
	3	Giant Trevally	2	1-2	Swam around cage chasing baitfish
	3	Mackerel	6-10	5-15	Swam around cage chasing baitfish
	3	Reef Shark	1	10	Swam around cage chasing baitfish
	3	Giant Trevally	2	2	
	3	Garfish	school	2	all around cage
	3	Small Trevally	school	2	
	3	Baitfish	school	in cage	Barra chasing baitfish
	2	Bat Fish	4	2	
	2	Baitfish	school	2	
	2	Garfish	school	2	
13-May	2	No fish			
	3	Mackerel	4-8	2-15	Swam past cage
	3	Giant Trevally	2	3	Swam around cage
	3	Garfish	school	1	all around cage
	3	Baitfish	school	1	all around cage
13-May	2	Bat Fish	3	2	around cage
	2	Tripletail	1	3	around cage
14-May	2	Baitfish	school	3	all around cage
14-May	3	Bat Fish	5-10	2	around cage
	1	No fish			
14-May	3	Mackerel	2	2	Swam past cage
	3	Reef Shark	1	5	Around boat
	3	Baitfish	school	2	around cage and boat
14-May	2	Bat Fish	6-10	1	Stayed close to cage
	2	Baitfish	school	1-5	Stayed close to cage
	1	Reef Shark	school	1	
	1	Garfish	school	1-5	
15-May	2	Garfish	school	2	Hanging around cage
	2	Baitfish	school	1	Hanging around cage
15-May	3	Baitfish	school	1	all around cage
	3	Mackerel	4-8	2-5	Swam laps around cage
15-May	1	Garfish	school	2	
		Bat Fish	4	3	
		Baitfish	school	2	
16-May	3	Mackerel	2	2-5	
		Small Trevally	school	2	
		Bat Fish	10-15	4	
	2	Garfish	school	2	
		Baitfish	school	2	
		Tropical Reef Fish	school	2	
	1	Garfish	school	3	
		Baitfish	school	2	
17-May	3	Small Trevally	school	2	
		Giant Trevally	2	2	Swam laps around cage
		Mackerel	4-8	5	Swam around cage and boat
17-May	2	Baitfish	school	3	Swam around cage
		Garfish	school	3	Swam around cage
18-May	3	Squid	1	1	Stayed under floats of cage
		Mackerel	4	2	Swam around cage
		Giant Trevally	2	3	Swam around cage
		Garfish	school	2	

		Baitfish	school	2	
		Bat Fish	10-15	3	
	2	Garfish	school	2	
		Baitfish	school	2	
		Tropical Reef Fish	school	4	
19-May	3	Mackerel	4	3	Swam laps around cage
		Giant Trevally	2	2	Swam laps around cage
		Squid	1	1	
		Baitfish	school	1	
		Bat Fish	10-15	4	
19-May	2	Bat Fish	6	4	
	2	Garfish	school	2	
20-May	3	Baitfish	school	2	
	3	Bat Fish	15-20	3	
	3	Garfish	school	2	
	3	Bat Fish	2	4	
	3	Squid	1	1	Hanging around cage
20-May	2	Garfish	school	2	all around cage
	2	Baitfish	school	3	all around cage
	2	Bat Fish	5	1	Stayed close to cage
21-May	2&3	Garfish	school	2	all around cage
		Baitfish	school	3	all around cage
		Bat Fish	10-15	2	Stayed close to cage
	3	Mackerel	4-8	1-6	Swam laps around cage
	1	No fish		2	
22-May	3	Mackerel	2	2	Swam past cage
	2&3	Garfish	school	5	Hanging around cage
	2	Baitfish	lge school	3	Swam past boat
22-May	3	Lemon Shark	2	5	Swam around boat
	3	Reef Shark	1	2	Swam around boat
	3	Mackerel	4	0.5	Swam around cage
23-May	all	Baitfish	school	0.5	Hanging around cage
	all	Giant Trevally	school	0.5	
	all	Bat Fish	5-10	0.5	
	3	Sleepy Shark	3	1	
25-May	3	Giant Trevally	1	1	Swam past boat
	3	Bat Fish	5-10	0.5	
	3	Baitfish	school	0.5	
	3	Lemon Shark	1	1	
26-May	2&3	Bat Fish	10	1	
	3	Baitfish	lge school	1	
	3	Crested Tern	3	100	Flying past/Feeding
	2	Garfish	3	1	
	3	Tuna	1	150	Jumping
	3	Sleepy Shark	2	1	
27-May	3	Crested Tern	1	150	Flying past
	2	Baitfish	school	1	Hanging around cage
	3	Spanish Mackerel	1	2	Feeding on baitfish around cage
		Tawny Nurse Shark	1	2	Swam around cage
		Bat Fish	6	1	
		Reef Heron	1	5	Feeding on baitfish around cage
		Dolphin	2	4	Feeding on baitfish around cage
28-May		Baitfish	school		all around cage
		Spanish Mackerel	1		

		Reef Shark	1		
		Reef Heron	1		
9-June 2006	2&3	Tuna	20	20-30	jumping
	all	Baitfish	school		
	2	Bat Fish	10	1	
	1	Spanish Mackerel	1	1-2	
10-Jun	2	Tuna	20-30		
	3	Spanish Mackerel	1	3	
	1&2	Baitfish	school		
11-Jun	3	Baitfish	school	1-2	in and around cage
	2	Baitfish	lge school	1-5	
		Giant Trevally	1	1-10	Feeding on baitfish around cage
	1	Long Toms	3	5	
	1	Crested Tern	1	100	
	3	Bat Fish	6	1	
	1	Grey Heron	1	15	Sitting on mooring rope
	3	Baitfish	school		
		Spanish Mackerel	1	5	
		Reef Shark	1	5	
12-Jun	3	Giant Trevally	2	1-5	Feeding on baitfish around cage
	3	Baitfish	school	1	
	3	Spanish Mackerel	1	2	
	3	Baitfish	school	1-2	
	2	Bat Fish	3	1-2	
	3	Mackerel	3	4-10	Feeding on baitfish around cage
	3	Giant Trevally	2	7	
	3	Baitfish	school	3	all around cage
	3	Mackerel	4	3-10	
	3	Giant Trevally	1	1	
13-Jun	3	Spanish Mackerel	2	3	
	3	Bat Fish	15-20	2	
	3	Garfish	school	3	
13-Jun	2	Grouper (Rock Cod)	1	1	seen by diver
	2	Baitfish	school	3	
14-Jun	3	Bat Fish	school	1	
	3	Baitfish	school	5	
	2	Baitfish	school	10	
15-Jun	3	Spanish Mackerel	1	5-10	Feeding on baitfish around cage
	3	Baitfish	school	5-10	Being fed on by mackerel
	2	Baitfish	school	5-10	
	3	Bat Fish	10-15		
16-Jun	3	Mackerel	2	2-4	
		Bat Fish	5-7	2-3	
21-Jun	2&4	Grey Stork	2	0	Sulking
22-Jun	3	Tuna	>5	10-15	Feeding
	3	Bat Fish	6	1-2	Hanging around cage
23-Jun	2	Reef Egret	1	1-2	Sitting on mooring rope
	2	Baitfish	school	2	all around cage
	2	Bat Fish	>6	1	Hanging around cage
	3	Brahminy Kite	1	20	Flying over cage
23-Jun	2	Grey Bird	2	0	Sitting on cage
	3	Baitfish	2	1	all around cage
	3	Mackerel	4	2	swam around cage
24-Jun	3	Baitfish	school	3	

	3	Sleepy Shark	1	2	swam around cage & boat
	3	Mackerel	4	4	
25-Jun	4	Small Trevally	1	2	
28-Jun	3	Crocodile	1	10	Hung around being cheeky! 2-3m long
29-Jun	4	Crocodile	1	10	Hung around and watched 2-3m long
30-Jun	2	Bat Fish	6	2	
	2	Baitfish	school	1-5	
	2	Reef Heron	1	5	
1-Jul	all	Baitfish	school	1-5	all around cage
	3	Mackerel	1	5	
	2	Reef Heron	1	5	
2-Jul	3	Bat Fish			
	2	Reef Heron	2	1	in the grey phase
2-Jul	2&3	Bat Fish	school	2	
	3	Small Trevally	school	4	
	3	Mackerel	2	4	
3-Jul	3	Baitfish			
	2	Baitfish			
3-Jul	1	Dolphin	5-8	5	Came to say g'day
4-Jul	3&4	No fish			
	2	Crocodile	1	10	Hung around and watched. 2-3m long
5-Jul	3	Garfish	>10	5	
	2	Baitfish	school	3	all around cage
6-Jul	4	Garfish	>10	5-10	Hanging around cage
	3	Bat Fish	5	5	Stayed close to cage
	3	Spanish Mackerel	1	5-10	Swam past boat
7-Jul	2	Baitfish	school	1	all around cage
8-Jul	3	Bat Fish	4	2	
	4	Squid	3	1	hanging around under floats
	4	Sleepy Shark	1	2	Swimming past cage & boat
	2	Sleepy Shark	1	1	Swimming past cage & boat
	2	Baitfish	school	1	
9-Jul	3	Sleepy Shark	1	2	Swam under boat
10-Jul	2&3	Baitfish	school	5	
	2&3	Bat Fish	>10	1-2	
	2	Cod	1	2-3	swam around cage & boat
12-Jul	2	Cod	1		swam around cage & boat
	3	Baitfish	school	1-2	
13-Jul	2	Grouper (Rock Cod)	1	2	inside cage -seen by diver
	2	Spanish Mackerel	1	2	swam around cage
	2	Baitfish	school	1-3	hanging around cage
14-Jul		Eastern Reef Heron	1	10	Flying over cage
		Sea Eagle	1	10	Flying over cage
		Baitfish	school	1-5	all around cage
		Tuna	school	200	
		Bottlenose Dolphin	3	20	swam past boat
		Frigate Bird	2	30	Fishing
	3	Baitfish	school	1	
	3	Frigate Bird	1	20	
	4	Hammerhead Shark	1	1-5	5m long. Swam under boat
15-Jul	3	Bat Fish	5-10	1-2	Stayed under floats of cage
16-Jul	2	Sea Eagle	1	10-20	Flying over cage
	4	Bat Fish	1		hanging around cage
17-Jul	2	Eastern Reef Heron	1	2	in the grey phase

	2	Cobia	1	3	swam around cage
	2	Baitfish	school	1	all around cage
	2	Small Trevally	school	1	around cage
22-Jul	4	Sleepy Shark	1	1	swam past boat
23-Jul	4	Garfish	school	0-5	hanging around cage
24-Jul	2	Eastern Reef Heron	1	5	in the grey phase
26-Jul	4	Eastern Reef Heron	1	0	sitting on cage
	3	Garfish	school	2	
28-Jul	2	Reef Heron	1	30	flying past
	2	Baitfish	school	1-2	hanging around cage
	3	Bat Fish	10	1-2	
	3	Garfish	school	3	
	4	Garfish	3	1-3	
	4	Small Trevally	1	1-3	
29-Jul	2	Baitfish	school	1-3	
	2	Small Trevally	10+	1-3	
	2	Reef Heron	1	0	sitting on cage
	4	No fish			
	2	Crocodile	1	100	Cruising past
30-Jul	3	Sea Eagle	1	0	Sitting on cage
	2	Baitfish	school	2	all around cage
	2	Small Trevally	>10	2	Swimming past cage & boat
	3	Garfish	school	1	hanging around cage
	4	Reef Shark	5	2	swam around cage
	4	Giant Trevally	3	3	swam around cage
	4	Garfish	school	1	hanging around cage
31-Jul	2	Baitfish	school	1	hanging around cage
	all	Garfish	school	1	hanging around cage
	4	Giant Trevally	1	4	hanging around cage
	3	Sea Eagle	1	0	Sitting on cage
	3	Reef Shark	1	1	Swimming past cage & boat
1-Aug	3	Eastern Reef Heron	1	0	sitting on cage
	3	Garfish	school	1	
1-Aug	2	Small Trevally	>10	1	swimming around cage
	2	Mackerel	1	2	swam around cage
	4	Baitfish	school	2	all around cage
	4	Small Trevally	school	2	swimming around cage
	3	Crocodile	school	10	2m long. Watching
4-Aug	3	Sea Eagle	1	0	sitting on cage
5-Aug	3	Crocodile	1	2-3	watching
	3	Sea Eagle	1	0	sitting on cage
8-Aug	5	Eastern Reef Heron	5	0	sitting on cage
	4	Sleepy Shark	1	1	swam around cage
9-Aug	3	Eastern Reef Heron	1	10	Flying past
	3	Scats	school	1-3	all around cage
	3	Mackerel	1	2	swam around cage & boat
	4	Garfish	school	1-4	Hanging around cage
10-Aug	all	Garfish	school	1-4	Hanging around cage
	all	Scats	school	2	Hanging around cage
11-Aug	all	Baitfish	school	2	Hanging around cage
	4	Mackerel	4	3	
12-Aug	5	Crocodile	1	10	2-2.5m long. Watching
	5	Tiger Shark	2	2	4m & 2.5m long. Swam around boat
	5	Reef Shark	3	2	swam around cage & boat

	all	Garfish	school	1-4	all around cage
	all	Scats	school	1	all around cage
	3&5	Eastern Reef Heron	1	0	sitting on cage
		Mackerel	1		swam around cage
16-Aug	3	Reef Heron	1		Flying past
17-Aug	4	Eastern Reef Heron	1	0	Sitting on cage
	4&5	Crocodile	1	5	hung around
	2	Tern	1	15	Flying over cage
	5	Mackerel	1	2	
	all	Garfish	school	1-4	all around cage
	all	Scats	school	1-4	all around cage
17-Aug	3&5	Baitfish	school	1	
18-Aug	all	Crocodile	1	10	hung around
	all	Eastern Reef Heron	1	0	sitting on cage
	5	Tiger Shark	1	1	2.5m long. Swam around & under cage
	4	Bronze whaler shark	2	2	1-1.5m long swam around cage
	all	Scats	school	1	all around cage
	all	Garfish	school	1	all around cage
	all	Bat Fish	5+	1	hanging around cage
19-Aug	all	Crocodile	1	20	watching
	all	Eastern Reef Heron	3	0	sitting on cage
	3	Reef Shark	2	2	swam around cage & boat
		Frigate Bird	1	20	all three flying over and swooping each other
		Brahminy Kite	1	20	
		Sea Eagle	1	30	
	3&5	Mackerel	1	1	
	5	Spanish Mackerel	1	1	
	all	Bat Fish	school	1	hanging around cage
		Garfish	school	1-5	all around cage
		Scats	school	1	all around cage
20-Aug	all	Crocodile	1	20	watching
	2,3&4	Mackerel	3		
	3&4	Reef Shark	1		
	all	Baitfish	school		
	3	Cobia	1	1	swam around cage
21-Aug	1	Crocodile	1	0	next to cage when boat arrived
	all	Mackerel	2		
	all	Bat Fish	10+		
22-Aug		Crocodile	1	20	watching
	all	Bat Fish	10	1	hanging around cage
	all	Garfish	school	1	all around cage
	5	Reef Heron	1	0	sitting on cage
	3&5	Mackerel	1	2	swimming around cage
23-Aug	3&5	Tuna	school	10-15	jumping & feeding
		Crocodile	1	5	hanging around
		Baitfish	school	1-5	all around cage
		Garfish	school	1-5	all around cage
	4	Crocodile	1	15	watching
	4	Garfish	school	2	
	4	Baitfish	school	2	
	3&5	Eastern Reef Heron	1	10	Flying over cage
	3&5	Baitfish	school		
	2	Bat Fish	2	1	
	5	Garfish	school	1-6	all around cage

24-Aug	4	Garfish	school	5	all around cage
		Crocodile	1	20	watching
		Bat Fish	6	2	
		Baitfish	school	5	
	3&5	Spanish Mackerel	1	5	hunting
	3&5	Baitfish	school	1	being hunted
	3&5	Crocodile	1	100	Cruising past
	3&5	Eastern Reef Heron	1	1	Sitting on mooring rope
	2	Mackerel	1	2	swam past cage
	2	Scats	school	2	all around cage
	3&5	Eastern Reef Heron	1	0	sitting on cage
	4	Garfish	school	2	
	4	Baitfish	school	2	
25-Aug	4	Bat Fish	10	1	
		Baitfish	school	3	
		Crocodile	1	5	watching
	3&5	Bat Fish	school	1	
	3	Spanish Mackerel	1	3	
		Baitfish	school	0-5	many schools swimming around
	2	Brahminy Kite	1	0	sitting on cage
		Eastern Reef Heron	2	10	Flying over cage
		Baitfish	school	1	
	3&5	Spanish Mackerel	1	5	
		Crocodile	1	100	Cruising past
26-Aug	3&5	Crocodile	1	5	hanging around
		Baitfish	school	20	all around cage
		Tuna	10+	20	jumping & feeding
		Eastern Reef Heron	1	0	sitting on cage
	3&5	Frigate Bird	1	30	flying past
		Baitfish	school	1	
		Bat Fish	5+	1	hanging around cage
		Queenfish	1	5	swimming around cage
		Mackerel	>5	5	
	2	Grey Stork	1	0	sitting on cage
	1	Cobia	1	0	swimming around cage
27-Aug	3&5	Frigate Bird	1	50	flying past
		Eastern Reef Heron	1	0	sitting on cage
		Bat Fish	school	1	
	5	Baitfish	school	5	
	2	Tuna	1	5	swimming around
		Small Trevally	10+	1	
	2	Bat Fish	10+	1	
		Scats	15	0	inside cage
28-Aug	4	Baitfish	school	1	all around cage
		Unidentified bird	1	0	sitting on cage
	3&5	Mackerel	10+	5	swimming around cage
		Queenfish	5	5	swam around cage
		Bat Fish	school	1	hanging around cage
		Baitfish	school	5	hanging around cage
	2	Giant Trevally	2	1	swam past boat
		Bat Fish	school	1-3	staying close to cage
		Scats	school	1	all around cage
	3&5	Eastern Reef Heron	1	3	Sitting on mooring rope
	2	Sting ray/Manta ray	1	10	swam past boat

29-Aug	3&5	Baitfish	school	5	all around cage
		Queenfish	1	1	swam past cage
		Bat Fish	school	1	hanging around cage
		Eastern Reef Heron	1	0	sitting on cage
	2	Bat Fish	5+	1	
		Small Trevally	10+	1	
	3&5	Baitfish	school	1-5	
		Bat Fish	5-10	1	
	4	Eastern Reef Heron	1	0	sitting on cage
30-Aug	4	Baitfish	school	1	all around cage
	4	Eastern Reef Heron	1	0	sitting on cage
	2	Sea Eagle	1	0	sitting on cage
	5	Crocodile	1	5	watching
	3&5	Baitfish	school	0	inside cage
31-Aug	3	Turtle	1	3	rose to surface for air and re-submerged
	3	Bat Fish	5	1	hanging around cage
	3	Baitfish	school	1	all around cage
	2	Bat Fish	12	1	
	2	Baitfish	school	1	
	5	Baitfish	school	1	
	5	Mackerel	1	2	chasing baitfish
	4	Baitfish	school	0	inside cage
	4	Garfish	school	1	
	4	Grey Stork	1	0	sitting on cage
1-Sep	4	Baitfish	school	1	
	4	Garfish	school	1	
	4	Reef Heron	1	0	inside cage - released easily by opening up one side of net
	3&5	Baitfish	school	1	all around cage
	5	Mackerel	1	2	hunting
2-Sep	4	Baitfish	school	0	inside cage
	4	Eastern Reef Heron	1	0	on cage
	3&5	Baitfish	school	1	hanging around cage
	5	Bat Fish	10	1	hanging around cage
	3	Mackerel	1	2	swam around cage
	2	Baitfish	school	1	all around cage
	2	Bat Fish	12	1	hanging around cage
	2	Tropical Reef Fish	10	1	staying close to cage
	2	Mackerel	1	2	swimming around cage
3-Sep	2	Crocodile	1	5	Hanging around watching
	3	Bat Fish	school	0	staying close to cage
	5	Bat Fish	school	0	staying close to cage
	4	Baitfish	school	1	all around cage
4-Sep	4	Baitfish	school	1	all around cage
	4	Garfish	school	1	all around cage
	2	Giant Trevally	1	2	swam past boat
	2	Bat Fish	20+	1	staying close to cage
	3&5	Baitfish	school	1	hanging around cage
	3&5	Garfish	school	1	hanging around cage
	5	Mackerel	2	2	Swimming past cage & boat
	3	Grouper (Rock Cod)	1	1	inside cage - seen by diver
5-Sep	4	Sea Eagle	1	0	sitting on cage
	4	Heron	1	0	sitting on cage
	4	Baitfish	school	0	inside cage

	2	Bat Fish	school	1	hanging around cage
	2	Mackerel	2	1	Feeding on baitfish around cage
	3&5	Baitfish	school	1	Jumping all around cage
	3	Tuna	1	5	Feeding on baitfish around cage
6-Sep	4	Crocodile	1	20	watching
7-Sep	all	Crocodile	2	10	stalking and following from cage to cage
	5	Brahminy Kite	1	50	Flying over cage
8-Sep	3&5	Mackerel	3	1	swam past cage
	2	Eastern Reef Heron	1	1	flew over cage
	1	Frigate Bird	1	50	Flying over cage
	1	Crocodile	1	10	watching
		Small Trevally	school		swimming around cage
9-Sep	all	Spanish Mackerel	6	5	swam past boat
	all	Baitfish	school	1-5	all around cage
		Garfish	school	2	all around cage
		Small Trevally	10+	1-5	swimming around cage
	2	Scats	school	3	swimming around cage
	all	Bat Fish	5-10	1	hanging around cage
	2	Eastern Reef Heron	1		
	3&5	Crested Tern	3	50	Flying past cage & boat
	4	Eastern Reef Heron	1	0	sitting on cage
10-Sep	all	Baitfish	school	1	
	2	Cobia	1	1	swam around cage & boat
12-Sep	a	Crested Tern	6	50	
	4	Eastern Reef Heron	1	0	sitting on cage
15-Sep	3&6	Bat Fish	10+	0-1	staying close to cage
	3&6	Baitfish	school	0-1	all around cage
	5	Bat Fish	school	1	all around cage
	1&6	Eastern Reef Heron	1	0	sitting on cage collar
16-Sep	5	Bat Fish	5+	0	staying close to cage
	1&6	Mackerel	2	2	swimming around cage
20-Sep	3&6	Crocodile	2	10	following from cage to cage
	3&6	Crocodile	2	50	following from cage to cage
21-Sep		Baitfish	school	1	all around cage
		Bat Fish	school	1	all around cage
22-Sep	3	Grouper (Rock Cod)	1	1	diver saw when diving in cage
	3	Giant Trevally	1	2	swam past cage
23-Sep	4&6	Reef Shark	1	3	swam past cage & boat
	4&6	Baitfish	school	1	all around cage
24-Sep	4&6	Mackerel	1	3	swimming around cage
	4&6	Crocodile	1	10-50	watching
	3&5	Eastern Reef Heron	1	0	sitting on cage
	3&5	Baitfish	school	2	
25-Sep	4&6	Crocodile	1	10	watching
		Reef Shark	1	10	jumping
		No small fish			
26-Sep	2	Giant Trevally	1	3	Cruising past
		Scats	10	1	staying close to cage
	3&5	Eastern Reef Heron	1	1	Sitting on mooring rope
		Baitfish	20	1	hanging around cage
27-Sep	3&5	Eastern Reef Heron	1	0	sitting on cage
	4&6	Baitfish	school	1-5	all around cage
	3&6	Bat Fish	school	1-5	all around cage
	5	Small Trevally	1	2	swimming around cage

28-Sep	3	Small Trevally	1	1	Swam around cage and boat
	all	Baitfish	school	1-5	all around cage
		Bat Fish	5+		staying close to cage
29-Sep	3&5	Crocodile	1	5	watching
	5	Eastern Reef Heron	1	0	sitting on cage collar
29-Nov	4&5	Sleepy Shark	1	<1	Cruising past
	4&5	Egret	1	0	on cage
	4&5	Trevally	1	1	swimming around
30-Nov	3	Sea Eagle	1	0	perched on cage - flew off when boat arrived
	4&3	Reef Heron	1	0	on cage
	all	Black tip Reef Shark	>5	1-5	in the grey phase
6-Dec	4,5	Reef Heron	1	0	hunting
	all	Sleepy Shark	3	1	swimming
	3	Sea Eagle	1	0	on cage
7-Dec	all	Trevally	school	2	
	2,3	cobia	2	2	
	all	Sleepy Shark	8-9	1-4	all just swimming around cage
	4,5	Blue Swimmer Crab	1	2	
	all	Garfish	school	1	
	4,5	Hammerhead Shark	1	2-3	swam past boat
8-Dec	4,5	Sea Eagle	2	0	
	4,5	Sleepy Shark	1	2-3	
9-Dec	all	Garfish	school	1	
	4,5	Trevally	3	2	
	2,3,4,5	Sleepy Shark	6	3	
	2,4	Eastern Reef Heron	2	10	in the grey phase
10-Dec	5	Sea Eagle	1	0	
	all	Garfish	school	<1	
	4,5	Trevally	school	2	
11-Dec	5	Sea Eagle	2	>20	Flying over cage
	3	Eastern Reef Heron	1	15	
	all	Garfish	school	1	
	all	Trevally	>5	1-2	
	4	Cobia	2	2	
15-Dec		Sleepy Shark	1	1-5	
		Sting ray/Manta ray	1	30	
		Sea Eagle	1	30	flying past
		Bat Fish	5	1-2	
16-Dec	2	Sea Eagle	1	0	juvenile perched on cage
	3	Sleepy Shark	1	1	Cruising past
17-Dec	2,3,5	Sea Eagle	1	0	perched on cage - flew off when boat arrived
	4	Eastern Reef Heron	1	0	in the grey phase
20-Dec	2	Sea Eagle	3	0	perched on cage - 1 juvenile
	2,3	Sleepy Shark	2	1-5	
	4,5	Sleepy Shark	8	1-5	cruising around cage - 2 juveniles
	1	Sleepy Shark	1	2	
	all	Baitfish	school	0-2	
21-Dec	2,3	Sea Eagle	1	50	Flying over cage
	all	Baitfish	school	0-3	
	2,3	Sea Eagle	2	0	on cage
	4,5	Sleepy Shark	3	1-3	
	4,5	Cobia	1	3.5	
	2,3	Sleepy Shark	1	1-3	
22-Dec	1	Sleepy Shark	1	2-5	

	2,3	Sea Eagle	1	20	flying past
	all	Baitfish	school	0-2	
	4	Bat Fish	1	1	
	all	Sleepy Shark	3	1-3	
23-Dec	2,3	Sleepy Shark	3	1-3	1 juvenile
	4,5	Sea Eagle	1	0	on cage
24-Dec	4,5	Sleepy Shark	3	1-2	
	2	Sea Eagle	2	0	on cage
	all	Baitfish	school	0-1	
	4,5	Sleepy Shark	6	1-2	swimming around cage
27-Dec		Sleepy Shark	7	1-2	
		Baitfish	school	3	
28-Dec		Cobia	4	2	
		Sleepy Shark	4	2	
29-Dec		Sea Eagle	1	0	on cage
		Sleepy Shark	3	1	
31-Dec		Baitfish	school	2	
		Cobia	4	2	
		Sleepy Shark	6	3	
2-Jan		Sleepy Shark	2	1	cruising past
		Cobia	3	2	
		Queenfish	2	2	
2-Jan		Sleepy Shark	2	1	
		Cobia	3	2	swimming around cage
		Queenfish	2	2	
5-Jan	4,5	Sleepy Shark	4	1	swimming around cage
	4	Sea Eagle	1	0	on cage
	2,5	cobia	1	1-2	
	all	Baitfish	school	1-2	swimming around cage
	2,3	Sleepy Shark	3	1-2	
	2	Sea Eagle	1	0	on cage
6-Jan	3	Sea Eagle	1	0	on cage
	4,5	Sleepy Shark	2	1-5	cruising around cages
	3	Sea Eagle	1	0	on cage
	7,3	Sleepy Shark	5	1-5	
7-Jan	2,3	Sleepy Shark	12	1-7	
	2,3	Crocodile	1	30	watching
8-Jan	3	Crocodile	1	5-10	cruising past
	2,7	Sleepy Shark	3	1	
	4,5	Sleepy Shark	2		cruising around
9-Jan	2	Sea Eagle	1	0	on cage
10-Jan	2,5	Sleepy Shark	10		
		Bat Fish	>30		hanging around cage
		Trevally	10	5	
		Long Toms	10	1	swimming next to cages
11-Jan	4	Sea Eagle	1	20	flying past
		Sleepy Shark	1		
		Trevally	1	3	
		Bat Fish	3		
12-Jan		Queenfish	2		
		Bat Fish	2	<1	
		Jellyfish	2	1	transparent - outside of cage
16-Jan		Queenfish	school	10	swimming past cages
		Trevally	school	5-10	

		Sleepy Shark	3	5	
		Sea Eagle	1	0	on cage
		cobia	1	4	swimming past cages
		Bat Fish	10	<1	hanging around cage
		Baitfish	school	0-2	hanging around cage
17-Jan	4,5	Sleepy Shark	2	<1	swimming around cage
	2,3	Sleepy Shark	3	<1	
20-Jan	4,5	Sleepy Shark	2	1-10	
	2,3	Sleepy Shark	5	1-10	
26-Jan	2,3	Sea Eagle	1	0	on cage
27-Jan	1,2,3,4	Crocodile	1	10	hanging around watching
	1,4	Bat Fish		1	
	1,2,3,4	Trevally		1	
	1,2,3,4	Sleepy Shark	1	1	
28-Jan	all	Sleepy Shark	1	1	
	all	Baitfish	school	0-2	
	all	Bat Fish		<1	
	4	Mangrove Heron	1	0	sitting on cage
29-Jan	2,3	Sleepy Shark	2	2	swimming around cages
31-Jan	2,3	Sea Eagle	1	0	on cage
	4,5	Sleepy Shark	3	1-5	
1-Feb	2,3	Sea Eagle	1	0	on cage
	2,3	Crocodile	1	10	watching
	2,3	Sleepy Shark	2	2	
	4,5	Crocodile	1	10-15	hanging around
2-Feb	4,5	Sleepy Shark	2	<1	
4-Feb	2,3	Crocodile	1	1	at cage when boat arrived - disapp.
7-Feb	2,3	Sleepy Shark	4	2	
	2,3	Sleepy Shark	1	1-5	
	2,3	Bat Fish	school	1-5	
	2,3	Baitfish	school	0-5	
8-Feb	1	Sea Eagle	1	10	flying overhead
	4,5	Cobia	1	2	swimming around boat
9-Feb	3	Bat Fish	1	<1	hanging around cage
	4,5	Sleepy Shark	1		
	4,5	Baitfish	school		all around cages
	2,3	Reef Sharks	>7		swimming all around cages feeding
11-Feb	2,3	Crocodile	1		watching
	2,3	Sleepy Shark			
12-Feb	4,5	Sea Eagle	10		flying past
		Sleepy Shark			
13-Feb		Bat Fish			
		Sleepy Shark			
14-Feb	2,3	Sleepy Shark	3	0-5	1 white sleepy
	all	Baitfish	school	0-6	all around cages
15-Feb	2,3	Sleepy Shark	1	1	
	all	Baitfish	school	0-5	all around cages
	4,5	Sleepy Shark	1		
	1	Turtle	1	10	swimming past cages
	1	Sleepy Shark	2	0-6	swimming around cages
	1	Tuna	2	1-5	
16-Feb	2,3	Cobia	1	between	
	2,3	Milk Fish (baitfish)	15	between	hanging around cages
	2,3	Tuna	6	between	swimming around cages

	2,3	Queenfish	10	between	
	2,3	Baitfish	school	between	hanging around cages
	2,3	Garfish	school	between	hanging around cages
17-Feb	2,3	Sleepy Shark	2	1-5	
	2,3	Cobia	1	1	
		Milk Fish (baitfish)	10	1	hanging around cages
		Queenfish	5	1-2	
18-Feb	2,3	Sleepy Shark	3	1	hanging around cages
		Cobia	1	between	
		Queenfish	4	between	
	2	Barramundi	5	2	hanging around cages
	1	Barramundi	1	<1	hanging around cages
	4,5	Crocodile	1	40	watching
		Sleepy Shark	2	1	
		Queenfish	4	1	
19-Feb	2,3	Sleepy Shark	3	1	
		Queenfish		1-5	
	1	Barramundi	4		hanging around cages
	4,5	Barramundi	3		hanging around cages
25-Feb	2,3	Sleepy Shark	3		
		Bat Fish	school		hanging around cages
1-Mar	4,5	Sleepy Shark	1	<2	hanging around cages
	5	Crocodile	1	>15	hanging around watching
2-Mar	4,5	Sleepy Shark	3	1	hanging around cages
	2,3	Sleepy Shark	2	1	hanging around cages
3-Mar	4,5	Sleepy Shark	1	1	hanging around cages
10-Mar	2,3	Sleepy Shark	1	1	hanging around cages
11-Mar	4,5	Sleepy Shark	1	1	hanging around cages
13-Mar	4,5	Sleepy Shark	5	1-10	hanging around cages
	4,5	Barramundi	1	2	
	3	Sleepy Shark	1	3	
14-Mar	6	Sleepy Shark	1	2	
		Giant Trevally	1	1	
		Trevally	6	1	
	2,3	Sleepy Shark	2	2	
		Giant Trevally	1	1	swimming past
		Barramundi	1	1	
19-Mar	1	cobia	2	4	
		Giant Trevally	1	1	swimming past boat
		Sleepy Shark	1	1-3	

8.3. Discussion

Observational notes of marine fauna around the cages have been recorded since February 2004. In that time, the presence of marine fauna has been observed to increase somewhat with the number of cages. Almost from the beginning, numbers of baitfish schools (eg garfish, scat etc) have been observed on a regular basis outside and surrounding the sea cages. Very little fauna have been observed in the sea cages and this is assumed to be due to the prevalence of predatory behaviour by the Barramundi inhibiting the baitfish from entering into the cages.

Some marine fauna has been observed in the cages including a rock cod (grouper) and a bird that managed to enter the cage despite the presence of the bird exclusion net. None of the fauna found in the cages have been entangled and the bird was been unharmed and released as soon as it was found. The bird exclusion nets have been updated and remodified as a result of the entries and no entries have been recorded since. The rock cod was thought to have entered through the mesh as a juvenile and grew with the Barramundi.

More recently the results have shown that some species eg Sleepy sharks, crocodiles and batfish are sighted almost on a daily basis. These sorts of species are generally resident species that become accustomed to an area or activity and tend to develop a behavioural "habit" such as swimming around the cages whilst feeding activity is occurring. No entanglements have occurred to date and no aggressive behaviour or unsafe interactions have occurred as a result of the crocodile activity. All staff have been made aware of the dangers and the correct procedures that should be undertaken when crocodile activity is observed. Few mammal or turtle activities have been observed over the years or logging.

Overall, the inception of the sea cages doesn't appear to have had an adverse impact on the surrounding biota and although a greater number of species have been observed with the increasing number of cages, it tends to be a number of different species observed at varying times and the species present appears to be largely correspondent to season. Very few marine mammal or other reptiles (ie turtles) have been observed and a many pelagic fish that have been sighted do not appear to 'hang around' the cages. This data will continue to be logged and reviewed as a part of the EMMP and EMS.

APPENDIX E

CONE BAY ENVIRONMENTAL MONITORING AND MANAGEMENT PROGRAM – PHOTOGRAPHIC RESULTS OF THE MANGROVE AND CORAL REEF COMMUNITIES

Mangrove Sample Site 1: Snapper Cove, Cone Bay

a)

b)

Figure E1: Close-up photographs of existing mangroves in Snapper Cove sampled on 30th May 2006. The three small trees are obvious to locate once near the GPS position.

a)

b)

Figure E2: Distant photographs of existing mangroves in Snapper Cove, Cone Bay sampled on 30th May 2006. The trees depicted in the close-up photographs are shown in the centre of the red circles in both a and b. The larger green circle is indicative of the extent of the whole community, above the top of the green circle is native terrestrial flora (eg eucalypts etc)

a)

b)

Figure E3: Close-up photographs of existing mangroves in Snapper Cove, Cone Bay sampled on the 12th December 2006 at high tide.

a)

b)

Figure E4: Distant photographs of existing mangroves in Snapper Cove, Cone Bay sampled on 12th December 2006 at high tide.

Mangrove Sample Site 2: SW Entrance, Cone Bay

a)

b)

Figure E5: Close-up photographs of existing mangroves in Mangrove Site 2, Cone Bay (SW Entrance) on 30th May 2006. The two trees at the right-hand edge of the community provide an easy reference point.

a)

b)

Figure E6: Distant photographs of existing mangroves at Mangrove Site 2, Cone Bay (SW Entrance) on 30th May 2006. The trees depicted in the close-up photographs are shown in the centre of the red circles in both a and b. The whole community within the small inlet extends out on both sides of the close-up point.

a)

b)

Figure E7: Close-up photographs of existing mangroves in Mangrove Site 2, Cone Bay sampled on 12th December 2006 at high tide.

a)

b)

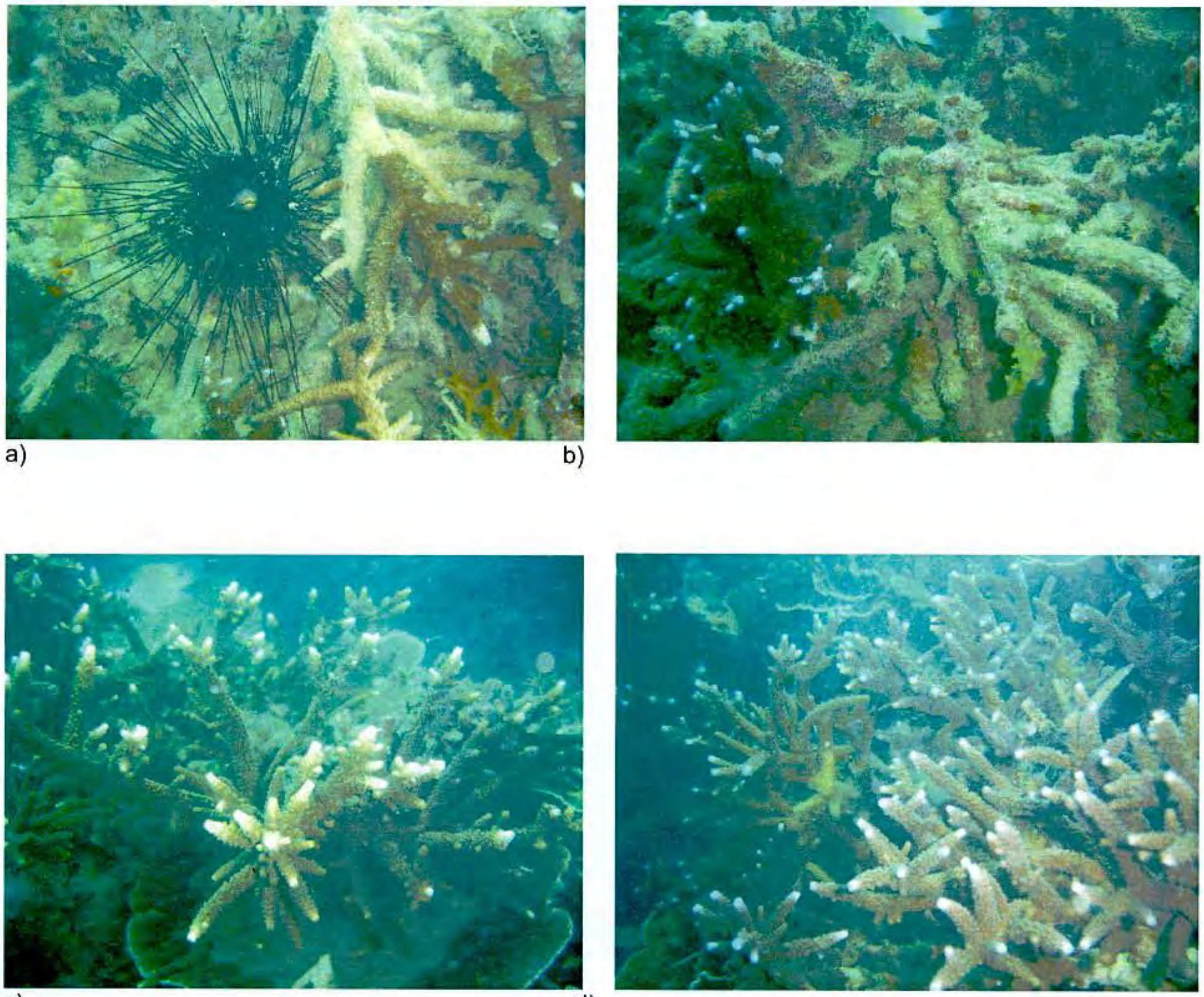
Figure E8: Close-up photographs of existing mangroves in Mangrove Site 2, Cone Bay sampled on 12th December 2006 at low tide.

a)

b)

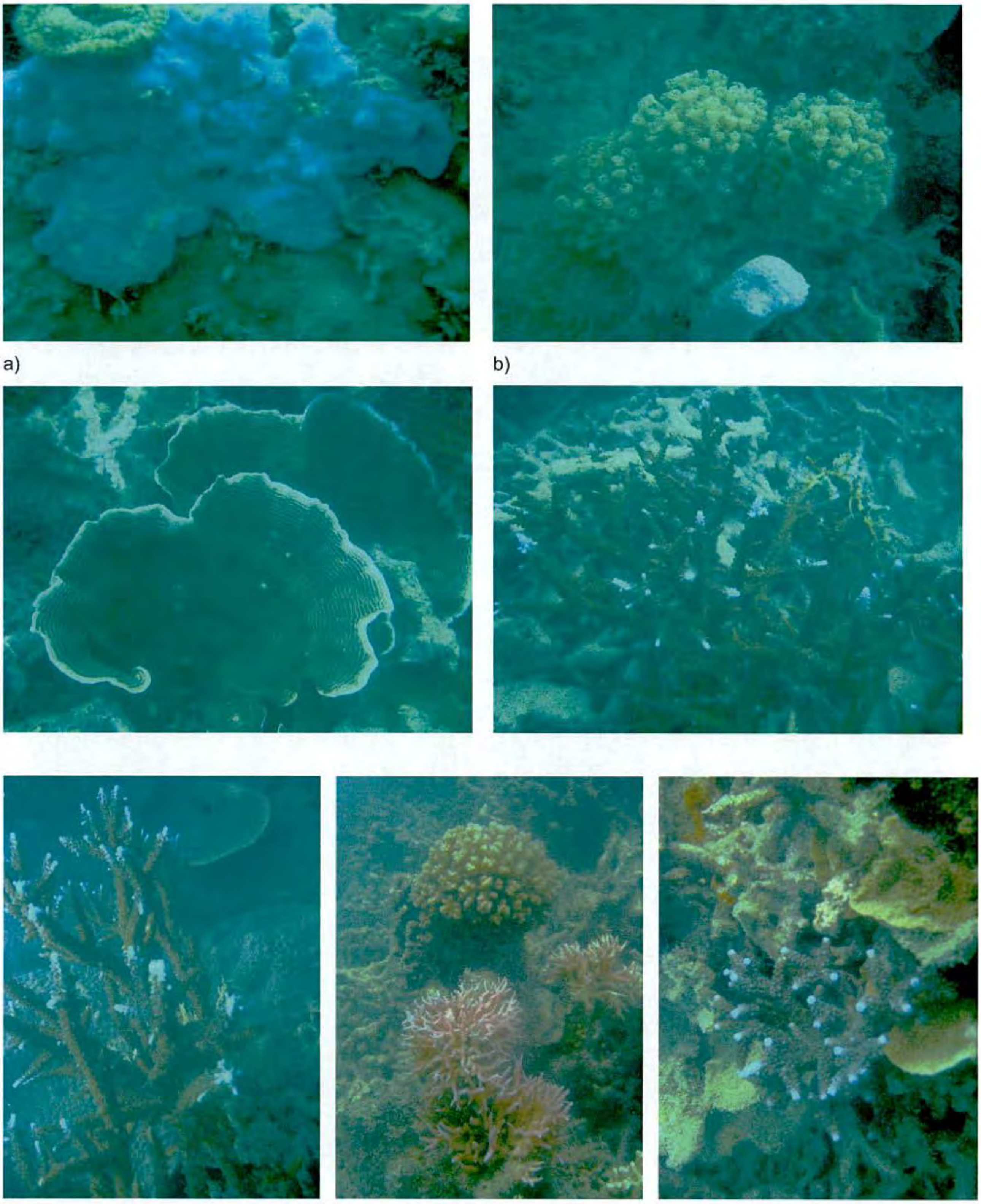
Figure E9: Distant photographs of existing mangroves in Mangrove Site 2, Cone Bay sampled on 12th December 2006 at high and low tides. The trees depicted in the close-up photographs (Figure E7 and E8) are shown in the centre of the red circles.

Coral Reef Sample Site: Sir Richards Pass, Cone Bay



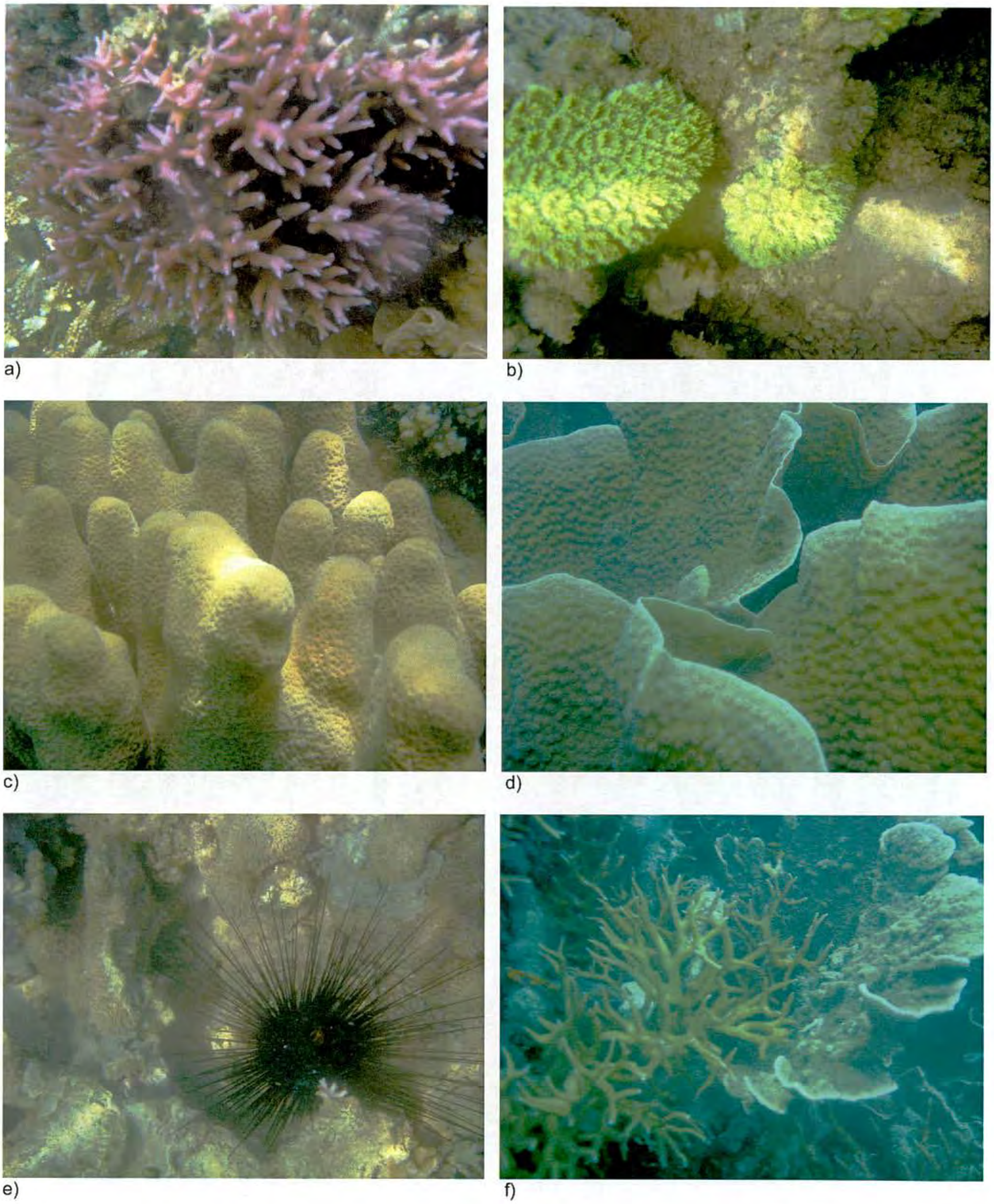
a) b) c) d)

Figure E10: Photographs of existing coral in the Sir Richards Pass sampling site, Cone Bay taken on 30th May 2006.



a) b) c) d) e)

Figure E11: Photographs of coral and coral reef inhabitants at Sir Richards Pass, Cone Bay taken on 12th December 2006.



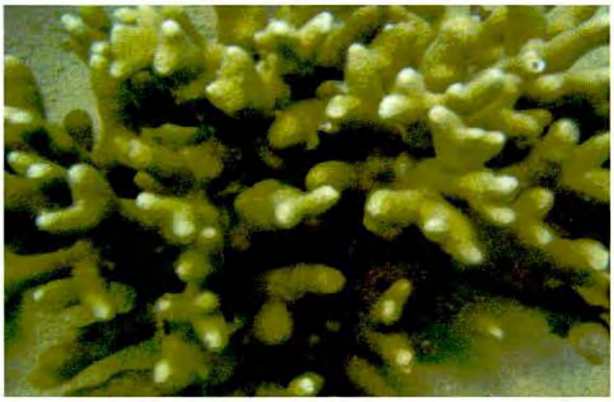
a) b) c) d) e) f)

Figure E12: Photographs of coral and coral reef inhabitants at Sir Richards Pass, Cone Bay taken on 12th December 2006.

Coral Reef Sample Site 1 & 2: Crawford Bay

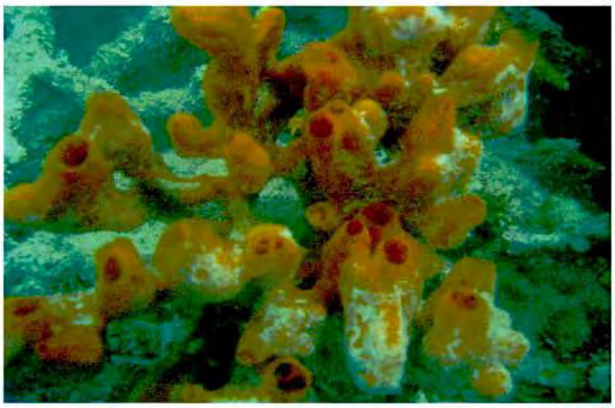
a)

b)

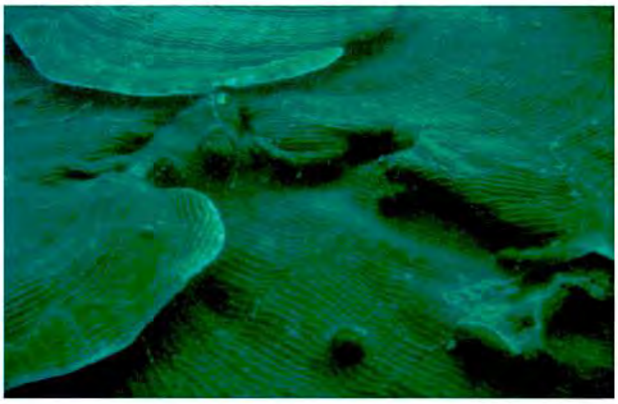


c)

d)



e)



f)

Figure E13: Photographs of coral and coral reef inhabitants at the Crawford Bay coral reef sites taken on 12th December 2006.

APPENDIX F

CONE BAY SEA CAGE AQUACULTURE ENVIRONMENTAL MONITORING AND MANAGEMENT PROGRAM

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For:
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1. Introduction

1.1. Background

Maxima Pearling Company Pty Ltd (MPC) are well known for their pearling operation along the Western Australian coastline as far north as Cone Bay, Yampi Sound. Currently MPC, in conjunction with Maxima Fish Farms (MFF), are also operating a Barramundi aquaculture venture in Cone Bay, Yampi Sound and believe that there is scope for the addition of other and expansion of existing aquaculture business in the area using the existing island-based infrastructure.

In 2005, a variation to increase the total production of aquaculture licence 1465 to 150T per annum was granted by the Department of Fisheries, WA (DoF). A condition stipulated by the WA Environmental Protection Authority (EPA) of that variation was to develop a formal Environmental Monitoring and Management Program (EMMP) to ensure best practice. This EMMP was originally approved and implemented in February 2006.

The scope and content of the EMMP was developed utilising results from previous studies conducted by Brown and Root during the period January to March 2000 in Cone Bay to determine spatial and temporal distributions of nutrients, total suspended solids and phytoplankton levels in seawater. Brown and Root also undertook hydrodynamic modelling of the bay to determine circulatory patterns and flushing rates.

As the EMMP was developed to study the potential environmental impact of sea cage culture, other parameters than those analysed in the Brown and Root study were incorporated into the program. Thus, in addition to water quality, the benthic (sediment) substrate, benthic infaunal assemblages, fringing mangrove and coral reef communities and marine biota will be monitored in an ongoing study. This will aid regulation and management of the system to prevent irreversible loss of ecosystem attributes.

The data collected prior to and since the implementation of the EMMP has enabled the development of the management strategies to ensure minimal environmental impact. Using this data, a solid baseline dataset has been formed from which the ongoing operations monitoring program can be continuously compared to for the sustainable management of the environment and the proposed fish farm.

1.2. Study Site

Maxima Pearling Company Pty Ltd operates a pearl farm and Barramundi aquaculture operation in Cone Bay, which is located 215 km NNE of Broome (123° 34' E, 16° 28' S) in the north-west of Western Australia. The bay is approximately 20 km long and 6.5 km wide near its west-facing opening and is fringed by granite cliffs on both sides. The eastern end of Cone Bay is divided into two "arms", both with shores characterised by rocky cliffs and tidal mangrove creeks (Brown and Root, 2000).

The northern side of Cone Bay is characterised by a deep channel (approximately 30 m depth at low tide), while the remainder of the bay is between 3 m and 15 m deep, depending on tidal conditions. Several reefs and rock outcrops are exposed throughout the bay during low spring tides. The Razor Islands and Turtle Island are also major features of the bay.

Tidal range at Yampi Sound is around 10 metres during spring tide, but less than 3 metres during neaps. Tidal range is somewhat less in Cone Bay at approximately 8 metres during spring tides (Brown and Root, 2000).

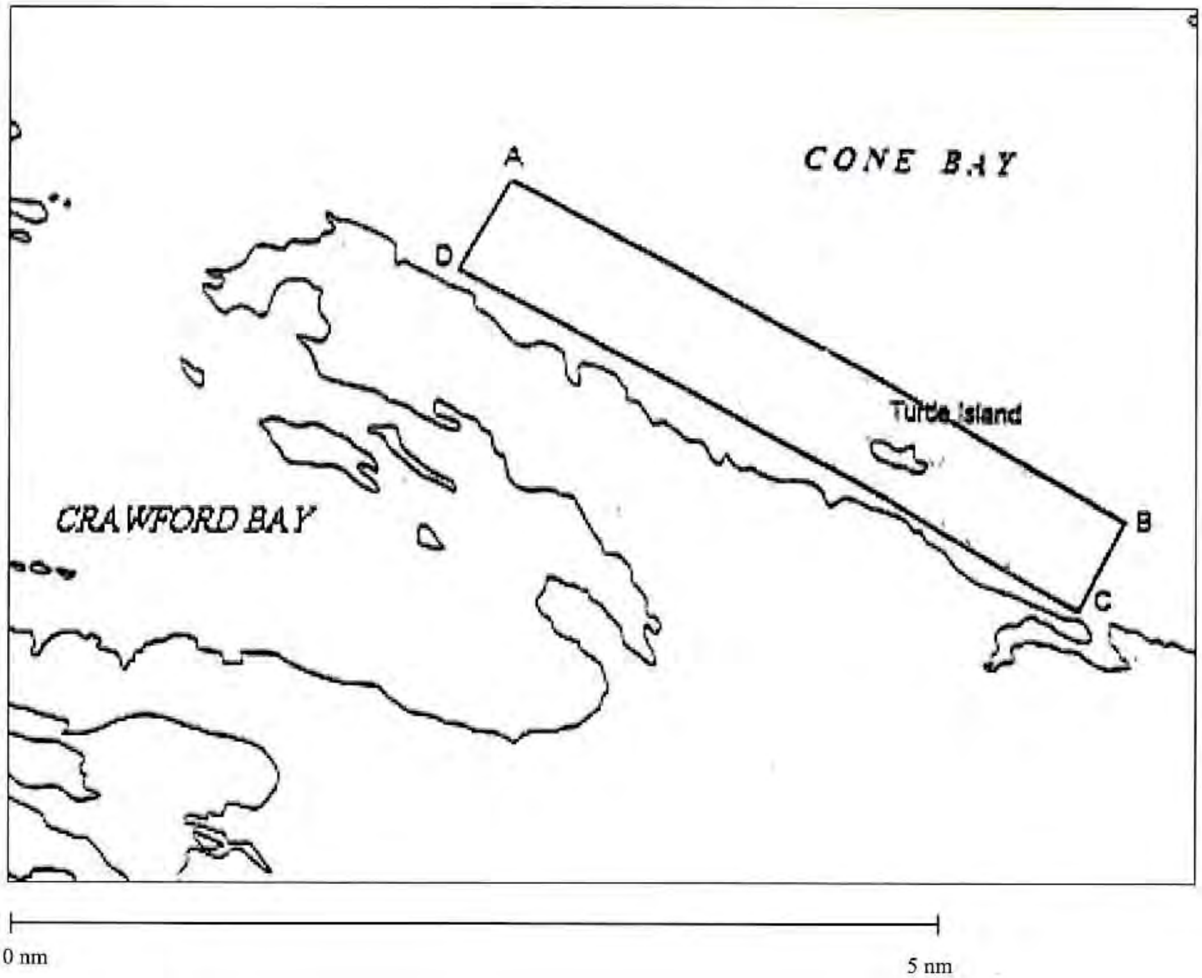
The aquaculture licence site is demonstrated in Figure F1 by boundary coordinates A, B, C and D.

1.3. Selection of Sample Sites

The hydrodynamic modelling information extracted from the Brown and Root Report, 2000 was utilised in selection of sampling sites for the Cone Bay EMMP to ensure that any environmental impact was captured within the zone of influence (directly east or west of the cages).

Reference sites were chosen that were representative of the cage sites in relation to depth, tidal flow and the proximity to potential land run off but at a distance and direction that would not be influenced by the sea cage operation. This will enable assessment of site and seasonal variation. As a result the original reference sites selected for the Cone Bay EMMP were located west and north of the cage sites in addition to a site located in Crawford Bay (Figure F2).

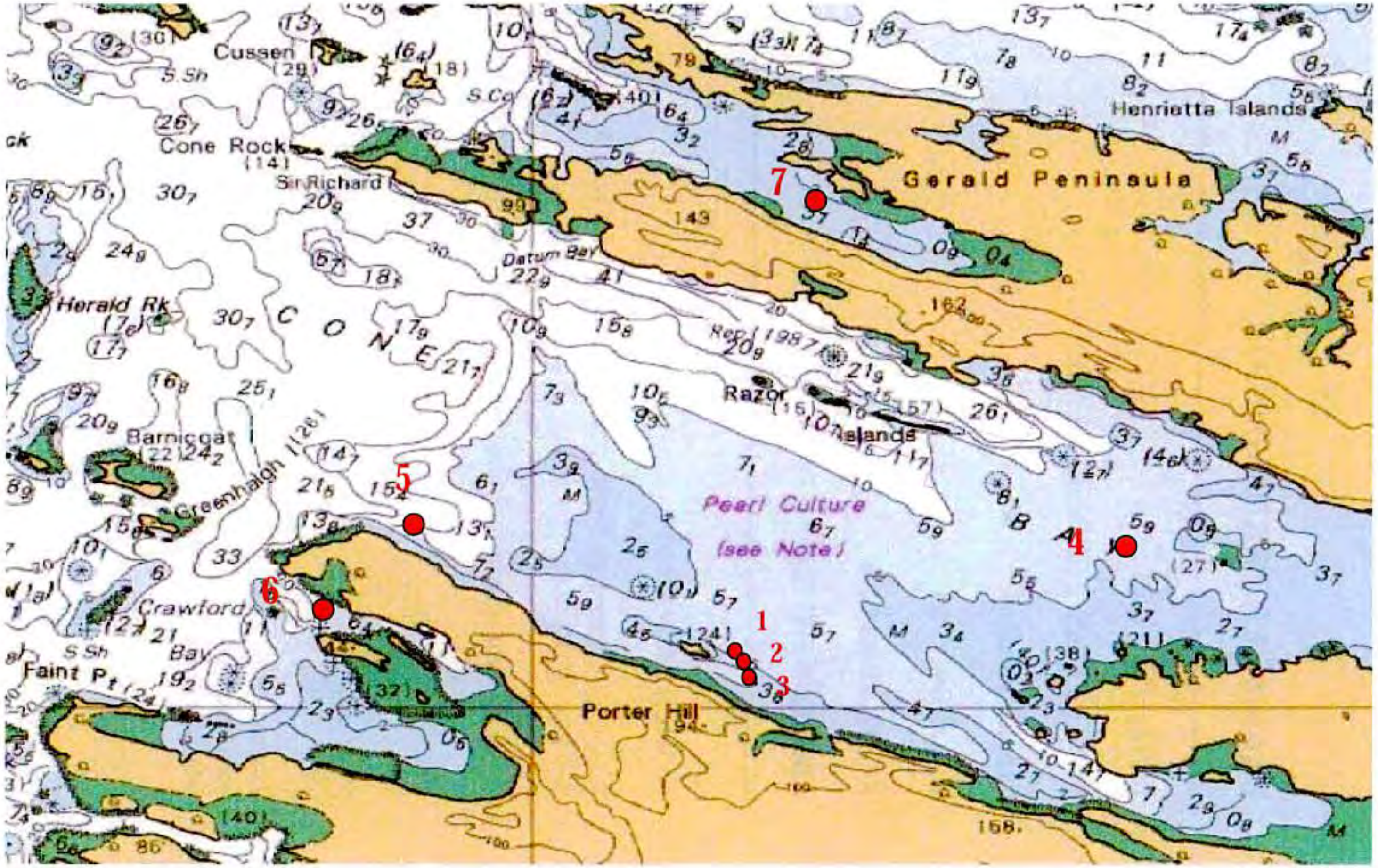
As a result of a proposed aquaculture licence operating in Crawford Bay, a new reference site was selected to replace the original Crawford Bay reference site which will become a sample site upon the inception of the Crawford Bay Aquaculture Licence operations. The new reference site is located in Gerald Bay, the adjacent bay to the north of Cone Bay and is demonstrated in Figure F2.



Boundary Corner Coordinates: Datum GDA94 (approximates WGS84):

Point	Latitude	Longitude
A	16° 28.0238'S	123° 29.2597'E
B	16° 29.7783'S	123° 32.7484'E
C	16° 30.2572'S	123° 32.4888'E
D	16° 28.5037'S	123° 29.0001'E

Figure F1: Cone Bay Aquaculture Licence No. 1465 Site. Area = 699.41 Hectares.



Sites:

1	Cage Site #1
2	Cage Site #2
3	Cage Site #3
4	South East Pearl Lease
5	SW Cone Bay
6	Crawford Bay
7	Gerald Bay (new)

Figure F2: Location of Sample Sites for the Cone Bay EMMP. Site 6 will become a sample site for the Crawford Bay Aquaculture licence at the onset of the proposed aquaculture application. Site 7 is the new reference site to replace Site 6.

2. Water Quality Management

EPA Objective:

To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.

MPC Objectives:

- To maintain water quality so that current and future aquaculture activities are not compromised.
- To obtain a long term pattern of natural water quality variability

2.1. Methodology

Water samples are collected, using a submersible pump that is lowered to a depth of three metres in the water column. The entire system is flushed for approximately one minute before sampling commences. Field sampling is completed within a three hour period. At each station, five litres of unfiltered seawater is decanted into polyethylene storage containers and stored on ice in the dark until return to the laboratory. Samples are then processed immediately on return to the laboratory or as soon as possible after collection.

All samples are stored on ice in the dark in new polyethylene sample bottles, and frozen prior to dispatch to the analytical laboratory. Samples are air-freighted to Perth in insulated containers to ensure that samples remain frozen during transport and they are generally analysed within two weeks from collection.

It was assumed in the Brown and Root study that the water body is well mixed because of considerable tidal movements and considerable level of mixing with oceanic water. These assumptions were confirmed by means of water column profiling of dissolved oxygen, pH, temperature and salinity as a part of the Brown and Root study conducted. As a result water samples are collected at a depth of three metres.

Water samples are collected on a six weekly basis at each of the six/seven stations listed in Table F1. Two five litre samples will be collected from each station approximately ten metres from the other to identify if spatial variation occurs and to reduce the probability of error.

The three cage sampling sites are in close proximity to the cages (less than 2 metres) to minimise mixing and/or dilution effect and to allow the detection of environmental impact if it occurs. Samples will be collected on the western side of the cages.

2.2. Phytoplankton (Chlorophyll-a)

Chlorophyll-*a* levels are determined after filtering 2L of seawater over a glass fibre filter (Whatmann GF/C) using a filter tower with a vacuum pump. The filter paper is wrapped in aluminium foil and frozen until dispatch.

Chlorophyll-*a* is determined in the laboratory, according to standard analytical techniques by acetone extraction, and determined spectrophotometrically by the trichromatic method (Brown and Root, 2001). Analysis of *Chlorophyll-a* is used to assess micro-algal biomass, as it is a photosynthetic pigment that occurs in phytoplankton (Butler, unpublished report). Chlorophyll-*a* in the water column is an early warning measure of phytoplankton response to increased nutrient availability and as a result is a good indicator for environmental quality guidelines (EQGs) (Sim *et al.* 2004).

Table F1 - Cone Bay sampling sites

Station	Location	Longitude	Latitude	Depth (m)
1	Cage Site #1	123°31.827'E	16° 29.638'S	10.3
2	Cage Site #2	123°31.772'E	16° 29.366'S	10.1
3	Cage Site #3	123°31.614'E	16° 29.387'S	10.1
4	SE Pearl Lease	123°33.9136'E	16° 28.6580'S	8.6
5	CB SW Entrance	123°29.025'E	16° 28.327'S	9.8
6	Crawford Bay	123°28.098'E	16° 29.029'S	10.5
7	Gerald Bay	123° 32.481'E	16° 24.801'S	11.5

2.3. Total Suspended Solids

Total Suspended Solids (TSS) are determined after filtering a known volume of seawater (normally 2L) over a pre-weighed glass fibre filter (Whatmann GF/C – 1.2µm) on return to the laboratory, using a filter tower with a vacuum pump. The filter paper is wrapped in aluminium foil and frozen until analysis for TSS. TSS is determined from the increase in dry weight of glass fibre filters, after filtering the water sample. Filters are pre-weighed individually. TSS provides an early warning indicator of organic enrichment and is therefore also used as an EQG (Sim *et al.* 2004).

2.4. Nutrients

Nutrient levels to date have been analysed as a part of the Brown and Root study and also from the original Cone Bay EMMP. The sampling stations will consist of three cage sites (cage site #1, cage site #2 and cage site #3) and three reference sites (S.E. Pearl Lease, S.W. Cone Bay, Crawford Bay/Gerald Bay) and will occur on a six weekly basis during a neap tide. Both Total Phosphorus (TP) and Total Nitrogen (TN) are determined on unfiltered seawater. All samples are stored on ice in new 125mL polyethylene sample bottles, and frozen prior to dispatch to a NATA registered laboratory. Both TN and TP are tested as indicators of the health of water bodies and its ability to support a cyano-bacterial and chlorophyte bloom.

2.5. Physico-chemical parameters

Dissolved Oxygen (DO), pH, temperature and salinity are recorded at each of the stations on a 6 weekly basis. Measurements are by means of a Hydrolab® Multiprobe and an OxyGuard Gamma® Probe, which are lowered to a depth of three metres via the cord. Turbidity (water clarity) is also measured at the same time utilising a Secchi disc to the nearest 0.5 metre interval.

Table F2 demonstrates the water quality parameters that will be measured and other relevant information.

Table F2 - List of water analysis parameters

Analytical parameter	Volume/Treatment	Detection Limit
Water quality parameters		
Total Suspended Solids (TSS)	Gravimetric (2 L)	-
Phytoplankton (*Chlorophyll-a*)	Filtrate (2 L)	<0.1 µg L-1
Total Phosphorus (TP)	125 cm3 (Unfiltered)	<5 µg P L-1
Total Nitrogen (TN)	125 cm3 (Unfiltered)	<50 µg P L-1
Physico-chemical parameters (in situ)		
pH	Hydrolab probe	<0.05
Dissolved Oxygen (DO)	OxyGuard probe	0.01 mg/L
Salinity	Hydrolab probe	0.1 ‰
Temperature	OxyGuard probe	0.01°C
Turbidity	Secchi disc	-

3. Benthic Quality Management

EPA Objective:
To maintain the integrity, ecological functions and environmental values of the seabed and coast.

MPC Objectives:
- To maintain benthic quality so that current and future aquaculture activities are not compromised,
- To ensure no permanent impacts occur to the benthic substrate,
- To obtain a long term pattern of benthic substrate quality and effective benthic monitoring procedure, and
- To determine and monitor benthic infaunal assemblages.

3.1. Methodology

Benthic samples will be collected for analysis using a core sampler at 3 cage sites (cage site #1, #2 and #3) and 3 reference sites (S.E. Pearl Lease, S.W. Cone Bay, Crawford Bay/Gerald Bay), once every 3 months.

A total of five core sub samples will be collected and combined to form one sample. As sampling is conducted by boat, sub-station sampling will be undertaken in a random fashion within the 'area' designated by the GPS point for each site.

All samples will be analysed for Total Nitrogen (TN), Total Phosphorous (TP), Total Kjeldahl Nitrogen (TKN), Loss on Ignition (LOI) and Red-Ox Potential (Redox). Samples will be stored in a dark container on ice and frozen prior to dispatch.

Where benthic samples are collected at the same sites as water samples, they will be collected after the water samples to avoid water contamination.

The following procedure has been extracted from the Environmental Protection Authority Report 21, January 2005 "Manual of Standard Operating Procedures" (SOP) and modified to better suit the dynamics of the region. The procedure is as follows:

- The "SOP" recommends that divers collect sediment samples but as this is not always practical samples will be collected from a boat utilising a Wildco core sampler.
- As recommended in the "SOP" a total of five sediment cores will be taken from within an approximate 1x1 m quadrant to make up one sample. As this is conducted from a boat the sampling will be random.
- Four replicate samples will be taken from cage sites and three replicate samples will be collected from all other sampling stations.
- All replicate samples for each station or sub station will be analysed separately to obtain an understanding of within-site variability.

3.2. Spatial Arrangement of Core Sampling

Benthic samples will be collected for analysis at 3 cage sites (cage site #1, #2 and #3) and 3 reference sites (S.E. Pearl Lease, S.W. Cone Bay, Crawford Bay/Gerald Bay). At each cage site, samples will be collected adjacent to the cage (0 metres), 50 metres west of the cage site and 200 metres west of the cage site to determine any environmental impact within the predicted zone of influence.

Four replicate samples will be collected at the cage site at the North, South, East and West boundary of the cage and three replicate samples will be collected from all other sites 12 metres apart in a triangular configuration to account for intra-site variability (Table F3). Site selection was determined as for the water quality sampling sites.

Table F4 demonstrates the benthic parameters that will be collected and analysed on a three monthly basis.

3.3. Nutrients

Total Nitrogen
TN is the sum of all nitrogen and measures Total Kjeldahl Nitrogen, nitrite and nitrate both organic and inorganic bound.

Total Kjeldahl Nitrogen (TKN)
TKN is the sum of the organic nitrogen and ammonium components. The organic nitrogen is derived from amino acids and proteins such as urea and uric acid. It is important to measure TKN as the ammonium components are toxic to fish and other aquatic life.

Total Phosphorous (TP)
TP is a measure of all the various forms of dissolved and particulate phosphorous. In excess it can cause algal blooms, which in turn reduce the levels of dissolved oxygen available to aquatic life.

Table F3 – Location of stations and substations and sample numbers for each.

Station	Location	Substation	Location	Sample #	Spatial Distance
1	Cage Site #1	1-1	0 metres	4	N, S, E & W
		1-2	50m west	3	12m
		1-3	200m west	3	12m
2	Cage Site #2	2-1	0 metres	4	12m N, S, E & W
		2-2	50m west	3	12m
		2-3	200m west	3	12m
3	Cage Site #3	3-1	0 metres	4	12m N, S, E & W
		3-2	50m west	3	12m
		3-3	200m west	3	12m
4	SE Pearl Lease	-	-	3	12m
5	SW Cone Bay	-	-	3	12m
6	Crawford Bay	-	-	3	12m
7	Gerald Bay	-	-	3	12m

Table F4 – Benthic Quality Parameters

Station	Location	TN	TP	TKN	LOI	Redox	Infauna
		3 monthly					6 monthly
1	Cage site #1	X	X	X	X	X	X
2	Cage Site #2	X	X	X	X	X	
3	Cage Site #3	X	X	X	X	X	
4	SE Pearl Lease	X	X	X	X	X	X
5	SW Cone Bay	X	X	X	X	X	
6	Crawford Bay	X	X	X	X	X	X
7	Gerald Bay	X	X	X	X	X	X

Particulate Organic Matter (Loss on Ignition - LOI)
Particulate Organic Matter content in a sediment sample is determined by measuring weight loss in samples after burning at selected temperatures, which has to date been conducted at 550°C. Elevated levels of organic matter in sediments are an indicator of the potential for sediment anaerobia to develop (Sim *et al.* 2004).

Redox Potential
The redox potential is driven by the dissolved oxygen concentration and the presence of organic matter. The decomposition of organic matter utilises dissolved oxygen and lowers redox potential (Schlesinger, unpublished). The laboratory analyses redox potential on a 1:5 ratio as received sample to deionised water extract. At the time of sampling, care will be taken to ensure that samples have limited contact with air to reduce bias or error of the results.

3.4. Benthic Infauna

To determine the diversity and abundance of the benthic macro-invertebrate composition to Family level an additional 500mL sample will be collected and placed into a separate container to the standard benthic samples.

Samples will be collected using a benthic grab, preserved in 10% formalin seawater solution, refrigerated and dispatched to a NATA registered laboratory where they are then sieved, stained, sorted and identified to family level once received.

Samples will be collected at 6 monthly intervals to investigate the differences in assemblages due to seasonal variations but direct comparisons between samples collected from different seasons will be avoided. Instead the characteristics of benthic assemblages will be investigated annually during the same season (same month each year) to better evaluate the impact of sea cage culture.

Four sampling sites will be investigated (Sea Cage #1, S.E. Pearl Lease, Crawford Bay and Gerald Bay) and 3 samples will be collected from each site. The coefficient variation will be calculated and if it is greater than 100% the number of samples collected from each site will be increased to 5.

Samples have already been collected from 4 sites and results are presented in the Cone Bay EMMP - results and analysis document.

3.5. Waste Feed Management

Effective management of potential waste feed impacts to marine biota will be conducted by undertaking the following procedures:

- Feeding will be managed through the use of feed tables and tide tables,
- Video monitoring during feeding to enable the 'fine-tuning' or adjustment of feed rates to minimise waste feed,
- Feeding will be conducted where possible around the tidal conditions in order to minimise the amount of pellets 'swept' out of the cages by tidal movement,
- All feed information will be recorded to enable regular review of feed rates and FCRs and to allow the calculation of feed rates for future implementation of an automated feeding system, and
- The utilisation of high quality manufactured feed pellets that allow the FCRs to be kept at a minimum.

3.6. Fallowing Program

In order to ensure the benthic substrate does not suffer permanent or irreparable damage a fallowing program has been developed and is given below:

- Cage positions will be left empty after each production cycle and allowed enough time for the sediments to recover to normal state or as near as possible.
- A fallowing period of 3-6 months will be scheduled before stock is reintroduced into the sea cage.
- Ongoing monitoring of the fallowed areas will be maintained to determine extent of rehabilitation.
- Regular reviews of monitoring results for fallowed areas will be undertaken to determine if fallowing time requires extension or reduction.
- Cages will also be fallowed if other monitoring parameters exceed their trigger values at which point no reintroduction of stock will be undertaken until such time that the levels fall within the EQC again and remained at those levels for a minimum period of 3 months.
- Continued monitoring, analysis and review of the fallowing program will occur in order to assess the extent and regularity of the program or whether the fallowing program is required at all.

4. Mangrove System Management

<u>EPA Objective:</u>

To maintain the abundance, diversity, geographic distribution and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

<u>MPC Objectives:</u>

- To ensure there is no loss of function to the surrounding mangrove communities,
- To ensure there is no loss of size of the surrounding mangrove communities, and
- To ensure there is no unnatural deterioration in health of the surrounding mangrove communities.

Two mangrove communities in Cone Bay have been selected as a part of the original EMMP. These sites were selected due to their proximity to the proposed lease area and because they are considered the most likely to be impacted by the Barramundi Farm.

When site selection was being conducted it was noted that the mangrove areas would be very difficult to reach during low tides due to the large mud flats that were exposed in each embayment. This associated with the risk of crocodile interactions and staff safety issues led to the decision to conduct all records of the mangrove communities at mid to high tides. As a consequence, in order to move the boat close enough for the close-up photographic records the mangroves were partially submerged.

At each site, two positions were chosen to photographically record the communities. One position was close to mangroves, focusing on a few trees and the other position was from a distance, focusing on the community as a whole. Both positions have provided a 'pre-proposal' status of each community and will enable comparisons of health and status over time as a part of the ongoing EMMP.

At both positions in each sampling site, the GPS points have been recorded and a series of photographs are taken to provide visual comparison at a later date. General visual observations of the health of the communities are also recorded. This included comments on the number of dead trees, faunal observations and where possible, species identification.

The sites will be monitored twice yearly, once at the end of the wet season (April/May) and once at the end of the dry (October/November). At the time of monitoring general comments about the health of the mangrove community will be recorded, where possible the species identified and photographs taken for future reference and to estimate growth or recession of the mangrove system.

5. Coral Reef System Management

EPA Objective:

To maintain the abundance, diversity, geographic distribution and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

MPC Objectives:

- To ensure there is no loss of function to the surrounding coral reef communities,
- To ensure there is no loss of size of the surrounding coral reef communities, and
- To ensure there is no unnatural deterioration in health of the surrounding coral reef communities.

One coral reef community in Cone Bay has been selected as a part of the EMMP. The site was selected as it is the only known and/or observed coral reef area in Cone Bay.

The site will be monitored on a six monthly basis to detect any unacceptable impacts arising from the outputs of the sea cages. Comparisons over time will enable detection of any changes and if required further monitoring will allow the source of the changes to be determined.

Site selection was conducted during a neap tide in an attempt to minimise the danger to the diver when collecting the baseline data. The risks associated with diving in the King Sound (including Cone Bay and surrounding areas) are many and are not eliminated during a neap tide, only reduced.

These risks include strong current flow and high turbidity with low visibility making it very difficult for the diver to see or stay stationary in order to photograph an area. The presence of crocodiles and sharks in the area also increase with increasing turbidity and current flow as these predators are more likely to attack in these conditions using the cover provided to surprise their prey.

All future coral reef assessments will be undertaken during a neap tide and as accurately as possible the same area will be photographed. It was obvious from statements from the diver and the photos provided for the EMMP that the turbidity and high current flow of the areas make it very difficult to photograph the same 'quadrant'.

As a result, future comparisons will need to be made on 'general health' observations obtained from both the photographs and the diver's comments. The same diver will be conducting the sampling to ensure as much continuity as possible.

At each sampling site, a GPS point was still taken to enable the return to as close as possible that same position. Landmarks were taken as they provide a far easier method of finding the general position, after which the GPS point enables further accuracy. General observations of the reef area were recorded along with any biota observed.

6. Marine Biota Management

EPA Objective:

To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

MPC Objectives:

- To minimise waste feed,
- To avoid entanglements of marine fauna,
- To minimise the attraction of marine fauna, including predators,

Observational notes are collected on a daily basis at the time of feeding at each cage. The notes will detail the species and approximate number of any visible mammals, birds, reptiles and/or fish fauna in close proximity to the sea cages (<200m). Comments on behaviour will be incorporated if considered different to normal behaviour.

All staff will be adequately trained in boat handling skills and educated in safe working practices on the water. All staff will be required to abide by the Code of Conduct addressed in the Standard Operating Procedures Manual (SOP)

7. Management Plan

7.1. Data Collation

The monitoring data needs to be collated and analysed in a manner in which it can be utilised as an interpretive management tool at an operational level. It also needs to be presented to licencing bodies such as the Department of Environment and Conservation (DEC) for assessment on an annual basis.

In addition to the environmental data collected, daily records are maintained as a part of the Maxima Fish Farms Standard Operating Procedures (SOP), to enable the standing biomass and feed rate to be estimated for each sampling period. This information will assist management in its assessment of the operation in relation to environmental impact as a ratio to the size of the operation or production levels and will assist in future projections of carrying capacity within the region.

7.2. Water and Benthic Quality

The management plan for water and benthic quality will incorporate the same environmental quality criteria (EQC) and trigger values. The EQC and trigger values have been developed using a percentile based calculation that is explained in detail in the following sections.

7.2.1. Environmental Quality Criteria and Trigger Values

Environmental quality guidelines (EQG), environmental quality standards (EQS) and environmental quality criteria (EQC) need to be established to enable management to make informed decisions regarding the sea cage culture operation.

Use of specific numerical guidelines from Guideline No. 4 is not appropriate due to the dynamics of the region. As a result, previous data from the EMMP and suitable reference sites will be utilised to ensure any measurable impact is site specific and that natural or seasonal variation is taken into consideration.

This is achieved by determining whether the monitoring data from cage sites fall within an acceptable range of values determined from appropriate reference sites (Sims *et al.* 2004). This type of analysis is known as a percentile based approach.

The percentiles calculated from reference site data are the EQC and the monitoring data obtained from the cage sites are compared against the percentile based EQC (Sims *et al.* 2004). In relation to the Cone Bay sea cage operation, the median of each sample site must lie between the 20th and 80th percentile of natural distribution for a biological parameter at the reference site (Report No. SWQ 6).

The median and percentile are described in the report as follows:

- A median is the middle value of a sequence of numbers. Half the values are numerically smaller and half are numerically larger (also known as the 50th percentile); and
- A percentile is the division of a frequency distribution of data into one hundredths. The p^{th} percentile of a distribution of data is the value that is greater than or equal to the p% of all values of the distribution. For example, the 80th percentile is greater than or equal to 80% of all values or 80% of all values are less than or equal to the 80th percentile.

If the values from the sample sites on any given sampling date exceed the EQC (ie fall below the 20th percentile <u>or</u> are higher than the 80th percentile), then a response by management will be triggered

Figure I3 demonstrates the fundamental basis of the above explanation in a less complicated manner. Simply put, the trigger values are A &/or B. Thus the sample site values must remain between A & B for any given sampling date. If a value exceeds either A or B (ie falls below A or is higher than B), then the trigger values have been exceeded and a management response will be put into action.

The 20th and 80th percentiles are calculated using a formula that utilises a weighted ranking of the reference values to more accurately determine the correct percentiles. This formula has been taken from the online statistics website: http://onlinestatbook.com/index.html
For a more detailed explanation of the statistical process refer to the above website address.

A number of EQCs have been developed for the Cone Bay EMMP as a result of previous results, however due to the seasonal variability of the region (as the results have shown) the percentile based calculation will be determined from the reference sites and compared to the median of the cage sites on each sampling date. Thus the EQC are also variable with seasons. If these criteria are exceeded a response by management will be triggered.

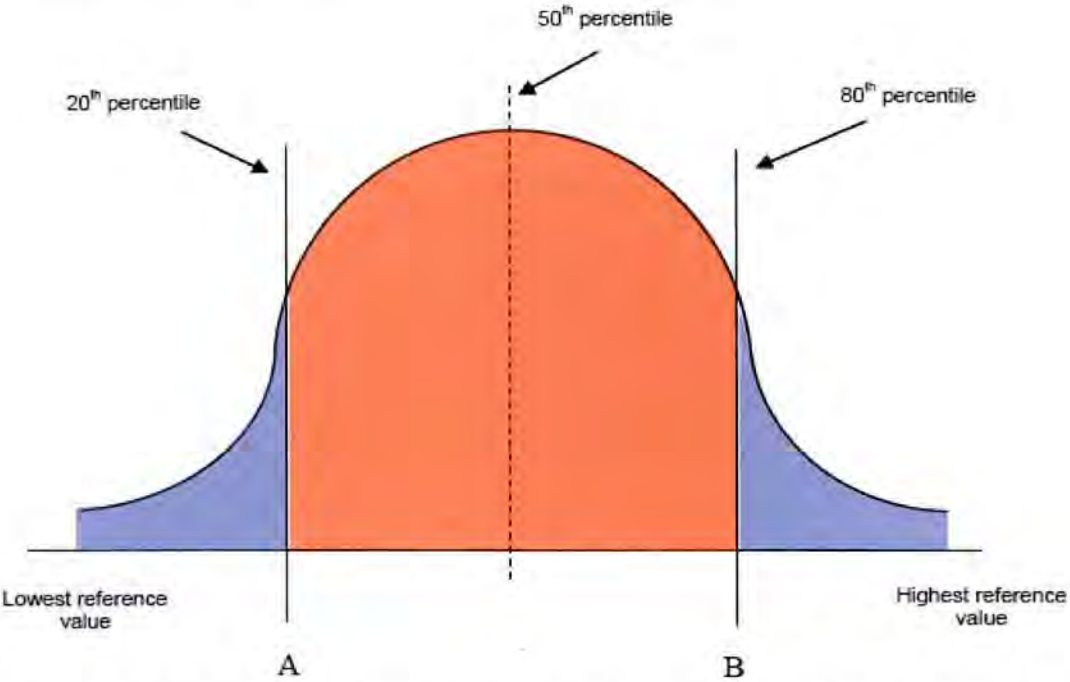


Figure F3: Diagrammatic representation of the percentile based calculation and trigger values. The normal distribution of reference site values enables the 20th and 80th percentiles to be determined. The median value of the sample sites can then be compared to these to determine if the environmental quality objective is being met.

7.2.2. Management Responses

A management response is an action that is automatically implemented if a trigger value is exceeded. Management responses are incorporated into the EMMP and are continually reviewed as a part of the EMS to ensure best practice is being maintained.

If a trigger value for any water or benthic quality parameter is exceeded, the immediate response will be to undertake a repeated assessment to confirm that the criteria have in fact been exceeded.

If the second analysis shows a result that falls between the 20th and 80th percentile (ie A & B in Figure I3) then sampling will return to the original schedule and methodology.

If the second analysis confirms that an EQC has been exceeded then MPC would immediately implement any or all of the following management actions as deemed appropriate:

- Notification of all relevant licencing bodies including:
  - Department of Environment and Conservation
  - Department of Fisheries, WA;
- An increase in monitoring periodicity;
- A reduction in feed rate;
- A reduction of stocking biomass within the sea cage system;
- Relocation of sea cages;
- Continued monitoring of impacted areas to ascertain the recovery rate; and
- A reduction in the number of sea cages operating at the site.

MPC would continue to monitor all parameters to establish the carrying capacity of the site and to monitor the recovery rate.

7.3. Mangrove and Coral Reef Systems

Effective management of all BPPHs surrounding the proposal will be accomplished by the following management strategies:

- Steel mesh nets and mooring system ensuring strong resilient infrastructure,
- All anchors and mooring components will be set a minimum of 100 metres from any BPPH,
- Sea cage mooring systems will be positioned within the proposed site in accordance with the findings of the hydrodynamic study to avoid particulate settlement and deposition outside the licence boundaries,
- Development of a fallowing plan.
- Ongoing monitoring of benthic sediment quality beneath the sea cages.

7.3.1. Trigger Values

As the mangrove and coral reef areas are monitored using photographic archives and visual observations of health, function and size, the trigger values that have been determined are based on the reduction in any of the above values and specifically include:

- A large increase in mortality of individuals within the community,
- An obvious reduction in community size and/or function,
- Large increases in epiphytic growth on root systems of the mangroves (when observed at low tide) or algal growth on corals,
- Any significant changes such as coral bleaching, algal blooms or distinct loss of health to the community

7.3.2. Management Response

If any of the above trigger values are exceeded the management response would be to undertake the same actions described for Water and Benthic Quality with monitoring periodicity increased to 3 monthly.

7.4. Marine Biota

Effective management of potential waste feed impacts to and attraction of marine biota and marine fauna entanglements will be ensured by undertaking the following procedures:

- Feeding will be managed through the use of feed tables and tide tables and video monitoring to minimise waste feed,
- Feeding will be conducted, where possible, around tidal conditions in order to minimise the amount of pellets 'swept' out of the cages by tidal movement,
- The utilisation of high quality manufactured feed pellets that allow the FCRs to be kept at a minimum.
- Proven predator-proof steel mesh nets utilised,
- Equipment requirements kept to a minimum,
- No loose ropes on mooring lines or sea cages,
- Bird exclusion nets constructed of heavy gauge polyethylene or nylon and a small mesh size will be installed on each cage,
- Bird exclusion nets to be pulled taut over the tops of the cages,
- Regular routine inspection of nets and mooring equipment and a strict maintenance and replacement program will be undertaken in accordance with the SOP,
- Any damaged equipment will be immediately repaired or replaced in accordance with the maintenance program, and
- All staff adequately trained and educated in correct boating procedures and code of conduct.

7.4.1. Trigger values

The trigger values determined for the management of biota include:

- Increase in amount of feed passing through the sea cage (either through being swept away or sinking through the bottom of the cage),
- An obvious increase in the amount of feed utilised,
- Significant increase in numbers of fauna present at the cages,
- Occurrence of any entanglements, and
- Occurrence of any unexplained mortalities.

7.4.2. Management Response

If any of the above trigger values are exceeded the management actions undertaken would include:

- Reduction in feed amount,
- Reassessment of feeding strategies,
- Closer observations of feeding behaviour using video monitoring and visual observations,
- Removal and release of the entangled animal,
- If the animal cannot be released immediately (ie stunned from impact etc), appropriate care and monitoring will be given until the animal can be released,
- If handling is required, all handling will be conducted using appropriate and humane methods to ensure the safety and wellbeing of the animal and to minimise any further stress.
- All mortalities will be removed and discarded of appropriately (burning or burying),
- All mortalities will be investigated as to the cause of death and recorded as a part of the biota logging program and be made available to all relevant licencing bodies upon request, and
- Reassessment of the skills, knowledge, training and experience of staff will be undertaken and if required, further training and education will be initiated.

8. Reviews, Auditing and Liaison Procedures

8.1. Liaison with Regulatory Bodies

Regular communication with the relevant regulatory bodies will be required as the licence conditions stipulate. The two main regulatory bodies are:

- Department of Fisheries WA (DoF)
- Department of Environment and Conservation (DEC) – formerly DoE

Both these organisations are to be notified of any change in operations or any deviation from the conditions set out in the approved licence. Other organisations that may require notification of relevant events include:

- WA Fish Health Laboratories, Department of Agriculture.
- Department for Planning and Infrastructure (DPI)

All staff are to be made aware of the licence conditions imposed by both DoF and DEC to ensure they are being met at all times. Staff who consider that any of the licence conditions are not being met are to notify their direct Supervisor and/or the Research and Development (R&D) Supervisor or General Manager.

The Manager and/or R&D Supervisor are responsible for ensuring all appropriate documents are comprehensively completed and submitted when required to all relevant regulatory bodies. The Manager and/or R&D Supervisor are also responsible for the ongoing regular communication and liaison with these organisations to ensure licence conditions continue to be applicable to the operations.

A summary of the liaison process is given in Table F5.

8.2. Reviews

Regular reviews of the EMMP will be undertaken in order to ensure environmental best practice. Timing and management of the reviews are the responsibility of the R&D Supervisor and the Manager. A summary of the requirements of a review of the EMMP is given in Table F5.

8.3. Auditing

Initially, annual auditing will be undertaken by MPC. The Manager and R&D Supervisor are responsible for ensuring that an unbiased, detailed and correct audit is completed. All audits will be made available to relevant regulatory bodies upon request.

As operations progress there is the potential for external auditors to be utilised if the ISO14001 standards certification is adopted.

A summary of the auditing process is given in Table F5.

Table I5: Summary of the Cone Bay Environmental Monitoring and Management Procedures and Protocols

Management Criteria		Timing/ Schedule	Staff Responsible	Requirements (ie procedures, analysis)	Report To	Trigger Values	Management Actions	Reviews/Auditing
Water Quality		6 weekly	▪ R&D Supervisor ▪ Appointed staff member	▪ 2 samples per site ▪ Filtering for chl-a and TSS required ▪ Analysed by NATA approved laboratory ▪ Results statistically analysed by MPC/MFF	If trigger values not exceeded: ▪ DEC annually in the form of a report. ▪ Manager – MPC/MFF If trigger values exceeded: ▪ DEC immediately ▪ WA Fisheries immediately	▪ Within the 20th and 80th percentile of the distribution of reference site values.	▪ Notification of all relevant licencing bodies including: ▪ An increase in monitoring periodicity; ▪ A reduction in feed rate; ▪ A reduction of stocking biomass within the sea cage system; ▪ Relocation of sea cages; ▪ Continued monitoring of impacted areas to ascertain the recovery rate; and ▪ A reduction in the number of sea cages operating at the site.	Review of procedures annually. Audit of results annually (both internal and by the DEC). Review of procedures can be requested at any time if new technology or equipment is made available
Benthic Quality	Sediment	3 monthly	▪ R&D Supervisor ▪ Appointed staff member	As for Water Quality (except for dot point 1&2) plus ▪ 5 cores required per sample. ▪ 3 replicates required per site	As for Water Quality Management	As for Water Quality Management	As for Water Quality Management Increased periodicity to 6 weekly	As for Water Quality Management
	Benthic Infauna	6 monthly	▪ R&D Supervisor ▪ Appointed staff member	As for Benthic Quality plus: ▪ 3 "grab" samples required per site ▪ Samples to be preserved in 10% Formalin solution	As for Water Quality Management	As for Water Quality Management.	As for Water Quality Management Increased periodicity to 3 monthly	As for Water Quality Management
Mangrove Communities		6 monthly	▪ R&D Supervisor ▪ Appointed staff member	▪ GPS coordinates recorded. ▪ Photographic evidence and archiving required ▪ General observations ▪ Results analysed by MPC/MFF	As for Water Quality Management	▪ A large increases in mortality ▪ A distinct reduction in community size or health, ▪ Increased epiphytic growth on root systems	As for Water Quality Management Increased periodicity to 3 monthly	As for Water Quality Management
Coral Reef Communities		6 monthly	▪ R&D Supervisor ▪ Appointed staff member	As for Mangrove Community Management	As for Water Quality Management	As for Mangrove Community Management	As for Mangrove Quality Management	As for Water Quality Management
Marine Biota		Daily	Feeding staff	▪ General observations of species and behaviour recorded ▪ Results analysed by MPC/MFF	▪ Manager – MPC/MFF ▪ Information needs to be made available to relevant authorities upon request.	• Increase in amount of waste feed • Significant increase in No. of fauna present at the cages, • Occurrence of entanglements • Occurrence of any unexplained mortalities.	• Reassessment of feeding strategies and behaviour • Removal and release of the entangled animal. If handling required, appropriate practices to ensure the safety and wellbeing of the animal. • All mortalities recorded, investigated, removed and discarded of appropriately. • Reassessment of staff skills, knowledge, training and experience. Further training and education will be initiated if required.	As for Water Quality Management

9. References

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Online Statistics: *An Interactive Multimedia Course of Study*, web address: http://onlinestatbook.com/index.html ; Chapter 1; Percentiles.

Schlesinger. Unpublished report. The redox potential of soils. Significance and processes.

Sim, C. and Masini, R. 2004. A framework to guide the development of environmental monitoring programs for marine aquaculture in seagrass dominated coastal environments in South Australia. Department of Environment, Government of Western Australia.

10. Environmental Data Sheets

Field Observation Form - Water Quality Monitoring

Farm Site: ____________________ Date: ______________

Instrument: ____________________ Samplers: ______________

Station # / Station name	Sample ID #	Spatial Distance (m)	Time HH:MM	Depth Ref. Pt (m)	Sample Depth (m)	Tidal Diff. (m) & direction (Sample depth does not apply to readings)	% Cloud	Wind Direction	Wind Speed (knots)	Turbidity (m)	Temp. (˚C)	Salinity (ppt)	pH	Dissolved Oxygen (mg/L)	Water sample volume (L)	Comments
1 / Sea Cage #1	1.2	10			3										5	
2 / Sea Cage #2	2.2	10			3										5	
3 / Sea Cage #3	3.2	10			3										5	
4 / SW Cone Bay	4.2	10			3										5	
5 / SE Pearl Lease	5.2	10			3										5	
6 / Crawford Bay	6.2	10			3										5	
7 / Gerald Bay	7.2	10			3										5	

Data and Analysis - Water Quality Monitoring

Sample Details							Data and Analysis Details									
Date Collected	Time (HH:MM)	Station #	Sample #	Depth Ref. (m)	Wind Direction	Sample Depth (m)	Variable List	Temp.	Salinity	pH	DO	Turbidity	Chl a	TSS @ 103°C	TN	TP
		Station Name	Spatial Dist. (m)	% Cloud	Wind Speed (knots)		Limit of Reporting (LOR)						0.0002	5	0.05	0.01
							Variable Unit						mg/L	mg/L	mg/L	mg/L
							Lab Method Code						PEI-068	PEI-003	PEI-069	PEI-070
							Water Sample Vol. (mL)						2,000	2,000	200	200
		1														
		Cage #1					average									
		2														
		Cage #2					average									
		3														
		Cage #3					average									
		4														
		SW Cone Bay					average									
		5														
		S.E. Pearl Lease					average									
		6														
		Crawford Bay					average									
		7														
		Gerald Bay					average									

Field Observation From - Benthic Quality Monitoring

Date: ____________________ **Samplers:** ____________________

Station	Location	Substation	Location	Longitude (East)	Latitude (South)	Number of Samples	Sample Id	Spatial Distance	Sub sample #	TN	TP	TKN	LOI	Redox	Infauna
1	Cage Site #1	1-1	0 metres	123°28.098'	16°29.029'	4	1.1.1	12m N	5	X	X	X	X	X	
							1.1.2	12m E	5	X	X	X	X	X	X
							1.1.3	12m S	5	X	X	X	X	X	X
							1.1.4	12m W	5	X	X	X	X	X	X
		1-2	50m west			3	1.2.1	12m	5	X	X	X	X	X	
							1.2.2	12m	5	X	X	X	X	X	
							1.2.3	12m	5	X	X	X	X	X	
		1-3	200m west			3	1.3.1	12m	5	X	X	X	X	X	
							1.3.2	12m	5	X	X	X	X	X	
							1.3.3	12m	5	X	X	X	X	X	
2	Cage Site #2	2-1	0 metres	To be determined	To be determined	4	2.1.1	12m N	5	X	X	X	X	X	
							2.1.2	12m E	5	X	X	X	X	X	
							2.1.3	12m S	5	X	X	X	X	X	
							2.1.4	12m W	5	X	X	X	X	X	
		2-2	50m west			3	2.2.1	12m	5	X	X	X	X	X	
							2.2.2	12m	5	X	X	X	X	X	
							2.2.3	12m	5	X	X	X	X	X	
		2-3	200m west			3	2.3.1	12m	5	X	X	X	X	X	
							2.3.2	12m	5	X	X	X	X	X	
							2.3.3	12m	5	X	X	X	X	X	
3	Cage Site #3	3-1	0 metres	To be determined	To be determined	4	3.1.1	12m N	5	X	X	X	X	X	
							3.1.2	12m E	5	X	X	X	X	X	
							3.1.3	12m S	5	X	X	X	X	X	
							3.1.4	12m W	5	X	X	X	X	X	
		3-2	50m west			3	3.2.1	12m	5	X	X	X	X	X	
							3.2.2	12m	5	X	X	X	X	X	
							3.2.3	12m	5	X	X	X	X	X	
		3-3	200m west			3	3.3.1	12m	5	X	X	X	X	X	
							3.3.2	12m	5	X	X	X	X	X	
							3.3.3	12m	5	X	X	X	X	X	
4	SW Cone Bay	-	-	123°27.760'	16°28.759'	3	4.1.1	12m	5	X	X	X	X	X	X
							4.1.2	12m	5	X	X	X	X	X	X
							4.1.3	12m	5	X	X	X	X	X	X
5	SE Pearl Lease	-	-	123°33.9136	16°28.6580	3	5.1.1	12m	5	X	X	X	X	X	X
							5.1.2	12m	5	X	X	X	X	X	X
							5.1.3	12m	5	X	X	X	X	X	X
6	Gerald Bay	-	-	123°26.393'	16° 30.210'	3	6.1.1	12m	5	X	X	X	X	X	X
							6.1.2	12m	5	X	X	X	X	X	X
							6.1.3	12m	5	X	X	X	X	X	X

Biota Log Sheet

Date	Time HH:MM	Sea Cage #	Common Name	No. of each species	Approx. Distance to Cage (m)	Comments

APPENDIX G

SUMMARY OF CONSULTATION – CONE BAY 1,000T BARRAMUNDI PRODUCTION PROPOSAL

Consultative Process and Results

A number of groups, businesses and organisations were contacted in order to provide the details of the Cone Bay Aquaculture Licence Variation and allow any to forward their comments and concerns regarding the proposal directly to Maxima Pearling Company Pty Ltd (MPC). These comments were then to be used to further develop the environmental values of the proposal, the potential impacts from the expansion to the sea cage operation and finally to develop appropriate management strategies for each potential impact so as to conform to the EPA objective set out for each impact and, where possible, satisfy those interested stakeholders with concerns related to the Cone Bay application. The following groups and organisations were contacted:

Community Groups

- Big Barras One Stop Shop
- Broome Aviation
- Buccaneer Sea Safaris
- Captains Cranes
- Derby 4x4 Marine
- Derby Building Supplies Home T H
- Derby Chamber of Commerce
- Derby Shire Council
- Derby Stock Supplies
- Derby Visitor Centre
- Derby Volunteer Marine Rescue Group
- Derby Weldall
- Elders Derby
- Golden Eagle Airlines
- Great Northern Enterprises
- Gugeri GTS Engineering
- Kimberley Waste Services
- King Leopold Air
- King Sound Sport Fishing
- Larinuwar (Yaluun) Community
- Mary Island Fishing Club
- North West Regional Airlines
- One Tide Charters
- Pacific Transport – Broome
- Reef Flights
- Toll West – Derby
- Unreel Adventure Safaris
- West Kimberley Fuels
- West Kimberley Guns & Ammo

Other Organisations

- Australian Petroleum Production and Exploration Association Ltd
- Aquaculture Council of WA
- Aquaculture Development Council
- Australia's Northwest Tourism
- Aztec Resources Ltd – Koolan Island
- Broome Fishing Club – Secretary
- Conservation Council of WA
- Department of Agriculture – Derby
- Department of Defence
- Department of Environment and Conservation – Broome
- Department of Environment and Conservation – Derby
- Department of Environment and Conservation - Kununurra
- Department of Environment and Conservation – Marine Conservation Branch
- Department of Environment and Heritage
- Department of Fisheries – Broome
- Department of Fisheries – Perth
- Department of Indigenous Affairs
- Department of Industry and Resources
- Department of Planning & Infrastructure – Broome
- Department of Planning & Infrastructure – Fremantle
- Environs Kimberley
- Henry Walker Eltin Mining Ltd – Cockatoo Island
- Kimberley Development Commission - Broome
- Kimberley Development Commission – Derby
- Kimberley Land Council – Broome
- Kimberley Professional Fishermen's Association
- Marine and Coastal Community Network
- Ministry for Planning
- NORFORCE – Derby
- Pearl Producers Association
- Portman Limited – Cockatoo Island
- Recfishwest
- Recreational Fishing Advisory Committee – Chairman
- The Great Escape Charter Company Ms K Bartle
- Tourism Western Australia
- WA Maritime Museum
- West Kimberley Regional RFAC

The availability of the Scoping Document and details on how it could be attained were advertised in the *Broome Advertiser* (1st March 2007), *The Muddy Waters* (1st March 2007) and the *West Australian* (24th February 2007). The notice advertised is provided over the page:

CONE BAY BARRAMUNDI PROPOSAL

Maxima Pearling Company Pty Ltd currently operate a successful Barramundi aquaculture licence in Cone Bay, King Sound, WA and are now considering expanding these operations. This expansion will provide many benefits to the surrounding community and businesses and MPC/MFF is keen to receive any comments regarding this proposal.

A Scoping Document that provides full details of the proposal has been approved by the EPA. Any interested parties are encouraged to peruse the document and provide comments on the proposal. Copies can be obtained by contacting Nikki Jack on the details provided below. All comments on the document can then be forwarded to the same contact details by Thursday 15th March 2007.

Maxima Pearling Company Pty Ltd
PO Box 843 BROOME WA 6725
Ph: 08 9193 7290
Fax: 08 9193 7291
Contact: Nikki Jack
Email: njack@maximapearling.com

APPENDIX H

BARRAMUNDI HEALTH MANAGEMENT AND EMERGENCY PLAN

MAXIMA FISH FARMS PTY LTD

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1. Overview

Pathogens causing a number of serious diseases in Barramundi are already present in the native populations found across northern Australia. While not harmful to humans, such diseases can cause significant mortality, particularly in juvenile stocks or fish in a weakened or stressed state.

Disease management in Australia is therefore based on a national plan to prevent exotic diseases from entering the country and at farm level, by ensuring the best possible environmental conditions and minimisation of stress to prevent the onset of endemic diseases.

Maxima Fish Farms Pty Ltd (MFF) (the operational company) operates its farms under the guidelines of this *Barramundi - Health Management and Emergency Plan* and best practice preventative measures such as optimal tank and equipment hygiene, fish health screening, and careful feeding regimes. We also ensure compliance with the Licence Conditions stipulated by the Department of Fisheries, W.A..

Early diagnosis and treatment of diseases are imperative in maintaining healthy fish and optimising survival throughout the production cycle, and is an integral part of our fish health strategy.

In formulating this management plan MFF recognises the following document sources:

- *AQUAPLAN 2005 – 2010, Australia's National Strategic Plan for Aquatic Animal Health;*
- *Fish Resources Management Act 1994;*
- *Fisheries Management Paper No. 159;* and
- *Cone Bay Sea Cage Aquaculture Environmental Monitoring and Management Plan.*

2. Key Elements of Fish Health Management

The key objective of Barramundi health management strategies adopted by MPC/MFF is to maintain the health and well being of all stock as a tool for optimising production.

2.1. General

MFF as a company, constantly takes a pro-active approach to managing stock health by :-

- Following Western Australia's Translocation Protocol, and testing all fish for known pathogens prior to transferring new stock to the farms.
- Ensuring all team members have a thorough understanding of "normal" fish behaviour, and are constantly looking for changes that might indicate the onset of a disease problem.
- Regular sampling by farm staff, and screening of fish for disease by the Fish Health Laboratory in Perth.
- Maintenance of the best possible environment for the stock.
- Use of the best quality diets and maintenance of optimal feeding programs.
- Maintenance of hygienic conditions in the nursery and of all fish farm equipment including boats.

2.2. Nursery

- Disinfection of all fish handling equipment after every use.
- Hygienic storage of feed and equipment.
- Maintenance of a clean working area.
- Cleaning and disinfection of tanks every time they are emptied so that all fish are stocked into clean tanks.
- Flushing tanks and cleaning screens after every meal.
- Restricted access to nursery area.

2.3. Marine Farm

- Keeping all nets clear of fouling organisms.
- Maintaining boats and feeding equipment in a clean and hygienic condition.
- Daily monitoring and removal of all dead fish.
- Effective protection of stock from both marine and airborne predators.

3. Health Management Protocols

MFF has developed and implemented aquatic animal health protocols to achieve and maintain the best possible level of stock health on our farms.

3.1. Source of Juveniles

- All juvenile Barramundi will be sourced from accredited hatcheries that operate to a high standard of professionalism and hygiene.
- Prior to dispatch, all stock will be screened in line with the Translocation Protocols described in *Fisheries Management Paper No. 159. W.A.* This involves issue of a Fish Health Certificate by the fish health authorities in the state of origin.
- Prior to dispatch of each batch of juveniles, the Translocation Officer at the Department of Fisheries will be notified and provided with a Fish Health Certificate from the Fish Health Laboratories in the state of origin.

3.2. Operational Management

3.2.1. Hygiene

- All visitors to nursery are required to disinfect footwear in footbath prior to entering area.
- All equipment is to be disinfected using a chlorine based cleaning agent, or anti-viral product in the event of a virus infection.
- Moribund or dead fish are to be removed from tanks or cages immediately and disposed off according to licence conditions.

3.2.2. Record Keeping

- MFF keep accurate records of all batches of fish stocked on its farms. These records include – source of fish, transfer date/s, number and size and health status.
- MFF records the following information by cage or tank on a daily basis – feed intake, mortality by cause, water temperature, and observations.
- Records are kept for monthly weight checks, regular fish health samples, stock splits or grades, and harvest number and weight.
- Environmental records are kept as outlined in the Environmental Monitoring and Management Plan, which is in accordance with Department of Environment guidelines.
- Recording of all fish health issues including treatments and mortality.

3.2.3. Use of Chemicals

- MFF plans to restrict the use of chemicals to chlorine or iodine based cleaning agents for disinfection of tanks, dip nets and other fish handling equipment.
- All chemicals used will be approved for use in aquaculture and will be registered on the List of Aquaculture Approved Chemicals.
- MFF takes all steps to avoid the use of antibiotics or therapeutists in its production. If fish are deemed to require treatment, advice and direction will be sought from the WA Fish Health Laboratories or a veterinary practitioner experienced in fish health.

4. Disease

All MFF staff are thoroughly trained to observe fish behaviour and report changes for farm management. In the event that we suspect the presence of disease among any of the fish groups on the farm, the company will immediately notify the Chief Veterinary Officer of Western Australia, or his associates at the Fish Health Laboratory in Perth. Criteria for notification are elevated mortality in combination with the following observations:

- Single mortality incident involving a loss of greater than 5% of stock in a tank or cage.
- Increased numbers of fish lingering near the surface at the edge of a tank or cage.
- Fish displaying unusual swimming behaviour.
- Increased numbers of fish with signs of external parasites or lesions.
- Reduced feed intake and failure to thrive.
- Unusual physical signs observed during routine sampling.

4.1. Disease Management

In the event of a suspected disease outbreak that does not require notification, MFF will implement the following program.

- Any group of fish showing signs of disease will be identified and isolated if possible.
- Where possible, groups suspected of containing sick fish will be fed at the end of the period or day to minimise the chance of spreading the disease to other groups.
- When working with potentially diseased stock, staff will be required to wash themselves and their equipment prior to working with other stock.
- Feeding will be reduced or ceased until the cause of the problem can be identified.
- Moribund or fish showing unusual physical or behavioural symptoms will be collected, preserved in formol saline and sent to the Fish Health Laboratories in Perth for histological analysis.
- If farm staff are unable to identify the cause of the problem, veterinary advice will be sought.
- Antibiotics or therapeutists will only be used as a last resort and will be done under the direction of an experienced fish veterinarian.

4.2. Disease Emergency Response

In the event of a major stock loss or outbreak of a notifiable disease, MFF will immediately: -

- Implement quarantine measures by restricting access to the affected group/s.
- Collect moribund fish or fish showing signs of disease. Preserve in formol saline and send to the Fish Health Laboratory as soon as possible for histological examination.
- Cease all feeding or stock handling operations for the affected stock.
- Isolate the cage if necessary.
- Prepare to medicate or treat the affected fish if advised by the CVO or an experienced fish veterinarian.
- In severe cases, consider culling the affected fish to stop the spread of the pathogen or parasite.
- Remove any dead fish and dispose immediately by incinerating or storing in sealed container and treating with Formic Acid.
- Disinfect boats and equipment used for dead fish removal.

4.3. Disease Notification Procedure

In the event of an outbreak of any notifiable disease or significant mortality, MFF will immediately inform the Chief Veterinary Officer or his associates at the Fish Health Laboratory in Perth.

5. Diseases in Barramundi (*Lates calcarifer*)

- Viral Nervous Necrosis (VNN) caused by the piscine nodavirus can cause high mortalities up to 40 days post hatch.
- *Streptococcus iniae.*
- Columnaris Disease caused by a filamentous *Flexibacter sp.* and is seen as fin rot or tail rot.
- Saltwater Vibriosis.
- White Spot, caused by the protozoan *Cryptocaryon irritans.*
- Lymphocystis, a viral disease sometimes called "Saltwater Ich".
- *Tenacibaculum maritimum* (formerly *Flexibacter maritimum*), a disease causing lesions on the gills and skin.
- A Monogenean parasite *Neobenedenia spp.*

APPENDIX I

TOXIC AND HAZARDOUS SUBSTANCES MANAGEMENT PROTOCOL – STORAGE, USE AND ACCIDENTAL SPILL CONTINGENCY PLAN

Donna Cahill

ConsultAqua

For:
Maxima Fish Farms
PO Box 843
Broome
Western Australia 6725

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1. Introduction

Toxic and hazardous substances (THS) are materials that can poison living things, disrupt their reproductive processes or their habitat or cause harm due to fires or explosions.

THS can harm humans, animals and plants (including aquatic ecosystems) if allowed to enter the environment. Some are harmful at very low concentrations (in the parts per billion range). Once THS enter the environment they may go undetected for long periods, cause extended loss of water resource values and can be very costly to remedy.

THS impacts on the environment can occur from:

- Leakage from damaged or corroded chemical storage vessels;
- Accidental spills during handling or storage containers;
- Poor chemical usage practice;
- Dispersion of a spill or leak by water used to control fires at THS stores; or
- Dispersion of chemical concentrates in uncontrolled storm water runoff.

Toxic hazardous substances (THS) for the purpose of this management plan include:

- Substances described in the Schedules of the *Poisons Act 1964*;
- Concentrates and substances listed in Schedule 3 to 9 of the *Explosive and Dangerous Goods Act, Classification Order of 1988*; and
- Substances that have the potential to contaminate waters (whether treated or otherwise) so they become unsafe for human, plant or animal use, or may significantly disrupt animal processes.

2. Key Objective

The key objective is to avoid accidental release of toxic hazardous substances (THS) into the environment and to minimise the impact from daily use and handling of THS.

During day-to-day operations a variety of cleaning agents, chemicals, fuels and lubricants are in use in production facilities as well as related offices. It is essential that correct use, handling, storage and disposal of these materials be maintained at all times to avoid potential contamination of the environment and ensure staff safety.

It is important to establish what kind of materials are being used as well as the potential risk these might pose to the environment and/or staff and if there is a more environmentally friendly substitute available.

3. Storage Facilities

Facilities are constructed to prevent THS escape to the environment under any conditions, such as during normal operations, equipment maintenance/malfunctions and/or emergencies. Storage facilities and practices include:

- All THS are stored in chemical-resistant containers;
- Containers of capacity less than 100 litres are held in weather-proof air conditioned buildings;
- Storage racks are constructed to minimise accidents during handling of containers;
- Large containers greater than 10 litres are fitted with appropriate chemical resistant taps to minimise spills during handling; and
- Volumes of THS greater than 250 litres are held in purpose built chemically resistant surface-mounted bulk storage tanks and/or containment areas.

4. THS Management Practices

The following practices are adhered to in relation to THS:

1 Minimisation of use of any chemicals on site and use of biodegradable products where available;

2 Designated person(s) responsible for chemical storage and stock control systems;

3 Material Safety Data Sheets (MSDS) for all chemicals stored on premise and made easily accessible if required;

4 Thorough annual inspection of chemical storage before placing new order, checking that there is less than one year's stock of any substance;

5 All new THS stock is dated on receipt;

6 Clear labelling of all bottles/containers. Replacement of damaged or peeling labels immediately. Any stock that shows signs of deterioration or has lost its label is disposed of by the recommended methods (check MSDS);

7 THS formulation, mixing, processing, container transfers and decanting is conducted within weatherproof buildings or containment facilities;

8 Prompt containment and clean up of spills should they occur according to MSDS instructions;

9 Establishment of a spill response plan ensuring proper procedures and the availability of appropriate equipment;

10 Wearing of appropriate personal protective equipment when handling hazardous materials;

11 Disposal of out of date or unused stock in an appropriate manner (check MSDS); and

12 Waste liquids, containers, rinse residuals or THS contaminated litter from spill clean-up is effectively contained until recycled or disposed of in correct manner (check MSDS).

In relation to vessels, machinery and equipment, the following practices are adhered to:

13 All machinery and equipment is maintained and operated in an appropriate manner at all times to reduce the potential risks of pollution such as petroleum products entering the marine system from marine engine combustion and during boat clean up and wash down procedures and/or to prevent tractors and other machinery operated on the shoreline accidentally leaking fuel and lubricants into the surface water or onto the ground;

14 All vessels are subject to yearly survey undertaken by the Department of Transport to ensure seaworthiness;

15 Vehicle, vessel and equipment operators have appropriate training and qualifications for proper and safe use of their equipment;

16 Operation of all vehicles, vessels and equipment conducted in a safe and professional manner;

17 Continuous care and maintenance of vehicles, vessels and equipment is conducted to minimise risk of spills or leakages of substances into the marine environment;

18 Use of biodegradable products where possible eg hydraulic fluid;

19 A contingency plan has been developed in case of vehicle breakdown in the intertidal zone; and

20 Proper disposal of all filters, oils, lubricants and other related materials.

5. THS Accidental Spill Contingency Plan

1. In the case of a THS spill, immediate notification of regulatory bodies such as the Department of Environment (DoE (formerly DEP)) and the Department for Planning and Infrastructure in the case of a THS spill on marine waters;
2. Equipment such as pumps are available and accessible to immediately reclaim and contain any spilt THS;
3. Sufficient stocks of absorbent material are readily available for cleaning up spilt fluids;
4. All THS contaminated absorbent materials are contained in suitable chemically resistant containers until correct disposal;
5. Regular staff training in safe management of THS, what to do in the event of a THS spillage and the implications of loss of these substances to the environment is conducted;
6. Suspension of feeding farmed fish if spill occurs on the water in close vicinity to the sea cages;
7. If the stock is at a marketable size, consideration shall be given to harvesting out a proportion or all stock;
8. Isolation of stock if possible; and
9. If feasible, cages should be relocated to an alternative clean site.

6. References

Irish Sea Fisheries Board, 2002. Ecopact – Environmental Code of Practice for Irish Aquaculture Companies and Traders.

Government of Western Australia Waters and Rivers Commission, 2002. Water Quality Protection Note. Toxic and hazardous substances – storage and use.

APPENDIX J

WASTE MANAGEMENT PLAN

Author: **Nikki Jack**
Maxima Fish Farms
PO Box 843
Broome, WA, 6725

February 2007

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1. Overview

A general overview of the Waste Management Plan (WMP) developed by Maxima Fish Farms (MFF) is summarised below:

Commitment	Minimise waste generated. Treat and dispose of waste products in accordance with the relevant Western Australian regulations. Regular review of the WMP and continual improvement of the principles of waste management practices.
Action	*Solid Waste* • Reuse of waste materials will occur where possible. • Recycling of waste materials will occur where appropriate. • Burning of all burnable products in incinerator drums of all waste items that cannot be re-used. • Where recycling, reuse or burning is not practicable, all items of waste as a result of the operational activities will be stored in categorised drums and transported to the nearest waste facility for proper disposal. *Liquid Waste* • Onsite servicing and maintenance programs are a requirement in operations. Oil and lubricant waste as a part of the equipment maintenance program will be captured, recycled and/or disposed of in compliance with relevant regulations. All drums of collected liquid waste will be transported in accordance with WA regulations to the nearest waste facility for proper disposal. • Sewage discharge point associated with operational and staff infrastructure will be directed into individual septic &/or leach drains in compliance with the relevant regulations. • Wash down activities will be conducted using salt water, where appropriate. • Wash down activities involving the use of the detergents or chemicals (eg for hygienic culturing techniques) will be minimised where possible. All wash down activities using detergents or chemicals will be conducted on hard floor areas with appropriate drainage requirements according to relevant regulations. *Chemical/Hazardous Waste* • All chemical and/or hazardous waste products will be captured, handled and disposed of in accordance with relevant regulations and/or Material Safety Data Sheets (MSDS) information. • The Farm Manager shall be responsible for ensuring all chemical or hazardous materials used onsite are identified and a database detailing the materials and controls relating to health, safety and environment is made available to all staff.
Objective	Waste minimisation and responsible disposal of all waste products.
Location	• Turtle Island, Cone Bay, Yampi Sound, WA • Aquaculture Licence (No. 1465) area, Cone Bay, Yampi Sound • Proposed Aquaculture Licence area, Crawford Bay, Yampi Sound
Responsible Party	MFF, Farm Manager
Review/Auditing	Annually, as determined by the Farm Manager
Regulations/ Requirements	• Litter Act, 1979 • Environment Protection Act, 1986

2. Introduction

A Waste Management Plan (WMP) enables Maxima Fish Farms (MFF) to comply with the ever increasing requirement for sustainable operational practices that ensure best practice measures are being utilised. If used effectively, a WMP can result in other benefits to the company such as:

- Cost-saving opportunities (Cost-effectiveness)
- Potential income from waste generation
- Increased marketing capabilities by promoting the 'clean-green eco-friendly' image that is MFF.

MFF is a strong advocate for waste minimisation and sustainable farming practices. Currently the existing Barramundi Aquaculture venture in Cone Bay produces 150 tonne of fish a year. Future operations are expected to include two licences each producing 1000 tonne Barramundi per year. One licence will be the existing Cone Bay Licence No. 1465 and a second licence in Crawford Bay, adjacent to Cone Bay. With the increase in production there is expected to be a subsequent increase in waste production. Thus to ensure maintenance of best practices, MFF has developed a WMP that:

- Assesses the operations and activities of the venture
- Identifies the waste products
- Records of the amount of each waste product
- Proposes management strategies for each waste product
- Establishes a regular review schedule

The overarching WMP developed by MFF is essentially an analysis of how the principles of waste minimisation and waste management will be applied to the overall operations of both Barramundi farms and follows the basics outlined in Figure 1.

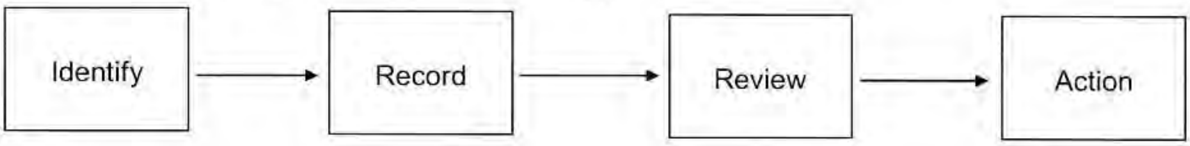

Figure I1: Process and analysis of waste minimisation.

3. Objectives

The development of a WMP is fundamentally site or operation specific where waste minimisation is the key objective to all components of the plan. In addition, the development of a WMP will also outline the responsible disposal of waste products.

The main objective of a WMP is to provide a workable system that achieves best practice in waste minimisation and management.

4. Waste Assessment Process

A waste assessment program was undertaken by MFF staff from all departments in March 2007. The objective of the assessment program was to:

- identify the current waste produced and existing management of these waste products,
- to discuss improvements that could be made to the existing waste management process, and
- to develop a WMP that is understood, approved and implemented by all staff members of MFF.

5. Identification of Waste Products

The identification of all waste products resulting from the operations and activities of the Barramundi farm in Cone Bay has been diagrammatically represented as a flowchart of products entering the entire operation and the resulting waste products exiting the system (Figure 2). This then enabled MFF to reassess current waste minimisation techniques and to determine if these could be improved to ensure best practice.

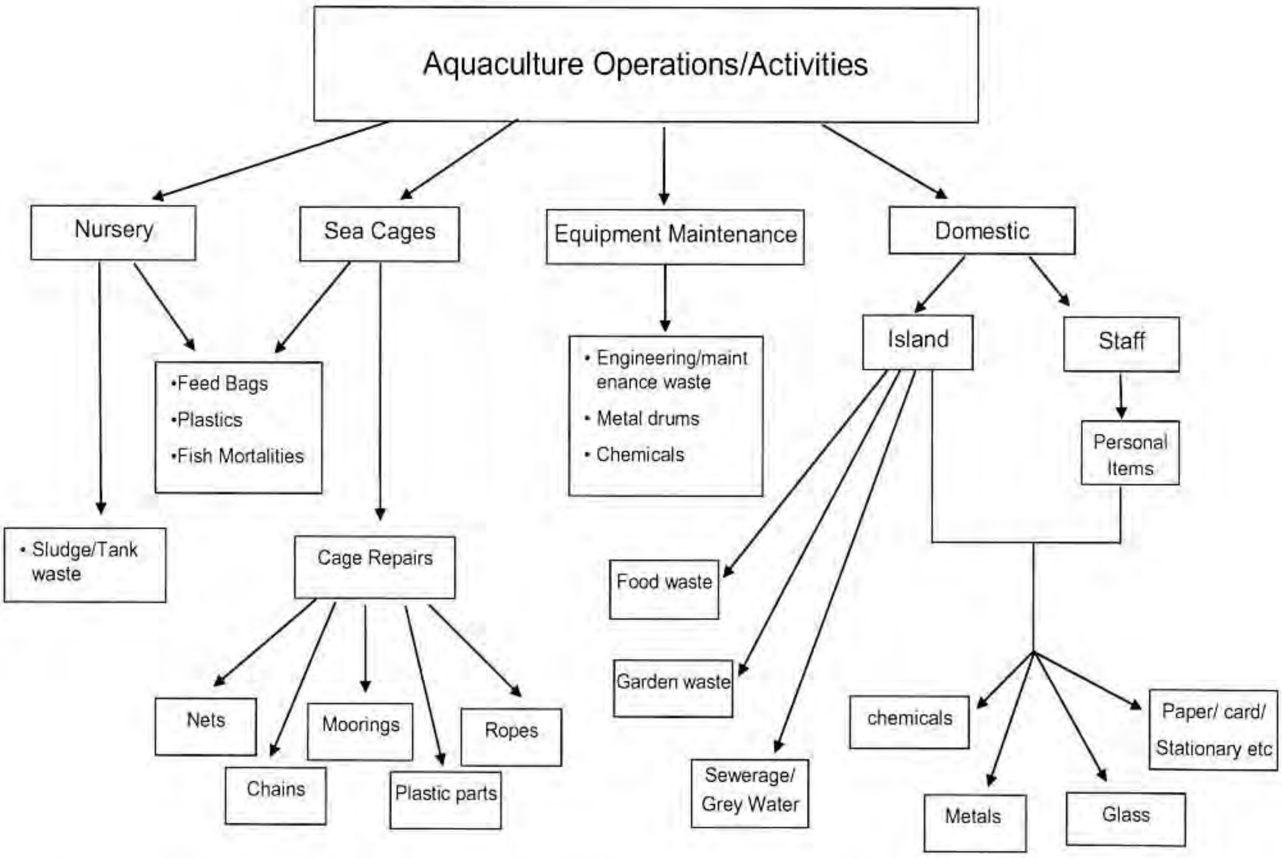

Figure I2: Identification of general waste products produced from the Barramundi Aquaculture operations.

Figure 2 provides a broad view of the types of waste produced from the operations, however each of these types of waste products are dealt with in more detail in Section 5 – Proposed Waste Management.

Waste generated during operational activities will fall into the following main categories:

- Nursery,
- Sea Cages,
- Equipment Maintenance (ie Engineering activities),
- Domestic Sewage
- Domestic Garbage
- Chemical or hazardous waste

6. Proposed Waste Minimisation and Management

The proposed management and minimisation of waste produced by the operations and activities of the aquaculture venture have been summarised below into the general categories and then tabulated for simplification and ease of use in operations.

Solid Waste

- Reuse of waste materials will occur where possible.
- Recycling of waste materials will occur where appropriate.
- Burning of all burnable waste items that cannot be re-used in incinerator drums.
- Where recycling, reuse or burning is not practicable, all items of waste as a result of the operational activities will be stored in categorised drums and transported to the nearest waste facility for proper disposal.

Liquid Waste

- Onsite servicing and maintenance programs are a requirement in operations. Oil and lubricant waste as a part of the equipment maintenance program will be captured, recycled and/or disposed of in compliance with relevant regulations. All drums of collected liquid waste will be transported in accordance with WA regulations to the nearest waste facility for proper disposal.
- Sewage discharge point associated with operational and staff infrastructure will be directed into individual septic &/or leach drains in compliance with the relevant regulations.
- Wash down activities will be conducted using salt water, where appropriate.
- Wash down activities involving the use of the detergents or chemicals (eg for hygienic culturing techniques) will be minimised where possible. All wash down activities using detergents or chemicals will be conducted on hard floor areas with appropriate drainage requirements according to relevant regulations.

Chemical/Hazardous Waste

- All chemical and/or hazardous waste products will be captured, handled and disposed of in accordance with relevant regulations and/or Material Safety Data Sheets (MSDS) information.
- The Farm Manager shall be responsible for ensuring all chemical or hazardous materials used onsite are identified and a database detailing the materials and controls relating to health, safety and environment is made available to all staff.

Tank Waste

- Waste from the land-based nursery tanks will be passed through a series of filters and treatment processes in accordance with the relevant regulations.
- Solid wastes will be removed from the system quickly and efficiently via appropriate waste removal mechanisms (ie filtration and fractionation etc), collected and stored in a geo-tube. The geo-tube allows for dewatering and containment of the solids whereby the disposable product becomes biodegradable and can be utilised in the garden or transported to the nearest waste facility for green waste disposal.

Fish Mortalities

- All fish mortalities (land-based or sea cages) will be collected on a daily basis and transported to the island based infrastructure for disposal and treatment.
- Fish mortalities will be treated in two ways:
    - Incineration – where the fish are placed inside an incinerator and reduced to ashes.
    - Ensiled – where the fish are placed inside an ensiler and reduced to a biodegradable liquid waste that can be utilised in the garden as fertiliser supplement, transported to the nearest waste facility for disposal or onsold to appropriate organisations for garden products manufacture.

As a result, a workable Waste Production and Management Form has been developed, by which all staff can easily utilise on a regular basis to provide accurate information to build a database of waste production. This information will also be utilised during review periods to help identify areas of waste production that can be improved.

This Waste Production Form is demonstrated on page 8 and details:

- The types of waste produced from each area of operation,
- The amount of waste produced (to be recorded for regular review and improvement),
- The current disposal method of the waste, and
- Other potential reuse/recycling or other beneficial activities.

Waste Production and Management Form - Template

Type of Waste		Amount Produced	Management &/or Disposal	Other potential uses.
Source	Waste product			
Domestic	Office supplies – burnable			
	Office supplies – non burnable			
	Aluminium Cans			
	Food tins			
	Foam Eskies			
	General rubbish			
	Soft Plastics			
	Hard Plastics			
	Food Wastes			
	Domestic sewage			
	Other burnable waste products			
	Other non-burnable waste			
Sea Cage Maintenance and Construction	Plastic feed bags			
	Waste feed (not feed to fish)			
	Cable ties			
	Ropes – various types and sizes			
	Floats/buoys			
	Steel Cables			
	Steel Coils			
	Steel Mesh			
	Plastic shavings from pontoon building			
	Chain – various size and type			
	Polyethylene netting			
	Fish Mortalities			

Nursery System	Feed and feed bags			
	Waste water – solids			
	Office supplies – non burnable			
	Office supplies – burnable			
	Fish mortalities			
	PVC pipe			
	Poly pipe			
	Ropes – various types and sizes			
	Foam Eskies			
	Probe Membranes and service kits			
	Nylon netting			
Equipment Maintenance	Waste Chemicals – incl degreaser and paints etc			
	Waste Fuel			
	Waste Oil			
	Steel, Aluminium and wood waste			
	Expired hydraulic hoses and fittings			
	Expired fittings and parts – general mechanical and engineering			
	Other miscellaneous waste items – inlc rags, grinding discs, tools etc			

7. Implementation & Review

The WMP has already been implemented at the outcome of the waste assessment program and will continue to be as a part of the Environmental Management System (EMS) for the Barramundi Aquaculture Project.

Regular reviews and audits will occur on an annual basis to ensure:

- Identification of new waste products or waste generation areas,
- Reassessment of current waste minimisation techniques to ensure best practice, and
- Identification &/or development of new, improved waste minimisation and management practices.

The Farm Manager will be responsible for ensuring review of the WMP is undertaken on an annual basis. All operational staff will be included in the review process to ensure a comprehensive assessment of practices is undertaken. The Farm Manager is also responsible for ensuring the WMP is updated by incorporating all improvements into the plan. The Farm Manager is also responsible for ensuring all outcomes of the review (ie actions required) are implemented.

MFF is committed to ensuring best practice measures are incorporated into the WMP by continual improvement of the principles of waste minimisation and management through the annual review and audits of the WMP as a part of the EMS.

8. References

EPA Information Bulletin, June 1993, Guidelines for Preparation of Waste Management Plans, website: http://www.epa.vic.gov.au

APPENDIX K

DVD OF UNDERWATER VIDEO IMAGERY

Prepared by: Jason Garwood
Marine Produce Australia Pty Ltd
PO Box 843
Broome WA 6725

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1. Key Objective

The aim of this project was to provide base line video data of the benthic substrate within the Southern Cone Bay aquaculture lease. This data is to be used to verify the benthic substrate type and to assist in the identification of any flora or fauna species found. This data can be later used to assess any impacts on the benthic substrate by aquaculture in the area.

2. Methodology

The primary method of capturing the video footage was the uses of commercial divers using a method commonly known as drift diving.

This method involves a qualified diver descending a work line to a weight attached towards the end of the line and this is trailed behind the dive boat.

The diver attaches to the work line and is towed or "drifts" off this line. Once the diver is suitable attached they signal the dive boat and the boat tows them at between 1.5 and 2.2 knots.

The video footage was shot at between 1 and 0.5 meters off the substrate due to visibility restrictions and each transect went for between 10 and 15 minutes. The video footage was shot using a JVC high definition HDD video camera.

3. Results and Observations

Transect 1

Location (starting point) – 16°28.189 S, 123°29.558 E
Location (finishing point) – 16°28.471 S, 123°29.521 E
Date – 20/11/2007
Time – 0645 – 0700
Tide – Turning, 6m
Visibility – 2.5m
Max Depth – 11.9m

Observations:
Primarily mud based substrate with only small areas of mixed shell grit. Weed mat that is observed on a seasonal basis seen on the substrate. Holes possibly from burrowing crustaceans are evident.

Transect 2

Location (starting point) – 16°28.334 S, 123°29.873 E
Location (finishing point) – 16°28.622 S, 123°29.818 E
Date – 20/11/2007
Time – 0715 – 0730
Tide – Turning, 6m
Visibility – 2.5m
Max Depth – 12.0m
Observations:

Primarily mud based substrate with only small areas of mixed shell grit. Weed mat that is observed on a seasonal basis seen on the substrate. Holes possibly from burrowing crustaceans are evident. A fern like flora that has been identified by the diver as seasonal to the bay was observed on this transect.

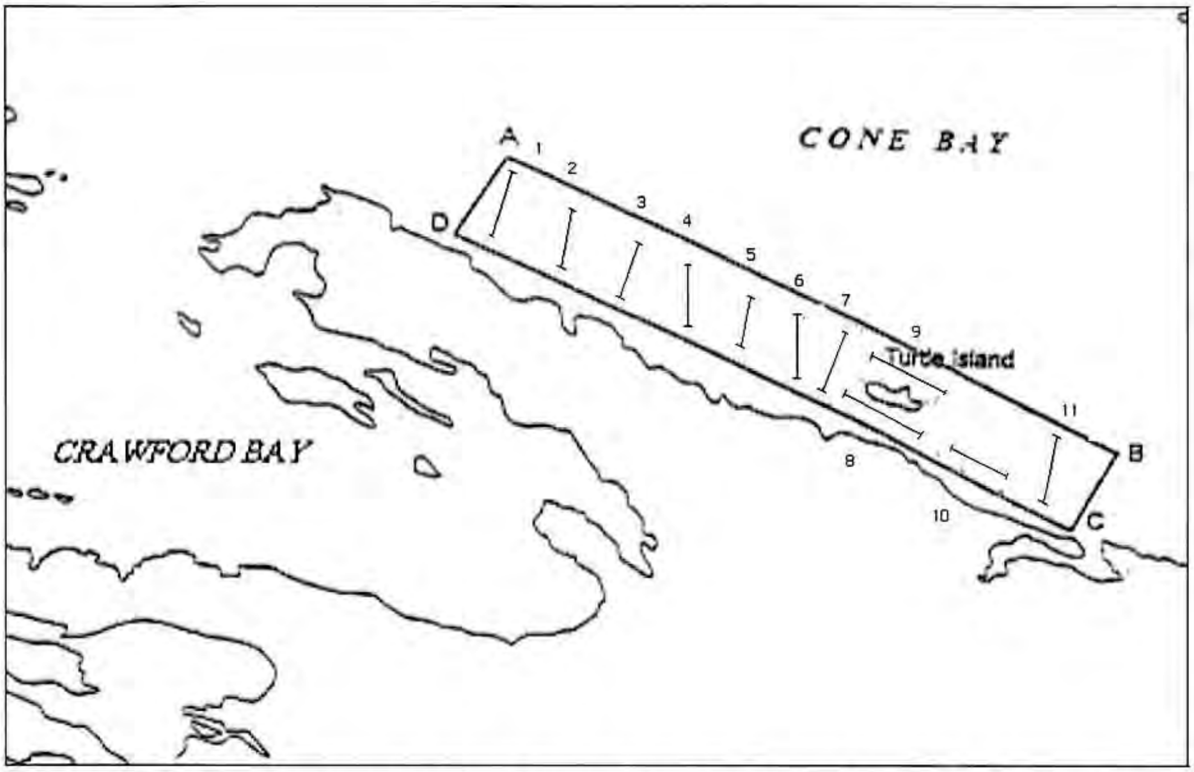


Figure K1: Diagram representing transects number 1 through number 11 within Cone Bay aquaculture licence site number 1465.

Transect 3

Location (starting point) – 16°28.543 S, 123°30.288 E
Location (finishing point) – 16°28.774 S, 123°30.115 E
Date – 20/11/2007
Time – 0745 – 0800
Tide – Outgoing, 5.8m
Visibility – 3m
Max Depth – 12.0m

Observations:
Primarily mud based substrate with only small areas of mixed shell grit. Weed mat that is observed on a seasonal basis seen on the substrate. Holes possibly from burrowing crustaceans are evident. A feather star and the fern like flora were observed towards the end of this transect.

Transect 4

Location (starting point) – 16°28.695 S, 123°30.499 E
Location (finishing point) – 16°28.947 S, 123°30.393 E
Date – 20/11/2007
Time – 0815 – 0830
Tide – Outgoing, 5.6m
Visibility – 3m
Max Depth – 12.1m

Observations:
Primarily mud based substrate with areas of mixed shell grit. Weed mat that is observed on a seasonal basis seen on the substrate. Holes possibly from burrowing crustaceans are evident along with fern like flora.

Transect 5

Location (starting point) – 16°28.803 S, 123°30.783 E
Location (finishing point) – 16°29.055 S, 123°30.598 E
Date – 20/11/2007
Time – 0845 – 0900
Tide – Outgoing, 5m
Visibility – 2.5m
Max Depth – 12.4m

Observations:
Primarily mud based substrate with areas of mixed shell grit. Weed mat that is observed on a seasonal basis seen on the substrate. Holes possibly from burrowing crustaceans are evident.

Transect 6

Location (starting point) – 16°28.933 S, 123°31.091 E
Location (finishing point) – 16°29.243 S, 123°30.957 E
Date – 20/11/2007
Time – 0915 – 0930
Tide – Outgoing, 4.5m
Visibility – 2m
Max Depth – 12.6m

Observations:
Primarily mud based substrate with areas of mixed shell grit. Weed mat that is observed on a seasonal basis seen on the substrate. Holes possibly from burrowing crustaceans are evident.

Transect 7

Location (starting point) – 16°29.048 S, 123°31.254 E
Location (finishing point) – 16°29.315 S, 123°31.099 E
Date – 20/11/2007
Time – 0945 – 1000
Tide – Outgoing, 4.5m
Visibility – 2m
Max Depth – 12.4m

Observations:
Primarily mud based substrate with higher concentrations of shell grit due to the proximity of this transect to the island. Weed mat that is observed on a seasonal basis seen on the substrate. Holes possibly from burrowing crustaceans are evident.

Transect 8

Location (starting point) – 16°29.380 S, 123°31.223 E
Location (finishing point) – 16°29.568 S, 123°31.570 E
Date – 20/11/2007
Time – 1015 – 1030
Tide – Outgoing, 4.3m
Visibility – 2m
Max Depth – 10.4m

Observations:
This transect is located on the Southern side of the island and is the primary mooring area for the islands work boats. This area is slightly shallower than other areas and has a higher percentage of shell grit due to the constriction of the water flow. Higher concentrations of the fronded flora were observed along with holes possibly from burrowing crustaceans. A shovel nosed ray (family *Rhionbatidae*) was seen at 7 minutes.

Transect 9

Location (starting point) – 16°29.265 S, 123°31.421 E
Location (finishing point) – 16°29.366 S, 123°31.693 E
Date – 19/11/2007
Time – 0645 – 0700
Tide – Outgoing, 5.5m
Visibility – 1.5m
Max Depth – 11.4m

Observations:
Primarily mud based substrate with areas of mixed shell grit. Weed mat that is observed on a seasonal basis seen on the substrate. Holes possibly from burrowing crustaceans are evident.

Transect 10

Location (starting point) – 16°29.611 S, 123°31.706 E

Location (finishing point) – 16°29.784 S, 123°32.090 E

Date – 19/11/2007

Time – 0730 – 0745

Tide – Outgoing, 4.8m

Visibility – 1.5m

Max Depth – 12.5m

Observations:

Primarily mud based substrate with areas of mixed shell grit. Weed mat that is observed on a seasonal basis seen on the substrate. Holes possibly from burrowing crustaceans are evident.

Transect 11

Location (starting point) – 16°29.691 S, 123°32.486 E

Location (finishing point) – 16°29.936 S, 123°32.387 E

Date – 19/11/2007

Time – 0800 – 0815

Tide – Outgoing, 4.4m

Visibility – 1.5m

Max Depth – 11.3m

Observations:

Primarily mud based substrate with areas of mixed shell grit. Weed mat that is observed on a seasonal basis seen on the substrate. Holes possibly from burrowing crustaceans are evident.

APPENDIX L

SEA CAGE GROWOUT PROCEDURES MANUAL

CONE BAY
Barramundi™
AUSTRALIA'S FLAVOURITE BARRAMUNDI

A Division of

MPA FISH FARMS PTY LTD

Sea Cage Growout

Procedures Manual

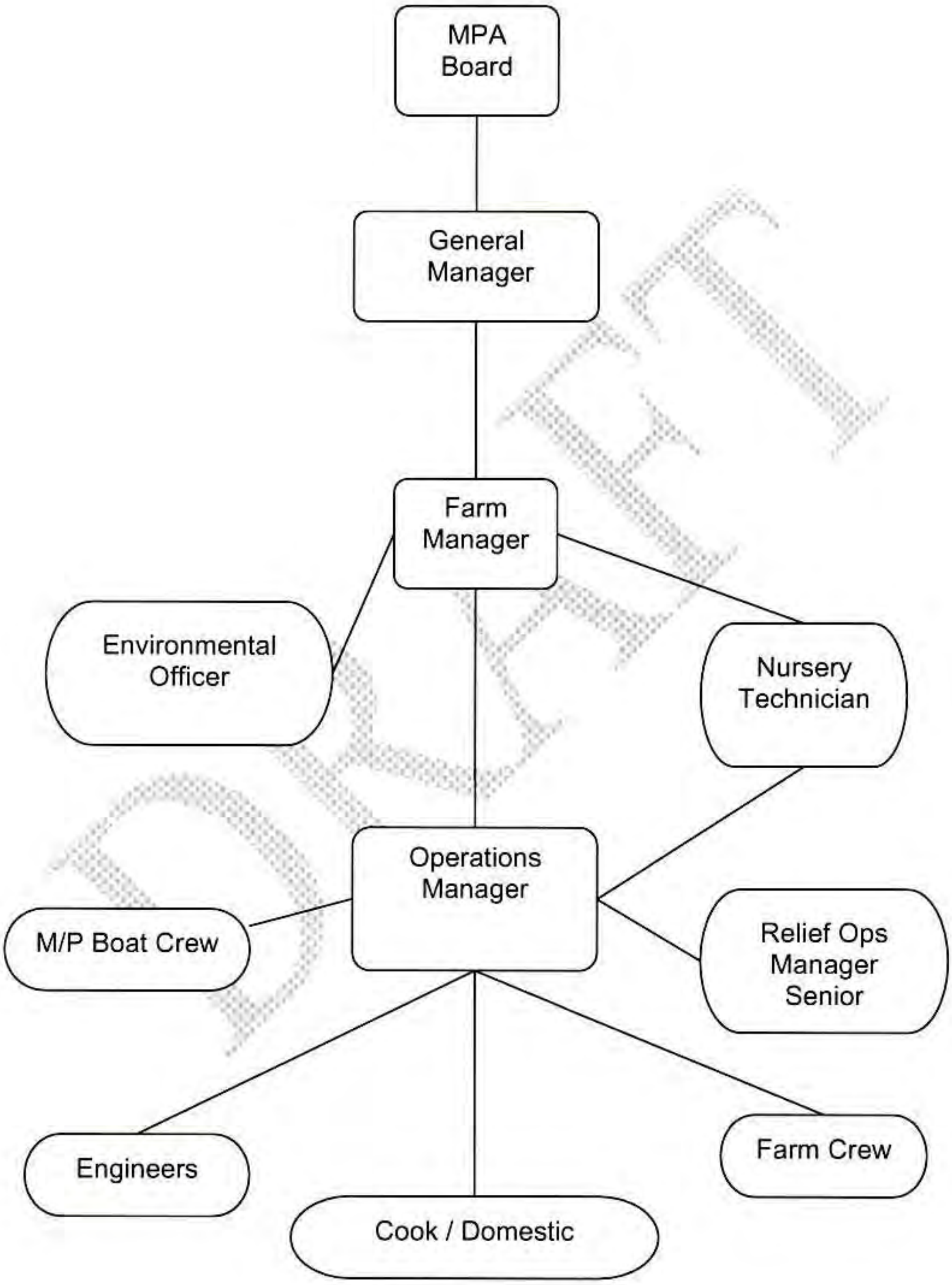
The Vision of MPA Fish Farms Pty Ltd is

To grow, farm and harvest high quality marine fish for profit whilst preserving the pristine marine environment in which these activities occur.

Cone Bay Barramundi, (a project of MPA Fish Farms) operates in a natural environment and consequently operates with implemented policies and procedures that respect the future sustainability of that environment. MPA Fish Farms is committed to identifying and implementing systems and procedures that at minimum are required by licensing regulations and also aims to identify and implement, or even exceed, best practice recommendations.

The following Operational and Environmental procedures are implemented by Cone Bay Barramundi as proactive measures to reduce or remove any associated risks to the staff, product or natural environment in which the Fish Farm operates:

Personnel Flowchart



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Sea Cage Fish Feeding Procedures

Responsibility:
The Operations Manager holds responsibility for this Activity

All fish are fed to saturation every day

Marine farming is about turning fish feed into saleable fish at the lowest cost while minimising the impact to the environment. The most important economic consideration is maximising growth of stock by ensuring an effective feeding regime is in place. Quick growing fish spend less time on the farm and accrue less cost on a per kilo basis. In addition less feed input & resulting waste is expelled to the environment.

Whilst the feeding program is aimed at feeding all fish to saturation, this does not mean putting out food that will not be eaten, so to prevent additional nutrient input.

All efforts should be made to ensure that all pellets are being eaten.

Feeding

- During times of strong tidal flow always position the feed boat so that feed can be dispensed into the up-tide side of the cage. This allows fish maximum time to eat the feed before it exits the leeward side of the cage.
- When feeding with the feed blower, choose the feed input rate that allows the fish to be fed to saturation within 20 minutes feeding time per cage.
- If using the camera, position the camera so that it is 1-2m above the bottom of the cage and in a position to capture pellets that are taken by the tidal flow.

Observe the Stop Feeding Signal

If feeding using surface visual cues: When the fish feeding behaviour ceases then slow feed input rate to the slowest possible input rate. Feed at the lowest possible feed rate until fish feeding behaviour ceases then cease feeding completely.

If feeding using underwater camera: When the fish feeding behaviour ceases and uneaten pellets are detected then slow feed input rate to the slowest possible input rate. Feed at the lowest possible feed rate until fish feeding behaviour ceases and uneaten pellets are detected then cease feeding completely.

Fish weight checking Protocols

- Fish sample size needs to be at least 0.5% of cage population numbers.
- Use anaesthetic (AQUI – S) at prescribed dosage.
- Make sure scales are mounted on the boat for greatest stability and accuracy.
- Do not sample if it is too rough to get an accurate weight reading.
- Fish are batch sampled in at least 250kg of seawater, and where possible in batches of greater then 50kg.
- Dip fish into weight check bin, record stable weight, count fish out and record.

Nursery to Sea cage Fish Transfer

Once fish are deemed size suitable to be transported to a cage, a boat is fitted with one or two transfer tanks. To service these tanks you will also need at least two bottles of oxygen on board and corresponding hoses and wedge lock stones.

- Fish are gravity fed to the tanks on the transport boat via a hose connected to the external drain on each tank. (Make sure that the hose is securely connected before pulling the plug in the tank).
- Preferably drop the water level in each tank prior to transfer which will decrease the amount of time spent transferring fish.
- Monitor oxygen levels whilst in transport, maintaining levels between five and eight ppm. If the fish look extremely stressed you may want to turn it up as high as ten ppm.
- Once along side, secure the boat to the selected cage.
- Commence to net the fish out of each tank and place them into the cage. **Remember to be as gentle as possible.**

Sea Cage to Sea Cage Fish Transfer

The transfer of fish from sea cage to sea cage is required to keep the biomass of any one cage at an acceptable level. This is required to promote fish health and to reduce environmental impact by limiting nutrient input in any one area over a given time.

The sea cage to sea cage fish transfer procedure is as follows:

- The day before the transfer is scheduled the raft is to be towed from Snapper Cove and moored in Cone Bay. The silk stream fish pump and appropriate hoses are then secured to the raft.
- On the day of the transfer the crew will be briefed on the details of the transfer before work begins. A dive team will assess both the cages and check the nets for and holes or damage prior to the start of the transfer.

- The raft with the silk stream fish pump will be towed to the designated cage and secured, the empty cage will then be position along side and secured to both the other cage and the raft.
- While the cage and raft are being positioned a crowd net will be run around the full cage in preparation for the transfer.
- Once all lines are secure and the dive team has given the 'all clear' the pipes will be positioned and the transfer will begin.
- When the required biomass has been transferred into the empty cage the pump will be shut down and removed from the cages. Whilst the equipment is being removed a dive team will re-inspect both cages to again check for net damage and to gauge fish health and fish numbers.
- After receiving the 'all clear' from the dive team, the cage that is out of its mooring position will be towed back to its allotted mooring ID and bridles and mooring lines will be secured.

The raft will then be towed back to the island to enable the silk stream fish pump and associated hoses to be removed, cleaned and stored. Following this, the raft will be returned to its mooring in *Snapper Cove.*

Equipment Required

- Raft
- Silk stream fish pump
- Pump hoses and all clamps and couplings
- Dive equipment (see dive operating procedure)
- Crowd net

APPENDIX M

FISH HARVESTING PROCEDURES MANUAL

CONE BAY

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AUSTRALIA'S FLAVOURITE BARRAMUNDI

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Harvest

Procedures Manual

The Vision of MPA Fish Farms Pty Ltd is

To grow, farm and harvest high quality marine fish for profit whilst preserving the pristine marine environment in which these activities occur.

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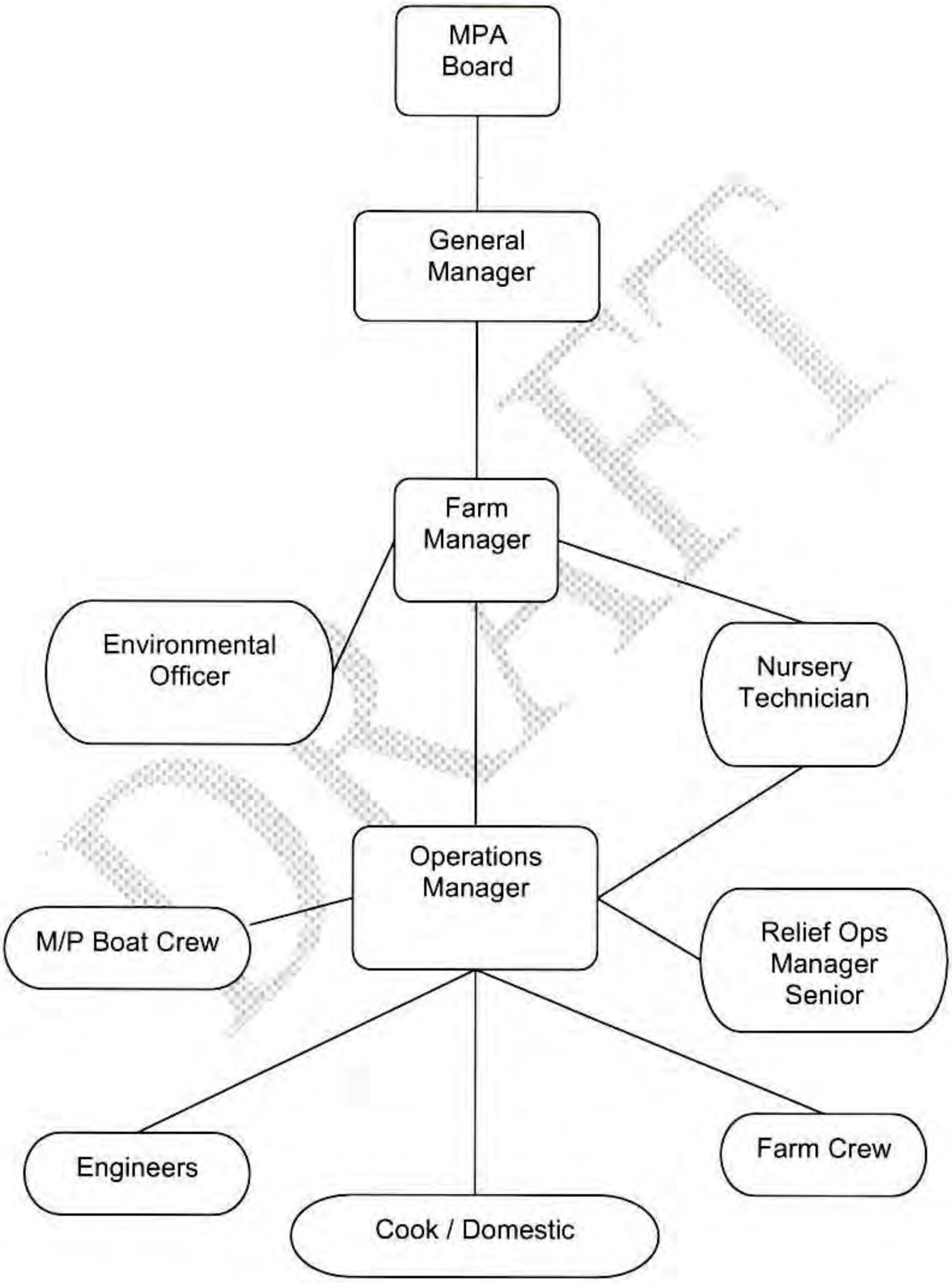
The following Operational and Environmental procedures are implemented by Cone Bay Barramundi as proactive measures to reduce or remove any associated risks to the staff, product or natural environment in which the Fish Farm operates:

Personnel Flowchart



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Harvesting:

Responsibility:
The Merindah Pearl Skipper holds responsibility for this Activity.

The harvesting of sea cages is currently a weekly operation involving both crew from the farm and crew from our primary supply vessel the *Merindah Pearl.*

All harvest operations will be commenced as early in the mornings as possible to give the crew as much time as possible to complete the harvest as quickly and efficiently and to also avoid the high temperatures encountered later in the day.

The harvest is organised and run by the skipper in charge of the *Merindah Pearl*, all activities involving harvesting are the skipper's responsibility.

Harvest Procedure

Crew members from the farm will prepare the harvest cage by releasing the mooring bridles where needed. While the cage is being prepared the rest of the harvest crew are to prepare the *Merindah Pearl* .

The *Merindah Pearl* is to manoeuvre alongside the harvest cage where the bridles have been removed and tied on securely. The crowd net will be deployed around the cage and a suitable size crowd will be gathered.

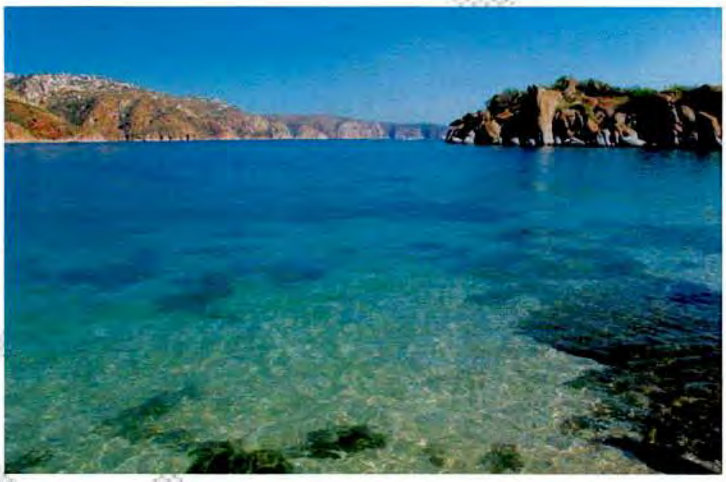
Using the dip net from the hiab (articulated hydraulic crane) on *Merindah Pearl's* deck the fish will be scooped from the crowd net and lifted onto the sorting table where they will be separated into harvest size and undersize, those undersize will be put back into the cage outside the crowd net, those of harvest size will be stunned humanely and placed straight into a prepared ice slurry for 5 hours.

APPENDIX N

ENVIRONMENTAL MANAGEMENT SYSTEM

CONE BAY
Barramundi™

AUSTRALIA'S FLAVOURITE BARRAMUNDI



Environmental Management System

October 2007

A division of

Marine Produce Australia

Cone Bay Barramundi

Environmental Management System

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Page Number

Marine Produce Australia. The farm site is located west of Derby in Western Australia's infamous and immaculate Buccaneer Archipelago.

Cone Bay Barramundi's 100 ton Nursery system and staff accommodation are situated on the land base of Turtle Island with the grow out polar sea cages anchored in the pristine waters of Cone Bay. Additional sea cages will soon be located in the nearby site of Crawford Bay.

Barramundi Fingerlings are reared in the Island based nursery system where they are continuously feed by a computerised automatic pulse feeding unit in addition to being hand fed up to three times per day.
Once grown to appropriate size fingerlings are transported to one of the 12 polar sea cages which are securely anchored to the mud based substrate of the bay. Fish are hand fed specialised Barramundi feed pellets by staff on a continuous basis throughout the day.

Whole Fish are harvested from the sea cages at a minimum of 2kg and transported by boat to Derby Wharf and by chilled transport on to Perth for sale to the domestic and future export market/s.

Marine Produce Australia Limited (MPA) recognises and respects the uniquely diverse business, social and natural environments in which the fish farm operates. Sustainability is a concept that brings together the expectations of many and varied interest groups and stakeholders. It is not a concept that is used lightly by any of these groups when engaging with a business environment. Essentially it is the combination of economic, social or community and environmental values and objectives in the right blend so as to have a business that is sound and robust while catering to the needs of its people and the community in which it operates, and does no lasting harm to the environment.

No longer can a business operate in a natural environment without implementing policies and procedures that respect the future sustainability of that environment. MPA is committed to identifying and implementing systems and procedures that at minimum are required by licensing regulations, and also aims to identify and implement, or even exceed, best practice recommendations.

Marine Produce Australia Pty Ltd is committed to demonstrating quality environmental performance and adopts the "Plan-Do-Check-Act" cycle by which the ISO-14001 Environmental Systems is based. This cycle ensures that there is continual improvement within the Company's Environmental Management System [EMS].

MPA has developed an Environmental Policy to establish the vision, direction and guiding principles for environmental management within its operations and this EMS manual to provide a framework for the implementation of the policy. The EMS documents how MPA as a Company is currently meeting our responsibilities within the *MPA Fish Farm Barramundi* operation in addition to outlining how the Business will adopt further measures to continually improve and demonstrate our ongoing environmental performance.

It is important that all MPA personnel are committed to, and involved in addressing environmental issues in the workplace. Environmental issues need to be an integrated component of every decision we make as part of our business. MPA Fish Farms has a duty of care to protect the environment in which we operate and all personnel should be aware of their responsibility to do the same.

COMPANY VISION

To grow, farm and harvest high quality marine fish for profit whilst preserving the pristine marine environment in which these activities occur.

SCOPE

The following activities have been identified as those which may have an impact on the natural environment in which the Fish Farm operates:

Activity:	Responsibility of:
• Sea Cages o Building Sea Cages o Mooring Sea Cages o Marine Entanglement o Floating Sea Cages o Sea Cage maintenance o Cleaning Sea Cages o Escapes	- Senior Farm Hands
• Translocation of Fingerlings o To Nursery o To Sea Cages	- Farm Manager
• Nursery o Stocking o Feeding	- Nursery Technicians
• Grow Out o Stocking o Feeding	- Senior Farm Hands

- Chemicals - Farm Manager
    - Fuel, Storage & Equipment refuelling
    - Use and Storage of Chemicals

- Predator Exclusion - Farm Manager

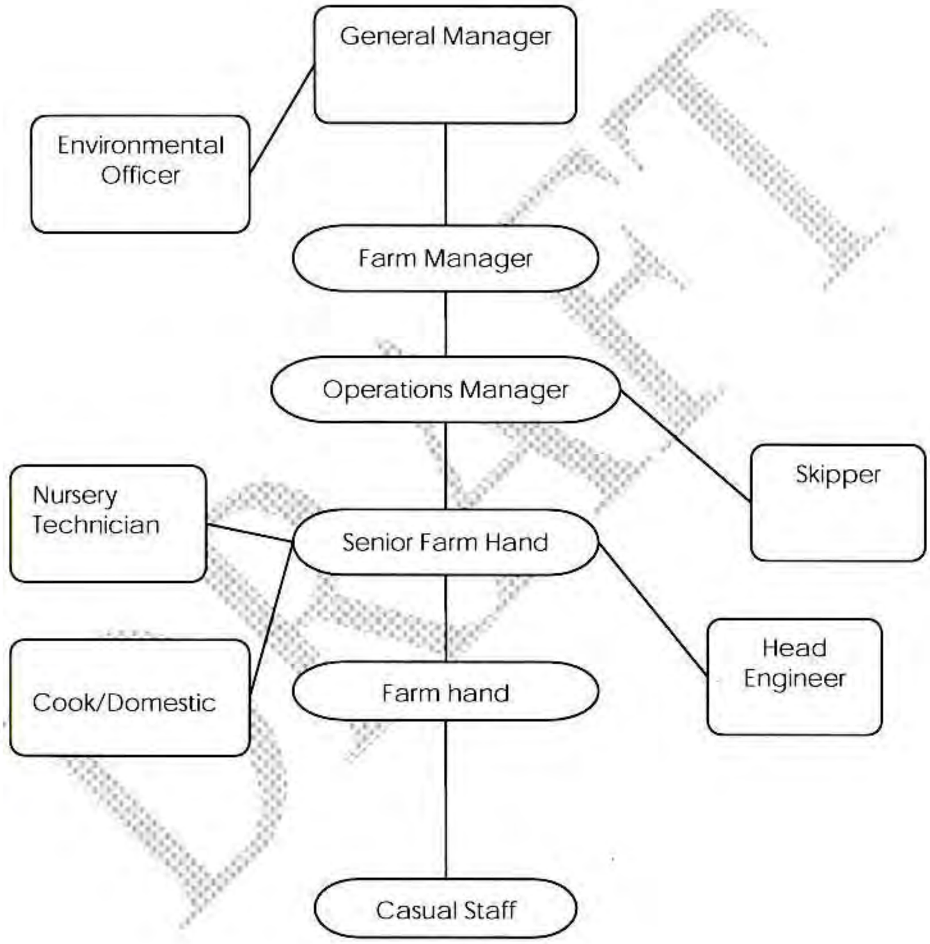
- Aesthetics - Farm Manager
- Infrastructure
- Waste
- Dead Fish
- Noise
- Fuel/energy use
- Purchasing of products

DEFINITIONS OF ROLES & RESPONSIBILITIES

The Managing Director of Cone Bay Barramundi is directly responsible to the MPA Company Board of Directors.

Cone Bay Barramundi

Roles & Responsibility Flowchart



General Manager

Core Responsibility:
- Implementation of Company policy
- Provide information to Board to aid in formation of policy

Environmental Officer

Core Responsibility:
- Maintain & Report on Environmental Performance

Farm Manager

Core responsibility:
- Work safely in accordance with company policy and government legislation.
- Lead and manage MPA marine operations.
- Provide information to General Manager on which to base discussions

Senior Farm Hand

Core responsibility:
- Work safely in accordance with company policy and government legislation.
- Maximise fish growth and performance.
- Safeguard stock security.
- Actively monitor fish health.
- Ensure budgetary targets are met or improved upon.
- Ensure farm compliance with Department of Fisheries marine farming license conditions.

Skipper

Core responsibility:
- Work safe in accordance with company policy and government legislation.
- Manage all vessel operations so as to maximize reliability, efficiency and flexibility of the Cone Bay logistical operation.
- Proactively maintain the transport vessel so as to minimise lost time through break down.

Nursery Technician

Core responsibility:
- Work safely in accordance with company policy and government legislation.
- Maximise fish growth performance.
- Minimise feed conversation ratio.

Head Engineer

Core responsibility:

- Work safely in accordance with company policy and government legislation.
- Proactively maintain all farm marine farm/ island plant and equipment so as to minimise lost production and stock loss due to equipment failure.
- Manage the marine farm and island maintenance/engineering operations.

Farm Hand

Core responsibility:

- Work safely in accordance with company policy and government legislation.
- Maximise fish growth.
- Safeguard stock security.

Cook /Domestic

Core responsibility:

- Providing high quality meals to the personnel staying at Cone Bay.
- Meeting or doing better then the allotted budget for stores.
- Meeting the nutritional guidelines.
- Maintaining exemplary standards of kitchen hygiene.
- Provision of laundry services on the island.
- Cleaning communal facilities.

LEGAL REQUIREMENTS

Aquaculture Licence No. 1465

Held by Maxima Pearling Company Pty Ltd

PO Box 843

BROOME WA 6725

Authorised until **Tuesday 15th January, 2008**

Pursuant to section 92 of the Fish Resources Management Act 1994, the licensee named above is authorized to engage in the aquaculture of the fish specified in the "Species" schedule in the waters as specified in the "Location" schedule and subject to the relevant conditions and restrictions as specified. (See Licence Schedule 4 - Conditions and Restrictions)

NB: Use of Licence No. 1465 by MPA Fish Farms is by Agreement with Maxima Pearling Company Pty Ltd.

RISK ASSESSMENT

The following potential risks were identified through a close analysis of each Farming Activity and ranked according to their potential impact. Control measures are implemented as standard operating procedures noting essential resources required to closely monitor and review the entire Management System.

Relevant Guidelines and Departmental legislations, regulations and licence conditions by which the Business needs to comply are also noted within this section.

Risk Matrix

		Consequences					
		1	2	3	4	5	6
Likelihood		Negligible	Minor	Moderate	Severe	Major	Catastrophic
6	Likely	6	12	18	24	30	36
5	Occasional	5	10	15	20	25	30
4	Possible	4	8	12	16	20	24
3	Unlikely	3	6	9	12	15	18
2	Rare	2	4	6	8	10	12
1	Remote	1	2	3	4	5	6

SEA CAGES:

Relevent guidelines:

Environmental protection act 1986.

Part 8 of the "Fish resource management act 1994".

Guidence statement 29, "Benthic primary producer habitat protection", EPA 2004.

Building sea cages & Nets:

The current building of sea cages & nets is done on the south beach of Turtle Island Cone Bay. The cages are constructed roughly halfway down the beach and the cages being constructed are covered during high tide.

Sea cages are built on the Island and launched at Bay View on high tide to avoid damage to the beach.

Issue	Risk or cause of risk	Like'hd (rank)	Impact	Cons (rank)	Risk (rank)	Current control measures (EMS actions)	Possible additional control measures (EMS actions)
Building sea cages on the beach	Change of beach demographic	2	Change to natural environment	1	2	The cages are always left flat so as not to trap fish at high tide	

Mooring sea cages:

The sea cages being used in cone bay are moored in two, six cage grid systems. The main issue with mooring the cages is the damage to the benthic substrate from the anchor system and the effects the cages will have on the substrate. The effect of anchor drag on the benthic environment is one of the primary concerns with the mooring of the cages. The substrate that the mooring system is located on is a mud based substrate (Brown and Root, 2000) which is ideal for the anchoring of sea cages as once the anchors have been placed they "dig-in" and there is little to no anchor drag.

Issue	Risk or cause of risk	Like'hd (rank)	Impact	Cons. (rank)	Risk (rank)	Current control measures (EMS actions)	Possible additional control measures (EMS actions)
Anchoring sea cages	Anchor drag	4	Damage to the benthic substrate	1	4	All anchors are at least 100 metres from coral or seagrass. All anchors are tensioned upon placement.	

Marine entanglement:

The entanglement of marine fauna in anchor lines is a concern yet there is no evidence that the local marine fauna could become entangled. All the anchor lines and related lines are kept taught and are checked regularly to minimize any chance of interaction with the local marine fauna.

Issue	Risk or cause of risk	Like'hd (rank)	Impact	Cons. (rank)	Risk (rank)	Current control measures (EMS actions)	Possible additional control measures (EMS actions)
Entanglement of fauna	Anchor lines & Predator exclusion nets	1	Dead or injured marine fauna	0	1	All anchor lines are kept taught and there is no predator exclusion nets	

* All nets are rigid mesh steel or plastic and do not fold

Floating the cages:

Floating the cages requires the tying of floats around the sides of the built cage and onto the bottom of the cage and using a high spring tide to tow the cage off the beach. The floating cage is then secured to a polar circle

Issue	Risk or cause of risk	Like'hd (rank)	Impact	Cons. (rank)	Risk (rank)	Current control measures (EMS actions)	Possible additional control measures (EMS actions)
Potential damage to the environment from the floating of cages	Floating cages on the south beach of turtle island	4	Impact on the aesthetic value from loss of bois when removing to attach to the polar circle	1	4	When floating cages there are staff in boats collecting all the bois that are removed from the cage	

Cage maintenance:

The cages require continuous maintenance in order to keep them in good condition. This includes cleaning the fowling off the steel mesh, checking for damage or areas that could potentially become holes; check support ropes and shackles and checking the overall condition of the cage.

* Nets are kept clean to minimize fouling and maximize water flow within the net.

Cleaning of the cages:

There is no anti-foul coating used on the cages so there is no risk of introducing this into the local marine environment. The cages are cleaned by divers using a high pressure water hose, this hose uses sea water so there is no impute of chemicals or fresh water into the environment.

Issue	Risk or cause of risk	Like'hd (rank)	Impact	Cons. (rank)	Risk (rank)	Current control measures (EMS actions)	Possible additional control measures (EMS actions)
Impute of chemicals from cage cleaning	Cleaning cages	1	No impact as no chemicals are used	0	0	No chemical or fresh water are used in the cleaning of the cages	

Escapes:

The problem of escapes is considered to be of the highest priority and all possible precautions are taken in order to prevent fish escapes. The sea cages are continually checked by divers looking for areas where holes could develop or areas on the cage that are damaged. There is no effective method of dealing with fish that have escaped so the emphasis is on escape prevention.

Issue	Risk or cause of risk	Like'hd (rank)	Impact	Cons. (rank)	Risk (rank)	Current control measures (EMS actions)	Possible additional control measures (EMS actions)
Fish escapes	Farmed Barramundi escaping into the local environment	4	Addition of no local Barramundi into the local environment	2	8	Continuous cage maintenance to prevent holes appearing	

- All nets are heavy duty steel or plastic mesh
- All nets are purpose designed for containment
- Mesh is sized appropriately for fish being held

TRANSLOCATION OF FINGERLINGS:

Relevant Guidelines:

Section 92 of the" Fisheries Resources Management Act 1992"

Translocation of barramundi under regulation 176 of the "Fish resource management regulations 1995"

Fisheries management paper 159, "Translocation of barramundi for aquaculture and recreational fishery enhancement in Western Australia"

Ministerial guideline number 5. "The aquaculture and recreational fishing stock enhancement of non-endemic species in Western Australia"

To Nursery:

The introduction of fingerling's from outside the local region has two primary risks. They are the introduction of new disease and the introduction of different genetic material into the local population. Our licence requires that all fingerling's are certified disease free by state veterinary authorities before they are transported to our Cone bay site. It is almost impossible for the fingerling's to escape during translocation into the nursery as they are in sealed containers until they are in the nursery tanks.

To Sea cages:

The possibility of losing fish from the nursery to the sea cages is remote and the staff involved in this process are experienced and well trained so as to minimise any chance of lost fish. The use of specially designed transfer tanks and strict operating protocols keeps the risk to a minimum.

Issue	Risk or cause of risk	Like'hd (rank)	Impact	Cons. (rank)	Risk (rank)	Current control measures (EMS actions)	Possible additional control measures (EMS actions)
Translocation of Barramundi	Introduction of disease or genetic variation	2	Damage to local Barramundi population	1	2	Certification that all fingerling's are disease free before coming to our facility and strict translocation protocols	

NURSERY:

Stocking:

The stocking density of the fingerlings in the nursery will be kept at as conservative a level as possible. The conservative stocking densities will produce less concentrated waste from each tank and also provide a better environment for the fingerling's to grow, producing lower mortalities and better growth rates.

Issue	Risk or cause of risk	Like'hd (rank)	Impact	Cons. (rank)	Risk (rank)	Current control measures (EMS actions)	Possible additional control measures (EMS actions)
Nutrient waste from nursery	Overstocking of nursery tanks	3	Increased pressure of filtration system	1	3	Conservative stocking densities and high capacity filtration system	

Feeding:

The waste water produced by the nursery is filtered through a screen filter system removing waste down to 100 microns in size; this is transferred into a "geo-tube" which is removed from the island when full. The filtered water then flows back into the bay. The introduction of a computerised auto feeding unit into the nursery helps minimise food wastage thereby decreasing the excess nutrients in the waste water.

Issue	Risk or cause of risk	Like'hd (rank)	Impact	Cons. (rank)	Risk (rank)	Current control measures (EMS actions)	Possible additional control measures (EMS actions)
Nutrient waste from nursery	Excess nutrient waste from feed	2	Increased nutrient outflow into the bay	1	2	Staff training to minimise overfeeding, computerised auto feeding system	

Each tank is designed to remove solids quickly in a separate water stream. This minimizes the amount of nutrient from dissolved particles.

GROW OUT:

Stocking:

Conservative stocking densities are used with a maximum of 50kg/m³. Conservative stocking densities will keep excess nutrient loads from any one particular cage down and will cause less stress on the fish.

Feeding:

The introduction of nutrients into the environment is one of our primary environmental concerns. Feeding is one of the most common ways for excess nutrients to enter the environment.

All staff that work on the feeding boats are trained in how to recognise fish feeding behaviour and modify the feeding rates accordingly. The introduction of mechanised feeders will also increase the efficiency of the feed delivery.

Issue	Risk or cause of risk	Like'hd (rank)	Impact	Cons. (rank)	Risk (rank)	Current control measures (EMS actions)	Possible additional control measures (EMS actions)
Increased nutrient load on the benthic habitat	The increase of nutrients in the environment from feeding and fecal matter	6	Deposition and or accumulation of uneaten feed and faeces increasing nutrients on benthic habitat	4	24	There is an extensive monitoring program in place and and if any damage is observed it is reported immediately	

Under water cameras are deployed whenever feeding is undertaken. These provide clear feedback to the feeder.

CHEMICALS:

Fuel:

The handling and use of fuel, both diesel and petrol, is a constant activity on the farm, and because of this strict operating procedures are in place. The three main activities are the transfer of fuel onto the island, the storage of fuel on the island and the transfer of fuel for use in equipment.

Fuel transfer on the island:

The transfer of diesel fuel onto the island is done from a supply barge and is pumped via a floating pipe into the storage tank on the island.
All petrol on the island is kept in 200 litre drums and this is delivered by a landing barge and forklifted into its storage area.

Fuel storage:

All fuel stored on the island is stored in accordance with the toxic and hazardous substance – storage, use and accidental spill contingency plan. The fuel and storage areas are checked every morning by the islands chief engineer and any problems reported to the island manager.

Refueling of equipment:

The refueling of boats and other equipment has to be done on a regular basis with different methods being used depending on the equipment being fueled. Diesel vessels are fueled on the water from the main supply tank. During this process there is always at least one senior farm hand overseeing the operation and all staff involved are suitably trained in both the fueling process and the accidental spill contingency plan. Petrol vessels are fueled on the south beach from 200 litre drums using a hand pump. As with all fueling procedures the staff involved are trained in both the fueling procedures and the accidental spill contingency plan. Fueling of The tractor and the tender is only done by the engineer on duty.

Use and storage of chemicals:

The use of chemicals on the farm site is strictly monitored and all chemical use is in accordance with our toxic and hazardous substance - storage, use and accidental spill contingency plan.

Handling - the handling of all chemicals will be in accordance with the chemicals material safety data sheet (MSDS) and work place health and safety guidelines will always followed. Storage facilities are constructed to prevent toxic or hazardous substance escape to the environment under any conditions.

Issue	Risk or cause of risk	Like'hd (rank)	Impact	Cons. (rank)	Risk (rank)	Current control measures (EMS actions)	Possible additional control measures (EMS actions)
Pollution from chemical into the local environment from spilled or incorrectly disposed of chemicals	Fuels, oils Paint and any other chemical substance	2	There would be an impact on the quality of the local marine environment affecting local marine life	4	8	A toxic and hazardous substance storage, use and accidental spill contingency plan has been developed and implemented. All fuels and chemicals are correctly stored and no chemicals are used on the sea cages.	

Predator exclusion:

Currently the only predator exclusion devices in use on the farm are bird exclusion nets on all the cages. These nets are designed to stop birds from accessing the fish within the cages by covering the entire top of the cage with extremely strong nylon netting. The possibility of birds getting stuck in or under the netting if the nets are properly maintained is very remote and all our bird nets are checked by staff daily to ensure they are tensioned correctly, as it stops fish getting out by jumping.

Issue	Risk or cause of risk	Like'hd (rank)	Impact	Cons. (rank)	Risk (rank)	Current control measures (EMS actions)	Possible additional control measures (EMS actions)
The possible entanglement of local birds in the predator exclusion nets	The use of bird exclusion nets over the sea cages and possible entanglement	2	Potential injury or death of local bird life from entanglement in the nets	3	6	All predator exclusion nets are kept properly tensioned and are checked by feeding crews daily.	

- All bird nets are made from small mesh to minimize risk of entanglement.
- All nets used to contain the fish are made from strong, rigid netting which also acts as a predator exclusion net.

AESTHETICS:

The aesthetic value of the Kimberly region is world renowned and with this in mind all decisions relating to any activity in the area will be carefully considered. The use of low-profile black polar circles for all sea cages to minimise the visual impact and using as few visual navigational markers as considered safe.

Issue	Risk or cause of risk	Like'hd (rank)	Impact	Cons. (rank)	Risk (rank)	Current control measures (EMS actions)	Possible additional control measures (EMS actions)
Lowering of aesthetic value	Reduction in the visual appeal due to infrastructure	2	Potential loss of visual appeal from sea cages and mooring systems in the bay	2	4	Use of low profile cages in dark colours and as few markers as is safe set in a neat and orderly way Always considering the visual impact of any new structure built on the island or in the bay.	

WASTE

Waste will be kept to a minimum and the policy of reduce, re-use and recycle is followed in all production areas. A waste management plan has been established and is currently in the process of being implemented.

Issue	Risk or cause of risk	Like'hd (rank)	Impact	Cons. (rank)	Risk (rank)	Current control measures (EMS actions)	Possible additional control measures (EMS actions)
General waste	General waste in the form of litter will be produced from normal farm operations	2	Potential reduction in water quality and harm to wildlife if entanglement or ingestion occurs. Could also spoil the visual amenity of the area	3	6	All rubbish and discarded material is removed from the sea based operation and transported to Turtle island for re-use, recycling or disposal. All waste will be recycled or disposed of in accordance with our pre-existing waste management program	

DEAD FISH:

With the current expansion of the farm the disposal of dead fish from the system will need to be addressed. Currently it is being proposed to ensile the dead fish and either use the by products on the island or transport them off the island for disposal or reuse.

Issue	Risk or cause of risk	Like'hd (rank)	Impact	Cons. (rank)	Risk (rank)	Current control measures (EMS actions)	Possible additional control measures (EMS actions)
Fish odour	Fish odour due to dead fish	3	Reduced air quality, adverse effect on the aesthetic value of the area	2	6	All mortalities are collected as soon as observed and are disposed of by burying them in a designated waste pit	Currently the process for ensiling the mortalities is being developed and will be implemented on the island once complete.

NOISE:

As Cone Bay is such a remote location the effects of noise on other users will be very minimal yet activities that produce excessive noise will be kept to a minimum and will only be conducted during daylight hours.

Issue	Risk or cause of risk	Like'hd (rank)	Impact	Cons. (rank)	Risk (rank)	Current control measures (EMS actions)	Possible additional control measures (EMS actions)
Excess noise in the ares	Noise from equipment	3	Loss of aesthetic value from noise y machinery	2	6	All machinery is serviced regularly to minimise noise emissions. Equipment will not be used while dark where possible	

* Noisy equipment is also an OH&S issue that must be addressed for staff health

ENERGY USE:

The efficient use of fuel and energy is both good environmental policy and good business sense.

The company is always looking into more sustainable energy products to both minimise our effect on the environment and better our business.

Issue	Risk or cause of risk	Like'hd (rank)	Impact	Cons. (rank)	Risk (rank)	Current control measures (EMS actions)	Possible additional control measures (EMS actions)
Emissions from diesel and petrol	Pollution from the inefficient use of energy		Reduced air quality from inefficient engines			Maintain all equipment to the highest standards and only use this equipment where absolutely necessary	The phasing out of all two stroke outboard engines and these will be replaced by four stroke engines with the highest emissions ratings available

PURCHASING:

The company will endeavor to purchase products from ISO 9000 and 14001 certified companies where possible or companies that are actively working on becoming environmentally sustainable.

Issue	Risk or cause of risk	Like'hd (rank)	Impact	Cons. (rank)	Risk (rank)	Current control measures (EMS actions)	Possible additional control measures (EMS actions)
Purchasing for the company in an environmentally conscious manner	Minimising the environmental effect of the products used in our operations	NA	General environmental impacts from our suppliers	NA	NA	There are currently no procedures in place for the purchasing of environmentally sustainable products	The development of a purchasing procedure for the company that focuses on purchasing from mpanies that are ISO 9000 and 14001 certified.

POLICY

MPA recognises the responsibility the organisation has in preserving the environments of the currently utilised Cone Bay and additional proposed Crawford Bay, in addition to the land base of Turtle Island and fully understands the significance of these areas for the Traditional Owners and also those in the Community who wish to visit the areas.

The Cone Bay Saltwater Barramundi project will always meet the environmental regulations required and where ever possible will aim to achieve the best environmental practices.

MPA through its Cone Bay Operation also has a number of environmental objectives that the organisation seeks to achieve on top of the aforementioned environmental regulations; these are as follows.

1. seek to not only protect but to enhance where possible the local and surrounding environment through working with the indigenous community and other stakeholders in the region;
2. work towards becoming a totally sustainable operation through research and innovation and the implementation of sustainable aquaculture practices;
3. contribute to the scientific research into the farming of saltwater Barramundi;
4. reduce, re-use and recycle in all levels of the operation;
5. conduct all environmental management in a transparent and professional manner;
6. regularly review all our environmental monitoring and management plan's and always seek to improve upon these;

These goals are the foundation of the organisations Environmental Management System and will guide any future development;

ACTION PLAN

The *Cone Bay Barramundi* Action Plan consists of several activities, designated people responsible for these actions, a clear communication strategy and required resources to make the Action Plan happen!

The General Manager, Farm Manager, Environmental Officer and Business Development Manager are all provided with a current copy of the Action Plan to ensure an understanding of what each key person is aiming to achieve and their roles within this plan.

Environmental Management *Responsibility of the Farm Manager and Environmental Officer*

Reference document:
Cone Bay Sea Cage Aquaculture
Environmental Monitoring and Management Program
Donna Cahill

Cone Bay Barramundi's environmental Management program includes managerial and technical actions to achieve environmental objectives and targets and to address significant environmental aspects. The environmental program is an action plan.

The *Cone Bay Sea Cage Aquaculture Environmental Monitoring and Management Program* was developed to study the potential environmental impact of sea cage culture. In addition to water quality, the benthic substrate, mangrove and fringing reef sites are monitored in an ongoing study. This aids regulation and management of the system to prevent irreversible loss of ecosystem attributes.

Community Relations & Development

Responsibility of the Business/Project Development Manager

Reference document:
Indigenous Employment Strategy
May 2007
Felicity Brown

MPA through its Cone Bay Barramundi project seeks not only to protect but also to enhance, where possible, the local environment by working closely with other stakeholders within the region in addition to enjoying an ongoing strong and positive relationship with the local Indigenous Community known as Yalun, located at the base of Cone Bay.

Through the Company's *Indigenous Employment Strategy*, implemented in 2007, Cone Bay Barramundi acknowledges the many benefits of working closely with the local Community and in particular encourages employment of local Yalun people within the Fish Farming project. This not only addresses labour and skill shortages and staff turnover but also builds a work force for the future and utilises unique skills and knowledge of the area. MPA nurtures the objectives of supporting the achievement of economic independence for local indigenous communities and employing **Local People for Local Jobs**!

Waste Management

Responsibility of the Farm Manager and Environmental Officer

Reference document:

Waste Management Plan (appendix J – PER)

Nikki Jack

February 2007

Cone Bay Barramundi is a strong advocate for waste minimisation and sustainable farming practices. Cone Bay has developed a WMP that assesses the activities, identifies waste products, records amount of waste product, develops management strategies for each waste product and establishes a regular review schedule.

Cone Bay Barramundi's Waste Management Plan enables the Company to comply with the growing requirements for sustainable operational practices that ensure best practice measures are being utilised.

Cone Bay Barramundi implements the objective to reduce, reuse and recycle waste in all levels of the operation in order to achieve the Company's commitment to minimise generated waste. Waste products are treated and disposed of in accordance with the relevant Western Australian Government regulations. Cone Bay Barramundi conducts a regular review of the Waste Management Plan and works towards continual improvement of the principles of waste management practices.

Communication Strategy:

Responsibility of the Managing Director, Farm Manager and Business/Project Development Manager

For effective Environmental Management, Cone Bay Barramundi's policies, objectives, desired outcomes and environmental information must be effectively and efficiently communicated between all parties which engage in, line with or influence the Fish farm's activities.

Effective two-way communication is an important tool to motivate employees. Current internal monthly communication meetings available to staff include:

- Operational meeting
- Licensing & compliance meeting
- Environmental Management meeting
- Community Development meeting

Operational Meetings:

Operational Meetings are held the first Tuesday of each month involving the Managing Director, the Farm Manager, Island Manager and Farm Supervisor's. The aim is to cover all operational issues on site.

Licensing and Compliance Meetings:

These meetings are held the second Tuesday of each month including the Managing Director, Business/Project Development Manager, Contracted Environmental Consultant and Environmental Officer. The aim is to update on all current license statuses, develop a plan for any further required input and ensure everyone is aware of and meeting Departmental requirements and compliance.

Environmental Management meetings:

These meetings are held the third Tuesday of each month involving the Managing Director, the Business/Project Development Manager, Farm Manager, Relief Farm

Managers, Environmental Officer and the Island Manager and cover all Environmental aspects of the Operation.

Community Development:

These meetings are held the forth Tuesday of each month involving the Business/Project Development Manager, the Relief Farm Manager and the Island Manager; primarily surrounding the relationship with neighbouring Yalun Community. These meetings also cover Employment of Yalun Community within the Fish Farming project in addition to any local Community issues pertinent to the Operation.

Training and Competency

Responsibility of the Farm Manager

It is important that all personnel are aware of MPA's commitment to a quality and systematic approach to environmental management and have the knowledge, skills and motivation necessary to ensure that Cone Bay Barramundi meets the Company's environmental Policy.

Development and Co-ordination of operational related environmental training programs ensure all personnel, including contractors, have awareness and are suitably trained.

MPA has established and maintains a training procedure which includes Induction training for new employees and contractors and ongoing training for existing employees.

Training is divided into specific areas including:

1. Operational Training
    a. Induction
    b. On the Job training pertinent to each individual activity
2. Systems Training
    a. Employees roles and responsibilities in achieving conformance with the Environmental Policy, EMS system requirements and procedures;
    b. Actual or potential hazards associated with their work activities;
3. Skills Training
    a. Training of employees in respect to specific skills or technical knowledge required to perform tasks competently;
    b. Development of further required skills;

Training programs have a process for identifying training needs, established and maintained procedures, documentation and records of training programs and who have completed them and an evaluation of the training program.

Cone Bay Barramundi
Training Form

Date:

Type of Training

Conducted By:

Location:

Participants:

Name: Signature:

Supervisors Signature: ____________________

Cone Bay Barramundi

Training Evaluation

Form

Date: ___/___/___

Course: ____

Name:

Course Comments:

Do you Require More Training:

[If so] What Type of Training:

Operating Procedures Manuals

Responsibility of the Farm Manager and Business/Project Development Manager

Each individual Fish Farming Activity has its own Procedures Manual developed and implemented. New and existing staff members are clearly instructed on how to carry out each activity whilst ensuring Safety and Management of personnel, fish and the Environment.

Hard copies of these manuals are kept on site at the farm in addition to copies kept in the Broome Office. Any operational changes are to be forwarded to the Business Development Manager as the designated role for making any such changes to the original Operational Procedures document.

Procedures Manuals Include:

- Nursery Operations
- Barramundi Health Management & Emergency Plan
- Information for Casual Staff
- Marine Farm Operating Procedures
- Dive Operations
- Occupational Health and Safety
- Induction Manual

Document Control

Responsibility of the Business Development Manager

Cone Bay Barramundi acknowledges the importance that all environmental management system documentation be developed and maintained in paper and electronic form to both describe the core elements, practices and procedures for the system and also provide direction to related documents.

With development of such systems and procedures the Company acknowledges the importance for a key person being marked as responsible for making any required alterations to documents and of only keep the latest version of documents to avoid confusion.

Document control procedures ensure:

- Documents can be readily identified and are marked with dates of revision;
- Documents can be easily retrieved;
- Labelling standards as a minimum included control factors such as page numbering and date printed on each page in addition to indicating the position/s responsible;
- Documents are periodically reviewed, revised as necessary and approved for adequacy by authorised personnel prior to use;
- Records of current issues or revisions of documents are maintained and supported by amendment and distribution records;
- The current versions of relevant documents, in particular environmental procedures, are available at all locations where operations essential to the effective functioning of the EMS are performed;
- Obsolete documents are promptly removed from all points of issue and points of use;
- A reference copy of all current and superseded documentation is maintained and filed;
- Obsolete documents retained for legal or other purposes are identified and

Copies of completed documents will be retained for a minimum of seven (7) years from being superseded.

In addition to the above implemented Actions, Cone Bay Barramundi is also strongly dedicated to becoming a totally sustainable operation and has an ongoing commitment to Research and Development supported through the Commonwealth funded *AusIndustry* Research &Development program.

Cone Bay Barramundi's Action Plan defines the goals we aim to achieve in addressing each priority risk, the actions needed to achieve those goals, persons responsible and a deadline for each action. Having clear goals and allocation of responsibility within the Company's personnel structure ensures the Action Plan is successful.

All staff involved will have a copy of the current Action Plan which will assist others to understand what individuals are aiming to achieve and clearly identify their roles in carrying out the Action Plan.

IMPLEMENTATION

Cone Bay Barramundi in carrying out its Environmental plan constantly monitors the Company's priority actions to ensure they are achieving the required outcomes. The Company needs to know that the actions which are implemented are also working and achieving as required and if they are not, then Management need be prepared to make appropriate & immediate changes as circumstances require. A selection of alternative actions should be identified that can be quickly implemented should those previous not be working.

Cone Bay Barramundi is committed to involving the local Community as much as possible acknowledging this continues to build the Company's credibility. Public opinion is always a good indicator of how well the Company is achieving its objective to effectively communicate to and operate within the local community.

AUDIT, CERTIFICATION AND REVIEW

MPA has established and maintains a periodic EMS audit program, which is a key tool to determine *Cone Bay Barramundi's* Environmental Policy is being applied and whether the operational EMS conforms to corporate requirements and to systems being implemented and maintained as per requirements of ISO 14001. This audit also ensures Community confidence - that the Company is achieving what we say we are.

This Audit program is carried out annually by Company Representatives including the Managing Director whose experience in Auditing selects him as the most likely candidate, the Business Development Manager for their experience in Environmental Management Systems and the Environmental Technical Officer position for their appropriate skills base. Apart from being suitably trained for conducting audits, these personnel are also independent of those having direct responsibility for the work being performed.

The results of audits are to be documented in an audit report and presented for Management Review. Where non conforming activities are identified, corrective and preventative action must be initiated.

MPA acknowledges that a formal review of Cone Bay Barramundi's environmental management system must take place on a regular basis to ensure continuing suitability, adequacy and effectiveness.

The Review process accounts for:

a. EMS Audit findings;
b. The Commitment to continual improvement;
c. Changes in economic circumstances;
d. Changing expectations and requirements of interested parties;
e. New or altered legislative requirements;
f. Advances in science and technology;
g. New business methods;
h. New activities;

i. Market preferences;

j. Complaints/views of stakeholders;

k. Correspondence from authorities regarding environmental performance;

EMS Element	Auditor	Audit Date	Location	Checklist Available	Audit Conducted
1. Company Vision					
2. Activities					
3. Legal Requirements					
4. Risk Assessment					
5. Policy					
6. Action Plan					
7. Implementation					
8. Audit, Certification & Review					
9. Reporting					
10. Reference Material					

Cone Bay Barramundi Auditing Schedule

Auditor's Signature: ....

REPORTING:

1. MPA Board

   Monthly reports are completed by individuals and forwarded to their respective Managers to then be compiled with other regular operational reports and submitted by the Managing Director to the MPA Board of Directors as a holistic monthly project report. Staff members are encouraged to submit their reports on the first day of each month for the Manager to compile and submit the comprehensive report to the Board prior to the 15th of each month;

2. Government Bodies

   Regular communication with Government Bodies is required as part of the license and approval conditions for *Cone Bay Barramundi*. The Business Development Manager's position is available for this ongoing liaison with the additional support of the Managing Director's role.

3. Joint Venture Partners:

   Regular liaison with Maxima Pearling Company as a Venture Partner take place on both a ground level and further financial level with required reports provided to MPC on a monthly basis.

4. Shareholders:

   Shareholders of MPA as an ASX listed Company are provided with regular press releases made public to the market in addition to an annual report and invitation to the Company's Annual General Meeting.

5. General Public:

   Communication with the General Public and local Community is an important part of the Fish Farming project's operations. Open communication gives the community confidence that Cone Bay Barramundi is adequately and responsibly managing the impacts of its activities and therefore environmental issues. Regular reports to the local media are provided in response to media releases to the market and further discussion is encouraged.

REFERENCE DOCUMENTS & MATERIAL;

- Marine Produce Australia Annual Report 2006
- Seafood Services Australia
- Pearl producers Association – Pearling industry environmental Management System
- Cone Bay Barramundi Indigenous Employment Strategy, May 2007, by *Felicity Brown*
- Waste Management Plan (appendix J – PER) by *Nikki Jack*, February 2007
- Aquaculture Licence No. 1465
- Cone Bay Sea Cage Aquaculture Environmental Monitoring & Management Program *by Donna Cahill*