DRAFT

Environmental Impact Statement

Proposed Barramundi Fish Farm at Port Patterson, Northern Territory

Prepared by
Enesar Consulting Pty Ltd

for
MARINE HARVEST

May 2006
(Report No. HO02072/02-Port Patterson EIS)

DRAFT

Environmental Impact Statement

Proposed Barramundi Fish Farm at Port Patterson, Northern Territory

Prepared by
Enesar Consulting Pty Ltd

for
MARINE HARVEST

May 2006

(Report No. HO02072/02-Port Patterson EIS)

Contents

Tables

Plates

Figures

Appendices

Foreword

This Environmental Impact Statement (EIS) for Port Patterson in the Northern Territory is one of three EIS documents for new barramundi fish farms which have been proposed by Marine Harvest. Marine Harvest's business strategy requires that three sites be operational in order for the barramundi fish-farming venture to be viable. The other two sites proposed for barramundi farms are Snake Bay and Channel Island. Marine Harvest has prioritised the sites on the basis of the distance and associated transport logistics from Darwin. It considers that the Channel Island site is the first priority, with Port Patterson being the second and Snake Bay being the third.

On 7 March 2006, Marine Harvest was bought out by Pan Fish, a Norwegian aquaculture company, producing, world-wide, around one third of the quantity of fish produced by Marine Harvest. It is likely, given the size and history of Marine Harvest, that many of its procedures and policies will be adopted by Pan Fish. Hence Marine Harvest's commitment to sustainable aquaculture is expected to be maintained.

As this EIS has been commissioned by Marine Harvest for the purpose of satisfying the EIS requirements for approval of a controlled action under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act), the report will continue to refer to Marine Harvest, rather than Pan Fish, as the proponent.

1 Executive Summary

1.1 Introduction

Marine Harvest is planning to develop and operate a barramundi sea-cage fish farm within a proposed marine farming lease located at Port Patterson, in the Northern Territory. The Port Patterson farm is proposed to be one of three barramundi farms, the other two sites being Snake Bay and Channel Island. Marine Harvest's business strategy requires that three sites be operational in order for the barramundi fish-farming venture to be viable. Marine Harvest has prioritised the sites on the basis of the distance and associated transport logistics from Darwin. It considers that the Channel Island site is the first priority, with Port Patterson being the second and Snake Bay being the third.

The Northern Territory Minister for Natural Resources, Environment and Heritage, confirmed that the proposal would require assessment under the *Environmental Assessment Act* 1994 at the level of an Environmental Impact Statement (EIS). The Minister provided Marine Harvest with guidelines for the EIS which were drawn up in accordance with Schedule 1 of the *Bilateral Agreement between the Commonwealth of Australia and the Northern Territory* under Section 45 of the EPBC Act. This EIS provides sufficient and detailed information relating to the proposal and the environment to permit informed public comment and to facilitate a decision relating to the approval for the development.

1.2 Description of Proposal

The proposed Port Patterson farm will be based on the pilot barramundi sea-cage fish farm which has been operated by Marine Harvest at Port Hurd, on Bathurst Island in the Northern Territory, since 2000. The proposed farm will have the capacity, after a lead up period of two years, to produce 1500 tonnes of fish per year.

The long term aim is to grow the site to the stage where it will be able to produce up to 5000 tonnes of fish per year. All stock, from juvenile-size upwards, will be housed in steel mesh pens and fed pelletised food from automatic feeding stations. Harvested fish will be transported to Darwin live, by well boat, or killed and chilled on the barge prior to transportation.

The farm will be run from a barge moored and situated in the centre of the nets. It will be serviced directly by boat from Darwin.

1.3 Objectives of the Proposal

Marine Harvest intends to develop a sustainable farmed barramundi fish industry and market, while preventing or minimising impacts to the surrounding environment.

The project will have many benefits including:

- Enhancement of the local economy through direct employment of local workers and contractors,
- Social enhancement of remote areas through employment opportunities, and
- A reduction of pressure on wild barramundi stocks

To justify its investment in improved infrastructure Marine Harvest needs to improve current economies of scale and to harvest more than 1000 tonnes per annum from each proposed farm. According to its research, Marine Harvest could sell up to 5000 tonnes of farmed barramundi in Australia before it would have a need to export.

1.4 Location

The proposed location for the barramundi farm site is near Doug Point, within Geranium Channel, Port Patterson, Northern Territory. Port Patterson is located approximately 45 kilometres to the south-west of Darwin. Port Patterson is connected to Bynoe Harbour, at the ocean entrance and to the south of Indian Island, which separates both bays over around 17 kilometres.

1.5 Schedule

It is anticipated that construction of the operation will be a staged process. Stage 1 of construction will take place over approximately 12 months and will involve the construction of sea pens able to farm up to 1500 tonnes of fish per year. It is expected that basic infrastructure to begin fish farming could be in place within the first 7 months, and the farm would be fully serviced from the farm-based barge.

Stage 2 will occur over a further 12-month period and will involve the construction of additional pens to allow production to increase to 5,000 tonnes per year. The farm is expected to operate indefinitely.

1.6 Layout and Infrastructure

The proposed long term facility will be entirely contained on water and will not comprise any on-shore facilities. The proposed farm will include the following infrastructure:

- A central automatic barge – which will comprise; live-aboard facilities, fresh water storage, a workshop, feed silos, feed distribution equipment, a dead-fish ensiler and chemical and fuel storage facilities;
- Steel mesh nets (pens);
- A mooring system consisting of cyclone-proof anchors; and
- Outboard motor boats for movement of personnel, day-to-day goods and waste disposal.

The pens will be plastic circles of approximately 48 metres circumference. The pens will be made with steel-net mesh which, at the pilot Port Hurd operation, has been proven to exclude crocodiles and sharks, and to not entrap predators. The holding nets will have 8-metre deep side walls with a maximum net depth of 8.5 metres. Each pen will have a minimum seabed clearance of around 2 metres as they will be placed over channel areas that are at least 10 metres deep. The pens will be positioned in two lines of 2 x 6 pens each. Nets will be constructed in Darwin and transported to site. The pens will be attached to the sea floor using steel anchors installed by cyclone-mooring specialists.

The site will be clearly visible during the day. At night the barge will be lit up with corner lights and a low impact light shining directly on the outer deck. The outer limit of the sea pens and the lease will be marked with flashing lights to be visible for navigational safety.

1.7 Preferred Design Criteria for the Facility

The main aims of the design include minimising impacts on the physical and biological environment, minimising stress on farmed fish, maximising control on feeding, maximising water circulation and oxygen input, minimising risks of infrastructure and farm fish losses and complying with applicable legislation and standards.

The following design criteria have been chosen for the fish nets:

- Use of galvanised steel nets, for grow-out and nursery pens, with 35-mm bar mesh.
- Use of polyethylene fibre net placed on the inside of the steel nets for nursery purposes.
- Placement of nursery pens in different current corridors to that of the grow-out pens.
- Use of sacrificial aluminium anodes suspended 4 metres below the water surface to protect the nets from corrosion below the water line.
- Placement of the nets over, at least, a 12 to 13 metre deep channel, so that all nets have at least 2 metres clearance from the seafloor; and
- Periodic replacement of approximately 1 metre of mesh around the collar of the cages to eliminate corrosion.

The barge will be sited in the centre of the array of nets and will be manned 24 hours a day. Concrete slabs will be used as the pontoon base for the construction of the barge, and Styrofoam will be used to pad the sides of the concrete slabs. Donga-style demountable buildings will be bolted onto the concrete slabs. The barge will be automated; it will have underwater cameras to monitor feeding. All fish feed will be stored in silos; the feed will be transferred with a blower system to the nets. The barge will have an ensiler which is designed to digest dead fish; the digested product will be transported to Darwin for use in fertilisers. Sewage from the barge will be treated with the 'Humphrey' system.

Mooring of the nets and the barge will be with the use of steel anchors to moor the facilities and prevent them from being washed away or turned over in rough weather, however, they will be able to move with wave motion and water currents. The mooring array proposed for Port Patterson will have six nets hooked up to each system.

1.8 Services and Support

1.8.1 Transport

Staff and construction contractors will reach the facility by sea from Darwin. Access to the farm site during the construction phase will be by outboard motor boat from the temporary local accommodation facilities within Bynoe Harbour, or from Darwin.

Initially, until Marine Harvest has its own well-boat, goods and equipment will be carried to and from site via a contracted sea-transport company (Darwin-based). Much of the waste disposal will take place via the same sea-transport contractor or company well boat. Waste will be transported to Darwin for transfer to licensed waste transport trucks which will dispose of all waste to Darwin's recycling or landfill facilities as appropriate.

1.8.2 Staffing

During construction of the site, there will be 10 to 15 people required on the operational side, 4 divers and 4 other support contractors.

It is anticipated that 2 to 6 people will be required on the barge, with two staff being on the barge at anytime. Additional contractors will be required periodically for particular tasks.

1.8.3 Power, Potable Water and Storage

Power to the barge will be supplied via a diesel generator which will operate 24 hours a day.

Potable water will be provided to the barge via a service ship from Darwin and will be replenished weekly or fortnightly.

Storage of all fuels, chemicals, feed and farm equipment required for day-to-day farm operations in manufacturer's containers and according to relevant regulatory methods.

1.9 Farm Operation

The proposed Port Patterson farm will operate much in the same way as the Port Hurd operation.

Juvenile fish will be stocked at a density of around 4 kg per cubic metre, based on 80,000 to 120,000 juvenile fish per pen, and is likely to have an upper limit of 35 to 45 kilograms of fish per cubic metre based on a fully stocked cage of 3-kilogram fish.

The fish will be fed on Nova ME pellets developed by Skretting, specifically designed for marine fish and their composition.

Pens will be inspected daily from the surface and fortnightly by divers. Repairs will occur immediately if required.

The steel mesh nets will last around 2 years. If 24 nets are present, this will require that around one net is built and replaced every month. Constructing the nets will only require manual handling and no machining will be necessary. The constructed nets will be floated to the farm mooring area with the help of a high tide.

An ensiler will be used for the disposal of dead fish (morts). It is likely that putrescible waste generated on the barge could also be disposed into the ensiler.

1.9.1 Emissions from the Operation

Emissions from the proposed operation are expected to include:

- wastes to water from excess feed not consumed by farm fish, fish faeces, dead fish (morts), parasite control treatment, and grey water from the barge;
- solid wastes from feed bags, dead fish (morts), and waste from the occupation of the barge by staff;
- noise from outboard motors, feeding equipment, occupation of the barge, harvesting operations, site maintenance, net and pen construction;
- light from the habitation of the site during night hours and illumination of farm outline for vessel safety; and
- emissions to air may include noxious smells from dead fish stock, and noxious smells and fumes from the presence of chemicals and fuels and from running outboard motors, the generator, and feeding equipment and emissions of greenhouse gases from the consumption and presence of fuels.

1.9.2 Chemicals

The operation will store a number of chemicals and hazardous materials which will be managed in accordance with Dangerous Goods Regulations.

1.9.3 Ongoing Management, Maintenance and Administrative Requirements

An engineer will be present on site whose responsibility will be to carry out maintenance on machinery and the barge. Most administrative duties would be conducted from the Darwin office.

1.10 Decommissioning and Rehabilitation

The life expectancy of the farm and barge facility is indefinite at this stage. Decommissioning and rehabilitation of the barge and farm facility will require removal of the barge, the nets and the plastic circles, removal of all anchor ropes and of any steel anchors. Where possible, some of the materials will be reused and recycled; any materials which cannot be reused or recycled will need to be disposed to appropriate waste-disposal facilities in Darwin and will be transported via licensed waste-disposal contractors.

1.11 Legislative Requirements

A licence is required for the development under Northern Territory Fisheries legislation. Part of the requirements for such a licence is that the proponent must first obtain a permit and a lease. A lease is granted by the Department of Planning, Infrastructure and Environment and the Minister decides the length of the lease.

Marine Harvest is in the process of applying to the Northern Territory Department of Infrastructure, Planning and Environment for a Crown lease over the proposed area.

Native title does not currently impact on marine areas but it is considered possible that this situation may change in relation to bay areas. Marine Harvest has been in contact with the Northern Land Council who will in turn contact the traditional landowners following the completion of the Environmental Impact Statement. Marine Harvest will comply with relevant requirements of the *Northern Territory Aboriginal Sacred Sites Act* (1989) and the *Aboriginal Land Rights (Northern Territory) Act* 1976.

The barge-based facilities, which will be constructed, will comply with all relevant Environmental Health Standards for Public Health, Food and Radiation Protection including, but not limited to all relevant Northern Territory legislation. The barge will be inspected regularly by a Food Health inspector.

1.12 Alternatives

The Marine Harvest-proposed Port Patterson Barramundi Fish Farm is a component of a three-farm business plan to establish a sustainable farmed-barramundi industry. Should the proposal for Port Patterson not proceed, Marine Harvest would still aim to pursue the establishment of the other proposed sites.

Marine Harvest has investigated much of the Northern Territory coastline for suitable sites for its proposed barramundi marine farming operations. Its selection criteria included proximity and accessibility to Darwin, shelter from cyclones and marine influences, suitable current speeds, adequate water depth and sea-bed clearance. The sites Marine Harvest has selected, including the Port Patterson site, are the most suitable and potentially available, for its aquaculture purposes.

Alternatives for components of the proposal have been trialled at the Port Hurd pilot farm. Marine Harvest is using this and other overseas experience to select the best components for its proposed farm infrastructure.

1.13 Existing Environment

Port Patterson is a branched bay with no off-channel embayment and with a multiple unconstricted mouth. Small tidal creeks, which support mangroves, occur around the bay and feed into Port Patterson and Geranium Channel.

Port Patterson is located around 45 kilometres south-west of Darwin. The climate of Darwin is tropical monsoonal. Tropical cyclones are regular events and would typically occur more readily during El Niña cycles.

Port Patterson functions seasonally as a large estuary. During the wet season, and shortly afterwards, rivers discharge substantial quantities of freshwater into the marine system via the bay. Near the proposed site, Phoenix Inlet discharges freshwater to the Geranium Channel. Sedimentary infill of this terrain has resulted in the development of narrow and broad embayments, islands and sand spits.

The two main habitat types, which support mangrove vegetation, include tidal flats and tidal creeks. Less common habitats include rocky islands, rocky shores, spits, cheniers and the occasional beach.

Tides are macrotidal reaching 7.5 metres. The currents in Bynoe Harbour near Point Ceylon can run at up to 2.2 knots during a spring tide and up to 0.8 knots during a neap tide.

The proposed site will be located over a narrow portion of Geranium Channel where water currents have scoured a meandering channel which is considerably deeper than in the remainder of the estuary. MacKenzie Arm feeds into the south of Geranium Channel and into Port Patterson.

Water quality is regarded as essentially natural and no significant potential sources of pollution have been identified.

The proposed barramundi farm falls within the Finniss Sub-Region of the Northern Territory Planning Scheme. There are no townships within the sub-region. Road access through the Finniss sub-region is provided by largely unsealed roads. There is no reticulated power, water or sewerage within the region. There is a temporary waste disposal site at Dundee Downs and limited urban services reflecting the small permanent population. Residents rely on services provided in Darwin and Palmerston.

1.14 Physical and Biological Environment

The proposed farm location is near Doug Point, within Geranium Channel. It is in an area of deep water in the centre of the channel. The environment of the farm is sheltered mangrove estuarine with great seasonal variation in fresh water inflow (Aquenal Pty Ltd (Aquenal), 2005). Bynoe Harbour is connected to Port Patterson; it hosts a pearling operation and several fishing and tourism sites. Bynoe Harbour has been proposed as the site of a new multiple-use Marine Park by the Northern Territory Government.

The main hydrological influences on the water body are the 6 to 7-metre tidal range, which results in large daily flushing of the mangroves with seawater, and run-off from heavy rains during the wet season. Towards the end of the dry season, when terrestrial run-off has ceased and hot temperatures prevail, negligible net flushing occurs through the bay, and evaporation results in increased salinity and potentially a net inflow into it.

The Aquenal report (2005) noted that there were no known coral reefs within Geranium Channel, and that seagrass is known to exist along the seaward end of Indian Island, in

Bynoe Harbour, and in some bays on the eastern shore of Indian Island. However, these seagrass beds are sparse and patchy.

Juvenile dugongs and turtles are known to occur in the area and it is likely that Green Turtles and Hawksbill Turtles will occur in the area. No dugong calving sites are known in the area but turtle rookeries occur on several islands, the closest being Turtle Island, located around 4.5 kilometres north-west of the proposed farm site.

Two coastal fauna species covered by migratory international migratory bird agreements (CAMBA, JAMBA) and migratory provisions of the EPBC Act are noted and probably occur sporadically along the mangrove edges at different times of the year. These are the White-breasted Sea Eagle *Haliaeetus leucogaster* (CAMBA) and Whimbrel *Numenius phaeopus*. Two further species that are covered by migratory provisions of the EPBC Act are likely to occur within the mangroves in the area; the Estuarine Crocodile *Crocodylus porosus*, and the Rufous Fantail *Rhipidura rufifrons*. Thirteen (13) Threatened Species and nineteen (19) Migratory Species are listed for the area covered by the proposal (EPBC Web Site).

The air quality, noise, lighting and visual amenity is of a high quality due to the lack of any population centres and major industry in the area.

1.15 Port Patterson Baseline Investigation

A baseline investigation has been carried out at Port Patterson to provide pre-operational data against which subsequent monitoring may be compared to assess potential impacts from nutrients released by the proposed aquaculture operation at Port Patterson. The investigations were carried out by Aquenal.

Water quality, nutrients levels, chlorophyll α, epiphytic algae, mangrove stand and composition and benthic infauna parameters were sampled and measured in Port Patterson within proposed farm locations, within potential receptor sites and within control sites in a neighbouring estuary. These results were compared by Aquenal to those obtained for the Port Hurd pilot farm and its control estuary at Gullula Inlet. Water temperature, dissolved oxygen and salinity readings show that water quality in Port Patterson is within the range of the quality of water in Port Hurd, and is therefore considered typical for this type of mangrove estuary. Water is very warm, with salinity greater than seawater at the majority of sites.

1.16 Port Hurd Pilot Farm Environmental Monitoring Results

Marine Harvest's first barramundi fish farm was established at Port Hurd in 2000 and was considered the pilot project for barramundi farming in the Northern Territory.

This farm and its surrounding environment has been the subject of environmental investigations aimed at assessing the potential long and short term biological impacts from the fish farming operation on its environment.

The monitoring results over two years showed that most water quality parameters were closely related to rainfall, i.e. were seasonally influenced. Nutrient levels were not uniformly seasonal in their variation and exceeded the ANZECC (2000) trigger levels on a number of sampling occasions at the Port Hurd, farm and nearby control sites at Maand Creek. A general increase in chlorophyll α levels was observed.

The monitoring results therefore suggest that the pilot farm at Port Hurd has not been causing any notable changes to water or sediment quality, or to nutrient-influenced parameters.

These results are relevant and applicable to the Port Patterson proposed fish farm development as there are strong similarities between the two sites and the operations.

1.17 Paspaley Pearls Oyster Studies

Paspaley Pearls have a pearl oyster farm operation located in Bynoe Harbour, adjacent to Port Patterson, where Marine Harvest is proposing to establish one of its barramundi farming operations. A trial was carried out by Paspaley Pearls to assess the impact of the presence of a fish farm on the health of oysters.

The trial showed that the oysters did not appear to suffer any adverse effects from the presence of the fish farm. These results can be extrapolated to native soft bodied shellfish located in similar water currents near the fish farm which would therefore be unlikely to be affected by any of the fish farming operations.

1.18 Risk Assessments

Qualitative risk assessments have been carried out for all identified aspects and impacts of the proposed barramundi farm. A summary of this is provided in the table below. The table shows that only four aspects have been assessed as having a risk ranking of 2 or 1, i.e. having serious or high risk. These are:

- fish faeces and nutrient loads,
- wastes and hazardous materials,
- predators, and
- personnel emergencies.

Risk Assessments Summary

Aspect	Likelihood of Impacts	Consequence of Impacts	Risk Ranking of Impacts	Comments
Construction	Possible	Minor/ moderate	3 = medium	Noise and traffic impacts will be temporary and managed via the EMP.
Fish Escape	Possible	Moderate	3 = medium	Some temporary adverse effects including predation on endemic smaller fish and removal of feed from the environment could occur.
Fish faeces and nutrient loads	Certain	Minor / moderate	2 to 1 = serious to high	Faeces will enter the water column, but monitoring at Port Hurd suggests little impact from added nutrient load.
Excess feed and quality	Possible / unlikely	Minor / moderate	4 to 3 = low to medium	Loss of feed will be strictly minimized by management methods and feed quality is high, hence impact on fauna, flora and overall environment will be low.
Removal of fish from the food chain	Likely	Minor	3 = medium	The amount of fish eaten will be minimal as farmed fish will be fed to satiation and will be captive.
Fish aggregation	Likely	Minor	3 = medium	No effect on fishing reported from Port Hurd pilot farm.

Aspect	Likelihood of Impacts	Consequence of Impacts	Risk Ranking of Impacts	Comments
Introduction of diseases	Unlikely	Moderate	4 = low	Very low incidences at Port Hurd pilot farm.
Introduction of parasites	Rare	Minor	4 = low	Very low incidences at Port Hurd pilot farm.
Introduction of chemicals	Rare / unlikely	Minor / moderate	4 = low	Port Hurd pilot farm experience has shown that there has been very little need for chemical usage due to low incidence of disease outbreaks.
Waste and hazardous materials	Unlikely / possible	Moderate / major	4 to 2 = low to serious	Stringent management methods will be implemented via the EMP to minimize the likelihood and mitigate the consequences of any potential spillages.
Loss of nets	Unlikely	Moderate / major	4 to 3 = low to medium	The new infrastructure proposed and the more moderate water currents at Port Patterson mean that risks are diminished.
Hydrodynamics	Likely	Minor	3 = medium	The only notable impact is likely to be redistribution of sediments around the mooring anchors.
Predators	Possible	Catastrophic	2 to 1 = serious to high	Increased exposure of humans to crocodiles and therefore increased likelihood of attacks.

Aspect	Likelihood of Impacts	Consequence of Impacts	Risk Ranking of Impacts	Comments
Flora	Rare / unlikely	Minor / moderate	4 = low	Impacts are expected to be minor or moderate due to the location of the farm and the proposed management methods.
Bird, reptile, fish and mammal habitats	Unlikely	Minor / moderate	4 = low	Baseline and Port Hurd information and monitoring suggests there is a low risk of impact on fauna habitats.
EPBC Act listed threatened and migratory species	Possible Unlikely	Moderate	4 to 3 = low to medium	Baseline and Port Hurd information and monitoring suggests there is generally a low risk of impact on EPBC listed, threatened or migratory species or their habitats. Measures will be put in place to minimise possible impacts from farm lighting on turtle hatchlings.
Land surface	Possible	Minor	4 = low	Use of unsealed areas will be minimal.
Air quality, noise, lighting and visual amenity	Likely	Minor	4 = low	Only low level intermittent nuisance is likely.
Social / recreational	Unlikely	Minor	4 = low	Lack of town centre, low population and staff working hours reduce the likelihood of any significant interaction with the local population.

Aspect	Likelihood of Impacts	Consequence of Impacts	Risk Ranking of Impacts	Comments
Local infrastructure	Unlikely	Minor	4 = low	Minimal local infrastructure. Use of local roads expected to be limited.
Archaeological / historical, cultural and aboriginal sites	Rare	Minor to moderate	4 = low	No impact expected.
Marine traffic	Unlikely	Minor	4 = low	The farm may increase boat trips along Geranium Channel by up to 20 percent, but traffic will still remain very low.
Insect pests	Unlikely	Moderate	4 = low	Managed by operational procedures.
Personnel emergencies	Possible	Minor to catastrophic	4 to 2 = low to serious	Personnel emergencies can occur in any workplace; dangers will be managed via standard operating procedures and the site EMP.

1.19 Environmental Management

Nutreco's company Health Safety Environment and Quality (HSEQ) Policy applies to all its business units, of which Marine Harvest is a part.

Underpinning the HSEQ Policy, the objectives of Marine Harvest are:

- To minimise the impact of its operations on the surrounding environment;
- To ensure that conservation of the biodiversity is not impacted by Marine Harvest operations;
- To ensure that environment program are developed and implemented in consultation with the Northern Land Council;
- To minimise the footprint of the development; and
- To maintain a low impact facility.

Marine Harvest will operate its Port Patterson facility in line with these objectives.

Based on its experience at its Port Hurd pilot barramundi fish farm on Bathurst Island, Marine Harvest is familiar with what is required to resource and implement an appropriate environmental management system tailored to the requirements of the tropical environment in Port Patterson.

As part of these site-specific management measures, Marine Harvest will develop and implement the following plans and procedures for the proposed Port Patterson barramundi farm:

- a site specific Environmental Management Plan, which will include a detailed environmental monitoring schedule and a thorough staff and contractors' induction procedure;
- a site specific Maintenance and Monitoring Manual; and
- site specific Standard Operating Procedures.

A regular monitoring and reporting program will be carried out at the proposed Port Patterson farm, which will follow up on the baseline work carried out by Aquenal Pty Ltd. This program should pick up early any potential changes in water and sediment quality brought about by the proposed farm.

A summary of the monitoring requirements for the site is provided in the following table. This will be used as the basis for the monitoring requirements to be included in the Environmental Management Plan for the farm.

Summary of Proposed Monitoring Requirements

Aspect	Reference Section No.	Monitoring Activity	Frequency
Construction	9.2	Meetings to be held with staff, contractors and farm management or construction manager. Meetings should cover procedures, incidents and corrective actions.	Weekly
Fish Escape	9.3	Inspection of nets and moorings	As noted
		Tide prediction software to be investigated	Daily or as needed
Disease and Parasite Transfer	9.4	Visual inspection of fish health	Daily
		Recording of mortality rate	Daily
		Analysis by Berrimah Government Veterinary Laboratory	As needed
		Visit by Berrimah Government Veterinary Laboratory	Annually
Faeces and Nutrients	9.5	Water sampling	Weekly
		Water, sediment, mangroves	Annually or biennially
Excess Feed and Feed Quality	9.6	Feed tested at the source by Skretting	As needed
		Underwater camera	During feeding
Wastes	9.7	Check all wastes are placed in dedicated containers, etc.	Ongoing/daily
		Records to be kept of all volumes and destinations of solid waste and prescribed waste disposed from the farm	Ongoing

Aspect	Reference Section No.	Monitoring Activity	Frequency
Treated Sewage effluent	9.7.3	Water samples of effluent analysed for target parameters	Initially weekly then six monthly
Farm Fish Deaths	9.7.6	Check level on ensiler	Monthly and as needed
Chemical and Hazardous sub-stances	9.8	Storage areas to be checked for leakages and storage integrity and compliance	Weekly
		Hazardous substances audit	Annually
Nets and Moorings	9.9	Mooring components checked by divers	Six monthly or as needed
		Nets monitored from surface	Daily
		Nets inspected by divers (from inside nets)	Fortnightly
		Diving inspection of nets and moorings (outside of nets)	Six monthly
		Nets and moorings replacement	Minimum every two years
Hydrodynamics	9.10	Seafloor inspections by divers for scouring around mooring anchors (same time as mooring inspections)	Six monthly
Water and sediments	9.11	Water temperature and oxygen levels	Daily
		Water sampling and mangrove roots	Fortnightly during the dry, two-monthly during the wet
		Water, sediment sampling and mangrove stands and roots	Annually or biennially

Aspect	Reference Section No.	Monitoring Activity	Frequency
Bird, reptile and fish habitats	9.13	Record and review record of impacts and complaints	Ongoing
		Record all animal deaths in and around the lease	Ongoing
		Monitor water sediments and flora as noted	As noted
Flora	9.14	Seagrasses – best method still to be determined	To be determined
		Mangrove stands and roots	Fortnightly, two-monthly, annually or biennially
EPBC-Act listed Threatened and Migratory Species	9.15	Monitoring of water, sediment and flora as noted	As noted
		Check that all farm lights are using low-impact lighting and monitor for potential the presence of turtle hatchlings	Quarterly for the lights and ongoing for the turtle hatchlings
		Recording and assessing any complaints, reports or sightings of dugongs and turtles and any other wildlife presence or death	Ongoing
Land surface	9.16	Inspections of unsealed surfaces upon vacating area	On vacating area
		Recording and assessing complaints	Ongoing
Noise, lighting, air quality and amenity	9.17	Log book of operating hours of all noisy equipment	Ongoing
		Maintenance schedule to be followed for all motorized equipment	According to equipment maintenance schedule

Aspect	Reference Section No.	Monitoring Activity	Frequency
		Recording and assessing any complaints	Ongoing
Social and recreational	9.18	Review and assess complaints or incidents reported	Ongoing
Archaeological, historical, cultural and Aboriginal sites	9.19	Record and review any complaints	Ongoing
Marine traffic	9.20	Record any incidents or complaints and assess	Ongoing
Pest insects	9.21	Incident reports to be review and assessed	Ongoing
Personnel emergencies	9.22	Incident, accident and emergency reports to be kept and assessed	Ongoing
Quality of farmed barramundi	9.23	Monitoring of health	Daily
		Testing of dead fish	As needed
		Regular checks by Berrimah Government Veterinary Laboratory	Annually

1.20 Public Involvement and Consultation

The proposed operation at Port Patterson has been in the public domain for a number of years now. Information regarding the proposal and the pilot project at Port Hurd has been disseminated through the newspapers.

In August 2005, the draft guidelines for this EIS were put up for public comment by the Minister for Natural Resources, Environment and Heritage of the Northern Territory, and feedback from this has been incorporated into the final guidelines for the EIS. The structure and content of this report is based on these guidelines.

Some preliminary consultation has occurred with the Northern Land Council (which represents all northern aboriginal groups). The Northern Land Council has stated that they are interested in further consultation and negotiation once the EIS has been approved.

An Open Day was held at Port Hurd on 22 November 2005. Around 70 people attended, including members of the Northern Land Council. Aboriginal groups indicated preliminary support for the other fish farming operations planned by Marine Harvest but want to have a detailed consultation once the EIS has been through the process.

Issues raised during the Open Day on 22 November 2005 included:

- maintaining the aesthetics of the surrounding environment,
- issue of wastes from the fish farm, and
- aggregation of wild fish beneath the sea cages.

The issues raised have been covered in the matters detailed in this EIS.

1.21 Conclusions

Environmental monitoring over the last two years, by well-regarded aquatic environmental analysts Aquenal Pty Ltd, has shown that the Port Hurd pilot farm has not resulted in measurable increases in nutrient concentrations in the water column, in sediments or on mangrove roots.

Observations at the Port Hurd farm have also shown that local fauna have not been adversely affected by the presence of the farm and local recreational fishing operators have not noted any decrease in catches.

The Port Patterson farm will have several differences in infrastructure with the Port Hurd operation including the use of an onsite barge, reduced net sizes, reduced number of nets per mooring cluster, and an increase in the number of moorings per net.

There are significant conservation and biodiversity issues apparent at Port Patterson. These include the presence of turtle rookeries around 5 kilometres from the proposed site, the regular presence of dugongs and turtles and to a lesser extent, crocodiles.

However, qualitative risk assessments carried out for all identified aspects and impacts of the proposed Port Patterson barramundi farm have identified only four aspects having a risk ranking of 2 or 1, i.e. having serious or high risks. These are:

- fish faeces and nutrient loads,
- wastes and hazardous materials,
- predators, and
- personnel emergencies.

These aspects have been assessed to have high risks due to factoring in the worst possible consequences. However, all of these aspects, have a low likelihood of causing significant impacts due to the use of previously tested infrastructure and management procedures, and site specific-management measures.

Marine Harvest is committed to the following objectives and will operate its Port Patterson facility in line with these:

- minimising the impact of its operations on the surrounding environment; and
- ensuring that environmental programs are developed and implemented in consultation with the Northern Land Council.

Marine Harvest believes that through its commitments and via the implementation of predominantly proven management methods, the proposed Port Patterson farm can be operated with very low risks of impacting the immediate or surrounding environment of Port Patterson.

Marine Harvest has built up a good working relationship with the local aboriginal people since the inception of its pilot farm at Port Hurd. It aims to develop an equally strong association with the local aboriginal language groups of the Port Patterson region through ongoing communication with the Northern Land Council, and through the provision of employment and business opportunities for local people. It is also committed to maintaining good relationships with other local operators and users of the bay and will endeavour to proactively address any issues that may arise.

2 Introduction

2.1 Background

Marine Harvest is planning to develop and operate a barramundi fish farm within a proposed marine farming lease located at Port Patterson, in the Northern Territory.

Referral for the project was lodged on 27 May 2005 with the Australian Department of Environment and Heritage under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act). The proposal was declared a controlled action under the EPBC Act, the controlling provisions being:

- Sections 18 and 18A (Listed threatened species and communities) and
- Sections 20 and 20A (Listed migratory species).

The Northern Territory Minister for Natural Resources, Environment and Heritage, Ms Marion Scrymgour, confirmed on 13 September 2005 that the proposal would require assessment under the *Environmental Assessment Act* 1994 at the level of an Environmental Impact Statement (EIS) (see Appendix A).

Following a public comment period, the Minister provided Marine Harvest with guidelines for the EIS which were drawn up in accordance with Schedule 1 of the *Bilateral Agreement between the Commonwealth of Australia and the Northern Territory* under Section 45 of the EPBC Act relating to EIS. The guidelines included provisions aimed at addressing issues which were raised during the public review process of the draft guidelines. A copy of the guidelines is provided in Appendix B.

2.2 Objectives and Scope of this Report

The objectives of this EIS report are to provide sufficiently detailed information on the proposal and on the environment to permit informed public comment and regulatory decisions to be made on the proposal, and to permit environmental management measures to be drawn up.

The scope of the report includes:

- a description of the proposal and an outline of the benefits from the proposal,
- a discussion of the alternatives,
- a description of the environment in which it will operate, and an outline of the potential impacts,
- a description of the management measures proposed to minimise any adverse impacts, and
- the provision for public involvement and consultation.

3 Description of the Proposal

3.1 Overview

Marine Harvest proposes to develop and operate a barramundi farm located within a marine farming lease site located at Doug Point, Geranium Channel, Port Patterson, in the Northern Territory (NT). The farm will be based on the pilot barramundi fish farm which has been operated by Marine Harvest at Port Hurd, on Bathurst Island, since 2000.

The proposed farm will have the capacity to produce 1500 tonnes of fish per year. The long term aim is to grow the site to the stage where it will be able to produce up to 5000 tonnes of fish per year. The site will initially be stocked with juvenile barramundi supplied from a hatchery using local NT broodstock. The juvenile barramundi will be transferred to the sea pens for on-growing, and will then take 18 months to reach their harvest size of approximately 3 kilograms. In the longer term, it is planned that the juvenile barramundi will be supplied by a Marine Harvest-run nursery, which it is planning to set up near Channel Island, in Darwin Harbour.

All stock, from juvenile-size upwards, will be housed in steel mesh pens and fed pelletised food from automatic feeding stations. Feeding will be monitored to ensure as little wastage as possible in the form of uneaten pellets. The proposed farm will be based on plastic circles of 48 metres circumference.

During the initial set up of the farm, staff and contractors will be accommodated temporarily at pre-existing facilities present in Bynoe Harbour. Workers will access the site via boat from Darwin and from their accommodation at Bynoe Harbour.

The final design of the site incorporates an autonomous floating barge which will contain all operational equipment for the farm and workers. The barge will include live-aboard facilities, a workshop and an ensiler for dead fish. The barge will also store up to 250 tonnes of feed which will be distributed to the fish via a blower system. The silos will supply feed to a blower system that will distribute the feed via a 75mm polyethylene (PE) pipe. This method can move feed up to 800m from the source. Feed used will be extruded dry feed which is specifically formulated for tropical fish and in which up to half of the protein used is non-fish.

Harvested fish will be transported to Darwin live, by well boat, or killed and chilled on the barge prior to transportation.

3.2 Objectives, Benefits and Justification for the Project

3.2.1 Background

The Marine Harvest Company of today was created in April 2005 by the merger of Marine Harvest and Stolt Sea Farm, the fish farming, processing, sales and marketing businesses of Nutreco Holding N.V. and Stolt-Nielsen S.A. respectively. Marine Harvest

has been subsequently bought out by Pan Fish. Marine Harvest is the world's leading fish farming company, and the leading producer and supplier of farmed salmon in the world. Marine Harvest is also an important supplier of sea trout**,** and is pioneering the farming of species new to aquaculture such as cod**,** halibut**,** yellowtail**,** sturgeon, tilapia and barramundi.

Marine Harvest's Mission Statement is:

> *'Marine Harvest is a leading provider of excellent quality fish products that satisfy consumers' current and emerging needs through sustainable production, reliable supply, innovation and competitive value, at all times holding the concerns of society and fair opportunities for our employees as top priorities.*'

Responsibility is a key value held by Marine Harvest and it notes that:

> '*as a leading and responsible company, Marine Harvest sets and meets the highest standards of production, especially in food safety and sustainability. We take account of the concerns of the communities where we work and of wider society and will only work with those organisations whose commitment matches our own.*'

The inception of barramundi fish farming at Port Hurd began from a vision of the then Pivot company to diversify Marine Harvest's customer base. The vision included establishing a tropical cage-based industry founded on the temperate fish-farming learning. Marine Harvest regards tropical aquaculture as a necessary part of its business.

The fish farming operation at Port Hurd (Barra Base) has been used by Marine Harvest as a feasibility and experimental trial for tropical fish marine farming. The operation has been underway since 2000 and, in keeping with its experimental nature, it has undergone several changes, dictated by adaptation to the environment and development of experience in the process. Changes have included, for instance, replacing steel cages and plastic nets with plastic polar circles and steel nets. The Port Hurd operation has allowed Marine Harvest to gain valuable experience and to make informed decisions and choices when planning the expansion to its tropical marine farming operations.

Marine Harvest is aiming to set up three more barramundi sea cage farms or nurseries in the Northern Territory; one at Snake Bay, on the north coast of Melville Island; one at Port Patterson, to the west of Darwin Harbour; and a nursery and grow out facility in Darwin Harbour to the northeast of Channel Island. The Port Patterson operation will be established following the Channel Island operation. Marine Harvest has budgeted around $15 million to get all three sites started up.

To justify its investment in improved infrastructure Marine Harvest needs to improve current economies of scale and to harvest more than 1000 tonnes per annum from each proposed farm. Marine Harvest is also considering building its own well boat for delivery of fish from the farm and it is intending to have barges built for on-site operations at Snake Bay and Port Patterson. According to its research, Marine Harvest could sell up to 5000 tonnes of farmed barramundi per annum in Australia before it would have a need to export. The purchase of a well boat would rely on an increase in farm throughput for

justification. Currently around 80 to 90 percent of Marine Harvest's farmed barramundi is being sold within Australia, the remainder is exported to the United States.

3.2.2 Objectives

The objectives of the project are:

- to develop a sustainable farmed barramundi fish industry and market,
- to operate a barramundi sea farm industry which will successfully and sustainably grow juvenile fish from the Darwin Aquaculture Centre to marketable sizes,
- to be an economically viable operation, providing reasonable returns to shareholders,
- to prevent or minimise impacts to the surrounding environment,
- to maintain good relationships with the local residents, providing both economic and job opportunities, and
- to provide a platform for the development of other tropical culture species.

3.2.3 Benefits and Justification

Marine Harvest Contributions

Marine Harvest has recognised the economic and environmental benefits of fish farming.

Aquaculture farms, just like the proposed Port Patterson farm, are typically located in remote coastal areas. The majority of the employees for Marine Harvest farms usually live in these areas, which are often noted for their limited employment opportunities. Marine Harvest is therefore aware of the significant economic and social role it has to play in these communities. Initiatives and continuing efforts are made to develop positive relationships in the communities, these include nature conservation programmes, environmental initiatives, sponsorship of local sports and cultural events.

Direct Employment

Around 8 to 16 staff will be required to operate the Port Patterson farm. In addition, contractors will be needed periodically:

- 4 people for diving and inspection, and
- 4 to 6 people for harvesting.

Employees will be sourced locally whenever possible.

Relieve Pressure on Wild Barramundi Stocks

The Port Patterson operation should help prevent additional pressure on wild barramundi stocks while providing a product which is in great demand in Australian and overseas markets. As the operation will be sourcing its juvenile stock from the Darwin Aquaculture

Centre, which breeds barramundi under controlled conditions, it will not be depleting wild barramundi stocks.

3.3 Location of the Project

The proposed location for the barramundi farm site is near Doug Point, within Geranium Channel, Port Patterson, Northern Territory (see Figure 1). Marine Harvest used its experience at Port Hurd to help it identify optimal tropical marine fish farming characteristics. The proposed farm location was chosen based on selection criteria such as sea-bed clearance, tidal currents, shelter from strong marine influences, and accessibility to Darwin.

Port Patterson is located approximately 45 kilometres to the south-west of Darwin and contains some of the Northern Territory's best quality reefs (pers. comm. Schmidt, 2005). Aquenal Pty Ltd (2005) noted that there are no known coral reefs within Geranium Channel. Geranium Channel is located on the western side of Indian Island (a Conservation Reserve) and is lined by mangroves. Currents are very strong in the channel. Turtles, dugongs and crocodiles are known to frequent the area.

Bynoe Harbour is located on the eastern side of Indian Island and is connected to Port Patterson. Bynoe Harbour functions seasonally as a large estuary. During the wet season and shortly afterwards, one major river discharges substantial quantities of freshwater into the marine system. Sedimentary infill of this terrain has resulted in the development of narrow and broad embayments, islands and sand spits.

Bynoe Harbour and Port Patterson are used for recreational and commercial purposes. Recreational uses include fishing, sailing and diving. Commercial uses include tourist operations, pearl farming and mud crabbing. Apart from the natural disturbance caused to vegetation from periodic cyclones, the clearing of mangrove vegetation has not been significant. Water chemistry is regarded as essentially natural. Bynoe Harbour has a high conservation value due to its relatively intact state and is being considered by the Northern Territory government as a potential Multiple Use Marine Park. Present threats to the fisheries and conservation values are regarded as low. No significant potential sources of pollution have been identified. Foreshores are sparsely developed with the exception of increased rural block development on the southern side of Bynoe Harbour.

Coordinates for the four corner points of the proposed lease area are provided in Table 3.1, below. Refer to Figures 2 and 3 showing the location of the proposed lease area.

Table 3.1: Coordinates of Lease Area

Point	Coordinate	Degrees	Minutes
A	Latitude	12	39.36
	Longitude	130	30.20
B	Latitude	12	39.49
	Longitude	130	30.09
C	Latitude	12	39.67
	Longitude	130	30.73
D	Latitude	12	39.77
	Longitude	130	30.59

3.4 Project Schedule

Construction of the project will commence once approval has been granted by all relevant authorities. It is expected this may be in the second half of 2006 based on the following time line:

1. submission of EIS in May 2006;
2. 28 days for public comment upon submission of EIS;
3. presentation to the NT Government of the outcomes of the EIS;
4. submission of addendum to answer public comments;
5. consideration by the NT Minister; and
6. submission to the Federal Minister.

Once approval is given, it is anticipated that construction of the operation will be a staged process.

Stage 1 will take place over approximately 12 months and will involve the construction of sea pens able to farm up to 1500 tonnes of fish per year, and installation of a fully self-contained barge. It is expected that basic infrastructure to begin fish farming could be in place within the first 7 months.

Stage 2 will occur over 12 months, and will involve the construction of additional pens to allow production to increase to 5,000 tonnes per year. The farm is expected to operate indefinitely.

When the early stages of the fish farming facilities have been constructed and have been put in place, the go-ahead will be given to the Darwin Aquaculture Centre to initiate spawning of barramundi brood stock. It is expected this would take around 1 month and would be followed by around 3 month's grow-out of hatchlings to juvenile stage (100 to 200 millimetres). The 3 months grow-out could be carried out in a specifically-designed nursery area at the farm.

3.5 Layout and Infrastructure

3.5.1 Infrastructure

The proposed facility will be entirely contained on water and will not comprise any on-shore facilities. The proposed farm will include the following infrastructure:

- A central automatic barge – which will include; live-aboard facilities, fresh water storage, a workshop, feed silos, feed distribution equipment, a dead-fish ensiler and chemical and fuel storage facilities;
- Steel mesh nets (pens);
- A mooring system consisting of cyclone-proof anchors; and
- Outboard motor boats for movement of personnel, day-to-day goods and waste disposal.

Nets will be constructed in Darwin and transported to site. A copy of the general plan arrangement of the typical central-feeding barge, which Marine Harvest is proposing to use for the operation, is provided in Figure 4. The barge will be situated in the centre of the mooring array and will be flanked by the pens. The barge will be constructed under contract in Darwin and will be sailed to the site. Both the nets and the barge will be moored to the sea floor using steel anchors installed by cyclone mooring specialists.

The pens will be plastic circles of approximately 48 metres circumference. The pens will be made with steel-net mesh which, at the pilot Port Hurd operation, has been proven to exclude crocodiles and sharks and to not entrap predators. The holding nets will have 8-metre deep side walls, and funnel-shaped net base, making the nets a maximum of 8.5 metres deep. The total volume of the nets will be around 1800 cubic metres. Each pen will have a minimum seabed clearance of around 2 metres as they will be placed over channel areas that are at least 10 metres deep. The pens will be positioned in two lines of two by six pens each. The pens will be grouped in straight arrays of six pens and the long axis of the arrays will be placed parallel to the channel's direction.

Plate 1, below, illustrates a first generation 86-metre plastic pens in grid mooring array, which is similar to the arrangement proposed for the Port Patterson site, except that the Port Patterson site will include a centrally moored barge and the nets will be smaller.

The site will be clearly visible during the day. At night the barge will be lit up with corner lights and a flood light shining directly on the outer deck. The outer limit of the sea pens and the lease will be marked with flashing lights to be visible for navigational safety.

Plate 1: Illustration of the type of 1st generation fish-pen infrastructure proposed for the site

3.6 Preferred Design Criteria for the Facility

The design of the farm is partly dictated by the unique characteristics of the estuarine environment in Port Patterson and partly by Marine Harvest's experience at its pilot project at Port Hurd, on the west coast of Bathurst Island.

3.6.1 Aims of the Design

The aims of the design include:

- minimising impact to the seafloor and the estuarine environment;
- minimising impact of the presence of the fish on other faunal species in the estuary;
- minimising stress to the farmed fish to optimise good growth conditions and minimise disease exposure;
- maximising the control over the feeding in order to maximise feed economy by minimising feed wastage and loss to the environment;

- maximising water circulation and oxygen input;
- minimising maintenance work in order to avoid excessive disturbance to the fish and the environment;
- minimising risk of mooring breakage and fish escape due to high waves and extremely high tides (king tides);
- minimising risk of fish escapes during extremely low tides; and
- complying with applicable legislation and standards.

3.6.2 Site Limiting Factors

There are a number of site characteristics at Port Patterson which impose some limitations to the design of the operation, these include:

- A narrow deep channel which means that the nets can only be set out along a narrow corridor;
- Large tides (6-7m range) and exposure to mild cyclonic influences, which means that anchoring needs to be able to withstand these stresses on the infrastructure;
- The presence of the pens in the middle of the channel means that in conditions of poor visibility, or at night, flashing lights will need to be present at the corners of the lease to signal their presence.

3.6.3 Fish Net Design Criteria

In order to achieve the aims listed in Section 3.6.1, the following design criteria have been chosen for the fish nets:

- Use of galvanised steel nets, for grow-out and nursery pens, with 35-mm bar mesh. These have been successful at Port Hurd in excluding predators, such as turtles, sharks and crocodiles, from feeding on the farmed fish, and in preventing predators from being entrapped in the mesh. The nets have also been found to minimise stock losses, fouling, net changing and repair. They have a life expectancy of eighteen to twenty-four months, though this may be longer at Port Patterson where the water currents are lower than at Port Hurd (2.2 versus 4.2 knots). This type of marine mesh assists in the maintenance of good water flow through the pens, therefore ensuring adequate oxygen supply to the fish and reduction in stress. Steel nets have also been found to be effective in minimising the incidence of gill fluke and parasites on the fish.
- Use of polyethylene fibre net placed on the inside of the steel nets for nursery purposes and until the fingerlings reach around 200g.
- Possible placement of nursery pens in different current corridors to that of the grow-out pens in order to maximise oxygen input, and minimise any potential bacterial load and therefore potential disease or pest transfer. This also facilitates the monitoring and feeding work by a nursery-dedicated staff member.

- Use of sacrificial aluminium anodes suspended 4 metres below the water surface to protect the nets from corrosion below the water line. The aluminium anodes are 1 metre long and they attract the corrosive ions that would otherwise cause the galvanising on the steel nets to disappear and cause them to corrode within only a few months. Sixteen anodes are placed on each net and these last for 2 years, i.e. essentially the life of the net.

- Placement of the nets over, at least, an 11-metre-deep channel, so that all nets have at least 2 metres clearance from the seafloor; and

- Periodic replacement of approximately 1 metre of mesh around the collar of the cages to eliminate corrosion.

3.6.4 Barge Design Criteria

The following design criteria have been nominated for the barge:

- The barge will be sited in the centre of the array of nets to permit farm staff to oversee all pens effectively;

- The barge will be manned 24 hours a day so that any problems can be attended to immediately;

- Sewage from the barge will be treated with the 'Humphrey' system which meets US Coastguard standards approval;

- Concrete slabs will be used as the pontoon base for the construction of the barge, and Styrofoam will be used to pad the sides of the concrete slabs;

- Donga-style demountable buildings will be bolted onto the concrete slabs;

- The barge will be automated and will provide staff with feeding figures. Underwater cameras will be used to monitor feeding and to prevent feed wastage;

- The barge will store all fish feed in silos which will supply a blower system to transfer feed into 75 millimetre polyethylene pipes, carrying feed up to 800 metres from the barge;

- The barge will have an ensiler which is designed to digest dead fish, thereby preventing them from fouling the estuary. The digested product will be transported to Darwin for use in fertilisers;

- Chemicals stored on board will be within a bunded facility and will be held in the smallest containers practicable to minimise the chance of large spills;

- During day-to-day operations, there will be no need for on-shore facilities as all equipment and consumables will be stored on the barge and supplies will be delivered by boat; and

- Contractors will be used for all construction including net replacement, diving, mooring work and harvesting.

3.6.5 Mooring Design Criteria

Mooring of the nets and the barge will be with the use of steel anchors, to moor the facilities and prevent them from being washed away or turned over in rough weather; however, they will be able to move with wave motion and water currents. The anchors are designed to bury themselves more deeply in the seafloor substrate when pulled upon and can burrow down to 4 metres below the seafloor.

The latest mooring arrays used at Port Hurd were successful in withstanding cyclonic and king tide conditions, though they failed in the highest king tide which coincided with high waves (2-3 metres). This failure was caused by the larger size of the nets (86 and 100 metres circumference) and the large number of nets (12) per mooring array. The mooring array proposed for Port Patterson will have six, instead of twelve nets, hooked up to each system, and will have smaller nets of 48 metre circumference and less total volume, thereby decreasing the drag by the currents and resultant stress on the moorings.

The mooring system for the barge will consist of four anchors and four mooring lines, hooked up to each of the corners of the barge.

Figure 5 shows the design for three six-pen mooring arrays with a central feeding barge. The proposed design for Port Patterson is for four six-pen mooring arrays with a central feeding barge. Figure 6 shows the details of the mooring equipment and connections which are likely to be used at Port Patterson.

Table 3.2 below provides a summary comparison of the mooring and net design arrangements proposed for Port Patterson as opposed to those used at Port Hurd. The comparison illustrates clearly that the proposed new design for Port Patterson nets and moorings will offer less drag in the water and will be secured more effectively with a larger number of mooring lines than the old design used at the Port Hurd pilot farm.

Table 3.2: Comparison Summary of the Mooring and Net Design Arrangements

Item	Port Patterson Proposed Design for Grow-out Nets	Port Hurd Old Design for Grow-out Nets	Port Hurd Old Design for Nursery Nets
Net circumference	48 metres	86 or 100 metres	48 metres
Net depth	8.5 metres	9.5 metres	5.5 metres
Net volume	1800 cubic metres	3200 cubic metres	1200 cubic metres
Mesh sizes	35 millimetres	32 millimetres	20 millimetres
Mooring lines	18 lines per 6 nets in a line	20 lines per 12 clustered nets	Dependent on number of nets per array
Width of nets facing oncoming currents	15 metres	27 -30 metres	15 metres

3.7 Services and Support

3.7.1 Transport and Boat Movements

Staff and construction contractors will reach the facility by sea from Darwin. Access to the farm site during the construction phase would be by outboard motor boat from the local accommodation facility within Bynoe Harbour. The operation will have at least one motor boat moored to the barge and this will be available at all times to permit rapid staff movement in the event of an emergency.

Until Marine Harvest has its own well-boat, goods and equipment will be carried to and from site via a contracted Darwin-based sea-transport company. Much of the waste disposal will take place via the same sea-transport contractor or company well boat. Waste will be transported to Darwin for transfer to licensed waste transport trucks which will dispose of all waste to Darwin's recycling or landfill facilities as appropriate.

Boat movements to and from the site during construction of mooring arrays will be via outboard motor boat. It is anticipated that morning and afternoon trips will be taken to the lease site and that the mooring contractors will take several weeks to complete the mooring system.

During day-to-day operations, movements from site to Darwin will be via outboard motor boat or well boat and would typically be only once a week, though these could be up to two to three times a week during harvesting, for instance.

Outboard motorboat movements will be required during day-to-day operations between the barge and the nets.

3.7.2 Staffing and Servicing Requirements

During construction of the site there will be a need for between 10 and 15 people on the operational side, a barge with 4 divers and 4 other support contractors. The numbers will fluctuate according to the tides, with no construction taking place during spring tides and most work taking place during neap tides. To coincide with the neap tides, it may occasionally be necessary to work evenings, nights or early mornings, otherwise most work will be carried out during normal daytime hours.

It is anticipated that between 2 and 6 people will be required on the barge, with two staff being on the barge at any time. Day-to-day operations will be carried out during normal daylight working hours, except in some circumstances where tidal schedules may dictate that work be done to coincide with a neap tide.

- contract divers will be needed fortnightly to inspect and mend the nets; and
- 4 to 6 contractors will be needed monthly to help with the harvesting operations.

Skeleton staff will be housed on the barge when it is commissioned.

3.7.3 Barge Facilities

The barramundi farm is to be exclusively marine-based with contractors being accommodated on land within existing facilities during the construction phase of the farm.

The barge will include live-aboard facilities consisting of kitchen, living room, two bedrooms, a laundry, a bathroom with toilet, sink and shower, a computer/office area, a workshop and an ensiler for dead fish. A large portion of the barge will consist of silos which will hold the fish feed. The barge will be equipped with satellite communications. A copy of a typical plan for the proposed barge is provided in Figure 4.

Basic requirements of the day-to-day live-aboard activities will include:

- cooking, storing food and disposing of food and packaging wastes and grey water;
- personnel washing and disposal of sewage wastes;
- clothes washing and disposal of grey water;
- power supply to the barge generator; and
- storage, supply and disposal of sundry consumables for personal, kitchen, laundry and office purposes.

3.7.4 Power, Potable Water Supply and Storage

Power

Power to the barge will be supplied via a diesel generator which will operate 24 hours a day. A small backup generator will be available in case of breakdown of the primary genset.

Potable Water

Potable water will be provided to the barge via a service ship from Darwin and will be replenished weekly or fortnightly as needed. It is estimated that around 5000L of fresh water would be required per week for a barge housing up to 4 staff.

Storage on Barge

Chemicals which will be stored on board the barge will include products such as diesel, petrol, cleaning fluids (e.g. calcium hypochlorite or Phoraid for disinfection of barges, boats and footwear), and chemicals required for digestion in the ensiler. They will be stored in a bunded area and in accordance with the requirements set out in the relevant Material Safety Data Sheets (MSDS). All chemicals and fuels will be stored under cover to shelter them from sun and rain. Feed and all other equipment will also require undercover storage. It is currently envisaged that all storage requirements will be accommodated on the barge itself and that no shore-based storage will be required.

3.8 Farm Operation

Marine Harvest proposes to operate the Port Patterson farm in a similar manner to the way the pilot Port Hurd barramundi farm has been managed.

3.8.1 Fish Cultivation

Marine Harvest intends to farm barramundi (*Lates calcarifer*) at their lease in Port Patterson. Juvenile fish will be bred at the Darwin Aquaculture Centre (DAC) which is a facility owned by the Northern Territory Government. In the natural environment, barramundi spawn on full and new moons over the summer months. Hatcheries such as the DAC are able to control spawning all year round using artificial light and temperature regulation. The availability of stock from the DAC, which uses local NT broodstock, has ensured that no potential exotic fish diseases are transferred from interstate-sourced fish. The hatchlings are vaccinated at the DAC for bloat (enteritis) and for streptococcus.

The proposed farm will have the capacity to produce 1500 – 5000 tonnes of fish per year, though this represents a long term target and it is expected that it would take a few years to reach that level of production.

The site will initially be stocked with juvenile barramundi sourced from the DAC. The fingerlings (10 – 20 grams) will be grown in specific nursery pens. The juvenile barramundi will be transferred to the grow-out pens for on-growing when they are approximately 200 millimetres long, i.e. after around 3 months. They will take around 18 months to reach harvest size of approximately 3 kilograms.

The stocking density of the nets with the juvenile fish will begin at around 4 kg per cubic metre, based on 80,000 to 120,000 juvenile fish per pen, and is likely to have an upper limit of 35 to 45 kilograms of fish per cubic metre based on a fully stocked cage of 3-kilogram fish. However, the fixed-net dimensions, harvesting programs, fish wellbeing, and slower current conditions at Port Patterson compared to Port Hurd mean that stocking densities are likely to be below 45 kilograms per cubic metre.

Intakes of juvenile fish are likely to be similar to those at Port Hurd, whereby two groups of fish will be taken in every two months, at one-week intervals, with around 80,000 to 120,000 fish taken in during the first intake week and another 80,000 to 120,000 fish taken in during the second intake week. The intake number will be governed by survival rate and market demand.

It is planned that ultimately the juvenile barramundi will be grown from hatchling to juvenile size within a nursery-type set up which is proposed to be located near Channel Island in Darwin Harbour. The hatchlings would still be sourced from the DAC.

3.8.2 Feeding

The fish will be fed on pellets from the automatic feed blower located on the barge. A blower system will transfer the feed from the barge to the pens via 75 millimetre diameter polyethylene (PE) pipe. The feed is mobilised by water and jetted into the pens.

The pellets vary in size from 4 to 15 millimetres, according to varying age classes of fish. Pellets will be shipped to the barge in 25 or 500 kilogram bags, protected by heat shrink-wrapping in one-tonne lots. Feed used is extruded dry feed which is specifically formulated for tropical fish where up to half of the protein used is non-fish.

The feed used will be Nova ME developed by Skretting. This is a high-performance sinking feed, which is mammalian-product free. No hormones are used in the feed.

The pellets are specifically designed for marine fish and their composition and ingredients are detailed in the tables below. Table 3.3 provides the typical composition of the fish feed. The typical ingredients included in the fish feed include: fish meal, plant protein meal, poultry protein meal, wheat, fish oil, poultry oil, vitamins and minerals. The percentage of these ingredients may vary according to the quality of the raw material used.

It is anticipated that the same feed mix combination will be used at Port Patterson as that currently used at the Port Hurd pilot farm, i.e. around 7/8 will be feed from Tasmania supplied by Skretting, and 1/8 will be feed from Queensland, supplied by Ridley's Aquafeed. This feed mix combination uses an increased amount of high quality feed from Skretting and is believed to have contributed to the good health in the fish at the Port Hurd pilot farm.

Table 3.3: Typical Composition of Fish Feed

Component	Percentage	
	3 or 4 mm pellets	6, 9 and 11 mm pellets
Crude protein	50	45
Crude lipid	17	20
Carbohydrates	15	18
Moisture	8	8
Ash	10	9
Total phosphorus	1.4	1.4
Available phosphorus	0.9	0.9

3.8.3 Pens Inspections and Cleaning

Pens will be inspected daily from the surface, and any damage to the pens will be repaired immediately where possible. In the case of major damage requiring divers' intervention, this will be synchronised with periods of slower currents and good visibility. Pen inspections by divers would typically be carried out fortnightly on neap tides, when water flows are lower and visibility is good. Divers will inspect the pens for integrity and will carry pliers and steel spirals with them to carry out any necessary repairs on the spot (refer to Plate 2).

Plate 2: Diver Carrying Out Repairs on Port Hurd Farm Nets

The steel nets do not require any cleaning. Fibre nets will be cleaned fortnightly on the neap tides. Divers will enter the nets and will use a rotating disk with high water pressure.

3.8.4 Grading and Counting

The fish will be graded and counted at set times. These events will be kept to a minimum in order to minimise the chances of damaging their skin and therefore increasing their chances of exposure to disease. They are generally graded and/or counted four times during their life: at the hatchery, prior to receipt by Marine Harvest, when they are transferred to the grower pens, and finally at harvest time.

Each group of fish is given a label, e.g. 03/05A would represent the group taken in March 2005 at the first intake, and 03/05B would represent the group taken in March 2005 at the second intake. If the groups become combined they would be labelled with an AB suffix. Each time they are handled for grading or any other reason, the label is tagged with an additional digit, e.g. 031/05B has been handled once, 032/05B has been handled twice, and so on. All specifics relating to the handling exercise, and other details about the fish groups are collated digitally on the on-site computers. This system of labelling assists with quality control.

Fish will be separated or removed from pens with the help of Seine nets, which are not gill nets. The Seine nets will be used to crowd the fish into one side of the pen and a fish pump will then be used to bring the fish up onto the barge for grading, counting and/or harvesting.

3.8.5 Growth and Harvesting

Predicted growth rates are based on those from the Port Hurd site where growth rates have been excellent. The fish will take approximately 18 months to reach a marketable size of approximately 3 kilograms.

A harvesting vessel will be deployed from Darwin. This will consist either of a well boat for live transport or a boat containing a large amount of ice stored in wells. The fish to be harvested will be crowded into a small area in the corner of the pen. The fish will then be sucked into a hopper and discharged to the boat well. If the fish are to be iced they will be discharged via a chute into an ice slurry on the harvesting vessel. The sudden reduction in water temperature from 30°C to 0°C kills the fish. The operation is carried out as quickly as possible to reduce the stress on the fish from overcrowding in the harvesting pen, and to ensure the temperature of the fish drops as quickly as possible. The fish are then packed into containers filled with ice to ensure the temperature of the fish remains at around 2° for the duration of the 12-hour trip to Darwin.

It is anticipated that in the long term the fish will be harvested live into well boats. This method has the advantage of providing a longer ‘shelf’ life to the fish.

3.8.6 Steel Nets Construction

As discussed previously, the nets will be constructed in Darwin and transported to the site by boat. Based on the Port Hurd experience, the nets will last around 2 years. If 24 nets are present, this will require that around one net is built and replaced every month.

3.8.7 Ensiler and Domestic Waste Disposal

An ensiler will be kept on the barge. The ensiler will be used for the disposal of dead fish (morts). All solid wastes generated will be disposed to dedicated bins and recycled via the landfill recycling system. It is likely that putrescible waste could be disposed into the ensiler. The resultant product would have different ratios of nitrogen, phosphate and potassium than the product issuing from fish only and this would need to be taken into account when supplying the product to the fertiliser company MOECO, so that it may adjust its admixtures when manufacturing its fertilisers.

3.8.8 Emissions

Emissions from the proposed operation include:

- wastes to water from:
  - excess feed not consumed by farm fish,
  - fish faeces,
  - dead fish (morts),
  - parasite control treatment, and
  - grey water from the barge;
- solid wastes from:
  - feed bags,
  - dead fish (morts), and
  - waste from the occupation of the barge by staff;
- noise, light and air:
  - noise from outboard motors, feeding equipment, occupation of the barge, harvesting operations, site maintenance;
  - light from the habitation of the site during night hours and illumination of the farm outline for vessel safety; and
  - emissions to air may include noxious smells from dead fish stock, and noxious smells and fumes from the presence of chemicals and fuels and from running outboard motors, the generator, and feeding equipment and emissions of greenhouse gases from the consumption and presence of fuels.

Table 3.4 provides an indication of the quantities of each waste type.

Table 3.4: Estimate of Quantities of Liquid and Solid Wastes

Waste receptor	Type	Quantity (estimate)	Comment
Water body	Excess feed	Minimal	Feeding is strictly monitored via feed tables so surplus feed is minimal. Any minimal stray amounts would be taken up by local wild fish.
	Fish faeces	16 - 20 kg per 1000 kg of fish produced	Would be expected to be mostly flushed by tides.
	Morts	Nil to minimal	Solid and liquid wastes from morts will be minimal given that they are removed daily from the nets and decay would be non-existent to minimal.
	Parasite control treatment	Nil to minimal	Fish at Port Hurd were found to not require any parasite treatment from the time steel mesh nets were used.
	Waste water from barge	5000 litres/week	Grey water consisting of treated sewage waste, and use of barge by personnel.
Recycler	Morts and putrescibles from ensiler	2% of fish produced	Would be sent to fertiliser company for recycling.
Landfill - recycling	Recyclables (e.g. cans, paper, plastics, etc.)	2 kg / week / per person, plus a small amount of other containers required for the operation.	Recycled at the Darwin landfill.
Landfill	Non-recyclable packaging and other non-recyclable wastes (e.g. feed bags)	5 kg of feed bags / 1000 kg of fish, plus a small amount of other wastes from the operation.	Disposed to the Darwin landfill.

3.8.9 Chemicals

The operation will store a number of chemicals and hazardous materials which will be managed in accordance with Dangerous Goods Regulations.

Small quantities of cleaners and detergents will be stored for use. Some laboratory and workshop chemicals will be stored and used. Minor quantities of greases and solvents for maintenance purposes will be stored in the workshop. The most significant hazardous materials stored on site are diesel and unleaded petrol. These will be used to power engines on the supply vessels and on the farm.

3.8.9.1 Diesel and Fuels

The main fuels required by the operation will be diesel and unleaded. It is anticipated that around 1000 litres of diesel will be required by the barge each month. It is estimated that around 1000 litres of unleaded fuel will be used monthly in the outboard motor boats and the Honda feeding pump. Car trips would be expected to be minimal as most transport will be by boat.

Storage quantities on the barge at any one time will probably be of the order of 2,500 to 5,000 litres of diesel and 1,000 litres of unleaded fuel. All diesel and fuel will be stored in a purpose-built, bunded area.

3.8.9.2 Solvents and Cleaners

The workshop on board the barge will contain solvents, cleaners and degreasers.

3.8.9.3 Chemicals, Fuels and Hazardous Materials Register

A list of chemicals which are expected to be required on site is provided in Table 3.5; these are grouped into laboratory chemicals, workshop chemicals and fuels. The chemicals held in the farm's laboratory are used for fish health reasons, such as disease identification.

Table 3.5: List of Chemicals Stored on Site, based on the Port Hurd Pilot Program Chemical Register

Chemical Name	Areas Stored	Typical Amount Held
Clean Hands Hand Cleaner	CLEANERS BUND	20 L
Country Wide Pine Disinfectant	CLEANERS BUND	20 L
Ethanol 100%	LAB	5 L
Formalin 10% neutral buffered	LAB	10 L
Lugol's Iodine	LAB	1 L
Methanol (AR)	LAB	1 L
Methylated spirits	LAB	10 L
Chlorine Bleach of Phoraid	LAB	5 L
Hydrochloric Acid	LAB	5 L
Giemsa stain	LAB	3 L
Gram stain kit	LAB	
Oxytetracyline (antibiotic)	LOCKED CONTAINER	200 kg

Chemical Name	Areas Stored	Typical Amount Held
Acetone	PAINT STORE	5 L
Cabots Deck Oil	PAINT STORE	10 L
Rustroy	WORK SHOP	
Aquadhere	WORKSHOP	500 ml
Araldite	WORKSHOP	200 ml
Bostic PVC glue	WORKSHOP	250 ml
Bostic PVC primer	WORKSHOP	250 ml
Braizing flux powder	WORKSHOP	1 L
CRC aerostart	WORKSHOP	1 spray can
CRC bulk	WORKSHOP	20 L
CRC lube	WORKSHOP	4 spray can
Diesel injector cleaner	WORKSHOP	500 ml
Duralac anticorrosion joining compound	WORKSHOP	3 tubes
Exhaust manifold cement	WORKSHOP	100 ml
Food Lube	WORKSHOP	1 cylinder
HIAB Skewing grease	WORKSHOP	100 ml
Lanotec bulk	WORKSHOP	20 L
Loctite 243	WORKSHOP	100 ml
Loctite 401 adhesive	WORKSHOP	25 ml
Loctite 567	WORKSHOP	250 ml
Loctite bluemax silicone	WORKSHOP	100 ml
Loctite gasket seal	WORKSHOP	500 ml
PBR rubber grease	WORKSHOP	100 ml
Pot Belly heat resistant paint	WORKSHOP	2 spray can
PVC glue	WORKSHOP	500 ml
PVC primer	WORKSHOP	500 ml
RTD metal cut compound	WORKSHOP	1 L
Silver braizing flux paste	WORKSHOP	100 ml
Tectyl spray	WORKSHOP	1 spray can
Trefolex cutting compound	WORKSHOP	1 L
Zinc It	WORKSHOP	6 spray can
Rust Guard Paint	WORKSHOP	1 spray can
Diesel Fuel	BUNDED AREA	5,000 – 10,000 L
Unleaded Petroleum Fuel	BUNDED AREA	1,000 – 1,500 L
Lubricating oil	BUNDED AREA	WORKSHOP
Air	BOTTLE CRATE	450 kg
Oxygen	BOTTLE CRATE	45 kg
Acetylene	BOTTLE CRATE	45 kg
Potassium Hydroxide (for ensiler)	BUNDED AREA	1000 kg

3.8.10 Ongoing Management, Maintenance and Administrative Requirements

An engineer, whose responsibility will be to carry out maintenance on machinery and the barge, will be present on site. General maintenance schedules will be documented in the site procedures and will follow a 'per hours of operation' scheme, whereby the generator is serviced every 250 hours of operation, the barge is serviced every 200 hours of operation, and so on.

It is anticipated that administrative work conducted on the farm will be minimal. The 'office' will be equipped with a computer, a telephone and a facsimile machine. The farm would be required to send stock information to Darwin, to confirm travel arrangements, and to pass on ordering requirements, etc. All other administrative duties would be conducted from the Darwin office.

3.9 Decommissioning and Rehabilitation

The life expectancy of the farm, barge and nets is indefinite at this stage. If operation of the site ceases in the future, Marine Harvest will discuss potential sale of the operation with the Government and with the Northern Land Council, who may be interested in taking over ownership of components of the farm for some other purpose.

Decommissioning and rehabilitation of the barge facility will require:

- removal of the barge,
- removal of nets and plastic circles,
- removal of all anchor ropes, and
- removal of any steel anchors which have not dug down too deep for removal.

It is possible that some of the materials could be reused and recycled:

- The barge or its components should be able to be recycled;
- The plastic circles have a very long life, around 10 years, which means that the material could be recycled;
- The anchor ropes can be reused for landscaping or other similar usage;
- The anchors are made of heavy steel and can be reused; and
- Any equipment or machinery can be sold for reuse.

Any materials that cannot be reused or recycled, will need to be disposed to appropriate waste-disposal facilities in Darwin and will be transported via a local sea-transport company.

3.10 Legislative Requirements

3.10.1 Lease Requirements

A licence is required for the development under Northern Territory Fisheries legislation. Part of the requirements for such a licence is that the proponent must first obtain a permit and a lease. A lease is granted by the Department of Planning, Infrastructure and Environment and the Minister decides the length of the lease. If the lease period is greater than 12 years then the proponent must also apply to the Development Consent Authority for approval of the lease before the title can be registered.

Marine Harvest is in the process of applying to the Northern Territory Department of Infrastructure, Planning and Environment for a Crown lease over the proposed area. A Crown Lease Term is a development lease containing conditions and covenants requiring development to be undertaken in accordance with the agreed development plan. A granted lease is valid for 10 years.

3.10.2 Native Title

Native title does not currently impact on marine areas but it is considered possible that this situation may change in relation to bay areas. Under the Northern Territory legislation, development applicants must have contact with traditional landowners in the area as part of the development consent process. Marine Harvest has been in contact with the Northern Land Council who will in turn contact the traditional landowners following the completion of the Environmental Impact Statement.

Marine Harvest will comply with relevant requirements of the *Northern Territory Aboriginal Sacred Sites Act* (1989) and the *Aboriginal Land Rights (Northern Territory) Act* 1976.

3.10.3 Compliance with Applicable Standards

The barge facilities which will be constructed, will comply with all relevant Environmental Health Standards for Public Health, Food and Radiation Protection including, but not limited to, the Northern Territory legislation, summarised in Table 3.6 below. The facilities will be inspected regularly by a Food Health inspector.

Table 3.6: Applicable Environmental and Health Legislation

Applicable Legislation	**Enforcement Agency**
Public Health (General Sanitation, Mosquito Prevention, Rat Exclusion & Prevention) Regulations	Territory Health Services
Water Act	Department Lands, Planning & Environment
Water Supply and Sewerage Services Act	Power and Water Authority
Public Health (Nightsoil, Garbage, Cesspits, Wells & Water) Regulations	Territory Health Services
Waste Management and Pollution Control Act, 1998	Department of Lands, Planning and Environment

4 Alternatives

4.1 Not Proceeding with the Proposal

The Marine Harvest-proposed Port Patterson Barramundi Fish Farm is a component of a business plan which includes the proposed Snake Bay barramundi fish farm, and the proposed Channel Island nursery site. The aim of the business plan is for Marine Harvest to develop a sustainable farmed-barramundi industry.

The plan requires that three grow-out sites be operational and 5000 tonnes of fish be harvested annually from all farms combined for the operation to be able to support a dedicated well boat. Without the economy of scale and its own well boat, production costs (and on-selling costs) would be much higher, since a well boat would need to be contracted and scheduling of harvests would be more difficult.

The Port Patterson proposal is ranked second, by Marine Harvest, in the priority list of the three proposed sites, with Channel Island being the first priority, and Snake Bay, the third. Should the proposal for Port Patterson not proceed, Marine Harvest would still aim to pursue the establishment of the other proposed sites. However the business plan would not allow for the purchase of a well boat until a longer period of time had passed. Consequently, production costs would be much higher and it is likely to be more of a challenge to establish the farmed barramundi market.

4.2 Alternative Locations or Layout for the Whole Proposal

Marine Harvest has investigated much of the Northern Territory coastline for suitable sites for its proposed barramundi marine farming operations. Its selection criteria included:

- proximity/accessibility to Darwin,
- shelter from cyclones,
- suitable current speeds, and
- adequate water depth.

Marine Harvest found that many of the optimal sites were already taken by existing pearl-oyster farming operators, whose selection criteria are similar to those for marine fish farming. The sites Marine Harvest has selected, including the Port Patterson site, are the most suitable and potentially available for its aquaculture purposes.

The Port Hurd farm operation has allowed Marine Harvest to trial its operational requirements and it is from these trials that optimal requirements from Port Patterson have been identified.

4.3 Alternatives for Components of the Proposal

4.3.1 Steel Nets

Based on the Port Hurd experience, it was found that the steel-cage cluster arrangement was not suitable for withstanding cyclonic conditions. The plastic circles with steel nets arrangement, which Marine Harvest propose to use at Port Patterson, were found to successfully withstand a Category 3 cyclone (March 2005) and a king tide (September 2005). The latter arrangement is therefore considered to be the best option and will be adopted for the proposed Port Patterson barramundi farm.

Marine Harvest has trialled both large and small net sizes at Port Hurd. The size of the pens is likely to be 48-metre circumference, as opposed to the larger sizes used at Port Hurd (86-metre or 100-metre circumference pens). Based on the Port Hurd experience, these smaller pens are considered optimal, as they are less visually obtrusive than the larger pens and they will help contain potential disease outbreaks to small groups of farmed fish. The smaller size means they will be lighter, and will therefore be exposed to less water drag and consequently put less strain on the mooring lines than the larger nets. The main disadvantages of the smaller nets are related to the extra amount of labour involved in constructing, mooring, maintaining the nets and the extra labour involved in feeding and monitoring more nets.

4.3.2 Mooring Devices

The nets will be anchored to the seafloor via cyclone-proof mooring devices installed by cyclone-mooring specialists. This system has proven at Port Hurd to be generally successful in withstanding cyclonic conditions and king tides. Marine Harvest has opted to use smaller mooring arrays, where fewer nets will be attached to each mooring line.

4.3.3 Operational Facilities

The aim is to have all operations centred at sea at the farm itself, as this process is more practical and efficient. It limits the amount of motor boat movements, permits staff to optimise working hours, and allows staff to be present at all times to monitor the farm and respond rapidly to any emergency.

The intention is to place the barge in the middle of the farm area with the pens in two rows on either side of the barge. This layout optimises the visibility and accessibility of the pens by staff for inspection, feeding, harvesting, security, etc.

The barge design will be based on existing, tried and tested barges used in Canada, which have a concrete base with Styrofoam casing. It will have a number of specifically-designed dongas bolted onto it. The barge is expected to be around 40 metres long. The barge will be anchored to the seafloor via cyclone-proof mooring devices installed by cyclone-mooring specialists.

4.4 Alternative Environmental Management Techniques

A summary of the proposed environmental management techniques is discussed in Sections 9 and 10. These will be further detailed in the Environmental Management Plan which will be drawn up separately for the site. Alternative management options will be discussed in the Environmental Management Plan.

Marine Harvest is committed to choosing the most effective environmental management techniques which will achieve the goals of preventing and minimising impacts to the environment from the operation.

5 Existing Environment

5.1 Regional Setting

Details on the physical location of Port Patterson and the proposed project area are provided in Section 3.3. Location maps are provided in Figures 1, 2 and 3.

There is very little documented environmental information about the Port Patterson and Bynoe Harbour area. A report detailing the findings of a marine survey conducted by the Northern Territory Department of Infrastructure, Planning and Environment is currently being completed but drafts are unavailable to the public. The only published information available is Brocklehurst and Edmeades' Mangrove Survey of Bynoe Harbour, Northern Territory (2003) and a draft Environmental Impact Statement (Suntay Aquaculture Pty Ltd, 2003) prepared for Point Ceylon Aquaculture Estates (located at the southern edge of Bynoe Harbour). Much of the information included below has been directly drawn from these two documents as well as from personal communication with DIPE researcher Neil Schmidt (May 2005) and has been inferred from information for the neighbouring Bynoe Harbour.

5.1.1 General

Port Patterson is part of a ria coast formed by post-glacial flooding of a dissected plateau. The morpho-hydrological character is described as a branched bay with no off-channel embayment and with a multiple unconstricted mouth (Saenger & Bucher, 1989). Small tidal creeks, which support mangroves, occur around the bay.

The Port Patterson area contains some of the Northern Territory's best quality reefs, and pearling operations are also located within Bynoe Harbour (pers. comm. Neil Schmidt, May 2005).

5.1.2 Climatic Factors

The relative proximity of Port Patterson to Darwin suggests that general climatological characteristics would be similar to those of Darwin.

The climate of Darwin is tropical monsoonal, characterised by a hot and humid 'summer' or wet season, and a hot and dry 'winter' or dry season. Darwin has an average annual rainfall of 1700mm. Average annual minimum temperatures range from 19ºC in July to 25ºC in November and December, and average annual maximum temperatures range from 30ºC in July to 33ºC in November. Relative humidity ranges from monthly means of 62 to 83% at 9am and from 38 to 77% at 3pm. According to the Bureau of Meteorology web site, tropical cyclone events are regular events and would typically occur more readily during El Niña events. Cyclone events would typically be Category 3 or 4, though Category 5 cyclones have been recorded.

5.1.3 Soils and Geomorphology

Port Patterson is an indented embayment. The hinterland is a dissected plateau underlain by Precambrian rocks with a variable cover of Cainozoic laterites and weathering products (Brocklehurst and Edmeades, 2003). Port Patterson functions seasonally as a large estuary. During the wet season and shortly afterwards, rivers

discharge substantial quantities of freshwater into the marine system. Phoenix Inlet discharges freshwater to the Geranium Channel near the proposed site. Sedimentary infill of this terrain has resulted in the development of narrow and broad embayments, islands and sand spits.

The two main habitat types which support mangrove vegetation include tidal flats and tidal creeks. The tidal flats are gently inclined, with slopes of 2-5 degrees, and can extend between 100 metres and 1.5 kilometre from the seaward edge to the landward edge. The tidal creek habitat has a moderate to steep bank along the tidal channels, backed by a gently inclined tidal flat extending landward to the hinterland zone. Tidal channels fluctuate from 2-10 metres deep and tidal creeks range from 3-100 metres wide. Muddy shoals develop in the tidal channels. Tidal creeks may occur within the main tidal flats creating diverse patterns. Less common habitats include rocky islands, rocky shores, spits, cheniers and the occasional beach. Islands occur in the entrance to Bynoe Harbour and Port Patterson; these support well developed *Rhizophora stylosa* closed-forests.

Soils are generally bio-turbated and root structured muds, homogeneous muds or muddy sands. Analytical results of soils are typical of those for the Darwin region (Brocklehurst and Edmeades (2003)). They are highly weathered, low in plant nutrients, with acid to neutral pH, and are dominated by kaolinitic clays. Ironstone gravels are characteristic of soils associated with lateritic parent materials. Sediments in the intertidal zone reflect the composition of the source materials. Throughout the sediments there are also localised concentrations of sulphur compounds, derived primarily from old, buried mangroves. Soil material high in oxidisable sulphur poses a high risk of acid sulphate soils forming following disturbance either naturally, from episodic storm damage, or as a consequence of human impact. However, this risk only exists above the water table when sediments are exposed to air and is non-existent within the permanently submerged seafloor area where the mooring anchors will be embedded.

5.1.4 Water Flows and Quality

Tides in Port Patterson are diurnal and macrotidal reaching 7.5 metres (Saenger & Bucher 1989 in Suntay (2003)). Maximum tidal range at Tapa Bay is 7.6 metres with a mean spring tidal range of 5.1 metres (Saenger & Bucher, 1989 in Suntay (2003)).

The currents near Point Ceylon can run at up to 2.2 knots during a spring tide and up to 0.8 knots during a neap tide. Tidal streams were recorded for two points in Bynoe Harbour and Port Patterson, one about 15 kilometres north of Point Ceylon, and one about 34 kilometres north.

Depths of the Geranium Channel in Port Patterson range from around 3 metres to 13 metres at the site of the proposed barramundi farm.

MacKenzie Arm feeds into Port Patterson. Indian Island separates Port Patterson to the west from Bynoe Harbour to the east for around 17 kilometres. Limited survey data were available from the bathymetric chart (AUS 29) (refer to Appendix C) for MacKenzie Arm, but the maximum depth of MacKenzie Arm is 17 metres at one point, and the general channel depth ranges from 5 to 10 metres. Strong flows would be expected during ebb

and flood tides. The narrow channel which separates Indian Island from the mainland to the south is about 250 metres wide at its narrowest. Tidal flows in this channel would be less than for the main channels to the east and west, although Schmidt (pers. comm., May 2005) notes that the currents in this channel are still very strong.

Water quality is regarded as essentially natural (Brocklehurst and Edmeades, 2003). No significant potential sources of pollution have been identified (Saenger and Bucher, 1989 in Suntay (2003)), and the foreshores are largely undeveloped, with the exception of rural block development at the heads of Milne Inlet and Mackenzie Arm. Paspaley Pearling Company Pty Ltd, whose oyster leases occur in the southern sections of Bynoe Harbour adjacent to Indian Island and to Point Ceylon, carry out regular measurements of temperature, salinity and turbidity. Secchi readings, which measure the visibility of a Secchi disk below the surface have also been taken periodically since 1998. The values, which provide an indication of suspended solids, showed a maximum of 8 metres, a minimum of 0.3 m, a median value of 1.6 m, and an average of 1.8 m. The readings tended to increase in the dry season, and decrease in the wet season.

5.1.5 Population, Buildings and Infrastructure

The proposed barramundi farm falls within the Finniss Sub-Region of the Northern Territory Planning Scheme. There are no townships within the sub-region. The population of around 1800 is concentrated in the rural subdivisions of Dundee Beach, Dundee Downs and Bynoe Haven. These subdivisions consist of both permanent residents and temporary weekender populations. As noted above, there is also some rural block development at the heads of Milne Inlet and Mackenzie Arm. Pearling operations are also located in the southern end of Bynoe Harbour and several tourism lodges are located in the region such as Crab Claw Island Fisherman's Village.

Access through the Finniss sub-region is provided by road, with private access by sea, river and air. Fog Bay Road provides largely unsealed access from Cox Peninsula to Fog Bay. There is no reticulated power, water or sewerage within the Finniss Sub-Region. There is a temporary waste disposal site at Dundee Downs and limited urban services reflecting the small permanent population. Residents rely on services provided in Darwin and Palmerston.

5.2 Physical and Biological Environment

5.2.1 Existing Environment

The proposed farm location is near Doug Point, within Geranium Channel, located to the west of Indian Island within Port Patterson. It is in an area of deep water in the centre of the Channel. A number of shallow mangrove creeks discharge into the Channel and are affected by tidal flows (Aquenal, October 2005). Bynoe Harbour is connected to Port Patterson and contains a pearling operation and several tourism sites. Bynoe Harbour has been proposed as the site of a new multiple-use Marine Park by the Northern Territory Government.

The existing physical environment at Port Patterson has not been documented in a comprehensive manner. Discrete studies have been undertaken in several areas and

general information is available from public sources. The following section is a summary of this information and attempts to provide an objective insight into the present status of the physical environment at Port Patterson.

5.2.1.1 Hydrology and Water Quality

The following summary draws upon findings from Aquenal's Baseline Environmental Survey – Doug Point (Aquenal, 2005).

The location of the proposed farm is in deep water in the channel to the east of Doug Point. The environment of the farm is sheltered mangrove estuarine with great seasonal variation in fresh water inflow.

The main hydrological influences on the water body is the 6 to 7 metre tidal range, which results in large daily flushing of the mangroves with seawater, and run-off from heavy rains during the wet season. Towards the end of the dry season, when terrestrial run-off has ceased and hot temperatures prevail, negligible net flushing occurs through the estuary, and evaporation results in increased salinity and potentially a net inflow into the estuary. During this period, nutrients from the aquaculture facility are most likely to accumulate in the estuary on intertidal flats and in deeper channels.

Water temperature, dissolved oxygen and salinity readings obtained during Aquenal's baseline survey (2005) show that water quality in Port Patterson is within the range of the quality of water in Port Hurd, and is therefore considered typical for this type of mangrove estuary. Water is very warm, with salinity greater than seawater at the majority of sites (38 – 40.7ppt) measured (Aquenal, 2005). More detailed water quality information is provided in Section 5.3 which summarises the baseline study carried out by Aquenal. Table 5.1 below summarises the water quality data for Port Patterson and Port Hurd, based on Aquenal's reports (2005 and 2006).

Table 5.1: Comparison of Water Quality in Port Patterson and Port Hurd

Parameter	Unit	Port Patterson	Port Hurd
Dissolved Oxygen	%	64-91	51-96
Salinity	ppt	38-40.7	22.5-38.5
Chlorophyll *α*	μg/L	≤2	1.1 to 4.6
Nitrate	mg/L	<0.005	≤0.043
Nitrite	mg/L	<0.005	≤0.055
Ammonia	mg/L	0.005 to 0.05	≤0.220

5.2.1.2 Bathymetry

The proposed site will be located over a narrow portion of Geranium Channel where water currents have scoured a meandering channel which is considerably deeper than in the remainder of the estuary. The western boundary of the proposed lease is located around the 10 metre depth contour (refer to Appendix C) but the channel quickly deepens to 12 and 13 metres in a south-easterly direction along the length of the lease. The channel connecting Geranium Channel with Bynoe Harbour is 6.3 metres deep at the entrance (Aquenal, 2005). The shallow Phoenix Inlet is the nearest shallow mangrove creek to the proposed farm site and much of the water flowing into it on a rising tide will contain waters which have recently passed through the farm on the preceding ebb tide.

5.2.1.3 Existing Coastal and Marine Flora Species

Mangrove vegetation occurs along the intertidal flat. Structurally, and floristically, mangrove zonation is strongly influenced by tidal elevation. There are approximately 24,000 hectares of mangroves in Bynoe Harbour, the Islands and north to Charles Point. *Ceriops tagal* forest is the most widespread community, forming closed forest, low closed-forest and open-forest comprising approximately 36% of mangrove area. *Rhizophora stylosa* closed-forest is also common, making up approximately 30% of mangrove area. It occurs along tidal creeks and the seaward fringes of the main tidal flat. Common species found with *Rhizophora stylosa* include *Avicennia marina*, *Bruguiera spp*., *Camptostemon schultzii* and *Aegiceras corniculatum*. Tall monospecific stands of *Rhizophora stylosa* occur in some regions (e.g. low tidal flat). Mangroves are noted (pers. comm. Schmidt, May 2005) to line both sides of Geranium Channel.

Sonneratia alba open-forest to open-woodland occurs on the seaward edge of mangrove forests and extends out onto the mudflats. Mixed species low closed-forests and closed-forests occur as narrow bands on the landward edge of the mangrove zone and include *Lumnitzera racemosa*, *Excoecaria ovalis* and *Ceriops tagal.* Grasslands and open woodlands abut the mangrove hinterland fringe, generally in seepage areas and include *Melaleuca spp*., *Corymbia polycarpa* and *Acacia auriculiformis*. The Suntay EIS (2003) notes that broad drainage basins across the area support mixed-species low-open woodland. Riparian communities comprise only 1.3% of the Lower Finniss Region.

Upland habitats are dominated by open woodlands of *Eucalyptus spp*. The dominant species in the upper stratum is typically Darwin Woollybutt *Eucalyptus miniata*, which occurs in association with Ironwood *Erythrophleum chlorostachys* and *Corymbia bleeseri*. This community is widespread across the Top End and constitutes 44% of the total area of the Lower Finniss Region. Woodlands dominated by *Melaleuca spp*. fringe the landward edge of mangrove forests in the area and are the second most dominant vegetation type in the area. The Melaleuca communities are common and constitute 6.4% of the Lower Finniss Region.

Monsoon vine forests also occur in patches throughout the area. The most diverse patches in terms of structure and composition occur on old beach ridges that fringe mangroves, and in association with freshwater streams. Some small patches of less well developed monsoon vine forest occur on shallower, gravelly soils. Monsoon vine forests

(rainforest) are well represented in the Lower Finniss Region covering 5.6% of the total vegetated area, compared to their coverage of only 0.2% of the NT.

5.2.1.4 Existing Marine and Coastal Fauna Species

Marine Fauna

Bynoe Harbour and Port Patterson have not been well studied and little or no literature exists on many scientific aspects of the estuaries including formal fish surveys, molluscs, and hard and soft corals. The Northern Territory Department of Infrastructure, Planning and Environment has, however, recently surveyed Bynoe Harbour through habitat mapping, fish surveys and trammel netting. The results have not yet been released but will include some information on the habitats adjacent to Point Ceylon and Toss Point which appear to include soft coral and hydroid gardens. Preliminary information from this survey suggests patchy seagrass beds to the south-east of Indian Island near Point Ceylon but no seagrass beds to the west of Indian Island. Other preliminary observations suggest that Bynoe Harbour appears to have more reef development than Darwin Harbour, including mature reef development. All reef development is sub-tidal. The reason for this better reef development is probably because the flow through Bynoe Harbour is stronger than in the broader Darwin Harbour. The stronger currents allow sediments to be held in suspension longer and to be flushed out more effectively and therefore not smother the reefs.

The Aquenal (2005) report noted that there were no known coral reefs within Geranium Channel and that coral reefs are known to be patchy in the waters to the west of Indian Island. Rocky reefs occur in patchy areas along the eastern shore of Geranium Channel. Reefs surround the off-shore islands. The Aquenal report also noted that seagrass is known to exist along the seaward end of Indian Island and in Bynoe Harbour in some bays on the eastern shore of Indian Island. However, these seagrass beds are sparse and patchy.

Juvenile dugongs and turtles are known to occur in the area and it is likely that Green Turtles and Hawksbill Turtles will occur in the area since they frequent rocky reefs to feed on algae.

Coastal Fauna

A terrestrial fauna survey conducted for the site covered by the Suntay EIS (2003) recorded the following results.

Nine species of amphibians and 22 reptile species were recorded. 61 species of birds were recorded within quadrats and an additional four species recorded incidentally in the study area. The only bird species recorded on the site with listed conservation status ('near-threatened' under the Territory Parks & Wildlife Act 2001) was Emu *Dromaius novaehollandiae* (Garnett and Crowley 2000 in Suntay (2003)), which was seen during both surveys in the dry open woodland.

Mammals were the least diverse vertebrate group on the study area, with only eight species recorded. This included two species of macropod, three rodents, one dasyurid, one possum and one fruit bat. Species recorded included *Taphozous kapalgensis*,

Scotorepens greyii, Chalinolobus nigrogreseus, Pipistrellus westralis, Miniopteris schreibersii, Nyctophilus walkeri, Nyctophilus sp. The Arnhem Sheath-tail bat *Taphozous kapalgensis* is considered 'near-threatened' under the Territory Parks & Wildlife Conservation Act 2001. Although not recorded within the study area, one mammal of significance, the Northern Quoll *Dasyurus hallucatus* was noted approximately 20 kilometres to the east. This species is listed as 'lower risk - near threatened' (TPWC Act 2001) and its range is becoming increasingly restricted and disjunct.

Two species covered by migratory international migratory bird agreements (CAMBA, JAMBA), and by migratory provisions of the EPBC Act, were noted and probably occur sporadically along the mangrove edges at different times of the year. These are the White-breasted Sea Eagle *Haliaeetus leucogaster* (CAMBA) and Whimbrel *Numenius phaeopus*. Two further species that are covered by migratory provisions of the EPBC Act are likely to occur within the mangroves in the area; the Estuarine Crocodile *Crocodylus porosus*, and the Rufous Fantail *Rhipidura rufifrons*. Schmidt (pers. comm., May 2005) notes that crocodiles are known in the area but that their population level is quite low.

EPBC-Listed Species

Thirteen (13) Threatened Species and thirty-one (31) Migratory Species are listed for the area covered by the proposal (EPBC Web Site). These are provided in Table 5.2 below.

Table 5.2: List of Threatened and Migratory Species from EPBC Web Site for the Proposed Development Site

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 smithii Partridge Pigeon (eastern)	Vulnerable	Species or species habitat likely to occur within area
Mammals		
Dasyurus hallucatus Northern Quoll	Endangered	Species or species habitat may occur within area
Xeromys myoides Water Mouse, False Water Rat	Vulnerable	Species or species habitat may 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
Lepidochelys olivacea	Endangered	Species or species habitat may occur

Pacific Ridley, Olive Ridley		within area
Natator depressus Flatback Turtle	Vulnerable	Breeding likely to 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		
Coracina tenuirostris melvillensis Melville Cicadabird	Migratory	Species or species habitat may occur within area
Erythrura gouldiae Gouldian Finch	Endangered	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
Poecilodryas superciliosa cerviniventris Derby White-browed Robin	Migratory	Species or species habitat likely to occur within area
Rhipidura rufifrons Rufous Fantail	Migratory	Species or species habitat may occur within area
Migratory Wetland Species		
Birds		
Actitis hypoleucos Common Sandpiper	Migratory	Species or species habitat likely to occur within area
Arenaria interpres Ruddy Turnstone	Migratory	Species or species habitat likely to occur within area
Calidris alba Sanderling	Migratory	Species or species habitat likely to occur within area
Calidris tenuirostris Great Knot	Migratory	Species or species habitat likely to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover	Migratory	Species or species habitat likely to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover	Migratory	Species or species habitat likely to occur within area
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
Limosa lapponica Bar-tailed Godwit	Migratory	Species or species habitat likely to occur within area
Limosa limosa Black-tailed Godwit	Migratory	Species or species habitat likely to occur within area
Numenius minutus Little Curlew, Little Whimbrel	Migratory	Species or species habitat may occur within area

Numenius phaeopus Whimbrel	Migratory	Species or species habitat likely to occur within area
Pluvialis squatarola Grey Plover	Migratory	Species or species habitat likely to occur within area
Migratory Marine Species		
Mammals		
Balaenoptera edeni Bryde's Whale	Migratory	Species or species habitat may occur within area
Dugong dugon Dugong	Migratory	Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca	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
Lepidochelys olivacea Pacific Ridley, Olive Ridley	Migratory	Species or species habitat may occur within area
Natator depressus Flatback Turtle	Migratory	Breeding likely to occur within area
Sharks		
Rhincodon typus Whale Shark	Migratory	Species or species habitat may occur within area

5.2.2 Air Quality, Noise, Lighting and Visual Amenity

The air quality, noise, lighting and visual amenity is of a high quality due to the lack of any population centres or major industry in the region.

5.3 Port Patterson Baseline Investigation

A baseline investigation has been carried out at Port Patterson to provide pre-operational data against which subsequent monitoring may be compared to assess potential impacts of the proposed aquaculture operation at Port Patterson. The investigations were carried out by Aquenal Pty Ltd in August and October 2005 and reported in November 2005. A copy of the full report is provided in Appendix D.

Aquenal Pty Ltd was previously contracted by Marine Harvest to carry out the baseline survey for the existing barramundi farm at Port Hurd in 2002. During the investigations for the proposed sites, a follow up survey of Port Hurd was carried out.

5.3.1 Investigation

A drogue survey was carried out on 4 and 5 August 2005 to identify water movements which, in turn, supported the identification of the proposed sampling sites for baseline studies. Six baseline sampling locations (labelled F1 to F6) were selected adjacent to Doug Point as well as separate control sites (labelled C1 to C6) within Madford and Tahlee Inlets, situated 12 kilometres to the west of Doug Point. Figure 7 provides the location plan of the sampling sites for the investigation. The investigation carried out by Aquenal Pty Ltd in 2005 was aimed at assessing 'the baseline conditions of several parameters expected to be sensitive to impact from elevated nutrient levels which may result from the proposed aquaculture operations'. In each estuary, three sites were in shallow water and three sites were in deep water. The shallow water sites needed to be accessible an hour after half tide on an outgoing spring tide to enable sampling.

Aquenal Pty Ltd (2005) noted that its drogue survey indicated that water moving through the farm on the flood tide will carry farm released nutrients through Geranium Channel and up into McKenzie Arm. On spring tides some nutrients may even be carried into Bynoe Harbour. On a single flood tide cycle, nutrients could be washed more than 6 kilometres up the estuary and some could be carried into the mangrove flats lining the channel and its tributaries. Waters passing through the farm on the ebb tide will primarily remain in the northern half of Geranium Channel with some dispersing out into Port Patterson. On slower moving ebb tides, particularly when a stiff sea breeze is blowing, floating and dissolved nutrients could be carried over the mud flats to the south-east of the farm site. It can be expected that the waters of Geranium Channel will wash back and forth past the farm with potential to accumulate nutrients during the dry season.

Aquenal Pty Ltd (2005) notes that sampling at the end of the dry season is considered optimal, as worst-case conditions would exist as a result of little or no terrestrial run-off, high temperatures, and likely nutrients accumulation on intertidal flats and in deeper channels. Sampling for this baseline survey was carried out during the first week of August 2005, i.e. near the end of the dry season.

Samples and observations were collected for the following criteria which would provide an indication of potential future impacts from the proposed farm:

- sediment description,
- redox,

- particle size,
- photography of mangrove root assemblages,
- mangrove stand structure and condition,
- benthic infauna,
- water borne nutrients,
- chlorophyll, and
- water quality parameters (temperature, salinity, pH and dissolved oxygen).

5.3.2 Findings

Aquenal Pty Ltd (2005) emphasises that the data collected is intended primarily as a snapshot of the situation at time of sampling. Its main purpose is to provide a pre-operation baseline against which subsequent investigations may be compared for the purpose of assessing any impacts from nutrients released by the proposed fish farming operation at Port Patterson. Comparisons have been drawn against the data collected at Marine Harvest's Port Hurd operation (discussed in Section 7.1) which has now been in operation for several years.

Observations

Observations at each of the sampling sites confirmed that they were all subject to depositional conditions. The presence of numerous burrows and observations of benthic cores indicated prolific animal life within the substrate at each location. The natural organic loading in all locations was moderate rather than high and reduction of organic matter was proceeding apace with its deposition. Animal burrows were observed in cores from all sites with the exception of F4 and C6, which had no burrows. There was no plant material, gas bubbles or strong smell recorded from any of the cores.

Water Quality

Water temperature ranged between 29.3 - 31.3 °C, pH ranged from 6.9 to 7.6 with the lowest readings taken from farm sites F1 and F3. Dissolved oxygen (DO) covered a large range, from 64.2% at F1 to 91.2% at F2. At the majority of sites, salinity was between 38 and 39 parts per thousand (ppt), but reached 40.7 ppt at F3. These were consistent with end of dry season conditions and comparable with data from Port Hurd and therefore may be considered typical of these mangrove-dominated estuarine environments.

Nutrients

Ammonia levels ranged from 0.005 to 0.05 mg/L. The highest value was recorded at F1, while the highest ammonia level in Madford Inlet (control site) was 0.020 mg/L. Nitrite and nitrate levels were below detection (0.005 mg/L) threshold values for all farm sites other than F4, where nitrate was 0.010 mg/L. Aquenal reported that the nitrate and nitrite results are similar to other studies of tropical estuaries.

Chlorophyll α

Levels of chlorophyll α at all sites were 1 μg/L or less, with the exception of the intertidal site F3, where 2 μg/L was recorded. There were no results for C4-2 or C5-1 as these samples were contaminated during transport to the laboratory. There was no noticeable difference in chlorophyll levels between deep and shallow water farm sites. The concentrations found in this survey are at the low end of the range of those recorded during the initial stages of monitoring at Port Hurd (1.1 to 4.6 μg/L) and at Channel Island (<2 μg/L), and are lower than those recorded at Snake Bay (2 to 4 μg/L), so may be considered typical of mangrove estuaries.

Macroscopic Epiphytic Algae

Macroscopic epiphytic algal growth was not detected on intertidal mangrove root and rhizome assemblages, indicating waterborne nutrient levels are too low for the establishment of epiphytic algal growth.

Mangrove Stand Structure and Composition

Mangrove stand structure in the Doug Point and Madford Inlet study areas (Aquenal, 2005) was dominated by *Rhizophora* sp. and *Ceriops* sp. Generally *Rhizophora* sp. dominated the sites nearest the water's edge and *Ceriops* sp. dominated the inland sites. The Rhizophora species were either *Rhizophora stylosa* or *Rhizophora apiculata*. Another species occurring in significant numbers was *Avicennia marina* which was the second most dominant species at sites at F1 and F3. *Bruguiera exaristata* and *Bruguiera parviflora* were also among the dominant species at two farm and two control sites.

Mangrove condition was generally healthy with less than 10% dead trees per hectare at all but five sites. The high percentage of dead trees at C2-2 (38.4%) was the result of one small dead *Ceriops* standing adjacent to the measuring site.

Benthic Infauna

The numerous burrows present indicated prolific animal life, as was also found in the benthic grab samples. A lack of burrows in coarse sediments reflects disturbance due to coring rather than a lack of benthic infauna. Macroscopic plants were absent due to the high attenuation of light in the muddy estuarine waters. Benthic infaunal communities were diverse, however abundance was about half that found at Port Hurd, Snake Bay and Channel Island. Analysis found no obvious signs of existing impacts on macrobenthic communities at the Doug Point farm sites or adjacent control sites in the Madford and Tahlee Inlets. Some habitat-related variation was observed, with intertidal communities distinct from the subtidal communities. Within the intertidal and subtidal groupings, some differentiation was also observed between farm and control sites, although overlap was observed between these localities, particularly in the subtidal samples. There were no consistent trends in biodiversity or dominance on the basis of habitat, depth or inlet. Communities were generally diverse and exhibited low levels of faunal dominance.

5.3.3 Conclusions

Aquenal Pty Ltd (2005) noted that if the proposed aquaculture facility becomes operational at Port Patterson, then follow-up monitoring will be required, at control sites and at sites most likely to show impact, in order to gain an understanding of natural variation and assess potential impact from nutrient input from the operation. The proposed monitoring program is discussed in Sections 9.11, 9.14 and 10.4.

6 Potential Impacts from Fin-fish Aquaculture

This section outlines a summary of the potential impacts which could occur as a result of the establishment of a fin-fish aquaculture facility.

6.1 Potential Impacts from Construction of the Farm

Construction of the farm will take place over a 12-month period. Potential impacts are:

- noise from motor boats,
- increase in boat and road traffic,
- localised seabed disturbance during placement of anchors,
- disturbance of potential acid sulphate soils, and
- temporary increase in people at pre-existing accommodation used by the contractors.

6.2 Potential Impacts of Escaped Fish

A number of parties, including the Australian Marine Conservation Society (2005), have suggested that the accidental release of farmed fish could lead to;

- The alteration of the genetic profile of the resident wild population;
- Disease and parasite transfer to wild population;
- Competition with wild populations for habitat and food; and
- Predation on local populations of wild species.

6.3 Potential Impacts from Fish Faeces and Nutrient Loads

Addition of localised input of fish faeces and nutrients could have the following potential impacts:

- accumulation of fish faeces on seafloor,
- effects on water quality and benthos,
- eutrophication of water column,
- growth of algae,
- effects on fauna habitats, and
- hydrogen sulphide production from sediment.

6.4 Potential Impacts from Excess Feed and Feed Quality

The potential impacts from excess feed are similar to those from fish faeces and nutrients inputs. These potential impacts and those related to feed quality are listed below.

- accumulation of fish feed pellets on seafloor,
- effects on water quality and benthos,
- eutrophication of water column,
- growth of algae,
- effects on fauna habitats, and
- effects on fish from ingestion of feed pellets.

6.5 Potential Impacts from Fish Feeding on Naturally-Occurring Food – Removal of Food from the Food Chain

The farmed barramundi may feed on naturally occurring food in the water, namely small fish which may swim through the farm cages. This may remove some small fish from the food chain, which may in turn affect the larger fish in that food chain.

6.6 Potential Impacts from Fish Aggregation

Fish aggregation beneath farm cages is expected to occur and the potential impacts from this could include:

- relocation of fish from other areas of the bay to beneath the cages,
- effects on the distribution of fish populations across the bay,
- changes in nutrient dynamics beneath the cages, and
- effects on the recreational fishery.

6.7 Potential Impacts from the Introduction of Diseases and Parasites and the Treatment of Fish using Introduced Chemicals

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

- transfer of diseases and parasites to wild fish, and
- effects from the introduction of chemicals to the water column from the treatment of farmed fish.

6.8 Potential Impacts from Waste Generation and Hazardous Materials

The most severe potential impacts from wastes and hazardous materials on the farm operation could include:

- disturbance to the amenity of the area;
- harm or disturbance to marine habitat and marine wildlife;
- poor water quality; and
- harm to human health.

Disturbance to the amenity could potentially be caused by:

- visual impacts of rubbish, and
- fuel spills on water.

Harm or disturbance to marine habitat and marine wildlife could potentially be caused by:

- chemical spills resulting in death of fish and mammals,
- excessive emission of nutrients to the seawater and changes to the water quality,
- possible accumulation of excessive or accidental wastes into the intertidal sediments and coastal vegetation, and
- entanglement with or ingestion of rubbish or solid wastes accidentally lost from the farm.

Water quality could potentially be affected by:

- excessive unconsumed feed, localised undispersed fish faeces and waste water from the barge entering the seawater, and causing eutrophication of the water column and nutrient inputs,
- exceptionally large disease outbreak in the farmed fish, resulting in mass deaths,
- accidental spillage of fuels or chemicals, and
- accidental spillage of untreated sewage from the barge.

Harm to human health could potentially be caused by:

- accidental untreated barge sewage entering the seawater,
- inability to optimally treat sewage generated on the barge,
- accidental spillage or mishandling of fuels and chemicals on and from the barge,
- inability to optimally treat or remove fish and putrescible wastes from the barge,

- lack of safety night lighting around boundary of farm, and
- accidental fire or explosion due to the presence of chemicals and fuels.

6.9 Potential Impacts from the Loss of Nets

Potential environmental issues from the loss of nets include:

- hazards to vessels and sea creatures from impact or entanglement with the nets or moorings;
- damage to coastal flora from impact or entanglement with the nets or moorings;
- damage to the seafloor from dragging of the moorings;
- littering of broken materials into the marine and coastal environment; and
- loss of farm stock to the environment.

6.10 Potential Impacts to Hydrodynamics

It is possible that there could be some minor changes to hydrodynamics from:

- the presence of mooring anchors in the seafloor, and
- the presence of mooring lines, nets and a barge in the water.

The main potential impacts would include:

- localized erosion of seafloor,
- local changes in water currents,
- local disturbance to marine flora,
- local disturbance to marine fauna.

6.11 Potential Impacts on and from Predators

Potential impacts on predators would include:

- encounters and potential injuries from steel nets,
- redistribution of predators around the bay, and
- increase in total predator numbers within the bay.

Potential impacts from predators would include:

- increased predation on aggregated fish, and

- increase presence of predators within a localized area which may increase the risk of attacks or injuries from predators on staff or locals.

6.12 Potential Impacts on Flora

There is little potential for local terrestrial or coastal vegetation to be disturbed by the presence of the farm as construction will take place from boats and ongoing operations will be entirely run from the barge.

Marine flora could potentially be disturbed by:

- the presence of mooring anchors in the seabed,
- the potential friction from the base of nets reaching the seafloor during extremely low tides,
- the potential accumulation of faeces or uneaten feed on the seabed,
- the potential changes in hydrodynamics and water quality, and
- the potential accumulation of excess nutrients in the water column and the associated potential increases in epiphytic algae.

6.13 Potential Impacts on Bird, Reptile, Fish and Mammal Habitats

Estuarine waters around the farm and the seabed beneath the farm could be impacted as detailed below. The possible effects on habitats could include:

- physical presence of the farm and moorings in and on the water,
- presence of nets providing suitable structures for wild fish aggregation,
- changes to the water quality,
- changes to marine flora,
- input of uneaten fish feed,
- changes to the abundance of small wild fish from farm fish feeding,
- changes to water hydrodynamics, and
- inputs of additional activities in and on the water.

6.14 Potential Impacts on EPBC Act-listed Threatened and Migratory Species

Potential effects from the farm on EPBC Act-listed threatened and migratory species may include the following:

- displacement of the EPBC Act-listed threatened and migratory species from the water column, and may also cause interruption to routes used to access feeding, breeding and calving sites;
- increased presence of predators which may in turn hunt EPBC Act-listed threatened and migratory species;
- potential injuries to EPBC Act-listed threatened and migratory species resulting from boat strikes or net entanglement;
- alterations to seagrass beds, or other marine flora used as feed, through nutrient inputs, which may cause microalgae (epiphytic) growth on the fronds resulting in a reduction in light intake, nutrients uptake and growth;
- impacts from night lighting which may distract turtle hatchlings; and
- impacts from noise or increased boat traffic on breeding species.

6.15 Potential Impacts from Disturbance to Land Surface

Disturbance to the land by farm operations is likely to be nonexistent or minimal as local land uses will be limited to contractors using preexisting local accommodation within Bynoe Harbour.

Disturbance to the land surface could cause impacts on shallow rooted plants, compaction of surface soils and mobilisation of soil particles, which could in turn generate airborne dust or sediment in water ways and marine areas.

6.16 Potential Impacts to Air Quality, Noise, Lighting and Visual Amenity

As motor boat traffic in Port Patterson and Bynoe Harbour is currently limited to recreational fishing and pearl farm operations, it is anticipated that the operation could probably increase that traffic by around 20 percent.

In addition, potential air, noise and lighting impacts from the operation could be brought about by:

odours and greenhouse gases

- emissions from the use of diesel generators and petrol engines,
- potential odours from dead fish,
- odours from used steel nets prior to disposal,

noise

- noise from the use of the feeding pump (small Honda fire-fighter pump), which is reportedly very quiet and is used daily for around 6 hours a day,

- noise from the use of the fish pump (4 cylinder diesel Perkins motor), used on average around 2 days per week,
- noise from the use of outboard motor boats,
- noise during the operation of hand tools during construction of farm.

lighting

- presence of flashing lights at corners of lease,
- presence of a flood light on the barge deck,
- presence of internal lights at night, and

aesthetic

- potential loss of remoteness, naturalness, and aesthetic and tourism values.

6.17 Potential Impacts on Social and Recreational Values

Potential impacts to social and recreational values and framework could include a small and temporary increase of people not local to the area.

Most of these impacts are considered to be essentially positive and to not have any negative repercussions.

Potential negative impacts could occur:

- from lack of respect for indigenous culture and values,
- from perceived imbalances in income or other benefits between employed and unemployed local residents, or
- from inappropriate, offensive or violent social behaviour.

6.18 Potential Impacts on Local Infrastructure

Impacts on local infrastructure are anticipated to be very limited as farm employees and contractors will essentially be using existing facilities and no additional infrastructure will need to be constructed to meet the needs of the farm personnel. Most goods and equipment will be sourced from Darwin and will be delivered to the farm via a contracted sea-transport company. It is possible that the area will experience a small increase in vehicular traffic on local roads.

6.19 Potential Impacts on Archaeological, Historical, Cultural and Aboriginal Sites

Potential impacts on archaeological, historical, cultural and Aboriginal sites could include the disturbance of artefacts, ruins and remains, or the disturbance of cultural and Aboriginal traditional values and beliefs associated with particular sites.

6.20 Potential Impacts on Marine Traffic

Potential impacts on marine traffic may include:

- increases in motor boat traffic on Port Patterson,
- increases in barge visits and traffic on the Darwin to Port Patterson route,
- increased demand on jetty facilities, and
- increased movements of large objects in the area when towing nets to the farm from Darwin.

6.21 Potential Impacts on Staff of Pest Insects

Potential impacts on staff of pest insects may include:

- itchiness,
- minor pain,
- nuisance, and
- illness.

6.22 Potential Impacts from the Farm on Personnel Emergencies

The type of personnel emergencies which could potentially occur at the farm include:

- body injury from working with farm equipment or from occupation of the barge;
- outboard motor boat or road vehicle accident;
- exposure to toxic fumes or fluids from fuels or chemicals used at the farm;
- heat stress or dehydration;
- other personal health issues, e.g. heart attack, or illness, which may require urgent medical attention;
- crocodile attack or exposure to other potentially lethal species e.g. box jellyfish, stone fish, sea snake, etc.; and

- cyclonic events potentially rendering the barge unsafe for inhabitation.

These will be managed via measures outlined in the forthcoming Environmental Management Plan for the site and summarised in Section 9.22.

6.23 Potential Impacts on the Barramundi Market

In order for Marine Harvest to sell the amount of fish it is aiming to produce from all three of its proposed barramundi farms in the future, it will need to establish new markets for the farmed barramundi, in retail areas not previously carrying barramundi. This means that it is not expected that the wild-caught barramundi market should be excessively affected by the presence of farmed barramundi.

6.24 Unknown, Unpredictable or Irreversible Impacts

During its five years' experience at the Port Hurd pilot farm, Marine Harvest has already encountered many of the potential problems that could face such marine farms in the Northern Territory. An Environmental Management Plan and monitoring programs were implemented during this period. As this experience has been drawn upon to design the Port Patterson proposed aquaculture development and compile this EIS report, it is considered that most potential problems have already been identified and addressed in earlier sections of this report.

7 Assessment of Impacts from the Port Hurd Pilot Farm

7.1 Port Hurd Environmental Monitoring Results

Marine Harvest's first barramundi fish farm was established at Port Hurd in 2000 and was considered the pilot project for barramundi farming in the Northern Territory.

The farm was first stocked in March 2001, and the first harvest occurred in May 2002. During 2002, approximately 210 tonnes of barramundi were harvested, followed by approximately 700 tonnes in 2003. In 2004, the harvest rate was 20 to 25 tonnes per week. The fish farm and associated on-shore facilities at Barra Base are the only man-made developments on Port Hurd or its tributaries which have significant nutrient output.

This farm and its surrounding environment has been the subject of environmental investigations aimed at assessing the potential long and short term biological impacts from the fish farming operation on its environment.

Information regarding the potential impacts on the estuarine environment from the Port Hurd site is considered to be important in understanding potential impacts which may also occur from the proposed Port Patterson barramundi fish farm. Consequently, it is considered important to discuss these here. This section provides a synopsis of the work carried out by Aquenal Pty Ltd. A copy of the full report is provided in Appendix D.

7.1.1 Port Hurd Investigations

In 2003, Aquenal Pty Ltd carried out an initial site specific investigation in the vicinity of Marine Harvest's aquaculture operations at Port Hurd. This investigation was carried out in October 2003 and it was designed to monitor nutrients and algal proliferation. Periodic monitoring by Marine Harvest was also carried out between October 2003 and October 2005, covering easily measured parameters. A follow-up investigation was carried out in October 2005 by Aquenal Pty Ltd (2006), with the aim of assessing both short and long term changes to the environment. Control sites had been established in Maand Creek, which is the south-west arm of Port Hurd, and in Gullala Creek, which is the neighbouring inlet north of Port Hurd. Due to the remoteness and distance, the Gullala Creek sites were only monitored during the October 2003 and October 2005 sampling events. Figure 8 provides the sampling locations.

A number of environmental parameters were chosen as indicators of long term biological impacts, these were:

- benthic infauna community structure,
- mangrove stand structure and condition,
- plank tonic algal concentrations in the water column,
- proliferation of epiphytic algae on mangrove roots, and
- sediment redox levels.

Other more easily measurable parameters were also chosen to help quantify any changes and to permit correlation with observational parameters; these included parameters such as rainfall, salinity, temperature, dissolved oxygen, nitrate, nitrite, ammonia nitrogen, and chlorophyll.

Two complete sampling rounds and assessments covering all the parameters listed above were carried out and reported in the 2003 and 2005 reports. Periodical monitoring during the intervening period between October 2003 and October 2005 only included measurement or sampling for parameters such as rainfall, salinity, temperature, dissolved oxygen, nitrate, nitrite, oxides of nitrogen, ammonia nitrogen, dissolved inorganic nitrogen and chlorophyll. These are reported separately in October 2005.

The October 2005 nutrient report pulled together all the nutrient information gathered during the preceding two years and provided an interpretation of the findings, these are summarised below.

7.1.2 Findings

Rainfall averages in 2005 are down on the previous two years. At September 2005, the cumulative total for 2005 was around 500 millimetres less than for 2004 and 2003. Both salinity and temperature had strong correlations with rainfall and were therefore seasonally influenced. Dissolved oxygen concentrations were closely correlated to seasonal fluctuations. NO_x (nitrate plus nitrite), ammonia and dissolved inorganic nitrogen concentrations were all above the ANZECC Interim Trigger Levels for estuaries at all sites at some stage throughout the monitoring period and these were not readily correlated to seasonal influences. Chlorophyll α levels increased in 2004 and 2005 at both farm and control sites and was generally above the ANZECC Trigger Levels. Assessment of mangrove root and rhizome assemblages showed these to be in excellent health with regard to epiphytic algal growth. Both farm and control sites showed similar good state of health with no sign of algal growth, therefore indicating that levels of waterborne nutrients are too low for the establishment of epiphytic algae. It should be noted that the ANZECC Trigger Levels are a “one size fits all” set of trigger levels, applying to all Australian and New Zealand estuaries. It is arguable that mangrove estuaries with little or no freshwater inflow for 6 months of the year and wide intertidal mud flats should have a separate set of trigger levels.

In summary, the October 2005 report found that most water quality parameters were closely related to rainfall, i.e. were seasonally influenced. Nutrient levels were not uniformly seasonal in their variation and exceeded the ANZECC trigger levels on a number of sampling occasions at both Port Hurd control sites (Maand Creek) and at the farm monitoring sites. A general increase in chlorophyll α levels was observed.

The significance, or not, of these results could not be assessed without the assessment of the results from the Gullala Inlet control site, which are discussed below.

7.1.2.1 Gullala Inlet Control Site

Gullala Creek and Inlet, located 13 kilometres north of Port Hurd, was chosen by Aquenal Pty Ltd as a control site. It was considered suitable as a control site for Port Hurd, due to:

- its proximity to Port Hurd,
- the relative sizes of both estuaries,
- the protection of the entrances by extensive offshore sandbars, and
- the same hydrological regimes and influences on both estuaries.

The initial survey at Gullala Inlet was carried out in October 2003, at the same time as the Port Hurd sampling, and the biennial sampling was also carried out at the same time in October 2005.

Six sampling sites were selected in Gullala Creek as control sites. These were selected to correspond as closely as possible to the monitoring sites in Port Hurd and were labelled C1 to C6. Sampling locations are show in Figure 9. A copy of Aquenal Pty Ltd's biennial report is provided in Appendix E. The following is a summary of the findings and implication from the results obtained from Gullala Creek.

Visual Assessment

Cores of sediments were taken and observed for length, colour, plant and animal life, gas vesicles and smell. Aquenal's interpretation noted that at all farm and control sites brown-grey mud was present in most cores and represented the material which is currently being deposited in both Port Hurd and Gullala estuaries; the sedimentation characteristics at both sites were similar; the natural organic loading was moderate and similar in all cores; and animal life and burrows were prolific and abundant at both sites in both years. Aquenal noted that organic matter was being reduced at the same pace as the deposition rate in most cores, with the exception of sites F3 (Port Hurd) and C3 (Gullala) where sedimentation was more rapid than organic matter reduction, causing sediments to become anoxic at those sites. As this was noted at both farm and control sites, it could not be attributed to nutrient outputs from the farm.

Redox Potential

Results reported by Aquenal from the baseline and monitoring surveys show that sediments at the study sites are poorly to moderately oxygenated indicating that reduction of organic matter is proceeding at a slightly higher rate than penetration of oxygen through the sediments. Redox values found in these surveys are similar to those expected in a healthy, undisturbed environment. Aquenal noted that given the influence of animal burrows and minor surface disturbance on the redox results, no conclusions could be drawn from them.

Chlorophyll α

Aquenal noted that there appeared to be a general rise in chlorophyll α levels at Port Hurd in 2004 and 2005 (from a mean of 2.8 to a mean of 3.3 µg/L = 17.8% increase). This general rise was also observed at the Gullala Inlet sampling sites, though to a lesser degree (from a mean of 2.33 to 2.41 µg/L = 3.47% increase). This could not be correlated to other parameters included in the study, and the Port Hurd increase could not be directly attributed to the farm operations. However, Aquenal noted that this could

be of concern and it recommended that levels should continue to be monitored regularly around the farm site to assess any further increase over time. Aquenal also recommended that if chlorophyll α levels were seen to continue to rise at Port Hurd, then a set of samples should be taken from Gullala Inlet to assess whether this was an ongoing generalised regional phenomenon.

Mangrove Stand and Composition

Aquenal noted that there were a number of dead and damaged trees within the survey sites, and these were probably caused by a cyclone which passed over the sites in 2004. The main changes in dominance at the two Gullala Inlet control sites were due to natural evolution of the maturing stand composition. Aquenal concluded that there were no changes attributable to marine farming.

Epiphytic Algal Growth

The three intertidal control sites at Gullala Inlet, C1, C2 and C3 were surveyed in 2003 and 2005 and Aquenal found that they showed a similar state of health in both years, with no sign of algal growth. Farm survey sites also showed an excellent state of health both in 2003 and in 2005; this indicated that levels of waterborne nutrients were too low for the establishment of epiphytic algae in the intertidal zone.

Benthic Infauna

Similar trends of decline in faunal dominance and increase in species richness and diversity were noted at the Gullala Inlet control sites and at Port Hurd survey sites. Aquenal concluded therefore that farming at Port Hurd had had no detectable impact on benthic infauna species richness or abundance.

7.1.3 Implications and Recommendations

Aquenal recommended that ongoing regular monitoring of water quality and nutrient parameters be maintained in order to help distinguish between natural variation and biological impact.

7.2 Comparison of Port Patterson versus Port Hurd Operations

There are a number of differences between the Port Patterson and Port Hurd operations. Some are related to contrasts in environmental conditions, some related to differences in infrastructure and others to the scale of the operations. Table 7.1 below summarises the notable differences which may influence the applicability of the Port Hurd and Gullala Inlet monitoring results, to the proposed Port Patterson operation.

Table 7.1: Comparisons of Port Patterson versus Port Hurd Operations

Item	Port Hurd	Port Patterson
Current speeds	Up to 4.2 knots	2.2 knots or greater (Bynoe Harbour)
Tidal fluctuations	7 metre tidal range	6 - 7 metre tidal range
Farm operations	Operated from a land base	Operated from a barge
Nets	Large nets (86 or 100 metre circumference); clustered in two close-spaced parallel lines with 6 nets in each line, i.e. 12 nets per group.	Small nets (48 metre circumference); set out in a single line of 6 nets per group.
Fish Tonnage	1000 tonnes	1500 tonnes to 5000 tonnes

The stronger tidal currents at Port Hurd compared to Port Patterson mean that flushing of the Port Hurd estuary may be slightly stronger than at Port Patterson and therefore any potential nutrients added to the water column may be removed more efficiently from Port Hurd than from Port Patterson.

The smaller nets and net clusters at Port Patterson mean that nutrient inputs potentially contributed by the fish and the feed are likely to be more spread out and to be more easily dissipated and diluted by the water currents, even though the currents are less in magnitude than those at Port Hurd.

The presence of a habitable barge at Port Patterson means that there is potential for other sources of nutrients to enter the water body. The risk of significant nutrients inputs is assessed to be low and stringent management measures will be applied to the barge operations to ensure that any water effluent from the barge is appropriately treated.

The Port Hurd and Gullala Inlet monitoring results suggest that the pilot farm at Port Hurd has not been causing any notable changes to water or sediment quality, or to nutrient-influenced parameters. A small increase in chlorophyll α has been noted but cannot be directly attributed to the farm. Similar management measures will be applied to the proposed Port Patterson operation as have been implemented at the Port Hurd pilot farm.

A regular monitoring program will be carried out at the proposed Port Patterson farm, which will follow up on the baseline work carried out by Aquenal Pty Ltd (2005) and summarised in Section 5.3. This program should provide early detection and any potential changes in water and sediment quality brought about by the proposed farm.

7.3 Paspaley Pearls Oyster Studies

Paspaley Pearls have a pearl oyster farm operation located in Bynoe Harbour, adjacent to Port Patterson, where Marine Harvest is proposing to establish one of its barramundi farming operations. Paspaley Pearls expressed concerns over the potential impacts of the proposed barramundi farm on its oyster farming operations. An agreement was reached between Paspaley Pearls and Marine Harvest to carry out a trial by placing oyster cages adjacent to the established barramundi farm at Port Hurd and then checking the health of the oysters after a nominated timeframe.

Two traps containing approximately 12 oysters each were hung on the fish farming cages at Port Hurd on 20 December 2004. Two lots of oysters were sent for pathology, one on 19 January 2005 and the second on 23 February 2005. The samples were analysed by the veterinary pathologist at the Berrimah Veterinary Laboratory in Berrimah, Northern Territory. All samples (except for one) were found to have no histopathological changes, no evidence of inflammatory, degenerative or proliferative lesions. There was no evidence of microbial (viral, bacterial, or fungal) organisms and no evidence of parasitic infections. One unhealthy oyster was found in the first batch of samples. This oyster was found to have marked atrophy or degeneration of glandular tissue in the digestive gland. Its heart was found to have a mild diffuse haemocytic infiltration with low-grade focal aggregates of haemocytes apparent. The veterinary pathologist interpretation noted that the changes to the digestive gland were severe and irreversible and were likely to be long-standing (over 2 to 3 weeks old). He also noted that there was no direct evidence of primary microbial (virus, fungal, bacterial or parasitic) cause, though an earlier bacterial septicaemia (unrelated to the Port Hurd operation) could not be excluded. A copy of the information is provided in Appendix F.

The trial showed that the oysters did not appear to suffer any adverse effects from the presence of the fish farm. The single unhealthy oyster was interpreted to be an isolated case, unrelated to the presence of the fish farm. The trial therefore provided reassurance to the pearl farmers that the proposed barramundi fish farm at Port Patterson was not likely to cause any impacts to its operation in Bynoe Harbour.

Importantly, the results can be extrapolated to suggest that other native soft bodied shellfish located in similar water currents near the fish farm would be unlikely to be affected by any of the fish farming operations.

8 Discussion of Potential Impacts and Risk Assessment

A summary of potential environmental impacts from a fin-fish aquaculture facility has been provided in Section 6.

This section discusses the potential environmental impacts in the context of the location of the proposed farm at Port Patterson and also provides a risk assessment for the salient potential impacts.

The risks have been evaluated using the Marine Harvest Risk Ranking System shown in Table 8.1.

Table A shows the classification levels for consequences, i.e. realistically the worst outcome that could occur; and Table B shows the classification levels for the likelihood, i.e. the likelihood that an incident will occur. These classifications are then combined using the risk table and a ranking is then attributed to the impact.

Risk rankings range from 1 to 4, as follows:

- 1 = high risk
- 2 = serious risk
- 3 = medium risk
- 4 = low risk

Table 8.1: Marine Harvest Risk Ranking System

Table A		
Consequence	Injury/Illness Classification	Environmental Impact
Minor	Localised First Aid Treatment	Event with no adverse effects
Moderate	Medical treatment required	Event with some (temporary) adverse effects; Exceedence of permitted levels.
Major	Extensive injuries, permanent part disability.	Event with long-term effects; Provokes actions from authorities, complaints from community, environmental action groups, limited media attention.
Catastrophic	Fatality(s) or permanent serious disability(s)	Event with major impact on environment

Step 1 – Using Table A

Realistically determine the worst outcome that could occur.

Consider the following:

- Extent of injuries
- Process loss
- Property damage
- Harm to the environment

Table B	
Likehood	Description
Almost certain	Common repeating occurrence
Likely	Known to occur or, 'it has happened before'
Possible	Could occur or, 'I've heard of it happening'
Unlikely	Not likely to occur
Rare	Practically impossible

Step 2 – Using Table

Determine the likelihood that an incident will occur/recur. Consider the following when making this decision:

- The number of times tasks are undertaken which could result in this, or a similar, incident;
- The number of people performing these tasks or exposed to the hazard at the time; and
- The probability of an incident occurring/recurring while the task is being performed.

Risk Table				
Likelihood	Minor	Moderate	Major	Catastrophic
Almost certain	2 Serious Risk	1 High Risk	1 High Risk	1 High Risk
Likely	3 Medium Risk	2 Serious Risk	1 High Risk	1 High Risk
Possibly	4 Medium Risk	3 Medium Risk	2 Serious Risk	1 High Risk
Unlikely	4 Low Risk	4 Low Risk	3 Medium Risk	2 Serious Risk
Rare	4 Low Risk	4 Low Risk	4 Low Risk	4 Low Risk

Step 3 – Using the Risk Table

Join the consequence and likelihood classifications together on the Risk Table to identify the risk rank. For example, a 'Moderate' consequence together with a 'Likely' likelihood gives a risk rank of 2 which is serious (S).

8.1 Construction

Potential impacts during the construction of the farm are expected to be very limited and minimal as:

- Construction of the barge and nets will be carried out in Darwin;
- Construction of moorings will occur in Darwin;
- Installation of mooring anchors will be carried out by divers and with the assistance of boats; and
- Installation of mooring anchors will occur within the permanently submerged seafloor area, hence the risk of generating acid sulphate soils is non-existent, as soil material high in oxidisable sulphur only poses a high risk of acid sulphate soils forming if they are exposed to air for some time.

8.1.1 Risk Assessment

Likelihood

The likelihood of construction works impacting on the environment is considered **unlikely**, particularly with regards to noise and increases in traffic and people. It is **possible** that installation of mooring anchors could cause local and temporary disturbance of the seafloor.

Consequence

The consequence of construction impacts on the environment are expected to be **minor** and short-lived.

Risk 3 = low risk

8.2 Escaped Fish

The Port Hurd farm has lost fish from its cages in the past. Originally nets were being damaged by crocodiles, however no crocodile damage has been recorded since the nets have been constructed using 3.2-mm-diameter steel mesh. Fish were lost during a cyclone when older-style cages collapsed, this style of net is no longer used. On another occasion fish were missing from a cage, possibly due to theft, while the farm was unattended during a cyclone. More recently (January 2006), the Port Hurd farm lost a large number of fish due to nets being washed away during strong water currents combined with a wave surge, all of which were brought about by low pressure conditions, direct westerly winds and a particularly high spring tide.

8.2.1 Interbreeding

While it is probable that escaped fish would breed with the local population, interbreeding is likely to have negligible impact on the genetic makeup of local barramundi stocks as the farm barramundi will be sourced from local Northern Territory broodstock. This is supported by the following papers.

A 2005 PhD thesis (Marshall, 2005) notes that the genetic structures found during the study indicated that there is a genetic division among river drainages, however it hypothesizes that due to the genetic diversity found in the Ord River, this river may have been the source site of most of the barramundi found in the north of Australia.

The Western Australian Department of Fisheries (1999) discussion paper 'The Translocation of Barramundi' notes that 'other scientifically recognised authorities believe there is no direct evidence that mixing gene pools will have deleterious 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.'

8.2.2 Disease and Parasite Transfer

The quality of the broodstock, the handling procedures, the use of quality feed and steel-mesh nets has led recently to a relatively disease-free and parasite-free farm fish population at the Port Hurd pilot farm. The same methods and procedures will be used for the Port Patterson operation. Any diseases or parasites carried by the farm barramundi (e.g. enteritis caused by *Vibrio carcheri* and *Photobacterium damsela*) are likely to be endemic in Northern Territory waters and the wild fish population will already have been exposed to them. Farm staff at Port Hurd has observed that wild barramundi populations carry a significantly larger number of parasites than the farm barramundi.

8.2.3 Competition with Wild Populations and Increased Predation

The balance of species may be offset during a brief period after a possible escape of farm fish, however the impact would be short-lived and would not be expected to have any long term consequences.

8.2.4 Risk Assessment

Likelihood

The likelihood of fish escaping is considered **possible**, as it has happened at Port Hurd during extremely adverse tidal and climatic conditions. However, design changes have been proposed for the Port Patterson farm which should significantly diminish the likelihood of fish escapes. These design changes include reduction in net sizes, reduction in the number of nets per mooring array and an increase in mooring lines per mooring array.

Consequence

The consequence of fish potentially escaping the proposed farm is classified as **moderate**, as the event could have some temporary adverse effects. The possible adverse effects include predation on endemic smaller fish and removal of naturally occurring feed from the environment.

Risk 3 = medium risk

8.3 Fish Faeces and Nutrient Loads

Fish faeces will fall through the water column and may reach the sediment on the sea floor. The nutrients from the faeces generated by a dense population of farmed fish have the potential to impact on the water column and on the benthos, causing eutrophication in the water column and benthos potentially resulting in increased aquatic plant growth and deficiencies in dissolved oxygen levels. In severe cases, hydrogen sulphide can be generated from the sediment. Eutrophication will be exacerbated by high water temperatures, excess fish feed passing through the water column and by lack of water movement.

The degree of impact is dependent on the number of fish, the amount of faeces generated and the strength of the water currents passing through and beneath the fish nets. Water currents in Port Patterson can reach up to 2.2 knots (Bynoe Harbour). The amount of waste generated is expected to be in the order of 79 to 107 kg per 1200 to 1500kg of feed eaten by the fish. However, much of this waste (63 to 88 kg) is dissolved waste, i.e. it is immediately assimilated into the water passing the nets, and the remainder (16 to 20 kg) is excreted as faeces. According to personal communications with Mr David Whyte of Skretting (8 March 2006), it is estimated that around 95 percent of the nitrogen waste is excreted via the gills, the remainder 5 percent of nitrogen and the bulk of the phosphorus is excreted as faeces. These data were obtained from Skretting and represent the 'environmental impact' calculations from their Nova ME feed which Marine Harvest are proposing to use for the farmed barramundi at Port Patterson. Skretting's 'environmental impacts' table for this feed is reproduced in Table 8.2, below.

Table 8.2: Maximum Amount of Discharge (kg) per 1000 kg of Fish Produced

Component	Waste Type	FCR = 1.2	FCR = 1.5	Waste Route*
Nitrogen	Dissolved Waste	56.4	78.0	95% of nitrogen waste is as ammonia via the fish gills and the remainder 5% as faeces
	Solid Waste	9.6	12.0	
	Total Nitrogen Waste	66	90	
Phosphorus	Dissolved Waste	6.7	9.4	Almost 100% of phosphorus is excreted as faeces
	Solid Waste	6.0	7.5	
	Total Phosphorus Waste	12.7	16.9	

Notes: FCR = feed conversion ratio, e.g. with FCR = 1.2 every 1000kg of fish produced requires 1200kg of feed.

*personal communication from Mr David Whyte of Skretting (8 March 2006).

Source: Skretting Nova ME Environmental Impact table.

The Australian Institute of Marine Science (AIMS) conducted some preliminary investigations of the nutrients inputs from the Port Hurd barramundi farm. Their data suggest that at the time of the survey, there was minimal difference in nutrient concentrations between water entering and exiting the cages. A rudimentary nutrient budget indicated that nitrogen inputs from the farm would contribute less than 10% of the nitrogen required for algal productivity in the estuary (pers. comm. Dr David McKinnon, AIMS, January 2006).

8.3.1 Risk Assessment

Likelihood

The likelihood of fish faeces and nutrients entering the water column is **certain**. However the actual amount of nutrients is more difficult to quantify as it is dependent on the number and size of the fish present at the farm; these parameters will vary regularly.

Consequence

On the basis of the monitoring results at Port Hurd (discussed in Sections 7.1 and 7.2) it is considered that the input of nutrients from the proposed farm is likely to have only minor, and at worst, only moderate consequences on the environment.

Risk 2 = serious, or at worst 1 = high risk

8.4 Excess Feed and Feed Quality

The eutrophication issues associated with fish faeces equally apply to excess feed passing through the cage. Due to cost implications, farmers take a great deal of care to prevent feed passing through the cages uneaten. However, any uneaten feed, which could be swept away by the currents, could have the potential to cause eutrophication at some distance from the cages. Careful monitoring of food usage and conversion rates is important in avoiding loss of feed and is a critical issue for the economics of the operation. However, since the fish also feed on naturally-occurring food sources such as small fish, calculation of conversion rates must be treated with some caution.

Uneaten feed could also be eaten by wild fish swimming around the cages. This could potentially cause changes in the wild fish feeding patterns, and the feed quality could potentially affect the fish.

8.4.1 Risk Assessment

Likelihood

The potential for loss of feed and accumulation of feed on the seafloor or in the water column is minimal due to:

- Stringent farm controls on feed input to minimise waste; this is done via strict feeding tables based on fish size/weight, number of fish, water temperature, etc.

- Uptake of the very small amounts of uneaten feed by wild fish swimming around and beneath the cages.
- The feed containing plant protein meal, which increases the pellets' water absorptivity thereby speeding up the breakdown of the pellets and the ability of the water currents to carry away and dilute the fragments.
- The presence of moderate water currents at the farm site given its location in a relatively narrow and deep water channel formed by water channelled through a narrow passage.

Consequences

The potential impacts on wild fish from eating farm feed are likely to be minimal, as the loss of feed will be very small and the quality of the feed will be very high (refer to Section 3.8.2).

Hence the risk of uneaten feed accumulating on the seafloor or in the water column is extremely low, therefore the risk of eutrophication and nutrient accumulation is considered negligible.

The consequences ranking is therefore considered to be generally **minor**, though at worst it could be **moderate**.

Risk 4 = low risk, at worst 3 = medium risk

8.5 Removal of Fish from the Food Chain

The waters of Port Patterson are likely to be home to small species of fish, which provide a natural food source for the barramundi. While the farmed fish are fed on the pelleted diet, fish are voracious eaters. Depletion of this food source by the farmed fish could impact on small endemic fish and ultimately on the rest of the populations in that food chain.

Likelihood

It is considered **likely** that a minimal amount of small endemic fish will be eaten by the farmed barramundi.

Consequences

The amount of fish eaten is likely to be small as the farmed barramundi will be fed to satiation with feed pellets and will not require much if any supplementation of their diet. Furthermore, the farmed fish are captive and cannot hunt and catch fish as they would in the open marine environment, hence they are not likely to have access to many small fish. It is also understood that farm cages may act as a habitat and therefore increase the carrying capacity of the estuary and, in turn, support a larger population of small food fish.

It is therefore considered that the consequences would be **minor**.

Risk 3 = medium risk

8.6 Fish Aggregation

Concerns have been raised by guided fishing tour operators relating to the impact of the fish farms on recreational fishing. It has been suggested that the farm acts as a fish aggregation device (FAD) and attracts fish from the flats to the farm where they are not available for recreational fishing. It is thought they are attracted to a floating device in a pelagic environment and to the provision of uneaten food (Dempster et al, 2002; Boyra et al, 2004).

While it is well established that floating cages will act as aggregation sites, it is unclear what overall effect they have on fish populations within particular areas. In Dempster *et al*, it was reported that a change in nutrient dynamics might be expected beneath the sea cages as a result of the local fish aggregation beneath them. The local fish are likely to consume any food falling through the cages and the resulting faeces would be expected to be dispersed more readily than uneaten pellets of food.

Anecdotal reports from recreational fishing charter boat operators around the Port Hurd pilot fish farm suggest that they have not noticed any reduction in fish catches on the flats, in fact fishing may have improved since the start up of the farm, and the size of the thread-fin salmon being caught was the same. The fact that the charter boat operators keep coming to Port Hurd suggests that fishing must not have been adversely impacted.

8.6.1 Risk Assessment

Likelihood

As discussed above, it is **likely** that wild fish will aggregate beneath the barramundi farm cages.

Consequences

It is considered that wild fish swimming beneath and around the farm cages will eat any of the uneaten pellets falling through the cages. The resultant faeces are likely to be more easily dispersed in the water column than the pellet materials would have been. Hence their presence would be considered beneficial to the environmental output of the farm.

Experience at the Port Hurd pilot farm has shown that although wild fish do aggregate beneath the farm cages, fishing in the surrounding waters at Port Hurd has not been affected and has reportedly even improved. The consequence would therefore be ranked as **minor**.

Risk 3 = medium risk

8.7 Introduction of Diseases and Parasites

Like all other cultured animals, barramundi are subject to a range of bacterial, fungal, viral and parasitic diseases. Disease outbreaks are usually associated with some form of stress, such as, extremes of temperature, low dissolved oxygen or poor nutrition and handling of the fish.

Bacterial infection is the most common cause of disease in barramundi aquaculture. Columnaris disease is particularly common in small fingerlings held in water below about 25°C. Other bacterial infections are seen throughout the year but generally become more prevalent in mid winter and mid summer. Another factor associated with bacterial infection is frequent grading of the fish. Once fingerlings are moved into grow-out cages and grading frequency declines, disease incidence also declines. Bacteria have numerous points of infection, however damaged skin seems to be a common focus.

Initial disease issues noted at the pilot project at Port Hurd were enteritis caused by *Vibrio carcheri* and *Photobacterium damsela*; both bacteria are endemic in Northern Territory waters. The fish are sourced from local broodstock and are grown in waters with similar conditions to their native context hence any diseases or pests are likely to be endemic to Northern Territory waters and other fish will already have been exposed to them.

Fungal infections are less common in warmer waters and are unlikely to cause a problem in Port Patterson.

Two viral infections have been reported in barramundi farm populations, however, they do not seem to cause a problem in fish-farming operations if appropriate hygiene measures are employed.

Epidemiological studies show that disease transfer requires a vector and water may be an adequate vector for some fish diseases. Direct contact between local fish populations and the farm fish is rare but may occur when either wild fish leap into the pens or when farmed fish escape. Due to the relative crowding within the cages, it is more likely that, should any disease appear within the farmed population, it will initially spread throughout the farm. The likelihood of disease is also increased in nursery fish if they are kept in the vicinity of older fish. This is why Marine Harvest is aiming to have a separate nursery site at Channel Island.

Should contact occur between diseased or parasite-affected farmed fish and wild fish, impacts on local wild fish are likely to be minimal given that most of the diseases and parasites are already endemic in the wild fish population.

8.7.1 Risk Assessment

Likelihood

Based on the Port Hurd experience, the farmed fish have very few parasites and it is therefore **rare** that parasites would transfer from the farmed fish to the wild fish population.

The management methods used and any diseases encountered at the Port Hurd pilot farm are expected to be similar to those used and encountered at Port Patterson. Although it is possible, that diseases from the farmed fish would be introduced to the wild fish population, experience at Port Hurd has shown that it is **unlikely** that this should happen.

Consequences

The presence of low numbers of parasites on the farmed fish at Port Patterson is expected to have nil or at worst **minor** consequence on the environment, as the wild fish population has been reported to have more parasites than the farmed fish.

The potential transfer of diseases from the farmed fish to the wild fish population is expected to have only **minor** to **moderate** consequences, as the diseases encountered are the same in both populations.

Parasite transfer risk 4 = low risk

Disease transfer risk 4 = low risk

8.8 Introduction of Chemicals from Treatment of Fish Parasites or Diseases

There are some concerns that treatment of fish diseases using chemicals can affect water quality and other native fish. Barramundi at the Marine Harvest Site at Port Hurd at Bathurst Island are noted to be relatively disease-free. Diseases previously found in these fish included a parasitic disease associated with gill flukes and two bacterial diseases.

Since using steel nets, it has been found that the parasitic diseases have all but been eliminated. The steel net surfaces appear to be unfavourable for the colonisation by parasites. Studies by Marine Harvest have shown that farmed fish have less parasites than wild fish and have not demonstrated any discomfort from the presence of low numbers of the parasites. As steel nets will be used at Port Patterson, it is anticipated that the farmed fish will not require any treatment for parasites.

The two bacterial diseases were previously being treated using antibiotics. Both diseases have had local autogenous vaccines developed and all hatchlings will be vaccinated for these diseases prior to being delivered to Marine Harvest. Hence the need to use antibiotics is likely to be extremely rare. All diseased fish will be sent to the government veterinary laboratories for diagnosis; feedback will determine whether antibiotic treatment is necessary, which antibiotic should be used and what dosage should be applied. No antibiotics have been used on vaccinated fish at the Port Hurd pilot farm.

Use of antibiotics at Port Patterson is likely to follow a similar trend to that at Port Hurd. It is therefore considered that the use of antibiotics will be rare and short-term and will therefore not have any notable impacts on the environment, biota or sediments.

8.8.1 Risk Assessment

Likelihood

The most recent infrastructure and fish management methods at the Port Hurd pilot farm resulted in the fish not needing any parasite treatment or use of antibiotics. Although the likelihood for the need of chemicals usage cannot be completely ruled out, the need for their use is likely to be either **rare** or **unlikely**.

Consequences

In the event of the need to treat the farmed fish with introduced chemicals, the amounts of unused chemicals reaching the surrounding waters are likely to be nominal; hence the potential consequences to the environment would be either **minor** or at worst, **moderate**.

Risk 4 = low risk

8.9 Waste Generation and Hazardous Materials

Wastes will be generated by the operation and hazardous material will be stored, used and handled for the purposes of the operation.

8.9.1 Risk Assessment

Likelihood

Wastes will be generated by the operation and hazardous material will be stored, used and handled for the purposes of the operation. Although there are inherent spillage and contamination risks, particularly with liquid wastes and liquid hazardous materials, it is expected that stringent management methods, similar to those used successfully at the pilot Port Hurd farm, will be applied to the proposed Port Patterson farm. These methods are discussed in Section 9.7. The likelihood for wastes and hazardous materials to impact on the environment is therefore assessed to be typically **unlikely** and at worst, **possible**.

Consequences

Despite thorough and stringent management methods, and although any potential spills of waste or hazardous materials are likely to be small, it cannot be ruled out that an accidental large spill could occur. The consequences of such a spill (e.g. spillage of fuel or oil) would be ranked as either **moderate** ('event with some temporary adverse effects') or **major** ('event with long-term effects') (refer to Section 6.8 for a list of potential impacts).

Risk 4 to 2 = low to serious risk

8.10 Loss of Nets

If moorings are inadequate to secure the cages, the nets may become detached and could drift, and the moorings and anchors could also be dragged across the seabed. This could cause environmental damage and have severe economic impact on the business.

8.10.1 Risk Assessment

Likelihood

Although nets have been lost from the Port Hurd pilot farm, the design criteria proposed for the Port Patterson nets and mooring system (refer to Sections 3.6.3 and 3.6.5) are expected to minimise the likelihood of net losses occurring at the proposed Port Patterson farm. Furthermore, tidal currents, maximum wave heights, and cyclonic effects are all of a lesser magnitude at Port Patterson than at Port Hurd. The likelihood ranking for the loss of nets is therefore assessed to be **unlikely**.

Consequences

The potential impacts from the loss of nets have been listed in Section 6.9. The consequences are considered to range from **moderate** in terms of physical impact, as the effects would be temporary to **major,** for impacts on species such as dugong, turtles or other threatened species, through entanglement and for navigation hazard.

Risk 4 to 3 = low to medium risk

8.11 Hydrodynamics

Minor localised changes to hydrodynamics will occur from the presence of the mooring anchors and lines, the nets, and the proposed barge.

8.11.1 Risk Assessment

Likelihood

It is **likely** that impacts from the minor changes to hydrodynamics from the farm's infrastructure will be registered by modifications to local water currents, by some seafloor scouring around the mooring anchors and associated effects on local marine flora, and by local fauna.

Consequences

The impacts from the localised changes to hydrodynamics would be expected to be minimal around the mooring lines and nets, and may be more marked around the barge and the mooring anchors. The impacts in the water column would be localised and would not impact on an area much larger than the lease itself. The impacts from hydrodynamic changes to water flows around the anchors could potentially cause minor scouring of the seabed surface around the anchors and potential redistribution of a small amount of sediments. Marine flora could be locally affected by the removal of sediment. Marine fauna would not be expected to be negatively affected by the small changes in

hydrodynamics. The overall consequences from localised changes to hydrodynamics would be assessed to be **minor.**

Risk 3 to 2 = medium to serious risk

8.12 Predators

The main predators would be fish larger than those present within the nets, as well as seabirds, turtles, sharks and crocodiles. Feed provided to the farmed fish is strictly controlled so that there is as little wastage as possible. This will limit the amount of wild fish circling the nets for an opportunistic feed. Seabirds have not been a problem at Port Hurd and are not expected to be a problem at Port Patterson either. Sharks and crocodiles will be avoided by staff and will not be fed or encouraged to visit the site. It is expected that potential predators will quickly learn that they cannot penetrate the steel nets and hence will not incur any injuries from encounters with the nets. There have been very few incidents of this type at Port Hurd, and then only in the early days of the operation.

It is possible that due to fish aggregation beneath the nets, larger predators may attempt to feed there, however this is not expected to be any different from them feeding on a school of fish elsewhere. The aggregation phenomenon is not expected to attract more predators than already live in the estuary, as total wild fish numbers in the estuary are not expected to be increased significantly as a result of the farm activities.

Increased activity by humans on the water for the purpose of operating the farm could increase the exposure of staff to large predators such as crocodiles.

8.12.1 Risk Assessment

Likelihood

The main impact from large predators is assessed to be related to the increased exposure of humans to crocodiles, for example, due to the increased amount of time spent by staff and contractors travelling and working for the proposed farm in crocodile-inhabited waters. Although the likelihood of an incident occurring with a large predator is considered **unlikely**, it is assessed to be **possible**.

Consequences

The very worst, possible consequence could be **catastrophic**, i.e. it could potentially involve a fatality or permanent serious disability.

Risk 2 to 1 = serious to high risk

8.13 Flora

As noted in Section 6.12 the farm operations are not expected to have any effects on terrestrial flora. However, it is possible that some impacts could be incurred by marine flora species. The risk of this occurring is discussed below.

8.13.1 Risk Assessment

Likelihood

The likelihood of marine flora being locally affected by the proposed farm is considered to be **possible**, given that mooring anchors will be placed in the seabed and there may be localised changes to the hydrodynamics around the anchoring points. It is considered **unlikely**, though possible that the base of the nets could reach the seafloor during extremely low tides.

It is however considered **unlikely** that any faeces or uneaten food would accumulate on the seabed as the nets will be placed in a channel flushed by strong tidal currents; furthermore, the feed is rapidly broken down, due to its vegetable meal component.

Marine flora in these areas is only sparsely developed as the strong tidal currents are likely to preclude extensive marine vegetation growth. Seagrasses are not known to occur in or close to the proposed farm lease site. The presence of strong currents will also encourage rapid dispersion of nutrient sources such as faeces and uneaten food pellets.

Monitoring at the Port Hurd pilot farm has also suggested that this type of barramundi farm does not appear to be causing any adverse impacts on mangrove stands in areas where nutrients could potentially accumulate.

Based on the above, it is considered that potentially adverse impacts on marine and coastal flora from the proposed farm would be only a **rare to unlikely** occurrence.

Consequences

Potential impacts to any existing and likely sparse marine flora beneath the proposed farm are assessed to be either **minor** (i.e. no adverse effects) to **moderate** (i.e. event with some temporary adverse effects).

Risk 4 = low risk

8.14 Bird, Reptile, Fish and Mammal Habitats

Potential direct impacts to bird, reptile, fish and mammal habitats have been listed in Section 6.13. Indirect effects could potentially affect a wider area than the farm via changes to the water quality, which could in turn potentially affect the marine and coastal plant growth (e.g. sea grasses, coral reefs and mangrove species) and hence the habitats for fauna species directly and indirectly dependent on these.

The Aquenal report (2005) notes that 'there are no known coral reefs within Geranium Channel' although 'coral reefs are known to be patchy in the waters to the west of Indian Island and reefs surround the off-shore islands'. The Aquenal report considered that these reefs are 'unlikely to be sites for nutrient concentration or deposition as the closest are more than 6 kilometres to seaward and they are predominantly washed by oceanic waters'.

The Aquenal report also noted that seagrass is known to exist along the seaward end of Indian Island and in Bynoe Harbour in some bays on the eastern shore of Indian Island. However, these seagrass beds are sparse and patchy in nature. Mangroves line Geranium Channel shown in Figure 7.

8.14.1 Risk Assessment

Likelihood

Direct physical impacts on coral reefs and seagrasses are unlikely given their distance and location in relation to the proposed farm. However, there is the potential for impacts on mangroves based on their close proximity to the proposed farm. The likelihood of the local fauna habitats being affected in terms of their physico-chemical parameters is, however, considered to be **unlikely**, based on the baseline information collected for the area, experience at the Port Hurd pilot farm, location of the habitats and the environmental monitoring results obtained at that operation (refer to Section 7.1).

Consequences

Potential consequences from any direct impacts on the local fauna habitats are unlikely (refer above and to Section 6.13). Indirect effects, as documented in Section 7.1, are likely to be non-existent or insignificant in their consequences. In summary, consequences from potential effects from the farm on bird, reptile, fish and mammal habitats are assessed to be **minor**, or a very worst, **moderate**.

Risk 4 = low risk

8.15 EPBC Act-listed Threatened and Migratory Species

There is potential for the proposed farm to cause disturbance to EPBC Act-listed threatened and migratory species and their habitats. The risk of these disturbances actually occurring is assessed below. The risks will be managed according to management methods which are listed in Sections 9.15 and 10.4. These will also be further refined in the Environmental Management Plan to be drawn up for the proposed operation.

8.15.1 Risk Assessment

Likelihood

Displacement

The presence of the proposed nets and barge are not expected to cause any significant displacement of EPBC Act-listed threatened and migratory species from their customary feeding or breeding routes. Dugongs and turtles are known to occur in the area. Dugongs rely on seagrass beds for feeding purposes, but there are no known dugong calving sites within the area. Turtles would typically feed in areas protected from strong tidal currents. According to verbal advice, there are a number of turtle breeding sites in the area; it is understood that the closest is on Turtle Island at the northern end of Geranium Channel and around 5 to 6 kilometres from the proposed farm lease. The beach that is used as a turtle rookery is on the northern end of Turtle Island, and faces away from the proposed farm site. Crocodiles are reportedly low in numbers in the bay. Birds are not expected to be affected by the farm operations. The likelihood of displacement of any species which could be affected by the farm is assessed to be **unlikely**.

Predators

There is unlikely to be any significant increase in total wild fish numbers in the estuary as a result of the presence of the proposed farm. As a consequence, it is unlikely that large predator numbers would increase beyond the present as their food source would not increase. Therefore it is **unlikely** that there would be any increase in predator attacks on threatened species such as turtles.

Potential Injuries

The larger number of outboard motorboat trips carried out on the estuary as a result of the farm operations, could potentially increase the likelihood of boat strikes on turtles and dugongs. However, boat speeds will be limited to less than 5 knots and awareness training will be given to staff. The risk of dugongs and turtles getting entangled in nets is considered non-existent given that the nets are made of solid steel mesh. There have not been any reported incidents of birds getting entangled or injured during the farm operations at the Port Hurd pilot farm. It is therefore considered **unlikely** that any injuries would be sustained by local fauna in the course of running the farm operation.

Night Lighting

Turtle nesting sites are located several kilometres from the site, with the closest being around 4.5 to 5 kilometres away on Turtle Island. Other nesting sites are located over 8 and 10 kilometres away on the north-western end of Indian Island and the islands located along the ocean front of Port Patterson and Bynoe Harbour respectively (Derek Shields, pers. comm. May 2006). It is understood that nesting sites occur around much of the coastline of Turtle Island. Turtle hatchlings use moonlight to guide themselves to the water at night, however artificial lighting can distract the hatchlings and cause them to follow an incorrect course. Lighting at the farm will be restricted to lease markers, an outdoor light on the barge and indoor night lighting. It is therefore possible that farm

lighting could pose a lighting distraction to turtle hatchlings. Mitigation measures will be put in place to minimise the reach of the farm night lights, this is discussed in Section 9.15.

It is therefore considered '**possible**' that the proposed Port Patterson operation night lighting could impact on the turtle hatchlings light-sensitive direction instincts, however measures will be put in place to mitigate this possible impact.

Consequences

The worst possible consequence rating attributable to the potential impacts listed in Section 6.14 could be '**moderate**', i.e. an event with some (temporary) adverse effects, this could include the displacement of shy creatures like the dugongs, which are particularly sensitive to noise and disturbance and the disorientation of turtles from their normal course.

Risk 4 to 3 = low to medium risk

8.16 Land Surface

Potential impacts from disturbance to the land surface are listed in Section 6.15.

Disturbance to land surface is expected to be non-existent as the farm will be operated almost exclusively from the barge and contractors will use pre-existing accommodation facilities within Bynoe Harbour. However it cannot be ruled out that road access may occasionally be required from time to time.

8.16.1 Risk Assessment

Likelihood

It is **possible** that minor impacts could be registered on unsealed tracks due to vehicular movements.

Consequences

The consequences from usage of unsealed roads could include increased erosion of surface materials and dust generation. There is a remote possibility that vegetation fringing the roads could be trampled or disturbed. However, all of these are **minor** consequences with short-lived effects.

Risk 4 = low risk

8.17 Air Quality, Noise, Lighting and Visual Amenity

The proposed farm operation is likely to have some limited impacts on aspects of air quality, predominantly due to combustion engine odours and greenhouse gas emissions; noise generation from the operation of motor boats, pumps and generators; lighting from

the farm's corner markers and the barge night lighting; and the general changes to the visual amenity of the area.

8.17.1 Greenhouse Gases

The main sources of greenhouse gases would be the generator used to produce power for the operation, the outboard motor boats and the feed and harvesting pumps. Calculations of potential greenhouse gases emitted by the main sources of the operation have been carried out and are provided in Appendix G. Table 8.3 provides a summary of the potential emissions from the operation. The total annual greenhouse gas emissions from the operation are estimated at 208.31 tonnes of CO_2 (equivalent). Estimated Australian annual greenhouse gas emissions are around 550 million tonnes; it could therefore be said that the operation would contribute around 3.78×10^{-5} percent to the total Australian emissions.

Table 8.3: Summary of Potential Greenhouse Gases Emissions from the Proposed Port Patterson Barramundi Farm

Source	Estimated Fuel Consumption	Total CO_2-Equivalent Emissions (tonnes CO_2 / year)
Barge-base generator	1000 litres of diesel/month	172.9
Outboard motors and pump engines	1000 litres of unleaded/month	35.41
Total Annual Estimated		208.31

8.17.2 Risk Assessment

Likelihood

It is considered **likely** that the impacts listed in Section 6.16 will cause some low level and intermittent environmental nuisance.

Consequences

Based on the operation of the Port Hurd farm, the consequences from the potential impacts listed in Section 6.16 are considered to be **minor** and more often unnoticeable.

Risk 4 = low risk

8.18 Social and Recreational

8.18.1 Risk Assessment

Likelihood

Due to the lack of a central township and low population in the area and the fact that farm workers will be working long days, it is not expected that there will be much opportunity for social mixing between farm staff and local residents. The likelihood for any negative impacts to occur is therefore considered to be **unlikely**.

Consequences

Minor consequences could occur if a local person felt disadvantaged and could be impacted financially or personally.

Risk 4 = low risk

8.19 Local Infrastructure

Local infrastructure, such as roads, jetties and accommodation, may experience an increase in use during the construction of the proposed farm and during the occupation of the shore-based facility.

8.19.1 Risk Assessment

Likelihood

It is considered **unlikely** that the small increases in vehicular traffic on the local roads would cause any negative impacts on the local infrastructure. There are limited options in terms of recreation for the limited number of staff that would be associated with the operation and hence traffic on local roads would be expected to be minimal. Most movements of staff and contractors would be via boat to and from Darwin and the accommodation in Bynoe Harbour.

Consequences

Effects on local infrastructure from the farm operation are considered to be very **minor** and are unlikely to bring about any adverse impacts on the local infrastructure.

Risk 4 = low risk

8.20 Archaeological, Historical, Cultural and Aboriginal Sites

No archaeological or historical features have been reported within the Port Patterson area.

Discussions and communications have been carried out with the Northern Territory Government and with the Northern Land Council in relation to the existence of any archaeological, historical, cultural and Aboriginal sites. No formal advice has yet been

received from the Northern Land Council regarding these matters, however preliminary discussions have not suggested that there would be any opposition to the proposed marine farming operation going ahead in Port Patterson. The Northern Land Council has recommended that formal discussions be held after the EIS has been approved.

8.20.1 Risk Assessment

Likelihood

It is considered '**unlikely**' that there would be any impacts to archaeological or historical sites as none have been reported for the area and the farm will be operated solely from a marine base. It is also considered unlikely that any cultural or Aboriginal sites would be impacted by the proposed farm, as no sites have yet been reported by the Northern Land Council or other parties. However, as requested, formal discussions will be held with the Northern Land Council after approval of the EIS.

Consequences

Based on the current knowledge of the absence of archaeological, historical, cultural and Aboriginal sites in the area, consequences of the presence of the farm are considered to be non-existent. However, it is possible that an unknown site may be present, and consequences from impacts to that site from the farm are assessed to be **minor** to **moderate**.

Risk 4 = low risk

8.21 Marine Traffic

A sea-transport barge will service the operation weekly during farm establishment and harvesting, and fortnightly at other times. It is expected that the requirements of the operation will not increase the movements of the barge beyond its current schedule.

It is anticipated that sailing of the live-on farm barge and the nets from Darwin to Port Patterson will not require any dedicated access corridors, however, the issue will be raised with the Darwin Port authority to ensure that movements of any large items through the harbour are carried out according to local regulations.

Movements of nets will be carried out during calm seas, at high tide and in good visibility conditions.

Existing traffic on the waterway is currently very limited given the small population base. It is anticipated that motorboat traffic from the farm will contribute up to around 20 percent of the boat traffic on the waterway.

8.21.1 Risk Assessment

Likelihood

It is considered **unlikely** that the increase in motor boat traffic at Port Patterson and Bynoe Harbour, as a result of the proposed farm operations, should cause any environmental impacts. Although it is estimated that the farm boat trips may increase the current boat traffic on the bay by around 20 percent, the total number of boat trips by the farm would still be very low, estimated to be around a maximum of three return trips per week during day-to-day operations and once a day during servicing by contractors for harvesting or similar tasks.

Consequences

No adverse effects are predicted from this increase in marine boat traffic, hence it is estimated that this would represent only a '**minor**' consequence.

Risk 4 = low risk

8.22 Insect Pests

No increase in pest insects such as mosquitoes is likely to occur due to the hygiene and management of the operation which will limit opportunities for insects to breed.

It is anticipated that most staff members will be sourced either from the local or the Darwin areas and that they will already be familiar with the ambient conditions of coastal Northern Territory, i.e. heat, humidity and associated pest insects. There is a small possibility that staff could contract some insect-borne disease such as malaria or Ross-river virus.

It is expected that the presence of biting and pest insects will not cause any significant difficulties in the day-to-day running of the farm operations and appropriate mitigation measures will be put in place to manage any potential nuisance or medical impacts on staff (Sections 9.21 and 9.22).

8.22.1 Risk Assessment

Likelihood

It is considered **unlikely** that the operation of the farm will encourage the breeding of any disease-carrying insects due to the high standard of hygiene implemented by Marine Harvest. Operational procedures will ensure that staff take precautions to prevent being bitten by disease-carrying insects.

Consequences

Potential consequences from a staff member contracting an insect-borne disease could be **moderate**, i.e. they could require medical treatment and a period of prolonged rest or convalescence.

Risk 4 = low risk

8.23 Personnel Emergencies

Personnel emergencies may occur in any workplace and there is potential for personnel emergencies to occur at the proposed barramundi farm at Port Patterson. Potential emergencies have been summarised in Section 6.22.

8.23.1 Risk Assessment

Likelihood

All of the potential impacts outlined as possible outcomes from personnel emergencies at the proposed farm, and listed in Section 6.22, are classified as being **possible.**

Consequences

The worst possible outcome from any one of these potential impacts could be a fatality, i.e. the consequences would be classified as **catastrophic**. This catastrophic outcome is very **unlikely**, given the experience at the Port Hurd pilot farm, where most incidents would be classified in the **minor** or **moderate** categories.

Risk 4 to 2 = low to serious risk

8.24 Risk Assessment Summary

Qualitative risk assessments have been carried out for all identified aspects and impacts of the proposed barramundi farm. A summary of these is provided in Table 8.4 below. The table shows that only four aspects have been assessed as having a risk ranking of 2 or 1, i.e. having serious or high risks. These are:

- fish faeces and nutrient loads,
- wastes and hazardous materials,
- predators, and
- personnel emergencies.

Table 8.4: Risk Assessments Summary

Aspect	Likelihood of Impacts	Consequence of Impacts	Risk Ranking of Impacts	Comments
Construction	Possible	Minor/ moderate	3 = medium	Noise and traffic impacts will be temporary and managed via the EMP.
Fish Escape	Possible	Moderate	3 = medium	Some temporary adverse effects including predation on endemic smaller fish and removal of feed from the environment could occur.
Fish faeces and nutrient loads	Certain	Minor / moderate	2 to 1 = serious to high	Faeces will enter the water column, but monitoring at Port Hurd suggests little impact from added nutrient load.
Excess feed and quality	Possible / unlikely	Minor / moderate	4 to 3 = low to medium	Loss of feed will be strictly minimized by management methods and feed quality is high, hence impact on fauna, flora and overall environment will be low.
Removal of fish from the food chain	Likely	Minor	3 = medium	The amount of fish eaten will be minimal as the farmed barramundi will be fed to satiation and are captive.
Fish aggregation	Likely	Minor	3 = medium	No effect on fishing reported from Port Hurd pilot farm.

Aspect	Likelihood of Impacts	Consequence of Impacts	Risk Ranking of Impacts	Comments
Introduction of diseases	Unlikely	Moderate	4 = low	Very low incidences at Port Hurd pilot farm.
Introduction of parasites	Rare	Minor	4 = low	Very low incidences at Port Hurd pilot farm.
Introduction of chemicals	Rare / unlikely	Minor / moderate	4 = low	Port Hurd pilot farm experience has shown that there has been very little need for chemical usage due to low incidence of disease outbreaks.
Waste and hazardous materials	Unlikely / possible	Moderate / major	4 to 2 = low to serious	Stringent management methods will be implemented via the EMP to minimize the likelihood and mitigate the consequences of any potential spillages.
Loss of nets	Unlikely	Moderate / major	4 to 3 = low to medium	The new infrastructure proposed and the more moderate water currents at Port Patterson mean that risks are diminished.
Hydrodynamics	Likely	Minor	3 = medium	The only notable impact is likely to be redistribution of sediments around the mooring anchors.
Predators	Possible	Catastrophic	2 to 1 = serious to high	Increased exposure of humans to crocodiles and therefore increased likelihood of attacks.

Aspect	Likelihood of Impacts	Consequence of Impacts	Risk Ranking of Impacts	Comments
Flora	Rare / unlikely	Minor / moderate	4 = low	Impacts are expected to be minor or moderate due to the location of the farm and the proposed management methods.
Bird, reptile, fish and mammal habitats	Unlikely	Minor / moderate	4 = low	Baseline and Port Hurd information and monitoring suggests there is a low risk of impact on fauna habitats.
EPBC Act listed threatened and migratory species	Possible Unlikely	Moderate	4 to 3 = low to medium	Baseline and Port Hurd information and monitoring suggests there is generally a low risk of impact on EPBC listed, threatened or migratory species or their habitats. Measures will be put in place to minimise possible impacts from farm lighting on turtle hatchlings.
Land surface	Possible	Minor	4 = low	Use of unsealed areas will be minimal.
Air quality, noise, lighting and visual amenity	Likely	Minor	4 = low	Only low level intermittent nuisance is likely.
Social / recreational	Unlikely	Minor	4 = low	Lack of town centre, low population and staff working hours reduce the likelihood of any significant interaction with local population.

Aspect	Likelihood of Impacts	Consequence of Impacts	Risk Ranking of Impacts	Comments
Local infrastructure	Unlikely	Minor	4 = low	Minimal local infrastructure. Use of local roads expected to be limited.
Archaeological / historical, cultural and aboriginal sites	Rare	Minor to moderate	4 = low	No impact expected.
Marine traffic	Unlikely	Minor	4 = low	The farm may increase boat trips along Geranium Channel by up to 20 percent, but traffic will still remain very low.
Insect pests	Unlikely	Moderate	4 = low	Managed by operational procedures.
Personnel emergencies	Possible	Minor to catastrophic	4 to 2 = low to serious	Personnel emergencies can occur in any workplace; dangers will be managed via standard operating procedures and the site EMP.

9 Proposed Mitigation, Management and Monitoring

The mitigation, management and monitoring measures for each risk are proposed as preliminary measures only and these will need to be refined in the Environmental Management Plan which will be drawn up for the operation following approval. Risk control measures will conform to the hierarchy of:

- elimination,
- substitution,
- engineering controls,
- procedural controls, and
- personal protective equipment.

Detailed management and monitoring requirements will be set out in the Environmental Management Plan to be designed for the site. The following are intended as general guidelines and indications of the proposed management and monitoring measures to be put in place to address potential impacts from the aspects listed in Section 6. These take into consideration the associated risk rankings discussed in Section 8 of this report.

9.1 Maintenance and Monitoring Manual

In concurrence with the construction of the proposed development, Marine Harvest will develop a Maintenance and Monitoring Manual for the operation of the site. The Manual will be based on lessons learned from the Port Hurd pilot operation and will include details of the maintenance schedule for equipment and structures and will also include the schedule for the environmental monitoring program. The Manual will form the basis of the site induction program and training program for all staff.

9.2 Construction

Risk Ranking 3 – Medium Risk

Mitigation and Management

A construction management plan will be drawn up to ensure that potential environmental impacts from the construction of the farm are minimised and effectively managed.

The plan will include:

- induction of staff and contractors into all aspects of the plan;
- hours of operation;
- marine traffic speed limits and codes;
- procedures for minimising environmental impacts from construction;
- noise management;

- use of equipment with low noise rating;
- maintenance of equipment for optimal operation; and
- social awareness training for all staff and contractors.

Monitoring

Weekly meetings will be held with all staff, contractors and farm management or the construction manager. The meetings will be held to ensure that all procedures are being adhered to and that any incidents are recorded and corrective action taken where necessary.

9.3 Fish Escape

Risk Ranking 3 – Medium Risk

The risk of fish escape has been discussed in Section 8.2.

Mitigation and Management

The steel mesh nets which have been trialled most recently at the Port Hurd operation have been found to be the most appropriate and robust for the environmental conditions and these nets will be used at Port Patterson. A maintenance and replacement schedule will be developed to include a routine inspection and replacement program for the nets and moorings (refer to Section 9.9).

Monitoring

Visual inspection will occur daily on the exposed net areas and a fortnightly inspection using divers will examine the net area below the water surface. An engineering inspection of the moorings will take place every six months to ensure any wear or sub-optimal mooring features can be identified and remedied prior to failure.

Marine Harvest will investigate the usefulness of using a tide predicting software package developed by the Australian Institute of Marine Science (AIMS) at its proposed farm.

9.4 Disease and Parasite Transfer

Risk Ranking 4 - Low Risk

Based on the Port Hurd experience, barramundi at the farm are likely to remain relatively parasite-free with gill fluke and copepod being the only minor problems with the fish. Disease and parasite management methods proposed at the Port Patterson farm are detailed below.

Mitigation and Management

The fish will be carefully screened within the hatchery for known diseases of importance prior to dispatch, reducing the likelihood that disease will be transferred to the farm and its environment from the hatchery.

Screening Juveniles

Through disease screening and treatment of juvenile fish from the hatchery, the likelihood of disease being introduced into the farm can be greatly reduced. The Darwin Aquaculture Centre carefully monitors fish stocks for disease to prevent the transfer into farmed or wild stocks.

Stress Reduction

Marine Harvest will reduce the stress on the fish, which could lead to disease, by ensuring water quality remains near optimal level, reducing stocking densities (to a sustainable yet economic level), by feeding high quality diets, and minimising fish handling.

Fish Treatment

Fish will be vaccinated at the hatchery against *Vibrio carcheri*, *Photobacterium damsela, and Streptococcus iniae* and will be handled as little as possible to avoid scale/skin damage and increased exposure to disease.

Treatment for gill fluke and copepod infestation is unlikely to be carried out. When the use of steel nets was implemented throughout the Port Hurd pilot farm, these parasites were reduced to very low numbers in the farmed fish, and they did not require any treatment.

Disease Management

Sick, diseased and dead fish will be immediately removed from the pens and placed in the ensiler. The dedicated onsite scientist will monitor the incidence of deaths and will carry out tests on the fish if any upward trend is noted.

In the case of a suspected disease outbreak, fish would be sent to a veterinary laboratory for diagnosis; the Berrimah Government Veterinary Laboratory will confirm the diagnosis and recommend what, if any, treatment is necessary. The veterinary report would confirm whether the problem was treatable by antibiotics or not and would confirm the dose required if antibiotics could be used. The powdered antibiotic would be mixed with vegetable oil in a machine similar to a cement mixer and the resultant sludge would then be mixed with the feed. The feed would be dispensed to the fish via air cannons.

Initial disease issues were enteritis caused by *Vibrio harveyi* and *Photobacterium damsela*; both bacteria are endemic in Northern Territory waters. Experience at Port Hurd has shown that good hatchery practice and vaccination of the fish at the DAC has reduced the problem. Use of antibiotics has not been necessary in any of the vaccinated fish.

Hygiene & Quarantine Procedures

A number of hygiene procedures will be used for the purpose of disease transfer prevention; these will include the following measures.

- Footbaths for all staff coming onto and leaving the farm.
- Morts will be collected first, and then disposed to the ensiler. After disposal of morts the boats and barge will be disinfected prior to being used for feeding.
- The fish tanker or well boat will be disinfected after delivery of juvenile fish to the farm and prior to going back to the DAC.
- The Berrimah Veterinary Laboratories will take samples and test the juvenile fish for a range of likely diseases prior to the fish leaving for the Marine Harvest farm.
- The disinfectant used will either be calcium hypochlorite (i.e. chlorine) or the same product used by the DAC, which is Phoraid. Phoraid is said to be non-toxic and biodegradable, but does not break down as rapidly as chlorine when exposed to the sun.

Monitoring

Staff at Marine Harvest will monitor fish health by looking for obvious disease signals such as appetite depression, irregular swimming patterns, increased frequency of gill movement, and any other general irregularities. Fish that are obviously unwell will be removed and either treated or destroyed.

The farm will have one staff member who is a laboratory scientific officer who will be dedicated to monitoring for disease in the fish. This person will record and monitor the daily mortality rate in each pen and will note whether there are any increases worthy of investigation. The scientific officer will be a trained bacteriologist who will carry out tests on fish in order to identify what might be a problem in the fish. The government veterinary laboratory at Berrimah will be used to confirm any diagnosis.

Marine Harvest has an excellent relationship with the Government Veterinary Service and should any problems occur within the farm, a government vet will be asked to inspect the site. The Service will make at least one routine annual visit to the lease.

9.5 Fish Faeces and Nutrient Loads

Risk Ranking – Serious or High

Mitigation and Management

Through careful management of fish feeding the potential impacts from excess nutrients entering the environment can be minimised. The siting of the cages in a high-current channel will help the rapid flushing of faeces and minor amounts of uneaten feed from underneath the cages. The cages will be moved around the lease site according to a documented schedule, to allow fallowing of the sediments below the cages, to allow any deposited nutrients to be broken down, and to diminish any potential build up on the seafloor. Water flow beneath the cages will carry most faeces and nutrients away from

the farm. Strong current are expected to break up any solid particles and to rapidly dilute any deposits. Scouring of the sediment surface will also occur during tidal flows and during rainfall events when copious quantities of water enter the catchment. The scouring of seafloor surfaces will assist in reducing the build up of faeces or nutrients below the cages.

Monitoring

Monitoring of the water column at the farm site on a weekly basis as noted in Sections 9.11 and 10.4 will provide an early indication of potential nutrient issues in the water column. The biennial ambient monitoring program will be carried out to ensure that any potential impacts attributable to the farm are identified and addressed early.

9.6 Excess Fish Feed and Feed Quality

Risk Ranking – Low to Medium

Mitigation and Management

A number of measures will be put in place to ensure that the feed is sourced from sustainable resources; that its quality satisfies relevant guideline levels; and that minimal feed is lost to the surrounding water.

Fish Feed Sources

The typical ratio of fish production to feed used is between 1:1.1 and 1:1.4, i.e. for 500 tonnes produced, between 550 and 700 tonnes of feed will be used. Marine Harvest has been working at developing feed which uses vegetable raw materials in addition to fish meal and fish oil in the fish feed. The aim is to achieve as low as practicable wild fish to barramundi conversion ratio, to reduce dependence on the wild catch, and to provide consumers with healthy fish products from sustainable fish farming. Marine Harvest applies a purchasing policy that requires fishmeal and fish oil to be sourced only from managed and sustainable fisheries. Fish oil is now used as part of the fish feed, when originally, fish oil was considered a by-product of fish meal production. It is understood that aquaculture marine fish production requires between 2.5 to 3.2 pelagic (other fish) equivalent inputs (wet weight basis) per unit of farmed fish output.

The wild fish component of the feed is provided by the Peruvian and Chilean anchovy, jack mackerel and sardine fisheries which are under direct government control. These governments play an active role in scientific monitoring of the fisheries, in ensuring that these are fished in a completely sustainable manner, and in setting quotas and bans. Mr David Whyte of Skretting (pers. comm. 9 February 2006) considers that the Peruvian and Chilean fisheries, from which Skretting source the wild fish component of their feed, are some of the most sustainable and well managed fisheries in the world.

Feed Quality

Details on the barramundi feed composition and ingredients are provided in Section 3.8.2. The barramundi feed is mammal-protein free, free of genetically modified organisms' DNA, no hormones or growth promoters are used in the fish feed, and all raw materials are sourced from areas of the world that are known to be very low in industrial pollution from heavy metals, dioxins and polychlorinated biphenyls (PCBs).

Feed Loss

Feeding will be managed by the use of feed tables. Feed tables are designed by a fish-feeding specialist who calculates the appropriate amount of feed required per pen according to the number and size of the fish in each pen and the water temperature. This method of feeding is based on optimising fish appetite and growth and minimising feed wastage; it diminishes overfeeding of fish, and has proven to be very successful in preventing feed wastage by encouraging fish to eat with full appetite when the feed is provided to them. Since its implementation at the pilot farm at Port Hurd, this feed program has reduced feed consumption by 60 percent and has resulted in only a minor reduction in growth rate. The farm has a vested interest in managing feed loss as feed costs are one of the biggest overhead costs.

Monitoring

Fish Feed Quality

Skretting carries out annual residue monitoring at the Cambridge feed mill in Tasmania, in conjunction with residue monitoring in the other 15 feed mills located worldwide. Residue monitoring analyses are carried out on the fish feed finished product and on source products such as poultry meal, feather meal, fish meal, fish oil, tuna meal and poultry oil. The samples are analysed for heavy metals, antioxidants, dioxins, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, flame retardants, nitrosamines and pesticides. The residue-monitoring analytical results are assessed against the most stringent European Union limits. Skretting factories have implemented a Risk Management System to ensure that quick action can be taken in the event of high residue levels being detected.

Results from Skretting's residue monitoring for 2003, 2004 and 2005 at the Cambridge Mill in Tasmania are provided in Appendix H. These show that residues for all the compounds analysed are well within the recommended limits set by the European Union.

Feed Loss

Any uneaten feed will be monitored by camera to ensure that as little wastage as possible occurs in the form of uneaten pellets. Any potential excess nutrient impacts will be monitored as described in Section 9.11.

9.7 Waste

Waste management in the Northern Territory is governed by the *Waste Management and Pollution Control Act 2003*. Waste includes any matter, whether solid, gaseous or radioactive, which is discharged, emitted or deposited in the environment in such volume, consistency or manner as to cause an alteration to the environment[1].

There are a number of operations at the Port Patterson marine farm that will generate waste on a day to day basis as discussed in Section 8.9. Provisions for the reduction, re-use, recycling and appropriate disposal of this waste will be outlined in detail in the Environmental Management Plan for the Port Patterson facility.

The amount of waste likely to be generated from the operations at Port Patterson is minimal, and provided waste disposal procedures are adhered to the risk of any on site impact from waste will be low.

Risk Ranking – Low to Serious (for major spillage)

The paragraphs below outline the proposed waste management measures to be employed at the Port Patterson farm.

9.7.1 General Mitigation Measures for Waste

Marine Harvest intends to implement actions which will be identified in the EMP for Port Patterson. The EMP will provide details on the following:

- Farm staff training regarding waste minimisation and waste management procedures;
- Monitoring and reporting of volumes, types and destinations of waste materials; volumes of all materials brought onto the farm should also be tallied for comparison purposes;
- Appropriate storage, transport and disposal of all materials and wastes generated;
- Regular reassessment of waste minimisation options to ensure that the operation remains current and proactive in limiting its waste generation; and
- Clearly documented procedures regarding waste management.

9.7.2 Solid Putrescible Waste

Putrescible waste is waste that can be decomposed by bacterial action[2]. The barramundi farm at Port Patterson is likely to generate putrescible waste from sources such as kitchen scraps (from meats and vegetable matter), office and kitchen paper and cardboard packaging, as well as the dead fish carcasses (morts).

---

[1] Pacific ETRS. May 2003. Environmental Systems Lead Auditor Training Manual.

[2] EPA. May 2004. Classification of wastes. Publication 448.1. Victorian EPA. WWW.epa.vic.gov.au.

Mitigation and Management

Kitchen food scraps will be stored on the barge in a standard, sealed rubbish container, in a store room to prevent attracting birds and crocodiles to the site. Kitchen scraps will either be removed from the barge regularly and transported by boat to a local landfill site or composting facility, or, it is more likely that all suitable materials will be disposed directly into the ensiler, the contents of which will be used for composting following shipment to Darwin. Morts will also be digested in an ensiler located on board the barge.

Office paper and all cardboard will be re-used where possible, or bundled and stored appropriately for recycling. Paper and cardboard will be collected at the same time as the other non-putrescible rubbish and will be transported by boat to a recycling centre.

Monitoring

Monitoring measures will include:

- checking the level of the ensiler monthly to ensure it operates optimally and is emptied when required, and
- checking that any putrescible waste not placed in the ensiler is stored in securely sealed containers in a dedicated storage area, and does not attract and scavenging birds or other animals.

9.7.3 Sewage and Grey Water

Liquid wastes are generated by sewage and sullage water. The number of personnel at the barge at any time is small and washing consists of personal hygiene, cleaning of the facility, washing of dishes and minimal clothes washing. Sewage and sullage will be treated with the best available on-board facilities to ensure processed water meets the most stringent guidelines prior to being discharged to the bay.

Management and Mitigation

All sewage generated on board the barge facility will be treated by the Humphrey system. The Humphrey system complies with US coast guard requirements.

In the Humphrey system, the sewage from the toilet(s) flows directly into the digestor unit(s), where it makes its way through a series of baffles. It is broken down and dissolved by natural bacterial action during this stage. The resulting effluent is pumped through the activated carbon filter and passes through the disinfecting system, where the final stage of purification and deodorising takes place prior to discharge to the water body. Maintenance of the system is simple and would be included in a regular program, which would entail:

- periodical addition of Humphrey Activator to keep bacterial action operating optimally,
- regular checking and replacement of the activated carbon filter, and
- regular checking and topping-up of disinfectant.

Monitoring

Quality of the effluent is expected to meet effluent standards set in the ANZECC 2000 *Water Quality Guideline for Fresh and Marine Waters*. These guidelines are recognised nationally and widely adopted by most relevant authorities. Samples of the effluent will be taken weekly during initial commissioning of the equipment on the barge. Once a steady state has been achieved the effluent will be sampled monthly. Analysis of the effluent will be by a NATA accredited laboratory. Results of the analysis will be submitted in the annual report to the Environment Protection Authority. Analyses will include a broad range of target compounds during the first rounds of screening, e.g.: faecal coliforms, ammonia, visual appearance and colour, odour, pH, temperature, oil and grease, heavy metals, pesticides, detergent compounds. The suite of anolytes will then be refined over time.

9.7.4 Solid Inert Waste

Solid inert waste is hard waste and dry vegetative material which has negligible chemical impact on the environment. Solid inert waste from the Port Patterson farm will include feed bags, plastics (kitchen and workshop), glass (kitchen and workshop), polystyrene (from damaged pens and from the barge), steel (from damaged or old pen mesh), and clean waste generated from the workshop.

Mitigation and Management

This waste will be stored in dedicated storage containers and areas; all recyclable waste will be separated into different containers. Solid wastes will be removed by boat regularly and will be disposed to an appropriate waste disposal facility in Darwin for recycling or landfill. Where possible all recyclable wastes such as plastic will be sent to a recycler in Darwin.

There is no ability to recycle the bag waste, which is by far the greatest volume of solid waste generated.

Monitoring

The farm will keep records of the volumes of solid waste it generates and will regularly reassess new reduction, reuse or recycling options for its waste.

9.7.5 Prescribed Waste

Prescribed waste can have hazardous properties. If not managed properly these wastes may pose a threat to life or health of living organisms due to their toxic properties. Other wastes in this category may pose a threat to safety of humans or equipment due to explosive, reactive or corrosive properties. The proposed barramundi farm at Port Patterson will only generate small quantities of prescribed waste and these will include small amounts of chemicals, laboratory materials for fish monitoring, spent batteries and waste oils.

Mitigation and Management

All prescribed wastes such as chemicals, laboratory materials for fish monitoring, spent batteries and waste oils will be stored in their original containers with lids on or in dedicated and sealable storage containers. All containers will be clearly labelled with appropriate warnings and will be kept in impervious storage areas. Waste containers of

incompatible substances will be stored separately from each other. These wastes will be picked up by the transport barge and will be disposed appropriately by Waste Master, which is a licensed waste disposal company in the Northern Territory.

Monitoring

The farm will keep records of the quantities and destinations of prescribed waste of which it disposes.

9.7.6 Dead Farm Fish

From experience at Port Hurd, around 2 percent of the farm population will die through natural causes. The management of this fish waste is described below.

Mitigation and Management

The pens will be inspected daily to ensure the fish remain healthy and any fish which appear sick are immediately removed and disposed of to the ensiler. The ensiler is an 11,000-litre tank with two access holes at the top. A chopper pump is built in to the ensiler to cut up fish into smaller pieces for faster decay and mechanical stirrers will keep the mixture moving to also help speed up decay. The tank will be made from tank-grade polyethylene and will contain potassium hydroxide diluted to between 1 and 10% by weight in water. Typically, potassium hydroxide in the ensiler will be used at a rate of about 10% potassium hydroxide per mort volume, i.e. 100 kilograms of potassium hydroxide would be required to ensile 1 tonne of dead fish. It is expected that at least 1 tonne of potassium hydroxide would be held on site at any time. In the case of a disease outbreak, storage of up to 2 tonnes of potassium hydroxide may be necessary. However, holding requirements may be reduced depending on the frequency of the supply barge visits.

The mort ensiler is developed to treat fish morts and offal. The wastes are thoroughly mixed with acids and form a stable, odourless end product. The end product can in some cases be used as a fertiliser or basic product for further processing. The end product has a commercial value in that it is rich in fish oils and proteins.

The ensiler will be emptied periodically. The process involves turning off the pump and stirrers so the contents settles. The supernatant liquid is then let out of an outlet at the side of the container and transferred to an iso-bin. The excess sludge left at the bottom of the ensiler does not build up rapidly as it keeps breaking down. When build up is excessive, the sludge is removed with a sludge pump inserted at the top of the ensiler and transferred to an iso-bin.

The material from the ensiler will be shipped to a proprietary composting operation in Darwin (MOECO) for mixing with their usual composting products.

Monitoring

The contents of the ensiler will be checked regularly (monthly and as needed) to ensure that the process is operating properly within the tank and that the level does not build up beyond its capacity.

The farm will keep records of the volumes of waste removed from the ensiler and recycled via the composting stream.

9.8 Storage, Handling and Containment of Chemical and Hazardous Substances

The barge facility will store a number of hazardous chemicals which must be managed according to Dangerous Goods Regulations.

Risk Ranking – Serious Risk

Mitigation and Management

Storage, handling and containment procedures for chemicals and hazardous substances will be drawn up as part of the site's Environmental Management Plan.

Some of the main procedures will include:

- Storing all substances in their original manufacturers' containers, with labels clearly visible and legible;
- Storing all substances in accordance with manufacturer's instructions or following instructions on pertinent material safety data sheets (MSDSs);
- Storing incompatible substances away from each other and in separate and dedicated storage areas;
- Storage of hazardous chemicals in excess of 200 litres will require a bunded area; the area will be bunded to contain at least 110% of the volume of the largest vessel it contains, or 25% of the total volume of fuel stored within the bund;
- The bunded area will have a roof for protection from the sun and from rain. This will help prevent overflow in the event of a spill in the bund;
- The bunded area will also include a sump for drainage of the spilled contents to a holding tank;
- All outlet points on all fuel storage containers will be fitted with safety / emergency valves for use in the case of a catastrophic event; and
- Training of all staff and contractors in the appropriate handling and storage of all substances to prevent injury to themselves and others, and to prevent impacts on the surrounding environment. If new products are to be brought onto the farm, a briefing needs to be held regarding any particular storage or handling requirements for that product.

Emergency Management of Chemicals and Hazardous Substances

Emergency and contingency plans for the management of chemical and hazardous substances spillages will be drawn up as part of the site's Environmental Management Plan.

Some of the main aspects of the plan will include:

- Procedures to address the immediate response to any chemical and fuel spillage to ensure clean up is carried out expediently and further spillage is averted;
- Procedures to notify all relevant company, local and government parties as soon as possible;
- Ensuring that appropriate clean up materials are available where needed and in appropriate quantities;
- Ensuring that all clean up waste is stored in appropriate containers;
- Ensuring that clean up waste is disposed to an appropriately licensed waste disposal facility;
- Ensuring that all staff are trained in the clean up procedures for all chemicals and hazardous substances;
- Ensuring that an appropriate response plan is in place to handle all eventualities that may arise from any chemical or hazardous substances spill;
- Ensuring that a post-incident debrief is carried out so that any lessons to be learned from the incidents are implemented; and
- Ensuring that regular refresher training is carried out to familiarize staff with such eventualities.

Monitoring

All storage areas will be checked weekly for evidence of leakages, and all containers will be visually inspected for integrity.

Annual auditing of all substances stored will need to be carried out to ensure that they are stored appropriately, that MSDS sheets are available, and that all staff is trained in the handling of all products used by the farm operations.

9.9 Nets and Moorings

Risk Ranking – Low to Medium Risk

Mitigation and Management

Nets

A number of measures will be put in place at Port Patterson to minimise the potential for the loss of nets and moorings. These will include engineering and procedural measures.

The steel nets proposed by Marine Harvest will greatly minimise the risk of escapes. These cages have proven to be very durable in adverse weather conditions throughout the world and at the Port Hurd pilot farm, and can handle waves greater than 2.5 metres.

The size of nets proposed to be used at Port Patterson will be smaller than those used most recently at Port Hurd; there will also be fewer nets attached to each mooring array than at Port Hurd. This will diminish the drag from water currents and the resultant stress on the mooring system. Moorings will be installed by cyclone mooring specialists.

Moorings

Moorings will be designed specifically for the size and type of nets used, and to the most stringent standards to withstand the maximum water currents and wave heights likely at Port Patterson and within the location chosen for the nets.

Monitoring

The site manager will be responsible for ensuring that the monitoring schedule and regular maintenance are carried out as specified in the forthcoming Environmental Management Plan.

Regular moorings inspections will be carried out during conditions suitable for diving, and a program of maintenance and replacement of mooring equipment will be put in place to ensure the moorings are in the best possible condition to withstand potentially harsh conditions.

- All mooring components will be checked by divers six monthly;
- Mooring components will be replaced regularly under a strategic maintenance program and at a minimum will be fully replaced each 2 years;
- Nets will be monitored daily from the water surface and fortnightly below the water line by divers;
- Components of nets will be replaced as needed and under a strategic maintenance program; and
- Nets will be fully replaced at a minimum each 2 years.

Contingency

In the event of a mooring failure, a warning will be broadcast to the Marine and Safety Authority and to local shipping. Where safe to do so some temporary mooring will be set up to secure the cages until a permanent replacement can be constructed. Measures will be taken to attempt to locate and retrieve any stray net or mooring materials which may have drifted away.

9.10 Hydrodynamics

Risk Ranking – Medium to Serious Risk

Mitigation and Management

The nets, moorings and barge design options chosen for Port Patterson and discussed in previous sections have had as their main focus the aim of minimizing water drag. Minimizing water drag will consequently minimize potential disruptions to the hydrodynamic processes.

Changes to the locations of the net mooring arrays may occur periodically and this will alleviate any potentially localized scouring of the sea floor sediments that may occur around the mooring anchors.

Monitoring

The farm will ensure that any complaints received by locals regarding potential disruptions to the hydrodynamics in the bay are registered and that an assessment of possible modifications to the operational set up is made if required.

Monitoring for potential seafloor scouring around the mooring anchors should be included in the mooring inspections carried out six monthly by the diving teams.

9.11 Water and Sediment Quality

Risk Ranking – Low Risk

Mitigation and Management

The proposed location for the barramundi farm is within a channel within Port Patterson which is flushed by high currents. This channel was chosen in part because of its strong currents, which will allow for good oxygenation of the nets and abundant oxygen input for optimum growth of the fish. It is therefore considered that the water quality will not suffer depletion of oxygen levels or eutrophication. As discussed in earlier sections, there will generally be no inputs of chemicals, excess feed will be very minimal and is likely to be eaten by local wild fish, and faeces will be predominantly washed away and diluted by the strong currents. The main mitigation and management methods will include:

- Managing feed input to ensure minimal excess feed is lost to the environment;
- Managing and monitoring fish health to minimise the need for chemical use and input;

- Ensuring that effluent from the barge is treated to appropriate standards;
- Ensuring that no other wastes are disposed to the marine environment;
- Regular monitoring of receiving environments, i.e. water and sediments;
- Comparative assessment of regular monitoring results with baseline data; and
- Implementation of a procedure to immediately respond to any indications that the farm may be impacting on water or sediment quality.

Monitoring

Aquenal Pty Ltd (2005) carried out baseline investigations at Port Patterson which included water sampling and sediment sampling at target sites. This work is summarised in Section 5.3. Aquenal Pty Ltd is well regarded in the field of marine, estuarine and fresh water environmental analysis.

Monitoring outlined below will be assessed against the baseline investigation results reported by Aquenal Pty Ltd.

Regular Monitoring

Daily monitoring of water temperature and oxygen levels will take place at the farm. In addition regular monitoring will also be carried out which will entail monitoring fortnightly during the dry and every two months during the wet. Parameters monitored and samples taken will include the following.

- Taking water samples from the Port Patterson sampling sites from the top and bottom of the water column;
- Measuring temperature and salinity of the water at those locations at intervals of several minutes;
- Taking photos of mangrove roots;
- Taking algal samples as necessary; and
- Submitting water samples for analysis for nitrite, nitrate, ammonia, pH and chlorophyll α.

Annual or Biennial (every 2 years) Monitoring

The periodic monitoring will entail sampling from the same locations as those sampled during the Port Patterson baseline survey by Aquenal and reported in October 2005. The locations included six sampling locations (labelled F1 to F6) within Geranium Channel and Phoenix Inlet as well as six control sites (labelled C1 to C6) within Madford and Tahlee Inlets.

Samples and observations will be collected for the following parameters:

- sediment description,
- redox,

- particle size,
- photography of mangrove root assemblages,
- mangrove stand structure and condition,
- benthic infauna,
- water borne nutrients,
- chlorophyll, and
- water quality parameters (temperature, salinity, pH and dissolved oxygen).

9.12 Management of Predators

Risk Ranking – Serious to High Risk

The risk ranking is serious to high based on the potential injuries which could be incurred from encounters with crocodiles.

Management and Mitigation

The main management and mitigation methods will include the following.

- As part of the induction process, all staff, visitors and contractors to the farm will be briefed on the potential dangers from crocodiles;
- Feeding of any wild animals by any farm staff, visitors or contractors will be prohibited;
- Disposal of any wastes to water, in particular food wastes, will be prohibited;
- Avoidance of crocodiles anywhere near or on the water;
- Regular maintenance of farm nets; and
- Inclusion of crocodile attack management procedures in the emergency procedures for the farm.

9.13 Bird, Reptile, Fish and Mammal Habitats

Risk Ranking – Low Risk

Mitigation and Management

The main mitigation and management methods will include:

- Running the operation predominantly during daylight hours.
- Minimising noise from the operation by limiting the use of outboard motors, pump generators, etc. to only the required usage period, and ensuring that all engines and generators are the quietest available and are well maintained.
- Limiting night operations to an absolute minimum.
- Use of low impact night lighting at all other times.
- Ensuring fish do not escape.
- Ensuring water and sediment quality is maintained via management of feed, wastes, chemicals, etc. (as outlined in sections above).
- Quarantine regulations in place at the Darwin wharf will be strictly adhered to by the sea transport company that will come to the site. This procedure is aimed at preventing the invasion of the Islands by weed and feral animal species.
- Ensuring procedures are in place to immediately and effectively manage any spills or other event which may impact on the environment.

Monitoring

The main monitoring measures will include the following.

- Keeping a detailed log of all farm operations so that links to any potential complaints or impacts can be made or discarded;
- Logging of all animal deaths found near or in the lease;
- Logging and responding to any complaints received regarding potential disturbance to local habitats; and
- Monitoring of water, sediments and flora at regular intervals as outlined in Sections 9.11 and 9.14.

9.14 Flora

Risk Ranking – Low Risk

Mitigation and Management

Mitigation and management methods will include the following:

- Implementation of methods outlined in Sections 9.4 to 9.12 will prevent most potential indirect impacts to flora;
- Induction of staff into the need to prevent and avoid any direct impacts to local flora from outboard motorboat uses or any occasional motor vehicle usage;
- Monitoring of mangrove extents and health, as noted below.

Monitoring

It is proposed that annual surveys of monitoring locations in coastal mangrove stands be carried out to check on the health of the mangrove stands and to assess the potential growth of epiphytic algae on the mangrove roots. The results will be compared to the baseline results obtained at Port Patterson by Aquenal in 2005 (refer to Section 5.3). This will help to provide early indicators of potential nutrient accumulation in the quieter embayments of Port Patterson.

9.15 EPBC Act-listed Threatened and Migratory Species

Risk Ranking – Low Risk

Mitigation and Management

Proposed mitigation and management measures to minimise risk of any potential impacts to EPBC Act-listed threatened and migratory species include the following.

- Inducting all staff, visitors and contractors about the need to avoid disturbance to any wildlife encountered in the bay, in particular dugongs, turtles and crocodiles;
- No feeding of wildlife will be permitted;
- Implementation of the mitigation, management and monitoring measures listed in Sections 9.2 to 9.14 will help minimise potential impacts on EPBC Act-listed threatened and migratory species; these will include as a minimum:
    - Implementing strict management of feed and wastes;
    - Limiting boat speeds on the bay to less than 5 knots;
    - Fitting guards around the outboard motors to prevent injuries from potential boat strikes;
    - Maintaining nets in good order;
    - Minimising disruption to fauna and flora;

- Providing appropriate and detailed training to all staff and contractors to ensure their awareness of issues and procedures;
- Employing minimal and low impact night lighting, e.g. low-pressure sodium vapour bulbs (Witherington and Martin 1996) which will be 'turtle friendly', fitting shades on the north-western side of any lights which could be visible from Turtle Island;
- Regular inspection of all lighting mitigation measures at the farm and from the beaches on Turtle Island at night, to ensure that mitigation measures are effective in rendering farm lights near-invisible from the Turtle Island beaches which face the proposed farm site;
- Minimising night-time operations; and
- Minimising noise from operations and occupation of the site.

Monitoring

Monitoring measures will include:

- monitoring of water, sediment and flora quality and health as per Sections 9.11 and 9.14; and
- recording any complaints, reports or sightings of dugongs and turtles or any other wildlife presence, unusual behaviour or death.

9.16 Land Surface

Risk Ranking – Low Risk

Mitigation and Management

The following management measures will be put in place to prevent and mitigate any potential impacts to land surfaces.

- Contractors and staff will be accommodated on the barge or in the pre-existing premises at Bynoe Harbour;
- The management of hazardous materials will follow methods outlined in Section 9.8;
- Motor vehicles will be kept to marked tracks and roads and will drive at or less than the nominated speed limit. If the surface is unsealed, vehicle speed will be reduced to limit either dust generation when dry or rut formation when wet;
- Any unsealed surfaces where active farm operations may take place will be monitored and corrective actions (i.e. remediation of land surface and operations procedure changes) will be implemented if any impacts are identified.

Monitoring

The proposed monitoring measures for the farm's potential impacts on land surfaces will include:

- Carrying out an inspection of any unsealed surfaces upon vacating the area; and
- Recording any complaints received regarding any potential impacts to land surfaces, and taking corrective actions as appropriate.

9.17 Air Quality, Noise, Lighting and Visual Amenity

Risk Ranking – Low Risk

Mitigation and Management

Noise

Use of equipment and motor boats during construction and operation will be limited as much as possible to daylight working hours, and where possible, will be kept at a distance from residential buildings. The equipment will generally be protected from sun and rain, with at least some temporary roofing, and as a result the sound will often be muffled.

Where possible, the generator will be positioned so as to minimise exposure to noise and odour emissions to the local residential buildings. The generator will also be protected from sun and rain with, at a minimum some roofing, which will have some sound muffling effect. Marine Harvest will investigate the use of a purpose-built sound-proofing enclosure for the generator.

Marine Harvest will endeavour to use the quietest outboard motors available and will ensure that they are maintained in optimal running order to minimise noise. The motors will be fitted with guards to prevent injury to marine wildlife in the event of an impact, and it is anticipated these guards may provide some noise muffling.

Outboard motor boats will only be used as needed by the operation and their speed will be limited to less than 5 knots in the bay.

Marine Harvest will endeavour to use the quietest pumps available for the fish and feed pumps. These will be maintained in optimal working order and will only be used when needed. The use of sound muffling boxes around the pumps will be investigated by Marine Harvest.

Odour

Dead fish will be removed daily from the pens and placed immediately into the ensiler, which is a closed unit and contains powerful chemicals for the digestion of fish. No persistent odours from dead fish would be expected.

Steel nets are used up to 2 years and then cut up and either used for erosion control or returned to Darwin and sold to metal recyclers. Prior to transport and disposal, used steel net components will be stored in a way to minimise odour generation or impacts.

All generators, pumps, and outboard motors will be kept in optimum working order to ensure that their emissions are as low as possible.

Lighting

Use of lighting at night will be kept to a minimum. Flashing corner lease markers are required for navigational safety reasons. Night work and light use will be required around once a month due to work requirements combined with tidal cycle parameters (height and current strength) and barge availability for harvesting, however, lighting will be focussed internally onto the barge.

Visual Amenity

The farm presence is low profile, with only 0.5 metres of the nets protruding above the water surface. The barge design will be a single storey building. Low impact colours will be used whenever possible and appropriate.

Monitoring

- A log book of operating hours will be kept for all equipment;
- All motorised equipment will follow a maintenance schedule set according to the number of hours of operation; and
- A record book will be kept for any complaints related to potential impacts from noise, to air quality, from lighting and to visual amenity. Procedures will be put in place to ensure corrective actions are taken immediately.

9.18 Social and Recreational

Risk Ranking – Low Risk

Mitigation and Management

Management methods will be put in place to ensure all staff is effectively introduced into the local cultural ways. In the main, staff will be on a fly-in fly-out roster and will remain on the barge for the major part of their work roster.

Staff and contractors working at the fish farm generally have a positive social framework and socialise readily after work hours. However, interactions with local residents are expected to be limited due to long work days, low staff numbers and low number of local residents and the absence of a local township. Options for recreational activities include:

- fishing,
- boat trips to other areas.

Marine Harvest will consider organising regular fishing days around the cages if they find that there is local interest in this activity. Marine Harvest will also organise Open Days at regular intervals.

Monitoring

Monitoring will be based on providing an easily available complaints and incident reporting procedure to record any potential social problems either internally or between farm staff and locals. A procedure will be put in place to ensure that all complaints are dealt with immediately and corrective actions taken.

9.19 Archaeological, Historical, Cultural and Aboriginal Sites

Risk Ranking – Low Risk

Management and Mitigation

The farm facility will be located entirely on water and, based on current knowledge, is not expected to overlap any sacred or spiritual sites.

Aboriginal cultural awareness training will be provided to all staff to ensure that non-indigenous and interested indigenous staff have a sound understanding of Aboriginal values and beliefs.

Monitoring

Records of any potential complaints will be kept and corrective action will be taken immediately by farm management if any potential impacts to archaeological, historical, cultural or aboriginal sites are reported.

9.20 Marine Traffic

Risk Ranking – Low Risk

Mitigation and Management

Speed restrictions should be applied to all boats visiting the farm, e.g. less than 5 knots. Any propeller driven boats used by the operation should be fitted with a propeller guard to limit the damage to marine animals in the unlikely event of a boat strike. All farm staff will need to be trained in the safe use of outboard motor boats and the general rules for maritime traffic and jetty usage. Whenever possible, motor boat use should be limited to daylight hours and to periods of better visibility and safer seagoing conditions. Marine Harvest will ensure that the Northern Territory Marine Act (1981) is followed.

Monitoring

Records will be kept of any marine-traffic related incidents potentially associated with the farm's operations, and corrective actions will be taken immediately by farm management to ensure procedures are implemented to minimise future incidents.

9.21 Mitigation of Nuisance and Health Risks from Pest Insects

Risk Ranking – Low Risk

Mitigation and Management

Induction procedures will make staff aware of the dangers of these insect-borne diseases and will inform staff about precautions such as the use of repellent and covering at night. Mosquito nets will be provided to limit exposure to insects at night.

If immunisation to communicable diseases is available, staff will be informed about this. When and where possible, Marine Harvest will use light bulbs that minimise the attraction of insects.

Monitoring

Staff members, visitors and contractors will be encouraged to report any problems they have with pest insects, or any health problems which could potentially be related to pest insect bites. Management procedures will be amended as required by farm management.

9.22 Personnel Emergencies

Risk Ranking – Low to Serious Risk

Mitigation and Management

The following management measures will be put in place by Marine Harvest:

- Safe operating procedures will be drawn up for all operations on the farm and all staff, contractors and visitors will be trained in each of the relevant procedures prior to carrying out any of the tasks;
- Staff, visitors and contractors will not operate alone or out of sight of another farm worker;
- Marine Harvest will draw up a clear emergency procedure;
- All staff, visitors and contractors will be briefed in the details of the emergency procedure at the time of their inductions; and
- Regular emergency training exercises will be carried out.

In the event of a medical emergency, the Medivac procedure will be followed. The Medivac procedure requires that the District Medical Officer be called, and in turn a plane would be ordered to be dispatched to the site with a paramedic. The person would then be airlifted to the hospital in Darwin.

Monitoring

Detailed records will be kept of any incidents, accidents and emergencies. All events will be assessed and corrective actions will be implemented immediately by farm management.

9.23 Management and Monitoring of Quality of Farmed Barramundi

Risk Ranking – Low Risk

Mitigation and Management

Management of the quality of the farmed barramundi will be based on:

- obtaining juveniles from locally sourced broodstock,
- managing the quality of the feed (refer to Sections 3.8.2 and 9.6),
- maintaining optimum ambient water quality, and
- minimising stress on the fish, via minimal handling, optimum feeding and lack of overcrowding.

Monitoring

Monitoring measures to ensure quality of farmed barramundi will include:

- daily monitoring of their health,
- daily removal of any dead fish,
- testing of dead fish for potential diseases, and
- regular monitoring by the Government Veterinary Laboratories at Berrimah.

10 Environmental Management

A detailed Environmental Management Plan (EMP) will be drawn up for the project after it has progressed to the next stage of the approval process. The EMP for the site will detail all aspects of the environmental management for the site including construction. The EMP will build on the mitigation, maintenance and monitoring described in Section 9.

The following sections set out some of the preliminary aspects of the EMP for the site.

10.1 Company Health Safety Environment and Quality Policy

Nutreco's company Health Safety Environment and Quality (HSEQ) Policy applies to all its business units, of which Marine Harvest is a part.

Nutreco HSEQ Policy

For Nutreco, Quality is a core value. This is valid for the quality of products, the health and safety of operations, and the quality of its environmental performance. Nutreco believes this to be an integral part of responsible, efficient and profitable business management.

Nutreco strives to participate in a responsible manner in the food chain, with sustainability, based on quality and safety, as a governing principle.

Therefore, Nutreco is committed to the following principles:

- *Ensure that working environments are safe and appropriate for employees, suppliers and third parties.*
- *Contribute to food safety and quality at all points of the food chain where Nutreco is active.*
- *Apply the principle of sustainability as a driver towards continual improvements in environmental performance. And*
- *Be conscious of and attentive to the impact activities may have on neighbours, the local community and the interests of society in general.*

We consider quality awareness and commitment to the HSEQ principles as the pillars of the future success of our Company.

The HSEQ policy is valid for all companies and activities where Nutreco has a managerial or operational role.

10.1.1 Objectives

Underpinning the HSEQ Policy, the objectives of Marine Harvest are:

- To minimise the impact of its operations on the surrounding environment;
- To ensure that conservation of the biodiversity is not impacted by Marine Harvest operations;
- To ensure that environment programs are developed and implemented in consultation with local residents and aboriginal groups;
- To minimise the footprint of the development; and
- To maintain a low impact facility.

Marine Harvest will operate its Port Patterson facility in line with these objectives.

10.2 Operational Standards

Based on its experience at its Port Hurd pilot barramundi fish farm on Bathurst Island, Marine Harvest is familiar with what is required to resource and implement an appropriate environmental management system tailored to the requirements of the tropical environment in Port Patterson.

Marine Harvest operates in a large number of countries and climates and farms a wide array of fish. It has developed a number of operational standards which it follows, namely:

- Marine Harvest is continuously seeking to achieve more sustainable production — neither depleting resources beyond their capacity, nor introducing into the environment materials or substances that are detrimental to it.
- Marine Harvest is aware of the significant economic and social role it has to play in the remote communities where it operates. It therefore participates in initiatives and makes continuous efforts to develop positive relationships in the communities – these include programs such as nature conservation work, environmental initiatives, sponsorship of local sports and cultural events.
- The Marine Harvest code of practice has a section specifically addressing animal welfare. The objective is described in the following words:

  Wherever our practices infringe on the "five freedoms" of animals under our management, efforts should be made to achieve improvements. The "Five freedoms" as defined by the Farm Animal Welfare Council and relevant to aquaculture, cover freedom from:

  - *hunger and thirst,*
  - *discomfort,*
  - *pain, injury or disease,*
  - *fear and distress, and*
  - *freedom to express normal behaviour.*

10.3 Standard Operational Procedures

Marine Harvest has developed a number of operating procedures for all aspects of its Port Hurd farm. These are to be found in Appendix I. These standard operating procedures (SOPs) will be reviewed and modified for the Port Patterson site operation prior to commissioning. The SOPs will be incorporated into the Maintenance and Monitoring Manual identified in Section 9.1. In addition, site specific procedures will be developed for Port Patterson as they relate to the operation of the barge facility.

10.4 Monitoring and Reporting Strategies

A baseline monitoring report for Port Patterson was prepared for Marine Harvest by Aquenal in October 2005. This report provides the background against which future monitoring results will be compared and assessed. The report results were summarised in Section 5.3 and a full copy of the report is provided in Appendix D.

A detailed monitoring and reporting plan will be drawn up as part of the EMP for the site, however an outline of the strategies is listed below.

The objectives of the monitoring program include:

- gathering data of sufficient quality and quantity to be able to meaningfully compare to the baseline survey;
- being able to assess whether changes observed are significant and whether they are caused by the operation or by other outside factors; and
- providing enough information to guide the management of the marine farm.

The monitoring program will address the following:

- detect environmental impact caused by farming operations to the satisfaction of regulatory bodies and the farm operator;
- target areas most likely to be impacted by farming operations;
- include adequate controls to assess unrelated, widespread temporal variation;
- have a statistically rigorous sampling design; and
- assess long term and short term (seasonal) impact.

The parameters assessed will reflect fish farming impact and, if possible, be directly linked to fish farm outputs.

On a short term basis they will be the simplest and most cost effective to measure while providing sufficient confidence that impact can be identified. They will identify short term changes and provide triggers for more extensive monitoring.

Long term monitoring will assess more subtle change through recognised indicators or environmental decline. The frequency of that monitoring will be related to risks, farming intensity, past performance and changes in short term parameters. The long term

monitoring will be carried out under the supervision of competent scientists with credible track records and according to strictly defined, widely accepted and repeatable methodologies.

A summary of the monitoring requirements for the site is provided in Table 10.1. This will be used as the basis for the monitoring requirements to be included in the Environmental Management Plan for the farm.

Table 10.1: Summary of Proposed Monitoring Requirements

Aspect	Reference Section No.	Monitoring Activity	Frequency
Construction	9.2	Meetings to be held with staff, contractors and farm management or construction manager. Meetings should cover procedures, incidents and corrective actions.	Weekly
Fish Escape	9.3	Inspection of nets and moorings	As noted
		Tide prediction software to be investigated	Daily or as needed
Disease and Parasite Transfer	9.4	Visual inspection of fish health	Daily
		Recording of mortality rate	Daily
		Analysis by Berrimah Government Veterinary Laboratory	As needed
		Visit by Berrimah Government Veterinary Laboratory	Annually
Faeces and Nutrients	9.5	Water sampling	Weekly
		Water, sediment, mangroves	Annually or biennially
Excess Feed and Feed Quality	9.6	Feed tested at the source by Skretting	As needed
		Underwater camera	During feeding
Wastes	9.7	Check all wastes are placed in dedicated containers, etc.	Ongoing/daily

Aspect	Reference Section No.	Monitoring Activity	Frequency
		Records to be kept of all volumes and destinations of solid waste and prescribed waste disposed from the farm	Ongoing
Treated Sewage effluent	9.7.3	Water samples of effluent analysed for target parameters	Initially weekly then six monthly
Farm Fish Deaths	9.7.6	Check level on ensiler	Monthly and as needed
Chemical and Hazardous sub-stances	9.8	Storage areas to be checked for leakages and storage integrity and compliance	Weekly
		Hazardous substances audit	Annually
Nets and Moorings	9.9	Mooring components checked by divers	Six monthly or as needed
		Nets monitored from surface	Daily
		Nets inspected by divers (from inside nets)	Fortnightly
		Diving inspection of nets and moorings (outside of nets)	Six monthly
		Nets and moorings replacement	Minimum every two years
Hydrodynamics	9.10	Seafloor inspections by divers for scouring around mooring anchors (same time as mooring inspections)	Six monthly
Water and sediments	9.11	Water temperature and oxygen levels	Daily
		Water sampling and mangrove roots	Fortnightly during the dry, two-monthly during the wet

Aspect	Reference Section No.	Monitoring Activity	Frequency
		Water, sediment sampling and mangrove stands and roots	Annually or biennially
Bird, reptile and fish habitats	9.13	Record and review record of impacts and complaints	Ongoing
		Record all animal deaths in and around the lease	Ongoing
		Monitor water sediments and flora as noted	As noted
Flora	9.14	Seagrasses – best method still to be determined	To be determined
		Mangrove stands and roots	Fortnightly, two-monthly, annually or biennially
EPBC-Act listed Threatened and Migratory Species	9.15	Monitoring of water, sediment and flora as noted	As noted
		Check that all farm lights are using low-impact lighting and monitor for the potential presence of turtle hatchlings	Quarterly for the lights and ongoing for the turtle hatchlings
		Recording and assessing any complaints, reports or sightings of dugongs and turtles and any other wildlife presence or death	Ongoing
Land surface	9.16	Inspections of unsealed surfaces upon vacating area	On vacating area
		Recording and assessing complaints	Ongoing
Noise, lighting, air quality and	9.17	Log book of operating hours of all noisy equipment	Ongoing

Aspect	Reference Section No.	Monitoring Activity	Frequency
amenity		Maintenance schedule to be followed for all motorized equipment	According to equipment maintenance schedule
		Recording and assessing any complaints	Ongoing
Social and recreational	9.18	Review and assess complaints or incidents reported	Ongoing
Archaeological, historical, cultural and Aboriginal sites	9.19	Record and review any complaints	Ongoing
Marine traffic	9.20	Record any incidents or complaints and assess	Ongoing
Pest insects	9.21	Incident reports to be reviewed and assessed	Ongoing
Personnel emergencies	9.22	Incident, accident and emergency reports to be kept and assessed	Ongoing
Quality of farmed barramundi	9.23	Monitoring of health	Daily
		Testing of dead fish	As needed
		Regular checks by Berrimah Government Veterinary Laboratory	Annually

11 Public Involvement and Consultation

The proposed operation at Port Patterson has been in the public domain for a number of years now. Information regarding the proposal and the pilot project at Port Hurd has also been disseminated through the newspapers.

In August 2005, the draft guidelines for this EIS were put up for public comment by the Minister for Natural Resources, Environment and Heritage of the Northern Territory, and feedback from this has been incorporated into the final guidelines for the EIS, a copy of which is provided in Appendix B. The structure and content of this report is based on these guidelines.

Some preliminary consultation has occurred with the Northern Land Council (which represents all northern aboriginal groups) and this included an Open Day conducted at Port Hurd in November 2005, and as detailed below. The Northern Land Council has stated that they are interested in further consultation and negotiation once the EIS has been approved.

11.1 November 2005

An open day was held at Port Hurd on 22 November 2005. Around 70 people attended including members of the Northern Land Council. Aboriginal groups indicated preliminary support for the other fish farming operations planned by Marine Harvest but want to have a detailed consultation once the EIS has been through the process.

Issues raised during the Open Day on 22 November 2005 included:

- maintaining the aesthetics of the surrounding environment.
- issue of wastes from the fish farm.
- aggregation of wild fish beneath the sea cages.

The issues raised have been covered in the matters detailed in this EIS.

11.2 Future Consultation

Marine Harvest will continue formal and informal liaison with the Northern Land Council during the operation of the Port Patterson site.

Marine Harvest will continue to brief the Northern Land Council at its meetings about proposed initiatives for potential changes to the operation which could impact on the local people and will seek advice about any considerations they require about the operation. Open Days at the farm will be held from time to time and fishing days around the cages will occur.

12 Conclusions

Marine Harvest has been operating a pilot barramundi sea-cage fish farm at Port Hurd, on Bathurst Island in the Northern Territory, since 2000. That farm operates within an environment very similar to that which will be encountered at Port Patterson located approximately 45 kilometres south-west of Darwin.

At Port Hurd, between 2000 and 2006, Marine Harvest has:

- Developed an Environmental Management Plan to cover all aspects of its operation. This includes Standard Operating Procedures applicable to operations; and
- It has carried out environmental monitoring within Port Hurd, including control sites within Port Hurd and Gullala Inlet.

During this period, Marine Harvest has fine-tuned its operations to adapt procedures and infrastructure to the demands and pressures of tropical sea-cage fish farming. It is therefore familiar with what is required to resource and implement an appropriate environmental management system tailored to the requirements of the tropical environment in Port Patterson.

Environmental monitoring over the last two years, by well-regarded aquatic environmental analysts Aquenal Pty Ltd, has shown that the Port Hurd pilot farm has not resulted in measurable increases in nutrient concentrations in the water column, in sediments or on mangrove roots.

The Port Patterson farm will have several differences in infrastructure with the Port Hurd operation; these include the use of an onsite barge, reduced net sizes, reduced number of nets per mooring cluster, and an increase in the number of moorings per net.

Qualitative risk assessments have been carried out for all identified aspects and impacts of the proposed Port Patterson barramundi farm. Only four aspects have been assessed as having a risk ranking of 2 or 1, i.e. having serious or high risks. These are:

- fish faeces and nutrient loads,
- wastes and hazardous materials,
- predators, and
- personnel emergencies.

These aspects have been assessed to have high risks due to factoring in the worst possible consequences. However, all of these aspects have a low likelihood of causing significant impacts due to the use of previously tested infrastructure and management procedures, and site specific-management measures.

As part of these site-specific management measures, the proposed Port Patterson barramundi farm will develop and implement:

- a site specific Environmental Management Plan, which will include a detailed environmental monitoring schedule and a thorough staff and contractors' induction procedure;
- a site specific Maintenance and Monitoring Manual; and
- site specific Standard Operating Procedures.

Marine Harvest is committed to the following objectives and will operate its Port Patterson facility in line with these:

- minimising the impact of its operations on the surrounding environment; and
- ensuring that environmental programs are developed and implemented in consultation with the Northern Land Council.

Marine Harvest believes that through its commitments and via the implementation of predominantly proven management methods, the proposed Port Patterson farm can be operated with very low risk of impacting the immediate or surrounding environment of Port Patterson.

Marine Harvest has built up a good working relationship with Tiwi people since the inception of its pilot farm at Port Hurd. It aims to develop an equally strong association with the local aboriginal language groups of the Port Patterson region through ongoing communication with the Northern Land Council, and through the provision of employment and business opportunities for local people. It is also committed to maintaining good relationships with other local operators and users of the bay and will endeavour to proactively address any issues that may arise.

13 References

Aquenal Pty Ltd (2006): *Biennial Environmental Assessment of the Biological Impact of Nutrients Released from Marine Harvest's Aquaculture Operations in Port Hurd, Bathurst Island*, October 2003 – October 2005, reported in January 2006.

Aquenal Pty Ltd (2005): *Baseline Environmental Survey for the monitoring of biological impact of nutrients released from a proposed aquaculture operation near Doug Point*, *Northern Territor*y, October 2005.

ANZECC (2000): *Australia and New Zealand Guidelines for Fresh and Marine Water,* 2000.

Australian Marine Conservation Society (2005): *Submission on Northern Territory Fish Farm and Aquaculture Environmental Assessments*, Letter to the Referrals Section (EPBC Act) of the Department of Environment and Heritage, 15 June 2005.

Boyra, A, Sanchez-Jerez, P, Tuya, F, Espino, F, Haroun, R. (2004): *Attraction of wild coastal fishes to Atlantic subtropical cage fish farms*, Gran Canaria, Canary Islands. Environmental Biology of Fishes, 70:393-401, 2004.

Brocklehurst, P. & Edmeades, B. (2003): *Mangrove Survey of Bynoe Harbour Northern Territory*. Department of Infrastructure Planning and Environment, Palmerston, Northern Territory, 2003.

Dempster, T, Sanchez-Jerez, P, Bayle-Sempere, JT, Gimenz-casaldeuro, F, Valle, C. (2002): *Attraction of wild fish to sea-cage fish farms in the south-western Mediterranean Sea: spatial and short-term temporal variability*. Marine Ecology Progress Series, 242:237-252, 2002.

DIPE (2003): *Draft Management Program for the Dugong (Dugong dugon) in the Northern Territory of Australia – 2003-2008*, published by Parks and Wildlife Service of the Department of Infrastructure Planning and Environment, 2003.

Marshall, Carina Rynn Ecremen (2005): *Evolutionary Genetics of Barramundi (Lates Calcarifer) in the Australian Region*, a PhD thesis at Murdoch University, 2005.

NRETA (2006): *Territory Environments – Mangroves*, published by Natural Resources, Environment and the Arts – Northern Territory, reviewed 2 March 2006.

Suntay Aquaculture Pty Ltd (2003): *Environmental Impact Statement for Point Ceylon Aquaculture Estates, Bynoe Harbour, Northern Territory*, 2003.

Western Australia Department of Fisheries (1999): *The Translocation of Barramundi – a discussion paper*, published July 1999, updated November 2004.

Witherington, B.E. and Martin, R.E., (1996): *Understanding, Assessing and Resolving Light-Pollution Problems on Sea-Turtle Nesting Beaches*, Florida Marine Research Institute, Florida Department of Environmental Protection, FMRI Technical Report TR-2, 1996.

Information Sheet

Information

Important information about your **Coffey** Environmental Site Assessment

Uncertainties as to what lies below the ground on potentially contaminated sites can lead to remediation costs blow outs, reduction in the value of land and to delays in the redevelopment of land. These uncertainties are an inherent part of dealing with land contamination. The following notes have been prepared by Coffey to help you interpret and understand the limitations of your environmental site assessment report.

Your report has been written for a specific purpose

Your report has been developed on the basis of a specific purpose as understood by Coffey and applies only to the site or area investigated. For example, the purpose of your report may be:

- To assess the environmental effects of an on-going operation.
- To provide due diligence on behalf of a property vendor.
- To provide due diligence on behalf of a property purchaser.
- To provide information related to redevelopment of the site due to a proposed change in use, for example, industrial use to a residential use.
- To assess the existing baseline environmental, and sometimes geological and hydrological conditions or constraints of a site prior to an activity which may alter the sites environmental, geological or hydrological condition.

For each purpose, a specific approach to the assessment of potential soil and groundwater contamination is required. In most cases, a key objective is to identify, and if possible, quantify risks that both recognised and unrecognised contamination pose to the proposed activity. Such risks may be both financial (for example, clean up costs or limitations to the site use) and physical (for example, potential health risks to users of the site or the general public).

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man and may change with time. For example, groundwater levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of the subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project and/or on the property.

Interpretation of factual data

Environmental site assessments identify actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from indirect field measurements and sometimes other reports on the site are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact with respect to the report purpose and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how well qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, parties involved with land acquisition, management and/or redevelopment should retain the services of Coffey through the development and use of the site to identify variances, conduct additional tests if required, and recommend solutions to unexpected conditions or other problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered with redevelopment or on-going use of the site. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. In particular, a due diligence report for a property vendor may not be suitable for satisfying the needs of a purchaser. Your report should not be applied for any purpose other than that originally specified at the time the report was issued.

Interpretation by other professionals

Costly problems can occur when other professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other professionals who are affected by the report. Have Coffey explain the report implications to professionals affected by them and then review plans and specifications produced to see how they have incorporated the report findings.

Important information about your **Coffey** Environmental Site Assessment

Coffey

Data should not be separated from the report

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, laboratory data, drawings etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel), field testing and laboratory evaluation of field samples. This information should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Contact Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to land development and land use. It is common that not all approaches will be necessarily dealt with in your environmental site assessment report due to concepts proposed at that time. As a project progresses through planning and design toward construction and/or maintenance, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Environmental reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than other design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

Figures

Appendices

Appendix A

Environmental Impact Statement Requirement Letter from Northern Territory Natural Resources, Environment and Heritage.

Appendix B

Environmental Impact Statement Guidelines for Port Patterson Proposed Aquaculture Farm

Appendix C

Port Patterson Bathymetry

Appendix D

Port Patterson Baseline Report by Aquenal Pty Ltd

Appendix E

Port Hurd Biennial Report by Aquenal Pty Ltd

Appendix F

Paspaley Pearls Oyster Trials at Port Hurd

Appendix G

Greenhouse Gases Calculations

Appendix H

Fish Feed Residue Monitoring

Appendix I

Marine Harvest Port Hurd Standard Operating Procedures