DRAFT

Environmental Impact Statement

Proposed Barramundi Fish Farm at Channel Island Darwin Harbour, Northern Territory

Prepared by
Enesar Consulting Pty Ltd

for
MARINE HARVEST

May 2006
(Report No. HO02072/02-Channel Island EIS-version 1)

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Foreword

This Environmental Impact Statement (EIS) for Channel Island 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 at Port Patterson, west of Darwin and at Snake Bay in the Tiwi Islands. 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, that produces, 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 to the north-east of Channel Island, in Darwin Harbour, Northern Territory. The Channel Island farm is proposed to be one of three barramundi farms, the other two sites being Snake Bay and Port Patterson. 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 Channel Island 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 500 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 1000 tonnes of fish per year. The farm will act as a nursery and as a grow-out facility. All stock, from fingerling-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 serviced directly by boat from a leased facility located in the port infrastructure of Berrimah.

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 the area 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 lease area is to be located off the north-eastern shore of Channel Island, between Channel Island and the eastern shore of Middle Arm, in the southern reaches of Darwin Harbour, around 12 kilometres south-west of the centre of Darwin.

1.5 Schedule

Construction of the project will commence once approval has been granted by all relevant authorities. It is expected this may be around the last half of 2006.

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 500 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 land base leased in Berrimah.

Stage 2 will occur over a further 12-month period and will involve the construction of additional pens to allow production to increase to 1,000 tonnes per year. The farm is expected to operate indefinitely.

1.6 Layout and Infrastructure

The land-based facility will be sited within pre-existing infrastructure in the port industrial area at Berrimah, on Darwin Harbour. It will act as a management and operational base during construction and operation of the fish farm.

At a minimum, Marine Harvest will need to have the following facilities available for the construction, management and servicing of the fish farm:

- undercover feed storage area, around 5 x 5 metres initially during start up but up to 10 x 10 metres when the farm is producing 1000 tonnes per annum,
- bunded area(s) for fuel and chemical storage,
- lockable storage for any hazardous substances,

- waste receptacles,
- equipment storage, eg. fork lift and/or loader for moving feed pallets, fish grader, fish pump, fish counter machines,
- net-construction facility, and
- workshop and office.

The pens will be constructed at the land base and will then be towed into position by boat. The pens will be attached to the sea floor using steel anchors installed by cyclone-mooring specialists. The pens will be plastic circles of approximately 48 metres circumference. They will be made with steel-net mesh which, at the pilot Port Hurd operation, has been proven to exclude all predators and to avoid entrapment. The holding nets will have 8-metre deep side walls, and a 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 11 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.

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.

Mooring of the nets 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 the Channel Island farm 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 via boat from the operational base at Berrimah in Darwin Harbour. Goods and equipment will also be taken to the site by boat.

Nets constructed at the Berrimah facility will be towed into position with the aid of a tug boat which Marine Harvest will contract from local operators.

The current infrastructure at Berrimah is designed to cater for port operations and is therefore ideally suited to handle the boat traffic generated by the operation.

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 at the land base to service the farm. Additional contractors will be required periodically for particular tasks.

1.8.3 Power, Potable Water and Storage

Power and water to the operational land base will be supplied by Darwin's town power and water supply grid. These are expected to be available at the pre-existing premises which Marine Harvest is proposing to lease.

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

1.9 Farm Operation

The proposed Channel Island 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 towed to the farm mooring area with the help of a high tide.

An ensiler will be used for the disposal of dead fish (morts).

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) and parasite control treatment;
- solid wastes from feed bags and dead fish (morts);
- noise from outboard motors, feeding equipment, 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 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 on the outboard motorboats. Most administrative duties would be conducted from the Darwin office.

1.10 Decommissioning and Rehabilitation

The life expectancy of the farm is indefinite at this stage. Decommissioning and rehabilitation of the farm facility will require removal of the nets and the plastic circles, removal of all anchor ropes and chains 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.

All movable equipment, rubbish and wastes will be removed from the land base and the premises will be left clean and tidy and free from mosquito breeding sites.

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 Aboriginal Areas Protection Authority has issued an Authority Certificate for Fish Farming – North Channel Island. The Authority Certificate number C2006/042 was issued 12 May 2006 for lease area NT Portion 4526, and it applies indefinitely provided works covered by the Certificate start within 24 months of the issue of that Certificate.

1.12 Alternatives

The Marine Harvest-proposed Channel Island Barramundi Fish Farm is a component of a three-farm business plan to establish a sustainable farmed-barramundi industry. Should the proposal for Channel Island 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 Channel Island 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

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 1700 millimetres with the bulk of it falling between November and April.

Cyclones typically occur between December and April, with an average of 3.4 severe cyclones per season (i.e. winds exceeding 120 kilometres per hour). Storm surges and storm tides occur periodically in Darwin Harbour.

Darwin Harbour is a large macro-tidal estuary that experiences maximum tidal level variations of around 7.8 metres (Williams and Wolanski 2003). The Harbour has two tidal cycles every 24 hours, i.e. diurnal tides. Caldwell Connell (1983) noted that peak flood (incoming tide) velocities reached 3.7 knots in the main channel of Middle Arm and peak ebb (outgoing tide) velocities reached 3.8 and 3.6 knots respectively in the main channel of Middle Arm and in the Channel Island bridge alignment.

1.14 Physical and Biological Environment

Middle Arm is part of the Darwin Harbour estuary system. It feeds fresh water and sediment to the harbour during the wet season via inputs from the Blackmore River and the dammed Darwin River.

The turbidity of the water changes markedly depending on the stage of the tide. Within three hours the water can change from blue to turbid and brown due to sediment load from the mangroves (Geoscience Australia, 1998).

Surface water temperatures in Middle Arm have are similar to those in other areas of the Harbour and range from 23 °C in early winter to 33 °C in late spring (Padovan, 2003). Highest salinity was measured during September-October at around 35 parts per thousand. The lowest salinity was measured in January-March, coincident with rainfall and run-off of fresh water into the Harbour. Oxygen levels in the Harbour range from 74 to 96, typically 84%, with no variation with seasonal effects, and slightly lower oxygen levels higher up the estuary. The pH of the Harbour waters remains between 8.3 and 8.6, averaging 8.5, with no seasonal or spatial effects across the Harbour. Vertical stratification of the estuary waters, including the area of Middle Arm relevant to this referral, is unlikely to occur given the tidal conditions and the surface area subjected to wind mixing.

Darwin Harbour is a drowned river system which was carved during the last ice-age. When sea-levels rose, the valleys were flooded and isolated hills became islands in Darwin Harbour (eg. Channel Island). The original drowned valley profile is being gradually infilled with sediments, coral reef growth and rubble.

Depth to the sea floor in the project area is likely to range from a maximum of 20 metres (at low water) in the north of the prospect area to around 5 metres (at low water) in the south of the prospect area, with the boundaries of the area possibly located in around 1 metre of water only (at low water).

According to most sources, Darwin Harbour is considered to be relatively pristine. The coastal areas around Channel Island and the eastern shore of Middle Arm have retained most of their native mangrove forests. Species diversity and abundances are reported to be high despite the harbour being fringed by a city. Aquenal (2005) reported that the mangrove communities assessed in the vicinity of Channel Island and Little West Arm were typical for similar published studies of Darwin Harbour habitats (eg. Brocklehurst and Edmeades, 2003). Mangrove condition was generally healthy with less than 10% dead trees per hectare at all but four sites, where the results were skewed by the sampling traverse position.

Whiting (2001) reported that the northern area of Channel Island is devoid of seagrasses, but low biomass algae are found on the rocky substrates around the Channel Island Bridge. Algal species include Sargassum, Padina, Turbinaria and Gracillaria, which are likely to be a food source for *Chelonia mydas* (green turtles), *Eretmochelys imbricata* (Hawksbill Turtle), and dugongs.

Darwin Harbour supports a diverse range of marine reptiles and marine mammals which include: 4 species of sea turtles: the green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), flatback turtle (*Natator depressus*) and olive ridley turtle (*Lepidochelys olivacea*), 20 species of marine snakes, one crocodilian (the saltwater crocodile *Crocodilus porosus*), dugongs and 14 species of Cetacea (Whiting, 2003). Dugong presence is documented in the harbour but their numbers are generally low. Little is known about the composition of the Cetacea species presence within Darwin Harbour, though a survey (Whiting, 1997 in Whiting, 2003) found that the most abundant was the Indo-Pacific humpback dolphin, followed by the Irrawaddy River dolphin and then the bottlenose dolphin. Other Cetacea recorded in the harbour include the great sperm whale, the pygmy sperm whale and the humpback whale.

The mangroves of Darwin Harbour support a very rich diversity of mangrove-specialised bird life. The birds act as pollinators and seed dispersers of a number of mangrove species (Noske, 2003).

There appears to be little change in the overall species community composition between the wet and dry seasons (Smit, 2003).

Air quality, noise, lighting and visual amenity in the vicinity of Channel Island are also affected by inputs from the liquified natural gas (LNG) plant at Wickham Point and the natural gas-fired power plant in the south of Channel Island, as well as by inputs from marine and road traffic.

The proposed lease area:

- is close to or overlaps two sites on the Register of National Estate, namely the historic Channel Island Leprosarium ruins and the natural Channel Island Reefs;
- it is also understood that the lease area may overlap heritage objects belonging to the SS Ellengowan Shipwreck which is declared as a heritage site under the NT *Heritage Conservation Act 1991*.

1.15 Port Patterson Baseline Investigation

A baseline investigation has been carried out at Channel Island 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 Middle Arm within proposed farm locations, within potential receptor sites and within control sites in Little West Arm. 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 Middle Arm 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 Channel Island 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	Moderate	3 = medium	Seabed disturbance will be temporary and localised.
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 to 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 to 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 will be captive.
Fish aggregation	Likely	Minor	3 = medium	No effect on fishing reported from Port Hurd pilot farm.
Introduction of diseases	Unlikely	Minor to moderate	4 = low	Very low incidences at Port Hurd pilot farm.

Aspect	Likelihood of Impacts	Consequence of Impacts	Risk Ranking of Impacts	Comments
Introduction of parasites	Rare	Minor	4 = low	Very low incidences at Port Hurd pilot farm.
Introduction of chemicals	Rare / unlikely	Minor to 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	Major	3 to 2 = medium 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 to major	4 to 3 = low to medium	The new infrastructure proposed and the more moderate water currents in Middle Arm 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.
Flora	Rare / unlikely	Minor to moderate	4 = low	Impacts are expected to be minor or moderate due to the location of the farm and the proposed management methods.

Aspect	Likelihood of Impacts	Consequence of Impacts	Risk Ranking of Impacts	Comments
Corals	Unlikely	Moderate	4 = low	The most severe impact would be from a fuel spill, but this would be less than 100 litres, and would have only very localised and temporary impact on the reefs.
Bird, reptile, fish and mammal habitats	Rare / Certain	Minor to moderate	3 = medium (average of all aspects)	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	Unlikely	Moderate	4 = low	Baseline and Port Hurd information and monitoring suggests there is generally a low risk of impact on EPBC Act-listed, threatened or migratory species or their habitats. Mitigation and management methods will diminish most risks to a very low level. Most species in Darwin Harbour are already adapted to a disturbed environment.
Land surface	Unlikely	Minor	4 = low	Use of unsealed areas will be minimal.
Air quality, noise, lighting and visual amenity	Unlikely	Minor	4 to 3 = low to medium	Only low level intermittent nuisance is likely.

Aspect	Likelihood of Impacts	Consequence of Impacts	Risk Ranking of Impacts	Comments
Social / recreational	Unlikely	Minor to moderate	4 = low	Divers or boaters could experience some inconvenience from the presence of the farm in Middle Arm.
Local infrastructure	Unlikely	Minor	4 = low	Local infrastructure is able to already cope with capital-city marine and road traffic.
Archaeological / historical, cultural and aboriginal sites	Unlikely	Minor	4 = low	No notable impact expected.
Marine traffic	Possible	Major	4 to 3 = low to medium	The farm may increase boat trips along Middle Arm by an estimated 20 percent.
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 Channel Island and associated land base 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 of Darwin Harbour.

As part of these site-specific management measures, Marine Harvest will develop and implement the following plans and procedures for the proposed Channel Island 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 Channel Island 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
Farm Fish Deaths	9.7.5	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
Bird, reptile and fish habitats	9.13	Record and review record of impacts and complaints	Ongoing

Aspect	Reference Section No.	Monitoring Activity	Frequency
		Record all animal deaths in and around the lease	Ongoing
		Monitor water, sediments and flora as noted	As noted
Flora	9.14	Mangrove stands and roots	Fortnightly, two-monthly, annually or biennially
Corals	9.15	Monitor water, sediments and flora as noted	As noted
EPBC-Act listed Threatened and Migratory Species	9.16	Monitoring of water, sediment and flora as noted	As noted
		Recording and assessing any complaints, reports or sightings of dugongs and turtles and any other wildlife presence or death	Ongoing
Land surface	9.17	Inspections of unsealed surfaces during occupation of land base	Weekly
		Inspections of unsealed surfaces upon vacating land base	On vacating premises
		Recording and assessing complaints	Ongoing
Noise, lighting, air quality and amenity	9.18	Log book of operating hours of all noisy equipment	Ongoing
		Maintenance schedule to be followed for all motorized equipment	According to equipment maintenance schedule
		Recording and assessing any complaints	Ongoing

Aspect	Reference Section No.	Monitoring Activity	Frequency
Social and recreational	9.19	Review and assess complaints or incidents reported	Ongoing
Archaeological, historical, cultural and Aboriginal sites	9.20	Record and review any complaints	Ongoing
Marine traffic	9.21	Record any incidents or complaints and assess	Ongoing
Pest insects	9.22	Incident reports to be review and assessed	Ongoing
Personnel emergencies	9.23	Incident, accident and emergency reports to be kept and assessed	Ongoing
Quality of farmed barramundi	9.24	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 Channel Island has been in the public domain for over a year. Information regarding the proposal and the pilot project at Port Hurd has been disseminated through the newspapers.

In January 2006, 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.

The Aboriginal Areas Protection Authority has issued an Authority Certificate for Fish Farming – North Channel Island; the Certificate applies indefinitely provided works covered by it start within 24 months of the issue of that Certificate.

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 Channel Island farm will have several differences in infrastructure with the Port Hurd operation including diminished net sizes, reduced number of nets per mooring cluster, and an increase in the number of moorings per net, as well as the use of a land base distal to the farm and located within existing port infrastructure.

There are several conservation and biodiversity issues apparent at Channel Island. These include the presence of dugongs and turtle feeding areas near the proposed site. The SS Ellengowan Shipwreck, which is popular dive site, lies close to the proposed lease, and the Channel Island Leprosarium is located on the northern end of Channel Island.

Qualitative risk assessments carried out for all identified aspects and impacts of the proposed Channel Island 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 Channel Island 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 Channel Island farm can be operated with very low risks of impacting the immediate or surrounding environment of Middle Arm and Darwin Harbour.

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 Larrakia aboriginal language group of the Darwin 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 harbour 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 Channel Island, Darwin Harbour, in the Northern Territory.

Referral for the project was lodged on 1November 2005 with the Australian Department of Environment and Heritage under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act). Subsequently, 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, the Honourable Marion Scrymgour, confirmed in December 2005 that the proposal would require assessment under the *Environmental Assessment Act* 1994 at the level of an Environmental Impact Statement (EIS). A copy of this correspondence is provided in 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 that 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 nursery facility located within a marine farming lease site located near Channel Island, Darwin Harbour, in the Northern Territory (refer to Figures 1 and 2). 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 be predominantly marine-based and will be run from pre-existing premises which Marine Harvest will lease.

The proposed farm will have the capacity, after a lead up period of two years, to produce 500 tonnes of juvenile fish per year which will be able to be on-grown at Marine Harvest's other farming operations in the region. The long term aim is to grow the site to the stage where it will be able to produce up to 1000 tonnes of fish per year.

The farm lease site will initially be stocked with barramundi fingerlings of 10 to 20 grams supplied from the Department of Primary Industry hatchery using local NT broodstock. The barramundi fingerlings will be transferred to the nursery sea pens for on-growing to a size of 200 grams at which stage they will be transferred to the grow-out farms at other sites. In the longer term, it is envisaged that the Channel Island site will also have a grow-out facility.

All stock 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.

Staff will access the site by boat from a pre-existing land base at the wharf facilities at Berrimah, south of Darwin. All farm equipment and goods will be kept in the facility at Berrimah, which will be leased by Marine Harvest.

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 juvenile fish will be transported by well boat to the two other proposed grow-out sites at Port Patterson and Snake Bay.

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, in the Tiwi Islands, 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 temperate fish-farming. 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 facility in Darwin Harbour to the northeast of Channel Island. 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 per annum of farmed barramundi 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 employment 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 are typically located in remote coastal areas. The majority of the employees for Marine Harvest farms live in these areas, and seek employment opportunities which provide sought after skills complimentary to the existing local fishing industry. Marine Harvest is aware of the significant economic and social role it has to play in indigenous communities where employment is scarce. A number of Marine Harvest's existing employees at the Port Hurd operation are from the indigenous community in the Tiwi Islands.

Direct Employment

Around 8 to 16 staff will be required to operate the Channel Island farm. In addition, contractors will be needed periodically, as follows:

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

Employees will be sourced locally whenever possible.

Establishment of a Sizable Local Business

The Channel Island site is proposed to be one of three new barramundi farm ventures for Marine Harvest in the Northern Territory. One farm (Snake Bay) will be operated in the Tiwi Islands and two farms will operate to the south and west of Darwin. The indigenous populations in these areas have expressed a keen interest both in working on, and in servicing the farms. For example, the Tiwi Barge, owned by the Tiwi people, is already used by Marine Harvest for servicing the existing Port Hurd farm. There is the potential

for other local operatives in the area to supply goods and services to the proposed Marine Harvest operations.

Relieve Pressure on Wild Barramundi Stocks

The Channel Island operation should help prevent additional pressure on wild barramundi stocks while supporting the provision of a product which is in great demand in Australian and overseas markets. As the operation will be sourcing its fingerlings from the Darwin Aquaculture Centre, which breeds barramundi under controlled conditions, it will not be depleting wild barramundi stocks.

Flow-on Benefits

Flow-on benefits from the operation to the local community will include:

- potential for employment of suitably qualified or trained local residents;
- sourcing of sundry everyday goods;
- use of local transport and construction contractors;
- use of local accommodation by contractors or visitors; and
- active support for cultural, environmental and sporting activities.

3.3 Location of the Project

The proposed lease area is to be located off the north-eastern shore of Channel Island, between Channel Island and the eastern shore of Middle Arm, in the southern reaches of Darwin Harbour, around 12 kilometres south-west of the centre of Darwin. The lease has a trapezoidal shape and is around 380 metres wide by 1.38 kilometres long. The distance between Channel Island and the coast is around 1 to 1.5 kilometres in the proposed lease area.

Coordinates for the four corner points of the proposed lease area are provided in Table 3.1, below. Refer to Figures 3 and 4 showing the location of the proposed lease area.

Table 3.1: Coordinates of Lease Area

Point	Coordinate	Degrees	Minutes	Seconds
A (Northeast)	Latitude	12	32	7.8
	Longitude	130	52	9
B (Southeast)	Latitude	12	32	45
	Longitude	130	52	36
C (Southwest)	Latitude	12	32	54
	Longitude	130	52	27
D (Northwest)	Latitude	12	32	16.8
	Longitude	130	52	0

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 around the last half of 2006 based on the following time line:

1. submission of the 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. discussions with Northern Territory Land Council;
5. submission of addendum to answer public comments;
6. consideration by the NT Minister; and
7. submission to the Federal Minister.

Once approval is given, it is anticipated that construction of the operation will begin immediately. Pens will be constructed at the land-based facility, which is most likely to be a leased existing facility in the Berrimah industrial area, south of Darwin. The pens will be floated from this facility to the proposed lease area where they will be anchored into place. It will take several months before the infrastructure is completed to the extent that it can begin receiving fingerlings.

When the development schedule for the fish farming facilities has been identified, 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. The hatchlings will take around 3 months to grow to fingerling stage (100-200mm).

The farm is expected to operate indefinitely.

3.5 Layout and Infrastructure

3.5.1 Infrastructure

The proposed land-based facility and farm infrastructure are described below.

3.5.1.1 Land-Based Facility

The land-based facility will be sited within pre-existing infrastructure in the port industrial area at Berrimah, on Darwin Harbour. Investigations and negotiations are currently being carried out by Marine Harvest to locate and lease appropriate premises for the purpose of acting as a management and operational base during construction and operation of the fish farm.

At a minimum, Marine Harvest will need to have the following facilities available for the construction, management and servicing of the fish farm:

- undercover feed storage area, around 5 x 5 metres initially during start up but up to 10 x 10 metres when the farm is producing 1000 tonnes per annum,
- bunded area(s) for fuel and chemical storage,
- lockable storage for any hazardous substances,
- waste receptacles,
- equipment storage, eg. fork lift and/or loader for moving feed pallets, fish grader, fish pump, fish counter machines,
- net-construction facility, and
- workshop and office.

The pens will be constructed at the land base and will then be towed into position by boat.

3.5.1.2 Farm Site

The pens will be attached to the sea floor using steel anchors installed by cyclone-mooring specialists. The pens will be plastic circles of approximately 48 metres circumference. They will be made with steel-net mesh which, at the pilot Port Hurd operation, has been proven to exclude all predators and to avoid entrapment. The holding nets will have 8-metre deep side walls, and a 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 11 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 Channel Island site, except that at the Channel Island site the nets will be smaller.

The site will be visible during the day. The outer limit of the sea pens and the lease will be marked with flashing lights to be visible at night 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 Channel Island 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 to 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 control over feeding in order to optimise 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 Channel Island 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 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 SS Ellegowan Shipwreck in the vicinity of the proposed lease;
- The presence of the Channel Island Reefs in the vicinity of the proposed lease; and
- 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

Channel Island where the peak water currents are slower than at Port Hurd (3.6 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 resultant 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 200 grams.
- 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 Mooring Design Criteria

Mooring of the nets will be with the use of steel anchors, installed by cyclone mooring specialists, 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 Channel Island will have six rather than 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.

Figure 5 shows the design for three six-pen mooring arrays. The proposed design for Channel Island is for four six-pen mooring arrays in two single lines. Figure 6 shows the details of the mooring equipment and connections which are likely to be used at Channel Island.

Table 3.2 below provides a summary comparison of the mooring and net design arrangements proposed for Channel Island as opposed to those used at Port Hurd. The comparison illustrates clearly that the proposed new design for Channel Island 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	Channel Island Proposed Design for Nursery and 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 via boat from the operational base at Berrimah in Darwin Harbour. Goods and equipment will also be taken to the site by boat.

Nets constructed at the Berrimah facility will be towed into position with the aid of a tug boat which Marine Harvest will contract from local operators.

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.

Movements to and from the site during day-to-day operations will be via outboard motor boats and will be initially twice daily, increasing to three times daily as the fish grow and require more feed.

The current infrastructure at Berrimah is designed to cater for port operations and is therefore ideally suited to handle the boat traffic generated by the operation.

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. 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 construction work will be carried out during normal daytime hours.

Staffing of the farm, once the site has begun growing fingerlings, will require around 2 staff per weekly roster, i.e. a total of 2 people on staff. These numbers would double when the farm begins its grow-out operations. In addition, contractors will be required periodically for particular tasks:

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

Employees will be sourced locally whenever possible, or would be expected, during their rosters, to be able to reside, within the Darwin area.

3.7.3 Power, Water Supply and Storage

Power and Water

Power and water to the operational land base will be supplied by Darwin's town power and water supply grid. These are expected to be available at the pre-existing premises which Marine Harvest is proposing to lease.

Storage

Unleaded and diesel fuel will be stored in small fuel containers (200-litre drums) and will be kept in a bunded area. Unleaded fuel is used by the feed-pumps and outboard motors, diesel fuel is used for the fish pump.

Storage of chemicals will be in the manufacturers' containers, 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.

3.8 Farm Operation

Marine Harvest proposes to operate the Channel Island 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 grow barramundi (*Lates calcarifer*) fingerlings at their lease in Channel Island. 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.

Marine Harvest hopes that, in the long term, the proposed farm will have the capacity to produce 500 tonnes of juveniles per year and 500 tonnes of plate fish per year, though this represents a long term target, and it is expected that it would take several years to reach that level of production.

The site will initially be stocked with juvenile barramundi sourced from the DAC. The hatchlings (10 – 20 grams) will be grown in specific nursery pens. The juvenile barramundi will be transferred to the grow-out farms at Port Patterson and Snake Bay when they are approximately 200 millimetres long, i.e. after approximately 3 months. Should the Channel Island farm also become a grow-out facility, conversion of the pens from nursery to grow-out pens will be via removal of the fibre net placed within the steel mesh pens. Juveniles would then take around 15 months to reach harvest size of approximately 3 kilograms.

The stocking density of the grow-out nets with the juvenile fish will begin at around 4 kilograms per cubic metre, based on 40,000 to 60,000 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 Channel Island compared to Port Hurd mean that stocking densities are likely to be below 45 kilograms per cubic metre.

Intakes of fingerling fish from the DAC are likely to be monthly. The intake number will be governed by survival rate and market demand.

3.8.2 Feeding

The fish will be fed on pellets from an automatic feed blower located on the outboard motor boats. A blower system will transfer the feed from the boats 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 facility at Berrimah 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.

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

It is anticipated that the same feed mix combination will be used at Channel Island 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 a large ratio of high quality feed from Skretting and this is believed to have contributed to the good health in the fish at the Port Hurd pilot farm.

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. Pens inspections by divers would typically be carried out fortnightly on neap tides, when water flows are less and visibility is good. Divers will inspect the pens for integrity and will carry pliers and steel spirals 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 used within the nursery pens will be cleaned fortnightly on the neap tides. Divers will enter the nets and will use a rotating disc 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 would generally be graded and/or counted four times during their life: at the hatchery, prior to receival by Marine Harvest, when they are transferred to the grower pens, and finally at harvest time.

Each group of fish will be given a label, eg. 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, eg. 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 is then used to bring the fish up onto the boats for grading, counting and/or harvesting.

3.8.5 Growth and Harvesting

Predicted growth rates are based on those observed during the operation of the Port Hurd site where growth rates have been excellent. The fish will take approximately 3 months to grow from fingerling to juvenile (200 millimetres) and a further 15 months to reach a marketable size of approximately 3 kilograms.

Transfer of juveniles from the Channel Island nursery pens to the Port Patterson and Snake Bay operations would be via a well boat.

Harvesting of fully grown barramundi will also be done via a well boat. 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 trip to Darwin.

It is anticipated that in the long term the fully grown fish will be harvested live into well boats. This method has the advantage of providing a longer ‘shelf’ life to the fish. Marine Harvest plans to contract a well boat in the short term and, in the longer term, to commission its own well boat.

3.8.6 Steel Net Construction

Based on the Port Hurd experience, the nets last around 2 years. If 24 nets are present, this requires that around one net is built and replaced every month.

Nets will be constructed from rolls of mesh which will initially be handled by a loader. Lengths of mesh will then be joined with steel wire spirals to achieve the required pen size. The work 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.

3.8.7 Ensiler and Domestic Waste Disposal

An ensiler will be kept at the land base at Berrimah. The ensiler will be used for the disposal of dead fish (morts). The resulting product will be sold to the fertiliser company MOECO to be added to its fertilisers. All solid wastes generated at the land base will be disposed to skip bins and recycled via the landfill recycling system.

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), and
  - potential parasite control treatment;
- solid wastes from:
  - feed bags, and
  - dead fish (morts);
- noise, light and air:
  - noise from outboard motors, feeding equipment, harvesting operations, site maintenance, net and pen mooring and installation;
  - illumination of the farm outline for vessel safety during night hours; and
  - emissions to air may include noxious smells from dead fish stock, noxious smells and fumes from the presence of chemicals and fuels, from running outboard motors and pumps, 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 kilograms per 1000 kilograms 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.
Recycler	Morts and putrescibles from ensiler	2 percent of fish produced	Would be sent to fertiliser company for recycling.
Landfill - recycling	Recyclables (eg. cans, paper, plastics, etc.)	small number of containers required for the operation.	Recycled at the Darwin landfill.
Landfill	Non-recyclable packaging and other non-recyclable wastes (eg. feed bags)	5 kilograms of feed bags / 1000 kilograms 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 at the Berrimah land base will be diesel and unleaded petrol. This will be used to power the engines of the outboard motor boats and the feeding and harvesting pumps.

3.8.9.1 Fuels

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 the majority of trips to and from the farm will take place by boat.

It is estimated that around 100 litres of diesel will be used monthly to power the fish pump.

The maximum amount of fuel to be stored at the land base is likely to be around 500 litres of unleaded fuel, and 500 litres of diesel. All fuel will be stored in a purpose-built, bunded area. Given the proximity to town, refuelling will be carried out regularly.

3.8.9.2 Solvents and Cleaners

The workshop at the land base 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. This list is based on the register kept at the pilot Port Hurd operation.

The chemicals held in the farm's laboratory are used for fish health reasons, such as disease identification.

Table 3.5: List of Chemicals Likely to be Stored at the Land Base, as per 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
Wattyl Ck Citronella	CLEANERS BUND	60 L
Citric Acid	LAB	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	

Chemical Name	Areas Stored	Typical Amount Held
Oxytetracyline (antibiotic)	LOCKED CONTAINER	200 kg
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
Duralac anticorrosion joining compound	WORKSHOP	3 tubes
Food Lube	WORKSHOP	1 cylinder
Geminex yellow label paint	WORKSHOP	1 L
HIAB Skewing grease	WORKSHOP	100 ml
Lanotec bulk	WORKSHOP	20 L
Leak sealer spray	WORKSHOP	1 spray can
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
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
Unleaded Petroleum Fuel	BUNDED AREA	500 L
Lubricating oil	BUNDED AREA	WORKSHOP
Diesel	BUNDED AREA	500 l
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, will be present on site, whose responsibility will be to carry out maintenance on machinery. General maintenance schedules will be documented in the site procedures and will follow a 'per hours of operation' scheme.

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 the Darwin office, to confirm travel arrangements, and to pass on ordering requirements. All other administrative duties would be conducted from the Darwin office.

3.9 Decommissioning and Rehabilitation

The land-based facility will be established in pre-existing premises at the port facilities at Berrimah. It is expected that this facility will be leased. The land-base facilities will be vacated and rehabilitated upon closure of the farm operations. Rehabilitation works of the land-based facility will encompass:

- removal of any temporary structures,
- removal of any equipment and fuel storage containers,
- recycling and reuse of any equipment and materials which can be recycled or reused,
- removal of any waste materials, and disposal to appropriate waste disposal facilities,
- leaving all ground surfaces in a stable and clean condition, not prone to erosion, and
- ensuring that no potential mosquito breeding sites are left on the premises.

The works will be carried out within four months of the facility being vacated, provided this is carried out prior to the wet season. The aim, where possible, will be to reinstate the facility to its previous condition and to leave the facility in a stable and clean state, free from wastes, and free of potential mosquito breeding sites.

If operation of the farm site ceases in the future, Marine Harvest will discuss the potential sale of the operation with the Government and with the Northern Land Council, who may take over ownership for some other purpose.

Decommissioning and rehabilitation of the nets and mooring areas will require:

- 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 plastic circles have a very long life, around 10 years, which means that the material could be recycled;
- The anchor ropes or chains 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 which cannot be reused or recycled, will need to be disposed to appropriate waste-disposal facilities in Darwin.

3.10 Legislative Requirements

As noted in Section 2.1, this proposal requires assessment under the *Environmental Assessment Act* 1994 at the level of an Environmental Impact Statement (EIS). The other two referrals pertaining to proposed barramundi farms at Port Patterson and Snake Bay were also assessed as controlled actions. Environmental Impact Statements have been drawn up for all three proposals; all three EIS are being submitted simultaneously as a coordinated proposal.

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 (NLC) to discuss the proposed development. Several meetings about Marine Harvest's plans have been held with the NLC and members have also attended an Open Day at Port Hurd. 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 Aboriginal Areas Protection Authority has issued an Authority Certificate for Fish Farming – North Channel Island. The Authority Certificate number C2006/042 was issued 12 May 2006 for lease area NT Portion 4526, and it applies indefinitely provided works covered by the Certificate start within 24 months of the issue of that Certificate. A copy is provided in Appendix C.

3.10.3 Planning Framework

The proposed nursery location is situated within the area covered by the Shire of Litchfield which is managed by the Litchfield Shire Council. The *Litchfield Area Plan 2004* regulates the use and development of land within the Litchfield area. It is an element of the Northern Territory Planning Scheme. Channel Island falls under the Specific Use (SU) Zone of the Plan and according to the Plan aquaculture development can be undertaken in this zone provided an environmental management plan for the development is approved under the *Environmental Assessment Act* (Northern Territory, 1994).

Channel Island and Middle Arm are also included within the boundary of the Darwin Harbour Plan of Management. The aim of the plan is to manage the resources associated with Darwin Harbour and its catchment, via an integrated and cooperative whole-of-catchment approach. Of particular relevance to the proposal are the Plan's aims to:

- Protect and enhance estuarine water quality,
- Protect the health of functioning ecosystems and conserve biodiversity,
- Protect and enhance recreational amenity and opportunity,
- Protect the diverse range of aesthetic values of the Darwin Harbour Region,
- Sustainable use of freshwater, and
- Protection of cultural values and heritage.

3.10.4 Compliance with Applicable Standards

The land-based facilities which will need to be adapted for the farm's operational purposes, 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 Channel Island Barramundi Fish Farm nursery is a component of a business plan which includes the proposed Port Patterson and Snake Bay barramundi fish farms. 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 Channel Island proposal is ranked first, by Marine Harvest, in the priority list of the three proposed sites, with Port Patterson being the second, and Snake Bay being the third. Should the proposal for Channel Island 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 Channel Island 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 for Channel Island 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 Channel Island, 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 Channel Island 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). Based on the Port Hurd experience, these smaller pens are considered optimal, as they are less visually obstrusive 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 less nets will be attached to each mooring line.

4.3.3 Operational Facilities

The farm will be operated from pre-existing land-based facilities at Berrimah. Negotiations are underway to secure suitable facilities. This option is considered the most effective for the Channel Island operation as:

- It is located within the Darwin Harbour port facilities;
- Most of the necessary infrastructure will already be in place, such as water, power, sealed surfaces, undercover and storage areas, car parking areas, boat mooring and jetty facilities;
- It is within easy access by car to Darwin and surrounds; and
- It is within easy boat access to the proposed farm lease location.

Establishing a new facility closer to the proposed farm lease area at Channel Island would be more environmentally invasive and would also result in land-based impacts which would require rehabilitation. This is therefore not considered a viable option, particularly given the proximity of established facilities within Darwin Harbour.

Establishing a barge at the farm site would be more visually and physically invasive on the waterway and given the proximity of the facilities at Berrimah, is not a justifiable option.

It is also considered that using boat transport from Berrimah to the lease is a more viable alternative that combining road transport from Berrimah to a jetty near Channel Island and then boating to the lease. The distance by boat from Berrimah to the lease is approximately 10 kilometres, whereas the distance from Berrimah to Channel Island by road is over 30 kilometres with another kilometre or more by boat to reach the proposed lease area. The road plus boat option would require more handling of goods to load and unload from the different transport vehicles. Additional handling would increase the potential for spillages, and could also require the use of intermediary storage facilities on land opposite Channel Island, thereby increasing the potential for land impacts.

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 Channel Island and the proposed project area are provided in Section 3.3. Location maps are provided in Figures 1 to 4.

5.1.1 Climatic Zones

Darwin Harbour is located in the tropical and monsoonal north of the Northern Territory where there are two distinct seasons, the wet and the dry. The wet extends from November to April. The region is located within the Southeastern Indian/Australian zone which is prone to cyclonic activity between the months of December and April.

5.1.2 Catchment Terrain Type

The Darwin Harbour catchment includes 18 sub-catchments (Padovan 2001 in DEH 2004) with an area of 1,724 km^2 within the seaward limits of Charles Point and Lee Point (Anon 2000 in DEH 2004). Land use within the study area includes urban, rural residential, horticulture, industry and low intensity uses (pastoralism, conservation, recreation, vacant Crown land). Within the Darwin Harbour catchment low intensity uses are the predominant land use (85%) (Anon 2000 in DEH 2004). The largest freshwater systems which feed into Darwin Harbour are the Blackmore River catchment (which feeds into Middle Arm), and the Elizabeth River catchment (which feeds into East Arm). The Darwin River Dam curtails the flow of the Darwin River, which is a tributary of the Blackmore River.

Darwin Harbour is described as a flooded river valley, made up of three arms which combine to form a large embayment. East and Middle Arms receive fresh water from rivers and creeks feeding into them. During the wet season, there is a very large input of fresh water to the harbour via these two arms. The river channels are being gradually infilled with sediment since being flooded during the last sea-level rise.

The proposed lease location is situated within the eastern branch of Middle Arm, between the eastern shore of Channel Island and the coast. Tidal currents are fairly strong in the Arm but wave action is mitigated by the proximity of the land.

5.1.3 Marine and Coastal Form and Habitat Structure

Darwin Harbour is fringed by inter-tidal mangrove and salt marshes and savanna woodland in the hinterland. The mangrove forests are some of the most diverse and abundant in the Northern Territory (The Environment Centre, NT, 2006). Thirty six of 48 mangrove species occur in the area. They provide nursery habitat for marine life and are home to waterbirds and other fauna. The mangrove forests are also said to provide some protection from storm surges and coastal erosion, and to improve water quality by acting as a sink for sediments and nutrients. The forests are in relatively good condition.

Coral reefs, with hard and soft coral, occur in the harbour at depths of up to 10 metres and are inhabited by an array of marine wildlife. One hundred and thirteen species of coral have been recorded (The Environment Centre, NT, 2006). The reefs are unusually

rich and diverse in sponges. The Channel Island Reefs and Darwin Foreshores are on the Register of National Estate.

At least 48 species of waterbirds occur, of which 25 are listed under international migratory bird agreements. At least 15 migrant shorebird species use the harbour. Dugongs and Irrawaddy River dolphins occur in the harbour as well as five species of marine turtles. Saltwater crocodiles range the harbour. Three hundred and forty species of fish have been recorded in Darwin Harbour (The Environment Centre, NT, 2006).

5.1.4 Regional Population Centres

Darwin is the capital city of the Northern Territory and greater Darwin has a population of around 110,000. Around three quarters of the residents live within the central area, the remainder in the wider metropolitan area. Darwin was completely destroyed by Cyclone Tracy in December 1974 and has been fully rebuilt since.

Darwin has an international airport which services international and interstate flights. There is a good network of sealed highways providing road access to and from Darwin; the Stuart Highway is sealed all the way from Adelaide, the Barkly Highway from Queensland and the Victoria Highway from Western Australia. There is also a railway from Adelaide to Darwin.

5.1.5 Local Industry and Infrastructure

A liquefied natural gas (LNG) plant is situated at Wickham Point, to the north of Channel Island, and a natural gas-fired power station is situated on the southern part of Channel Island. New port infrastructure is located off East Arm at Berrimah. A prawn farm is established in the Blackmore River and the Darwin Aquaculture Centre, located on Channel Island, acts as a barramundi hatchery.

Horticultural produce, livestock and aquaculture products can be exported through Darwin's marine and airport facilities. Tourism is a strong industry in Darwin and the Northern Territory as a whole. The harbour is also used for commercial fishing.

Channel Island is linked to the mainland via a bridge and a gas pipeline. A good network of sealed roads connect it to Darwin and beyond. Jetties are available on the mainland opposite Channel Island and on Channel Island itself.

5.1.6 Land and Water Use

Darwin Harbour is used for recreational and commercial purposes. Commercial uses include commercial fishing, pearl culturing, aquaculture and tourism; recreational uses such as fishing, scuba diving, boating, sailing, water skiing and beach use are popular activities.

The low wooded hills, mangrove forests, rocky foreshores, cliffs and sandy beaches enhance Darwin Harbour's aesthetic and recreational values. Wrecks of warplanes and ships scatter the harbour providing popular fishing and dive sites (The Environment Centre, NT, 2006).

The mangrove forests of Darwin Harbour are relied upon by Aboriginal people, especially local Larrakia people, for traditional foods (The Environment Centre, NT, 2006).

5.1.7 Land and Water Sensitivities

There is a growing interest from local, Aboriginal and environmental groups, and government departments, in the preservation of the amenity and environmental health of Darwin Harbour. Considering its proximity to a capital city and international port facilities, Darwin Harbour's natural environment is in good condition. Some of the aims of these groups are:

- to preserve the harbour's environmental health and therefore help maintain the habitats of all the endemic and migratory water birds, the reptiles and the mammals that range the harbour; and
- to preserve the natural amenity for its aesthetic value, recreational uses and tourism appeal.

5.1.8 Aboriginal Relationships to the Land and Cultural Values

The traditional owners of the Darwin area are the Larrakia Aboriginal People. They are often referred to as the 'saltwater people' though their boundaries extend up to 50 kilometres inland. The Larrakia Nation Aboriginal Corporation (LNAC) was established in 1997 and is considered the peak representative body for any issues regarding Larrakia people. The LNAC maintains close links with the Northern Land Council (NLC).

The LNAC and Larrakia people are actively involved in producing art and maintaining traditional dances, both of which are sold or shown at public venues.

5.1.9 Feedback from Consultation with Larrakia and other Aboriginal People

Formal and informal consultation and discussions have been ongoing with the Larrakia people and the Northern Land Council for several years since the establishment of the pilot project at Port Hurd. This is further discussed in Section 11. The Larrakia people and the Northern Land Council have been supportive of the investment, the operation and the opportunities which tropical fish farming can bring.

Representatives of the Northern Land Council and the Larrakia people attended an Open Day at Barra Base, Port Hurd, in November 2005 (refer to Section 11). They were able to see the existing barramundi farm in operation and heard an update on the EIS process and the findings of the baseline studies to that time.

The main issues raised during the November Open Day were:

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

Marine Harvest has been contacted by a several local aboriginal representatives which have voiced their interest in investing into the barramundi aquaculture venture when the leases are granted.

An Aboriginal Areas Protection Authority Certificate (C2006/042) has been granted for the proposed lease area NT Portion 4526 for fish farming. Refer to Section 3.10.2 and Appendix C.

5.2 Physical and Biological Environment

5.2.1 Existing Environment

5.2.1.1 Climatic Factors

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 1700 millimetres with the bulk of it falling between November and April. 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.

Dominant wind directions in the morning (9 am) are typically east or south-easterlies, changing to 'sea-breeze' north-westerlies in the afternoon (3 pm). Average wind speeds range from 4 to 11 kilometres per hour in the morning (9 am) to 7 to 13 kilometres per hour in the afternoon (3 pm). Average wind speeds are generally greater in the afternoon than in the morning with the exception of the period between April to June when the opposite occurs (Australian Bureau of Meteorology web site).

Cyclones typically occur between December and April, with an average of 3.4 severe cyclones per season (i.e. winds exceeding 120 kilometres per hour). Storm surges and storm tides occur periodically in Darwin Harbour.

5.2.1.2 Hydrology and Water Quality

Hydrology

Darwin Harbour has a small catchment to estuary ratio (0.75) (Padovan, 2003) which means it has a reduced potential for disturbance to the estuary. Middle Arm is part of the Darwin Harbour estuary system. It feeds fresh water and sediment to the harbour during the wet season via inputs from the Blackmore River and the dammed Darwin River.

Darwin Harbour is a large macro-tidal estuary that experiences maximum tidal level variations of around 7.8 metres (Williams and Wolanski 2003). The Harbour has two tidal cycles every 24 hours, i.e. diurnal tides. There is some amplification of the tidal range in the order of 100 to 150 millimetres as the tide progresses through Darwin Harbour. The tidal range does not begin to reduce until well into the upper arms; given its location, the proposed lease area would be expected to experience the full tidal ranges of the Harbour. The tidal ranges produce strong currents that peak at speeds of up to 2 to 2.5 metres/second in the harbour (Williams and Wolanski 2003). The peak water currents would be expected to be greater in the tighter channel areas. Tidal flows are also large.

Caldwell Connell (1983) carried out a drogue survey in Middle Arm around the proposed infrastructure locations for the then proposed Channel Island Power Station. They noted

that peak flood (incoming tide) velocities reached 3.7 knots in the main channel of Middle Arm and peak ebb (outgoing tide) velocities reached 3.8 and 3.6 knots respectively in the main channel of Middle Arm and in the then proposed Channel Island bridge alignment.

Water Quality

The turbidity of the water changes markedly depending on the stage of the tide. Within three hours the water can change from blue to turbid and brown due to sediment load from the mangroves (Geoscience Australia, 1998). Modelling of tidal currents in the Harbour has shown that they do not readily flush particles out of the harbour via particle transport, instead, particles tend to move to and fro and often migrate from one arm of the harbour to another (Williams and Wolanski 2003).

Fringing mangroves, within estuarine systems, trap mud, some of which is transported back into the estuary, especially when wet-season fresh-water inflows occur. The fresh water inflows remobilise and disperse the sediments through the water column. The muds impact on plankton, they can smother coral reefs and can impact on primary productivity of fisheries.

When the fine sediments reach higher salinity water they begin to flocculate (grow larger) and settle to the bottom. The finest sediments are generally transported to the ocean boundary where they may stick to phytoplankton, kill the organisms and then settle to the bottom. It is possible that tidal processes may rework the sediments back into the estuary.

Surface water temperatures in Middle Arm have been shown to be similar to those in other areas of the Harbour and show distinct seasonal variations ranging from 23 °C in early winter to 33 °C in late spring (Padovan, 2003). Highest salinity was measured during September-October at around 35 parts per thousand. The lowest salinity was measured in January-March, coincident with rainfall and run-off of fresh water into the Harbour. In the upper reaches of Middle Arm salinities as low as 5 parts per thousand were reported (Michie *et al*. 1991 in Padovan, 2003). Oxygen levels in the Harbour ranged from 74 to 96, typically 84%, with no variation with seasonal effects, and slightly lower oxygen levels higher up the estuary. The pH of the Harbour waters remained between 8.3 and 8.6, averaging 8.5, with no seasonal or spatial effects across the Harbour. Vertical stratification of the estuary waters, including the area of Middle Arm relevant to this referral, is unlikely to occur given the tidal conditions and the surface area subjected to wind mixing.

There have been no reported incidents of harmful algal blooms or hypoxia. Heavy metal loadings in the harbour were ‘higher than expected immediately around wharf areas’; the metals included arsenic, chromium and zinc (Geoscience Australia, 1998).

Further details on water characteristics are provided in Section 5.3, which summarises the Channel Island baseline study results.

5.2.1.3 Bathymetry

Darwin Harbour is a drowned river system which was carved during the last ice-age. When sea-levels rose, the valleys were flooded and isolated hills became islands in

Darwin Harbour (eg. Channel Island). Ever since, there has been gradual deposition and reworking of sediments of marine and terrestrial origin. Near Channel Island and the eastern shore of Middle Arm, erosion and depositional processes have formed mud flats in low energy/weak current environments, and coral reefs in areas where sediments have not covered hard substrate (weathered rock) (Neil Smit, 2003). As a result the original drowned valley profile is being gradually infilled with sediments, coral reef growth and rubble.

The area between Channel Island and the eastern shore of Middle Arm is dominated by muddy substrate nearer the shore, as well as some areas of coral reef, and a more deeply incised channel area (refer to Figures 4 and 7).

The shipping channels in the harbour are generally 12 metres deep. Depth to the sea floor in the project area is likely to range from a maximum of 20 metres (at low water) in the north of the prospect area to around 5 metres (at low water) in the south of the prospect area, with the boundaries of the area possibly located in around 1 metre of water only (at low water) (refer to Appendix D).

5.2.1.4 Existing Coastal and Marine Flora Species

Mangal Forests (mangroves)

According to most sources, Darwin Harbour is considered to be relatively pristine. The coastal areas around Channel Island and the eastern shore of Middle Arm have retained most of their native mangrove forests. Species diversity and abundances are reported to be high despite the harbour being fringed by a city.

The Northern Territory government is committed to protecting over 90% of the mangrove communities in Darwin Harbour. The area around the northern and eastern shore of Channel Island was included in the proposed areas for rezoning to 'Conservation' in Figure 12 of *Management Issues for the Darwin Harbour Region* prepared by the Working Group to the Darwin Harbour Advisory Committee (June 2003).

It is documented in McGuinness (2003) that around 36 mangrove species occur in Darwin Harbour, the six most common being: *Rhizophora styloca, Ceriops tagal, Sonneratia alba, Bruguiera exaristata, Avicennia marina,* and *Camptostemon schultzii.*

As part of its baseline report for the project, Aquenal Pty Ltd (2005) carried out a survey of mangrove stand structure and condition. This is summarised in the following paragraphs and a copy of the baseline report is provided in Appendix E.

Mangrove stand structure in the study areas of Channel Island and the control sites at Little West Arm 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*. The other species occurring in significant numbers were *Avicennia marina* dominating the water's edge at one control site, and *Bruguiera exaristata* and *Bruguiera gymnorrhiza* at several control sites.

Mangrove condition was generally healthy with less than 10% dead trees per hectare at all but four sites, where the results were skewed by the sampling traverse position. Only a low number of trees were recorded by Aquenal as having any crown damage or dead branches. At several sites, older *Rhizophora* sp. and *Avicennia marina* trees were leaning to some degree but were healthy.

Aquenal (2005) reported that the mangrove communities assessed in the vicinity of Channel Island and Little West Arm were typical for similar published studies of Darwin Harbour habitats (eg. Brocklehurst and Edmeades, 2003).

Marine Flora

Seagrass is an important habitat as a fish nursery and as feeding grounds for dugongs. Aquenal (2005) reported that there are no known areas of seagrass in the vicinity of the proposed farm. According to comments published in *Marine Flora and Fauna, Seagrass in Management Issues for the Darwin Harbour Region* (June 2003) it is suggested that there may be some seagrass beds in the area between the north-eastern coast of Channel Island and the eastern shore of Middle Arm, though that report noted that these would not be well developed. Whiting (2001) reported that the northern area of Channel Island is devoid of seagrasses, but low biomass algae are found on the rocky substrates around the Channel Island Bridge. Algal species include Sargassum, Padina, Turbinaria and Gracillaria, which are likely to be a food source for *Chelonia mydas* (green turtles), *Eretmochelys imbricata* (Hawksbill Turtle), and dugongs.

5.2.1.5 Existing Coastal and Marine Fauna Species

Fauna

In a comprehensive survey of soft sediments in mangroves in Darwin Harbour, Hanley (1993), in McGuinness (2003), documented 131 invertebrate species, comprising 33 polychaete worms (Phylum Annelida); 31 crabs and related species (Phyllum Mollusca); 28 insects (Phylum Uniramia); and several species from other groups, as well as 2 species of gobies.

Most of the fish found in Darwin Harbour are small (Larson, 2003). The most diverse group in the harbour are the gobies, followed by the cardinalfish and the syngnathids or pipefishes. This family includes the CITES-listed seahorses, of which there are 4 species in the harbour. The harbour also shelters other threatened marine fishes such as the dwarf sawfish and the whipray genus Himantura. There are over 400 fish species in the harbour, however little is known about their habitat preferences or other characteristics (Larson, 2003).

Darwin Harbour supports a diverse range of marine reptiles and marine mammals which include: 4 species of sea turtles: the green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), flatback turtle (*Natator depressus*) and olive ridley turtle (*Lepidochelys olivacea*), 20 species of marine snakes, one crocodilian (the saltwater crocodile *Crocodilus porosus*), dugongs and 14 species of Cetacea (Whiting, 2003). Dugong presence is documented in the harbour but their numbers are generally low. Little is known about the composition of the Cetacea species presence within Darwin Harbour, though a survey (Whiting, 1997 in Whiting, 2003) found that the most abundant

was the Indo-Pacific humpback dolphin, followed by the Irrawaddy River dolphin and then the bottlenose dolphin. Other Cetacea recorded in the harbour include the great sperm whale, the pygmy sperm whale and the humpback whale.

The report *Marine Flora and Fauna, Seagrass in Management Issues for the Darwin Harbour Region* (June 2003) notes that the small areas of seagrasses present in Darwin Harbour are unlikely to sustain a large number of dugongs as an adult dugong can eat up to 28 kilograms per day. Nevertheless, seagrasses form an integral part of the detrital food chains and nutrient cycling and are important nursery grounds for marine animals such as juvenile fish and crustaceans.

The mangroves of Darwin Harbour support a very rich diversity of mangrove-specialised bird life. The birds act as pollinators and seed dispersers of a number of mangrove species (Noske, 2003).

There appears to be little change in the overall species community composition between the wet and dry seasons (Smit, 2003).

EPBC-Listed Species

Table 5.1, below, lists the threatened and migratory species likely to range the area of the proposed lease, based on information obtained from the EPBC web site.

Table 5.1: List of Threatened and Migratory Species from EPBC Web Site for the Proposed Development Site

Threatened Species [Dataset Information]	**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

Threatened Species [Dataset Information]	**Status**	**Type of Presence**
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 * Pacific Ridley, Olive Ridley	Endangered	Species or species habitat may occur 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 [Dataset Information]	**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	Migratory	Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle	Migratory	Species or species habitat likely to occur within area
Hirundo rustica Barn Swallow	Migratory	Species or species habitat may occur within area
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

Threatened Species [Dataset Information]	**Status**	**Type of Presence**
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
Orcaella brevirostris Irrawaddy Dolphin	Migratory	Species or species habitat may occur within area
Orcinus orca Killer Whale, Orca	Migratory	Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin	Migratory	Species or species habitat may occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations)	Migratory	Species or species habitat likely to occur within area
Reptiles		
Caretta caretta *	Migratory	Species or species habitat may occur within

Threatened Species [Dataset Information]	**Status**	**Type of Presence**
Loggerhead Turtle		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

Pests

A report into the marine species present in Darwin Harbour, dated September 2000 (Russell & Hewitt), concluded that there were no introduced marine pests within the Port of Darwin. Monitoring to date appears to show that measures such as intercepting foreign vessels and checking hulls has thus far prevented any invasion by introduced marine pests within Darwin Harbour.

5.2.2 Turtles and Dugongs

Darwin Harbour provides an important habitat for turtles and dugongs and several studies have been conducted to provide data relating to species and habitat. Whiting (2001) conducted a survey of dugongs and turtles in the vicinity of the Channel Island Bridge. This study was *ad hoc* in nature with 47 surveys conducted from the bridge over a two-year period from May 1998. Whiting confirmed (pers. comm. 10 March 2006) that there has not been much additional information published on Darwin Harbour turtles and dugongs since the 2001 Whiting report.

Dugong Occurrences

Whiting (2001) reported that dugongs were observed on 21 of the 47 visits. Dugongs were present for most months of the year with a total of 37 dugongs sighted, of which 35 were foraging. Dugongs were not observed from September to December. The food source was believed to be predominantly intertidal algae in the vicinity of the eastern end of the Channel Island bridge, because seagrasses are not present in this area (Whiting 2001). There are no known dugong calving sites within Darwin Harbour.

Marine Turtle Occurrences

Three species of turtles were observed from the Channel Island Bridge (Whiting, 2001). Numbers of turtles were not recorded because they were not the focus of the study. Green turtles (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*) were abundant and regularly used the intertidal area in the vicinity of the Channel Island Bridge. They appeared to forage on the algae to the east of the island. Green turtles outnumbered hawksbill turtles by 4:1. Adults comprised 5-15% of the total green and hawksbill turtles observed. One adult and one immature flatback turtle (*Natator depressus*) were also observed during the study period.

There are no known turtle nesting sites within Darwin Harbour.

Findings of Whiting's 2001 Report

Several important findings came out of Scott Whiting's 2001 report; these included:

- the fact that there is a regular presence of dugongs and sea turtles foraging in the vicinity of the Channel Island Bridge,
- this was the first record of dugongs regularly eating algae, and
- the evidence that rocky reefs in Darwin Harbour are extremely important for both dugongs and sea turtles, as they host algae used as one of their food sources.

Existing Pressures on Dugongs and Turtles

There are a number of existing pressures on dugongs and turtles and their habitats in Darwin Harbour (Whiting, 2001 and Whiting pers. comm. 11 May 2006). In the context of this proposal, these include:

- boat strikes,
- boat activity,
- marine debris, and
- habitat destruction.

Whiting (pers. comm. 11 May 2006) notes that most of the threats are incremental and each additional activity adds to the overall threat.

5.2.3 Air Quality, Noise, Lighting and Visual Amenity

Established commercial and recreational activities in and around the harbour already contribute to disturbance of the air quality, noise, lighting and visual amenity.

Air quality, noise, lighting and visual amenity in the vicinity of Channel Island are also affected by inputs from the liquified natural gas (LNG) plant at Wickham Point and the natural gas-fired power plant in the south of Channel Island, as well as by inputs from marine and road traffic.

Commercial ships and recreational vessels make regular and extensive use of the harbour. However most of the marine traffic up Middle Arm would typically be small craft.

The bridge linking the mainland to Channel Island also contributes to changes in the noise, lighting and visual amenity of the area.

No current data have been obtained relating to air quality within the proposed area, but considering the distance from Darwin, and the distribution of both the LNG plant and the power plant, it is unlikely to be of poor quality.

5.2.4 National Estate and Heritage

The proposed lease area:

- is close to or overlaps two sites on the Register of National Estate, namely the historic Channel Island Leprosarium ruins and the natural Channel Island Reefs;
- it is also understood that the lease area may overlap heritage objects belonging to the SS Ellengowan Shipwreck which is declared as a heritage site under the NT *Heritage Conservation Act 1991*.

5.2.4.1 Channel Island Leprosarium

The Channel Island Leprosarium was built on Channel Island around 1920 and was closed in 1955. Its location is shown in Figure 4. The Leprosarium now consists of the remains of numerous buildings, floor slabs, a cistern, a chimney and a jetty, as well as

unmarked burial places for around 142 leprosy sufferers who died there. A large amount of the building material was taken to Bathurst Island after closure of the Leprosarium.

The island will not be used for the purpose of building or servicing the proposed farm so the site will not be at risk of disturbance by the proposed development.

5.2.4.2 Channel Island Reefs - Corals

Coral reefs are situated to the north east of Channel Island (south of the proposed site). The coral communities around Channel Island have not been mapped in detail (Dr Phil Alderslade, NT museum pers. comm. 11 May 2006). A survey of the extent of soft and hard coral communities around Channel Island was reported in Caldwell Connell (1983) (refer to Figures 4 and 7). The extent of these communities is unlikely to have changed markedly since that report (Dr Phil Alderslade, pers. comm.). It is possible that the southwestern edge of the proposed lease overlaps the northern tip of the reef cluster situated between Channel Island and the mainland (refer to Figures 4 and 7).

The Channel Island reefs were used as one of the control sites for a pre-dredge sampling program conducted by GHD Pty Ltd (GHD) for the Darwin Cove Consortium on July 30 and 31, 2005 (GHD, 2005). Four sites were chosen for this survey; they were Channel Island, Wickham Point, South Shell Island and Weed Reef. Coral diversity, health and abundance were assessed along four 20-metre transects at each site. The survey methods used were the same as those recommended by the Great Barrier Reef Marine Park Authority (GHD, 2005). The following is summarised from the GHD report.

The Channel Island reefs were reported as having maximum reef depths of around 5.2 metres (less than other reefs surveyed during that study) and to cover an area of approximately 270 hectares. Visibility in the area is between 1 to 3 metres during neap tides in low wind conditions. The corals occur on a narrow rock shelf. Coral diversity included around 28 species (less than other reefs), comprising mostly hard corals (around 40% of reef), dominated by Faviids, with lesser numbers of Mussids, Pectiniids and Acroporids. The reef displayed low hydroid and very low macroalgae abundances, and sponges were fairly common (around 8 %).

GHD (2005) noted that all four reef systems were representative of reefs exposed to harsh environmental conditions such as large seasonal fluxes in freshwater inputs, high proportion of suspended sediments, and cyclonic effects. The large seasonal fluxes (wet/dry) affect sediment and freshwater inputs, which in turn affect diversity, distribution and abundance. The reef assemblage at Channel Island is typical of very silty coastal or near-shore reefs, and is well adapted to low light and turbid water conditions. The restricted size of the colony and the presence of abundant deep loose coral rubble is a direct result of the reef being subjected to frequent disturbance by cyclonic and storm wave action, by freshwater inundation and high water temperatures. The reef is also characterised by low fish diversity, as might be expected from very silty inshore conditions (GHD, 2005). GHD also noted that the reefs at Channel Island were in a healthy condition, though isolated colonies exhibited partial bleaching.

A video record was maintained of the surveys and was expected to be repeated after the dredge operations.

The relative diversity of the corals, the clear reef zonation and its accessibility make it an important area for research and education.

5.2.4.3 SS Ellengowan Shipwreck

The SS Ellengowan Shipwreck is declared as a heritage place under the NT *Heritage Conservation Act 1991.* It is located approximately 1.5 kilometres south of Wickham Point and is situated mid-way between the north-eastern shore of Channel Island and the eastern shore of Middle Arm; it is estimated to be lying at around 16 metres depth (at low water) (Wind-Waves and Safety NT website). The estimated location of objects from the SS Ellengowan wreck is shown in Figure 4. The proposed lease area may overlap the heritage wreck location. The SS Ellengowan was built in 1866 in Norway. It is the oldest known shipwreck in Darwin Harbour and is the only Norwegian iron hull steamship in Australia. The ship sank in 1888 due to holes in the hull. It was discovered in 1991, was gazetted on 30 August 1995 and is now a popular dive site.

5.3 Channel Island Baseline Investigation

A baseline investigation has been carried out at Channel Island to provide pre-operational data against which subsequent monitoring may be compared to assess potential impacts from nutrient inputs from the proposed aquaculture operation at Channel Island. The investigation was carried out by Aquenal Pty Ltd (Aquenal) on 2, 3, 21, 23, and 30 August 2005. A copy of the full report is provided in Appendix E.

Aquenal was previously contracted by Marine Harvest to carry out the baseline survey for the existing barramundi pilot farm at Port Hurd in 2002. During the investigations for the proposed sites, a follow up survey of Port Hurd was also carried out (refer to Section 7).

The following sections are summarised from the Aquenal (2005) report.

5.3.1 Investigation

The environment of the farm and control sites at Little West Arm is that of a sheltered mangrove estuary with great seasonal variation in fresh water inflow. The two main hydrological influences include the 7-plus metre diurnal tides and the large run-off from heavy rains during the wet season.

Towards the end of the dry season, terrestrial run-off has all but ceased, high temperatures prevail, evaporation results in increased salinity and negligible net flushing occurs through the estuary. This is the period when nutrients from the proposed farm are most likely to accumulate in the estuary on intertidal flats or in deeper channels.

A drogue survey, to identify water movements, and to support the choice of sampling sites for the baseline study, was carried out in early August 2005 to coincide with the end of the dry season. Pairs of drogues were released at two-hourly intervals from the proposed farm site at Channel Island during the spring tides of the 2 and 3 of August 2005.

Six baseline sampling locations were selected adjacent to Channel Island as well as separate control sites within Little West Arm, situated six kilometres to the west of Channel Island. Figure 8 provides the location plan of the sampling sites for the investigation. Sample sites were labelled F1 to F6 at Channel Island, with F1 to F3 being intertidal sites in small creeks or on mud flats, and F4 to F6 being deep water sites where suspended material was likely to be deposited when tidal flows slowed at the turn of the tides. Sample sites in Little West Arm were selected by visual assessment to reflect sample sites at Channel Island as closely as possible. These were labelled with coincident site numbers; C1 to C3 for intertidal sites and C4 to C6 for deep water sites.

5.3.2 Findings

The movement of the drogues indicated that water moving through the farm on the flood tide will carry any farm-released nutrients both out into the main channel and up into Jones Creek. On a single flood tide cycle, any nutrients released by the proposed farm could be washed more than 3 kilometres up Jones Creek and could eventually be carried into the mangrove flats lining the creek and its tributaries. It can be expected that the waters of Jones Creek will wash back and forth past the farm with the potential for nutrients to accumulate during the dry season. However the waters which flow back to the main channel on the flood can be expected to mix with the larger volume of water there and become dispersed. Thus the sites where nutrients may be expected to accumulate in the incoming tide are located within Jones Creek.

Potential nutrients carried on the ebb tide would primarily be washed through the back channel in which the farm site is situated and out into the main channel of Middle Arm. A significant portion of those washed into the main channel would not return on the subsequent tide but be dispersed in the main channel. On slower moving ebb tides, particularly when a stiff sea breeze is blowing, floating and dissolved nutrients would also be carried over the mud flats to the north-east of the farm site.

Water Quality

The temperature of surface waters at all sites was very consistent, with temperatures ranging from 26.5 – 27.0 °C, while salinity varied between 34.8 and 36.2 parts per thousand (ppt). The pH of the water at the farm sites (F1-F6) was considerably lower (6.0-6.5) than the control sites (7.4-7.8), except C1 (6.2), although no other parameters measured followed this pattern. This result suggests instrument error during the recording of pH because pH values this low in marine conditions are rare. The recorded dissolved oxygen (DO) was approaching or above 80% at all sites except C4 and C5 (with a mean DO of 70 and 67.6% respectively). The data were consistent between replicate readings, indicating low variability.

Nutrients

NO_X (nitrates and nitrite) varied from 0.005 to 0.020 mg/L with the control sites being slightly lower than the farm sites. However given the near detection threshold levels and the rounding to the nearest 0.005 mg/L little can be interpreted from this variation. Aquenal (2005) reported that nitrite and nitrate levels were consistent with those found in earlier studies (Pardovan 1997, Parry and Munksgaard 1999, Pardovan 2002). Ammonia

levels ranged from <0.005 mg/L (detection threshold level) to 0.035 mg/L with values above 0.020 mg/L at 2 shallow sites, F2 and C1, and one deep site, C5 (control). Aquenal (2005) also reported that ammonia concentrations in their study were consistent with the earlier studies, with the exception that the 0.035 mg/L concentrations were approaching the highest wet season level of 0.040 mg/L measured in Ludmiller Creek.

Chlorophyll α

Chlorophyll α levels found in this study were consistent with results of earlier published studies within Darwin. They were equal to or below ANZECC Interim Trigger Levels (ITLs) of 2 mg/L for slightly to moderately disturbed ecosystems for estuaries (Table 3.3.2, ANZECC 2000). The results are within the range of those recorded during the initial stages of baseline monitoring conducted by Aquenal (2006) at Port Hurd (<2 μg/L) and Doug Point (Port Patterson proposed barramundi farm) (<2 μg/L) and lower than those recorded at Snake Bay (proposed barramundi farm) (generally 3 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, which appeared in excellent health.

Mangrove Stand Structure and Composition

Mangrove stand structure in the study areas of Channel Island and Little West Arm (the control site) 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*, the former of which has brown spots on its leaves and the latter does not. However the two interbreed to form a hybrid, and various trees had spots on some leaves and not on others, apparently identical trees had spots on one but not the other and most trees were too tall to inspect their leaves so a distinction could not be made. With *Ceriops sp*. the only way the species can be differentiated is by their flowers and fruit. Since very few Ceriops were in flower or fruit no distinction could be made between these species either.

The other species occurring in significant numbers were *Avicennia marina* dominating the water's edge at F2 and *Bruguiera exaristata* and *Bruguiera gymnorrhiza* at several control sites.

Mangrove condition was generally healthy with less than 10% dead trees per hectare at all sites but four. At two of these sites, F2-2 and C1-4, the high calculated percent dead was the result of measuring one very small dead Ceriops adjacent to the measuring position. Low numbers of trees with crown damage or dead branches were recorded. At several sites with older trees of *Rhizophora* sp.or *Avicennia marina* many of the trees were leaning but were healthy.

Benthic Infauna

Benthic infaunal analysis found no obvious signs of existing impacts on macrobenthic communities at Channel Island or the adjacent Little West Arm. Analysis of faunal similarities amongst samples from these inlets detected habitat-related variation, with intertidal communities distinct from the majority of the subtidal communities. Within the intertidal and subtidal groupings, some differentiation was also observed between Channel Island and Little West Arm, although overlap was observed between these localities, particularly in the case of subtidal samples. Diversity indices and K-dominance curves revealed no consistent trends in biodiversity or dominance on the basis of habitat or inlet. In general communities were diverse and exhibited low levels of faunal dominance (suggesting low impact).

A summary of the comparison of water quality parameters at Channel Island and Port Hurd is provided in Table 5.2 below.

Table 5.2: Comparison of Water Quality in Channel Island and Port Hurd

Parameter	Unit	Channel Island	Port Hurd
Dissolved Oxygen	%	78-84	51-96
Salinity	ppt	33.1 and 36.9	22.5-38.5
Chlorophyll *α*	μg/L	≤2	1.1 to 4.6
Nitrate	mg/L	0.010-0.015	≤0.043
Nitrite	mg/L	<0.005	≤0.055
Ammonia	mg/L	0.005-0.035	≤0.220

5.3.3 Conclusions

Results indicate that the water quality of the proposed site (and control) is similar to tropical estuarine environments. Nutrient levels were generally low and consistent with previous surveys within Darwin Harbour. Chlorophyll α levels found in this study were consistent with results of earlier published studies within Darwin Harbour. They were equal to or below ANZECC Interim Trigger Levels (ITLs) of 2 mg/L for slightly to moderately disturbed ecosystems for estuaries and within the range of those recorded during the initial stages of baseline monitoring conducted by Aquenal (2006) at Port Hurd and Doug Point (Port Patterson proposed barramundi farm) and lower than those recorded at Snake Bay (proposed barramundi farm). Epiphytic algal growth was not detected on intertidal mangrove root and rhizome assemblages. Mangrove stand structure in the study areas of Channel Island and Little West Arm (control site) was dominated by *Rhizophora* sp. and *Ceriops* sp. Mangrove condition was generally healthy with less than 10% dead trees per hectare at all sites. Benthic infaunal analysis found no obvious signs of existing impacts on macrobenthic communities at Channel Island or at the adjacent Little West Arm.

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 marine sea-cage fin-fish aquaculture facility.

6.1 Potential Impacts from Construction of the Farm

- noise from hand tools at the land base,
- noise from motor boats,
- nominal increase in boat traffic,
- movement of large nets between the land base and the proposed farm lease, and
- localised seabed disturbance during placement of mooring anchors.

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 the 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 harbour and the channel to beneath the cages,
- effects on the distribution of fish populations across the harbour,
- effects on the distribution of predators across the harbour,
- 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 unmanaged rubbish, and
- by accidental fuel spills on water.

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

- 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,
- entanglement with or ingestion of rubbish or solid wastes accidentally lost from the farm, and
- potential chemical or fuel spills.

Water quality could potentially be affected by:

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

Harm to human health could potentially be caused by:

- accidental spillage or mishandling of fuels and chemicals on the outboard motor boats,
- inability to optimally treat or remove dead or sick fish from the nets,

- 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 and nets in the water.

The main potential impacts would include:

- localized erosion of seafloor,
- local changes in water currents,
- local disturbance to marine flora, and
- 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 harbour, and
- increase in total predator numbers within the harbour.

Potential impacts from predators would include:

- increased predation on aggregated fish, and

- increased 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 terrestrial or coastal vegetation to be disturbed by the presence of the farm as any on-land activities will take place within pre-existing premises at Berrimah.

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. The increase in epiphytic algae can lead to a reduction in plant photosynthesis.

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 or 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 or shy species.

6.15 Potential Impacts from Disturbance to Land Surface

Disturbance to the land by farm operations is likely to be non-existent or minimal as land-based operations will be restricted to pre-existing premises within the port infrastructure at Berrimah.

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

Potential air, noise, lighting and visual amenity impacts from the operation could be brought about by:

odours and greenhouse gases

- emissions from the use of petrol engines,
- potential odours from dead fish, and
- 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 and during construction of the nets on the beach;

lighting

- presence of flashing lights at corners of lease,

aesthetic

- presence of net cages,
- potential loss of naturalness, aesthetic and tourism values.

6.17 Potential Impacts on Social and Recreational Values

Potential impacts to social and recreational values could include:

- increased employment and training opportunities for local residents,
- potential hindrance to shipwreck divers, and
- potential hindrance to recreational fishing and boating.

6.18 Potential Impacts on Local Infrastructure

Potential impacts on local infrastructure could include the increased use of port facilities at Berrimah. However, the impacts on local infrastructure are anticipated to be very limited as farm employees and contractors will essentially be using existing facilities which are equipped to deal with a large amount of marine traffic and goods. Most goods and equipment will be sourced from Darwin and will be delivered to the land base at Berrimah either by road or by boat.

It is possible that jetty facilities at Channel Island or on the mainland opposite Channel Island will be used infrequently by farm operators, however this is not expected to create any significant impact on those facilities.

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

The SS Ellengowan Shipwreck, the Channel Island Leprosarium and the Channel Island Reefs occur in relatively close proximity to the proposed lease area. Potential impacts on these may include:

- Hindrance in accessing the shipwreck site of the SS Ellengowan, and
- Accumulation of nutrients or wastes from the farm on the reefs.

As the farm operation will not be carried out on Channel Island *per se*, it is not expected that the proposed farm would impact the Channel Island Leprosarium site in any way.

6.20 Potential Impacts on Marine Traffic

Marine traffic in the Harbour could be impacted by:

- a nominal increase in motor boat traffic,
- the movement of farm nets being floated and towed from Berrimah to the farm site, and by
- the presence of nets permanently moored within the back channel of Middle Arm.

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;
- 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 injury from other potentially lethal species eg. box jellyfish, stone fish, sea snake, etc.; and
- cyclonic events potentially creating hazardous conditions on sea and on land.

These will be managed via measures outlined in the forthcoming Environmental Management Plan for the site and summarised in Section 9.23.

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 proposed Channel Island aquaculture development and compile this EIS report, it is considered that most potential problems have already been identified and have been 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 that 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 on the environment from the fish farming operation.

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 Channel Island 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 F.

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. Periodical 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 9 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,
- planktonic 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 were 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 were 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 10. A copy of Aquenal Pty Ltd's biennial report is provided in Appendix F. 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 (2006) 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 (2006) 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 (2006) 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 (2006) 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 (2006) 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 (2006) 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 (2006) 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 (2006) 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 (2006) 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 (2006) 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 (2006) 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 (2006) 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 Channel Island versus Port Hurd Operations

There are a number of differences between the Channel Island and Port Hurd operations. Some are related to contrasts in environmental conditions, some are 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 Channel Island operation.

Table 7.1: Comparisons of Channel Island versus Port Hurd Operations

Item	Port Hurd	Channel Island
Current speeds	Up to 4.2 knots	Maximum of around 3.6 knots*
Tidal fluctuations	7 metre tidal range	7-8 metre tidal range
Farm operations	Operated from a land base	Operated from a land base, within established port precinct and distant from the farm lease
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); in 1-net wide lines, and 6 nets per mooring cluster.
Fish Tonnage	1000 tonnes	500 tonnes increasing to 1000 tonnes

*Caldwell Connell (1983)

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

The smaller nets and net clusters at Channel Island 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 lower in magnitude than those at Port Hurd.

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 Channel Island operation as have been implemented at the Port Hurd pilot farm.

A regular monitoring program will be carried out at the proposed Channel Island 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 pick up early 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 sets 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 G.

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 marine sea-cage 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 near Channel Island 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:

- The only construction work involved for the proposed marine lease farm site will be construction and installation of nets and moorings;
- Construction of the moorings and nets will be carried out in Darwin within the facility which is proposed to be leased at Berrimah, and these will be towed into place by boat;
- Installation of mooring anchors will be carried out by divers and with the assistance of boats. Specialised contractors will be used to install the mooring points. Contractors will be briefed in the requirements to minimize seafloor disturbance. Disturbance to fauna habitat and to the seafloor will be short lived and very limited in extent;
- It is expected that the pre-existing premises which will be leased at Berrimah will be equipped with most of the infrastructure required for the land-based operations of the proposed farm. Hence, little or no construction work will be required there.

8.1.1 Risk Assessment

Likelihood

It is considered that the only environmental impacts from the construction of the farm would be seabed disturbance during placement of the mooring anchors. These impacts would be temporary and localized and are rated as having a **possible** likelihood.

Consequence

The consequences from the temporary and localized seabed disturbance are considered to be at worst **moderate**, as there may be some mobilization of sediments which could cause a temporary increase in turbidity of the water around the mooring anchors.

Risk 3 = medium 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 Channel Island operation. Any diseases or parasites carried by the farm barramundi (eg. 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 have 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 Channel Island 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 the number of mooring lines per mooring array.

Consequence

The consequence of fish potentially escaping from 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 (as are found in Darwin Harbour), 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. Peak water currents in Middle Arm on the eastern side of Channel Island are expected to reach up to 3.6 knots during spring tides. 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 Channel Island. Skretting's 'environmental impacts' table for this feed is reproduced in Table 8.2, below.

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 Port Hurd estuary (pers. comm. Dr David McKinnon, AIMS, January 2006). This percentage would be much lower for the proposed farm contribution to nitrogen required for algal productivity in Darwin Harbour, due to the size of the harbour and the existing disturbance in the harbour.

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, eg. 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.

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 are likely to have only **minor**, and at worst, only **moderate** consequences on the environment.

Risk 2 = serious, 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 strong 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 of the estuary.

The likelihood ranking is therefore considered to be somewhere between **possible** to **unlikely**.

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 Channel Island are likely to be home to small species of fish, that 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 at the proposed Channel Island barramundi farm.

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 the proposed Channel Island farm. 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 the proposed Channel Island barramundi farm is expected to have nil or at worst **minor** consequence on the environment, given that 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 parasites. As steel nets will be used as grow-out nets at the proposed Channel Island site, it is anticipated that the farmed fish will not require any treatment for parasites. The use of fibre nets within the steel nets for nursery purposes may increase the risk of parasites, though fortnightly cleaning of nets is likely to minimise that risk.

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 the proposed Channel Island farm 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.

General Waste

Solid waste in the form of feed bags, all plastics, glass, redundant equipment and clean workshop waste will be collected and transported to the Darwin waste disposal facility. There is no ability to recycle the bag waste, which is by far the greatest volume of solid waste generated.

Dead Fish

Dead fish will be digested in an ensiler located at the land base in Berrimah. The contents will be periodically transported to the MOECO facility in Darwin for use as a component of its fertilisers.

Waste Water

It is expected that the land base will have waste water disposal facilities linked to the town waste water systems.

Hazardous Chemicals and Fuels

Diesel and petrol is used to power engines on the supply vessels and on the farm. Leakage or spillage of fuel or oil could impact on water quality and on marine life and presents an increased danger of fire.

The land base at Berrimah will store a number of hazardous chemicals which must be managed according to Dangerous Goods Regulations. Small quantities of cleaners and detergents will be stored for use. Minor quantities of greases and solvents for maintenance purposes will be stored in the workshop.

Marine Harvest proposes to store chemicals and fuels at the land base in secure bunded areas and in keeping with regulatory requirements. These issues will be covered in the EMP which will be drawn up for the site. A summary of proposed measures is provided in Section 9.8.

8.9.1 Risk Assessment

Likelihood

The likelihood of any wastes, chemicals or fuels being lost or spilled in the waters of Darwin Harbour is considered to be **possible** though **unlikely** as all possible measures will be taken to minimise the risk of spillage. The farm workers have a vested interest in keeping the harbour waters clean for the health of the farmed fish.

Consequences

All fuels and chemicals will be stored on land in bunded areas, only small quantities of fuels and chemicals will be kept on the motor boats. All wastes generated at the farm lease will be stored on the boat for disposal to Darwin. The worst possible event could be the spillage of a small quantity of fuel or chemical into the harbour waters or the loss of rubbish which could become marine debris. The worst consequence could potentially be the injury of a marine animal (eg. turtle) due to entanglement with this marine debris, this would be rated as **major**. Small quantities of fuel or chemicals would not be expected to cause any significant damage to the environment, given the large body of water.

Risk 3 to 2 = medium 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 Channel Island 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 Channel Island farm. Furthermore, tidal currents, maximum wave heights, and cyclonic effects are all of a lesser magnitude at Channel Island 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, and the nets.

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 marine fauna.

Consequences

The impacts from the localised changes to hydrodynamics would be expected to be minimal around 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, though given its sparse distribution in the channel, this is not likely to be significant. Marine fauna would not be expected to be negatively affected by the small changes in hydrodynamics as they are accustomed to responding to local variations in

underwater currents. The overall consequences from localised changes to hydrodynamics are assessed to be **minor.**

Risk 3 = medium 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 the proposed Channel Island farm 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 and 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 likely to be only sparsely developed as the strong tidal currents are likely to preclude extensive marine vegetation growth. Seagrasses would typically develop in areas of relatively weak water currents. 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 **minor** (i.e. no adverse effects) to **moderate** (i.e. event with some temporary adverse effects).

Risk 4 = low risk

8.14 Corals

A small portion of the northern extents of the reefs, which are located between Channel Island and the mainland, may be overlapped by the proposed lease area. Most of the hazards from the operation have been discussed above and include generation of fish faeces, uneaten or spilled feed, spillage or leakage of chemicals and hazardous substances, spillage or leakage of wastes. It is considered that management practices will prevent most of these hazards from posing a significant risk of impact on the reefs. It is also considered that tidal currents in this part of Middle Arm are such that flushing and

dilution of fish faeces and minor amounts of uneaten feed or other substances will prevent the reefs from experiencing any significant impact from the farm. The risk of impact from chemicals and hazardous materials is nevertheless serious.

Likelihood

Based on the Port Hurd experience, and given that Marine Harvest will put in place detailed staff training and overall mitigation and management procedures to manage the output of nutrients from the farm, and to control wastes and hazardous substances at the farm, it is considered **unlikely** that the any of these aspects could impact on the reefs.

The likelihood of spillage of hazardous substances is considered unlikely as:

- the outboard motor boats will be refuelling at the wharf facility at Berrimah and will not be carrying any backup fuel containers on board, and
- the service ships, such as net towing boats or harvesting ship, will also be refuelling in their dedicated wharf areas and will not be operating in rough weather conditions.

Consequences

The most severe potential impacts could be incurred in the event of a fuel spill. The most likely cause could be from an outboard motor boat accident and a resultant fuel leakage from its tank. The outboard motor boats will only carry the equivalent of their tank capacity which is likely to be around 100 litres. The consequences would therefore be **moderate** (i.e. event with some temporary adverse effects), as it could affect the reefs locally. The possible area of reef affected would be small, given the small quantity of fuel, and due to the one-off and not chronic effect of the spillage, the coral is likely to only suffer from 'injury' and to not be killed. It would therefore recover relatively quickly (NOAA).

Risk 4 = low risk

8.15 Bird, Reptile, Fish and Mammal Habitats

There are no known breeding sites, such as turtle rookeries or dugong calving sites within Darwin Harbour. The most sensitive habitat which could potentially be affected by the farm is the coral reef area which is discussed in the previous section.

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. mangrove species) and hence the habitats for fauna species directly and indirectly dependent on these.

The risk assessments for most of the aspects, which would affect fauna habitats, have been discussed in Sections 8.3 fish faeces and nutrients, 8.4 excess feed and feed quality, 8.5 removal of fish from the food chain, 8.6 fish aggregation, 8.8 introduction of

chemicals, 8.9 waste and hazardous materials, 8.11 hydrodynamics, 8.13 flora, 8.14 corals, 8.18 air quality, noise and lighting and 8.22 marine traffic. Their risk assessment results have been summarized in Table 8.4, provided in Section 8.25.

Fish faeces and nutrient loads have the highest risk ranking for potential impacts to fauna habitats, with a risk ranking of 2 or 1, i.e. serious to high risk. However this high risk ranking is obtained due to the high likelihood of the farm emitting fish faeces and nutrients. The assessment notes that the consequences would be minor or at worst moderate based on biennial monitoring results at the pilot farm at Port Hurd.

8.15.1 Risk Assessment

Likelihood

As discussed above, fauna habitats could potentially be affected by a large number of factors (listed above), which range in likelihood from **rare** to **certain**.

Consequences

The potential consequences of any of these aspects (listed above) impacting on fauna habitats range generally from **minor** to **moderate**. The only potential 'major' consequence was from the possible spillage of hazardous materials, though management procedures will render this an unlikely event.

Monitoring at Port Hurd has shown that nutrients, emitted by the farm from fish faeces and possibly minor amounts of uneaten feed, are not affecting the nutrient-sensitive ecosystems, hence there is a low risk of impact on fauna habitats.

Given that a likelihood ranking has been factored into the risk ranking it is considered a reasonable approximation to average the risks assessed for each of these aspects (see Table 8.4). The average gives a result of **3.09**, i.e. there is a medium risk that bird, reptile, fish and mammal habitats could potentially be affected by the farm's operations. It is considered that this risk will be significantly diminished by the implementation of stringent mitigation and management methods which will be outlined in the EMP for the site, and summarized in Section 9.13.

Risk 3 = medium risk

8.16 EPBC Act-listed Threatened and Migratory Species

As noted in Section 6.14, 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 9.16 and 10.4; these will be further refined in the Environmental Management Plan to be drawn up for the proposed operation.

8.16.1 Risk Assessment

Likelihood

Displacement

It is not expected that any of the bird species listed in Table 5.1 (EPBC Threatened species for the proposed lease area) would suffer from displacement as a result of the presence of the nets within the proposed lease area as there are no documented feeding areas within the lease, which is entirely contained on water.

Most *cetacea* are not well documented within the Harbour (Whiting, 2003) and observations from the Channel Island Bridge by Whiting (2001) have not noted their presence in that part of Middle Arm.

The estuarine crocodile is expected to be present, but the presence of the nets would have negligible impact on its customary range as the proposed lease area is likely to only be a transit route rather than a feeding or resting area.

There are no known breeding sites for turtles or dugongs within Darwin Harbour, however the presence of dugongs and turtles around Channel Island Bridge is well documented (Whiting, 2001) (refer to Section 5.2.2). These were seen foraging on intertidal algae near the eastern end of the bridge.

It is considered **unlikely** that the presence of the proposed nets would cause any noticeable displacement of EPBC Act-listed threatened and migratory species from their customary feeding routes; the nets are placed within deeper water and higher current areas and both dugongs and turtles would be expected to generally use areas of gentler currents for feeding and transiting.

Predators

There is unlikely to be any significant increase in 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. Aggregation of fish beneath cages could encourage more predators to frequent the vicinity of the nets, however, this was not found to be the case at Port Hurd. It is therefore **unlikely** that there would be an 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. Boat speed will be limited to less than 5 knots in the vicinity of the lease and in shallow areas, and propeller guards will be fitted.

The risk of dugong, turtles and crocodiles getting entangled in nets is considered non-existent given that the nets are made of solid steel mesh.

Birds have not appeared to be disturbed around the Port Hurd pilot farm and are not expected to be around the Channel Island operation either. If birds are found to be feeding off the farmed fish, cover nets will be used; these will have small mesh size to prevent entanglement by birds.

It is therefore considered **unlikely** that any EPBC-listed species would incur any injury as a result of the presence of the proposed farm and associated operations.

Alterations to Seagrass Beds

Given the lack of reported seagrass beds in the vicinity of Channel Island, it is unlikely that the farm would cause any alterations to them. Should any small unreported seagrass beds be present, it is considered **unlikely** that they would be affected by the nutrient inputs from the farm, based on the monitoring results from the Port Hurd pilot farm (Section 7.1).

Night Lighting

There are no known turtle rookeries in Darwin Harbour. Night lighting will be limited to corner markers located low in the water and are therefore **unlikely** to affect any EPBC-listed species.

Noise and Marine Traffic

Darwin Harbour is already a fairly busy harbour, with commercial and recreational boats regularly navigating most of its reaches. It is considered that all local fauna species and those frequenting the Channel Island area (such as dugongs and turtles) would be already well adapted to the existing noise and traffic, and that the extra boat trips, generated by the proposed farm's operations, will not cause any significant extra disturbance. It is therefore **unlikely** that noise and marine traffic generated by the proposed farm would cause disturbance to the EPBC-listed species.

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, such as in the case of a marine animal being hit by an outboard motorboat equipped with a propeller-guard.

Risk 4 = low risk

8.17 Land Surface

Disturbance to land surface will be limited as the farm will be operated from pre-existing land-based facilities in the built-up port infrastructure at Berrimah. Disturbance to the land surface could potentially occur if unsealed areas exist within the site leased by Marine Harvest.

8.17.1 Risk Assessment

Likelihood

It is considered **unlikely** that the farm operations should impact on any land areas as Marine Harvest is intending to lease pre-existing facilities within the port facilities at Berrimah, which will have most of the infrastructure necessary for the operation. It is anticipated that the majority of the ground area of the premises will be covered with sealed pavements and floors. However, even if there were unsealed areas, Marine Harvest would ensure that any potentially contaminating activities would be carried out within the sealed impervious surface areas; this will be addressed in the EMP for the site.

Consequences

The consequences from any potential impacts on land surface would be **minor**, given that all potentially contaminating activities will be carried out on sealed surfaces. Mitigation and cleanup measures will be drawn up and included in the EMP for the site.

Risk 4 = low risk

8.18 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 engines odours and greenhouse gas emissions; noise generation from the operation of motor boats and pumps; lighting from the farm's corner markers; and general changes to the visual amenity of Middle Arm.

8.18.1 Noise

Noise from the operation of outboard motors, feeding equipment and harvesting operations has the potential to impact on the environment, in particular breeding populations of birds and animals. Disturbance of fauna is a potential issue in the case of rare or endangered species.

The project is situated in an area that is already impacted by port recreational and commercial activities, traffic noise over the Channel Island Bridge, the operations of the gas power plant in the south of the island, and the operation of the LNG plant to the north of the site, at Wickham Point. The increase in noise, due to the farm's operations, is therefore likely to be minimal.

8.18.2 Lighting

The presence of nets will require that corner night lights be present within the lease area. These could potentially disturb local fauna, however the area is already impacted by port recreational and commercial activities, traffic lights over the Channel Island Bridge, lights from the operations of the gas power plant in the south of the island, and lights from the LNG plant to the north, at Wickham Point.

8.18.3 Greenhouse Gases

The main sources of greenhouse gases would be 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 H. 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 35.41 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 6.44×10^{-6} percent to the total Australian emissions.

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

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

8.18.4 Risk Assessment

Likelihood

It is considered **likely** that the impacts listed in Section 6.16 will cause some low level and intermittent environmental nuisance, in the form of minor engine noise and gas emissions, night lighting and some visual impact, however it is considered **unlikely** that these effects would cause any notable disturbance to any local fauna.

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 to 3 = low to medium risk

8.19 Social and Recreational

Increased employment and training opportunities are seen as positive impacts from the farm and Marine Harvest is keen to make these opportunities available to local residents.

The presence of nets could present some access hindrance to the SS Ellengowan Shipwreck or to recreational fishing or boating activities.

8.19.1 Risk Assessment

Likelihood

It is considered **likely** that the farm's operations will have a positive impact on local employment and training opportunities as Marine Harvest will endeavour to employ local workers.

It is considered **unlikely** that there will be any significant hindrance from the farm presence on divers or recreational and fishing activities, as Marine Harvest will endeavour to provide ease of access to the shipwreck site by avoiding net moorings near the area, and it will also provide regular fishing days around the farm and will ensure its nets are well marked so boats do not collide with them.

Consequences

It is **possible** that divers or boaters could consider it a significant inconvenience to have to avoid the farm nets when using the area, however this consequence would be considered **minor** to **moderate**.

Risk 4 = low risk

8.20 Local Infrastructure

The main local infrastructure which will be used by Marine Harvest is the existing wharf facility at Berrimah. In addition, it is possible that some equipment or materials will need to use freight transporters which might include the use of road, rail or airport facilities. It may also be occasionally necessary to use the existing jetty facilities on Channel Island or on the mainland opposite Channel Island.

8.20.1 Risk Assessment

Likelihood

It is **unlikely** that any negative impacts should be incurred by the small increment in usage by the farm operations of the local infrastructure listed above; all these facilities already serve a large population base, and are already designed to cope with significant demands.

Consequences

The impact from the farm's usage of local infrastructure is considered to be **minor** as it will not be placing excessive demands on the facilities.

Risk 4 = low risk

8.21 Archaeological, Historical, Cultural and Aboriginal Sites

Since Channel Island will not be used for the purpose of building or servicing the proposed farm it is considered that the Leprosarium is not at risk of disturbance by the proposed barramundi farm development.

The SS Ellengowan wreck is a popular diving site due to its proximity to Darwin. It is located at a depth of 16 metres, at low water, which is well clear of the maximum depth of the fish nets. It is possible that a small amount of fish faeces and uneaten feed could deposit on areas of the wreck, however it is considered that tidal currents are likely to be strong enough for the effect to be minimal or non-existent. The main impact on the wreck is likely to be the presence of the operation which may hinder direct access to the wreck and may require recreational divers to show consideration for its presence. Marine Harvest will endeavour to ensure that nets are moored a safe distance from the wreck.

There are no other known cultural or Aboriginal sites near the proposed lease. Marine Harvest has been in contact with the Northern Land Council and the Larrakia People. Neither has voiced any opposition to the proposed lease area. An Authority Certificate (C2006/042) has been granted by the Aboriginal Areas Protection Authority for the proposed lease area for the purpose of a fish farm (refer to Appendix C).

8.21.1 Risk Assessment

Likelihood

Based on the above discussion, it is **unlikely** that any archaeological, historical, cultural or Aboriginal sites would be impacted by the proposed farm.

Consequences

The worst possible consequence could be the accumulation of small amounts of nutrient-rich wastes around the SS Ellengowan Shipwreck which could encourage a slight increase in algae growth. Given that the wreck probably already has some algae and other marine growth on its surface, a small potential increase is considered to be a **minor** consequence.

Risk 4 = low risk

8.22 Marine Traffic

Construction of the site will be via boat; nets will be towed by boat; and access to the farm nets will be via outboard motorboat or harvesting well boat.

8.22.1 Risk Assessment

Likelihood

The total number of outboard motorboat trips by the farm during construction and day-to-day operation will be very low, and are estimated to be a maximum of three return trips per day. Nets will be towed to or from the farm around once per month. Harvesting with a well boat will be around once to twice per month. Darwin already has a relatively busy

harbour so the proposed farm traffic increment is likely to represent a very small percentage (estimated to be less than 1 percent) in the main part of the harbour, and possibly up to 10 or 20 percent of the traffic in Middle Arm. It is therefore considered **possible** that there will be some noticeable increase in marine traffic in Middle Arm.

Consequences

The small increase in marine traffic could have as worst consequence the incrementing of disturbances which could bring about the displacement of shy marine species such as the dugongs. This impact is given a '**major**' rating, though it is considered **unlikely** due to the already existing traffic around Channel Island and the likely adaptation of the dugongs to these occurrences.

Risk 4 to 3 = low to medium risk

8.23 Insects 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 from the Darwin area and 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).

8.23.1 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 will 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

8.24 Personnel Emergencies

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

8.24.1 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

8.25 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	Moderate	3 = medium	Seabed disturbance will be temporary and localised.
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 to 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 to 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 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	Minor to 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 to 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	Major	3 to 2 = medium 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 to 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 to moderate	4 = low	Impacts are expected to be minor or moderate due to the location of the farm and the proposed management methods.
Corals	Unlikely	Moderate	4 = low	The most severe impact would be from a fuel spill, but this would be less than 100 litres, and would have only very localised and temporary impact on the reefs.
Bird, reptile, fish and mammal habitats	Rare / Certain	Minor to moderate	3 = medium (average of all aspects)	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	Unlikely	Moderate	4 = low	Baseline and Port Hurd information and monitoring suggests there is generally a low risk of impact on EPBC Act-listed, threatened or migratory species or their habitats. Mitigation and management methods will diminish most risks to a very low level. Most species in Darwin Harbour are already adapted to a disturbed environment.
Land surface	Unlikely	Minor	4 = low	Use of unsealed areas will be minimal.

Aspect	Likelihood of Impacts	Consequence of Impacts	Risk Ranking of Impacts	Comments
Air quality, noise, lighting and visual amenity	Unlikely	Minor	4 to 3 = low to medium	Only low level intermittent nuisance is likely.
Social / recreational	Unlikely	Minor to moderate	4 = low	Divers or boaters could experience some inconvenience from the presence of the farm in Middle Arm.
Local infrastructure	Unlikely	Minor	4 = low	Local infrastructure is able to already cope with capital-city marine and road traffic.
Archaeological / historical, cultural and aboriginal sites	Unlikely	Minor	4 = low	No notable impact expected.
Marine traffic	Possible	Major	4 to 3 = low to medium	The farm may increase boat trips along Middle Arm by a estimated 20 percent.
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 generally 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 and training programs to be provided to 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.

Construction will preferably be scheduled between September and December when dugong numbers are reportedly less and disturbance is less likely to impact on their usage of the area.

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, in particular contractors will be briefed in the requirements to minimize seafloor disturbance;
- 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 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 is 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 Channel Island. A maintenance schedule will be developed to include a routine inspection program for the nets and moorings (refer to Section 9.9).

Monitoring

Visual inspections 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. Management methods proposed at the Channel Island 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), and 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. 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 antibiotics 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, then disposed to the ensiler. After disposal of morts the boats will be disinfected prior to being used for feeding.
- The fish tanker 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 will test the juvenile fish for the 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 and does not break down as rapidly as chlorine when exposed to the sun.

Monitoring

Staff at Marine Harvest will monitor fish health 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, which 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 annual routine 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 the wet season when copious quantities of water enter the catchment. The scouring of sediment 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 production, 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 only resulted in 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 I. 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 nutrients 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].

The Channel Island marine farm that will generate wastes of various types as discussed in Sections 3.8.7 and 3.8.8. 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 Channel Island facility. An outline of the main aspects is discussed below.

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

Risk Ranking – Medium to Serious (for major spillage)

The paragraphs below outline the proposed waste management measures to be employed at the Channel Island farm.

9.7.1 General Mitigation Measures for Waste

Marine Harvest intends to implement a number of waste management actions. These will be detailed in the EMP for Channel Island and will include:

- 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

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

- 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 Channel Island 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 from dead fish carcasses (morts).

Mitigation and Management

Kitchen food scraps will be stored on the land base in a standard, sealed rubbish container, in a store room to prevent attracting birds or other scavenging species to the site. Kitchen scraps will either be removed 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 land base.

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 on 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 Solid Inert Waste

Solid inert waste is hard waste and dry vegetative material, which have negligible chemical impact on the environment. Solid inert waste from the Channel Island fish farm will include feed bags, plastics (kitchen and workshop), glass (kitchen and workshop), polystyrene (from damaged pens), 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

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

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.

9.7.4 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 Channel Island will only generate small quantities of prescribed wastes, 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 Waste Master, which is a licensed waste disposal company in the Northern Territory.

Monitoring

The farm will keep records of the quantities of prescribed waste which it disposes of, and the destination of its disposal.

9.7.5 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 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 land base 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 pertaining 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 to 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 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 are 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 Channel Island 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 Channel Island 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 Channel Island 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 for the site.

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 and moorings design options chosen for Channel Island 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 potential localized scouring of the seafloor 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 channel, 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 back channel of Middle Arm which is flushed by high currents. This channel was chosen in part because of its strong currents which will allow for 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 wildfish, 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 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 carried out baseline investigations at Channel Island 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 will include:

- Taking water samples from the Channel Island sampling sites from the top and bottom of the water column;
- Measuring temperature and salinity of the water at those locations at several minutes interval;
- 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 periodical monitoring will entail sampling from the same locations as those sampled during the Channel Island baseline survey by Aquenal (2005) and reported in November 2005.

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 α, 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:

- 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 and 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 – Medium 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.
- Minimising disturbance to any dugongs or turtles seen within the transit routes to and from the farm, or near the farm nets.
- Limiting night operations to an absolute minimum.
- Ensuring fish do not escape.
- Ensuring water and sediment quality is maintained via management of feed, wastes, chemicals, etc. (as outlined in sections above).
- 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 9.11 will prevent most potential indirect impacts to flora; and
- Induction of staff into the need to prevent and avoid any direct impacts to local flora from outboard motorboat uses, or any other.

Monitoring

Seagrasses

Given the lack of reported seagrasses in the area surrounding the farm (Whiting, 2001 and 2003), it is not considered necessary to monitor these specifically. Nutrient monitoring should pick up any early any changes to water quality which could later affect any existing seagrasses.

Mangrove Stands and Roots

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 Channel Island by Aquenal in 2005 (refer to Section 5.3). This will help to provide early indicators of potential nutrient accumulation in the quieter embayments identified by Aquenal (2005).

9.15 Corals

Risk Ranking – Low Risk

Mitigation and Management

The location of the Channel Island Reefs will be shown to all staff and contractors as part of their induction. They will be required to avoid interference with the reefs and to avoid mooring nets near the reefs.

Monitoring

Monitoring outlined in Section 9.11 for water and sediment quality, will pick up early any quality changes to these which could in turn potentially affect the Channel Island Reefs.

A video record was taken during the pre-dredge surveys (GHD, 2005) and will be repeated after the dredge operations. This post-dredge survey could be used as additional monitoring of the corals, if the timing is suitable for such a comparison.

Records will be kept of any comments received by divers visiting the reefs and complaints will be addressed immediately.

9.16 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 will include:

- Inducting all staff, visitors and contractors about the need to avoid disturbance to any wildlife encountered in the channel, in particular any dugongs and turtles;
- No feeding of wildlife will be permitted;
- Implementation of the mitigation, management and monitoring measures listed in Sections 9.2 to 9.14 will also help minimise potential impacts on EPBC Act-listed threatened and migratory species; these will include:
    - Implementing strict management of feed and wastes;
    - Limiting boat speeds in the channel 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;
    - Employing minimal and low impact night lighting;
    - Minimising night-time operations; and
    - Minimising noise from operations at the farm 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 or death and implementing changes to the operation should a link be identified between impacts to wildlife and the farm's operations.

9.17 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.

- The land base will restrict its operations to pre-existing sealed footprints within already established premises;
- The management of hazardous materials will follow methods outlined in Section 9.8;
- 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;
- Monitoring of unsealed surfaces where active farm operations take place, and taking corrective actions (i.e. remediation of land surface and operations procedure changes) if any impacts are identified.

Monitoring

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

- Carrying out regular (weekly) inspections of any unsealed surfaces within the land base;
- Carrying out an inspection of unsealed surfaces upon vacating the land base; and
- Recording any complaints received regarding any potential impacts to land surfaces, and taking corrective actions as appropriate.

9.18 Air Quality, Noise, Lighting and Visual Amenity

Risk Ranking – Low to Medium 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. All net construction will be carried out at the land base in Berrimah, hence any associated noise will be emitted only in that location.

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 emissions. The motors will also 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 Middle Arm.

Staff will be briefed in the need to keep attentive to the possible presence of large marine fauna and to keep a good distance from any sightings, particularly from dugongs, and to reduce their travel speed to less than 5 knots when in the vicinity of these animals.

Marine Harvest will endeavour to use the quietest pumps available for feeding and harvesting the fish. 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 for 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. Marine Harvest will investigate the feasibility of using low-impact lighting for night work at the farm.

Visual Amenity

The farm presence is low profile, with only around 0.5 metres of the nets protruding above the water surface. Low impact colours will be used whenever possible.

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 and lighting, and to air quality and visual amenity. Procedures will be put in place to ensure corrective actions are taken immediately.

9.19 Social and Recreational

Risk Ranking – Low Risk

Mitigation and Management

In order to provide opportunities for local residents to work at its proposed farm, Marine Harvest will advertise any staff and contracting positions locally. It will provide training where required.

Management methods will be put in place to ensure that all non-local staff are effectively inducted into the local cultural ways.

Net moorings will be placed away from the SS Ellengowan Shipwreck items in order to provide ease of access by divers.

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. A procedure will be put in place to ensure that all complaints are dealt with immediately and corrective actions taken.

9.20 Archaeological, Historical, Cultural and Aboriginal Sites

Risk Ranking – Low Risk

Management and Mitigation

Staff will be briefed in the significance and location of the SS Ellengowan Shipwreck items and of the Channel Island Leprosarium. They will be instructed in the need to avoid any disturbance to either of these sites.

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.

9.21 Marine Traffic

Risk Ranking – Low Risk

Mitigation and Management

Speed restrictions should be applied to all boats visiting the farm, eg. 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 related to the farm's operations, and corrective actions will be taken immediately by farm management to ensure procedures are implemented to minimise future incidents.

9.22 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.

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.

9.23 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.

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.

9.24 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 items 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.*
- *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 activites 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 the Northern Land Council;
- To minimise the footprint of the development; and
- To maintain a low impact facility.

Marine Harvest will operate its Channel Island 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 of Darwin Harbour.

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.
- 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's 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 J. These standard operating procedures (SOPs) will be reviewed and modified for the proposed Channel Island 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 the proposed Channel Island farm as they relate to the operation.

10.4 Monitoring and Reporting Strategies

A baseline monitoring report for Channel Island was prepared for Marine Harvest by Aquenal in November 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 E.

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 these 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

Aspect	Reference Section No.	Monitoring Activity	Frequency
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
Farm Fish Deaths	9.7.5	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

Aspect	Reference Section No.	Monitoring Activity	Frequency
		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
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	Mangrove stands and roots	Fortnightly, two-monthly, annually or biennially
Corals	9.15	Monitor water, sediments and flora as noted	As noted
EPBC-Act listed Threatened and Migratory Species	9.16	Monitoring of water, sediment and flora as noted	As noted
		Recording and assessing any complaints, reports or sightings of dugongs and turtles and any other wildlife presence or death	Ongoing
Land surface	9.17	Inspections of unsealed surfaces during occupation of land base	Weekly
		Inspections of unsealed surfaces upon vacating land base	On vacating premises
		Recording and assessing complaints	Ongoing

Aspect	Reference Section No.	Monitoring Activity	Frequency
Noise, lighting, air quality and amenity	9.18	Log book of operating hours of all noisy equipment	Ongoing
		Maintenance schedule to be followed for all motorized equipment	According to equipment maintenance schedule
		Recording and assessing any complaints	Ongoing
Social and recreational	9.19	Review and assess complaints or incidents reported	Ongoing
Archaeological, historical, cultural and Aboriginal sites	9.20	Record and review any complaints	Ongoing
Marine traffic	9.21	Record any incidents or complaints and assess	Ongoing
Pest insects	9.22	Incident reports to be review and assessed	Ongoing
Personnel emergencies	9.23	Incident, accident and emergency reports to be kept and assessed	Ongoing
Quality of farmed barramundi	9.24	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 near Channel Island has been in the public domain for over a year now. Information regarding the proposal and the pilot project at Port Hurd has been disseminated through the newspapers.

In January 2006, 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.

Formal public consultation was carried out in August and September 2005, and November 2005, details of which are provided below.

An Authority Certificate (C2006/042) has been granted by the Aboriginal Areas Protection Authority for the proposed lease area for the purpose of a fish farm (refer to Appendix C).

11.1 August to September 2005

Meetings were held in August and September 2005 with a number of government, non-government organisations and private stakeholders, these included:

- Peter Robinson of the Northern Territory Environment Centre,
- Department of Lands, Northern Territory Government,
- Department of Primary Industries, Northern Territory Government,
- Northern Territory Environment Protection Authority, formerly the Office of Environment and Heritage,
- Kate Hadden of the Tiwi Land Council,
- Snake Bay community people,
- Adele Pedder of the Environment Centre and Australian Marine Conservation Centre,
- Bill Briscoe of Crab Claw Island, Bynoe Harbour, Port Patterson, Northern Territory,
- Chris Makepeace of Amateur Fishermen's Association of the Northern Territory, and
- Paspaley Pearls, Bynoe Harbour, Port Patterson, Northern Territory.

Feedback from these meetings mostly centred on the need to answer all concerns raised regarding preservation of habitat and minimisation of risks to species of concern, namely turtles and dugongs. Concerns were also raised about the proposed farm's potential impacts on aesthetics and on game fishing; of particular concern was the possibility of wild fish aggregating under the farm's sea cages and therefore not being accessible to amateur fishermen. Restrictions to access to the channel and changes to water current flows due to the presence of the fish farm were also noted as issues of concern.

11.2 November 2005

An Open Day was held at Port Hurd on 22 November 2005. Around 70 people attended, a list of which is provided in Appendix K. A large number of the attendees were members of the Tiwi community on Melville and Bathurst Islands. The Tiwi Land Council and the Tiwi community have been very supportive of the Snake Bay proposal. Members of the Northern Land Council were also present at the Open Day. They have 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.

11.3 Future Consultation

Marine Harvest will continue to keep all stakeholders informed in its progress with the proposal and any changes to its operations.

Marine Harvest will also 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 around Channel Island, located in Middle Arm of Darwin Harbour.

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 Darwin Harbour.

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 proposed farm, near Channel Island, will have several differences in infrastructure with the Port Hurd operation; these include the use of smaller net sizes, reduced number of nets per mooring cluster, and an increase in the number of moorings per net, as well as a land base situated further from the proposed farm lease and within multi-use commercial wharf infrastructure.

Qualitative risk assessments have been carried out for all identified aspects and impacts of the proposed Channel Island 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 Channel Island 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 Channel Island 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 Channel Island farm can be operated with very low risk of impacting the immediate or surrounding environment of Middle Arm.

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 Larrakia aboriginal language groups of the Darwin 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 harbour and will endeavour to proactively address any issues that may arise.

13 References

Aquenal Pty Ltd, 2005: *Baseline Environmental Survey for the Monitoring of Biological Impact of Nutrients Released from a Proposed Aquaculture Operation near Channel Island, Darwin Harbour*, August 2005.

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 200*5, reported in January 2006.

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.

Bryars, S., Neverauskas, V., Brown, P., Gilliland, J., Gray, L., and Halliday, L., 2003: *Degraded seagrass meadows and evidence of eutrophication in Western Cover, Kangaroo Island.* Fish Habitat Program, Primary Industries and Resources South Australia, Adelaide, 2003.

Caldwell Connell Engineers, 1983: *Draft Environmental Impact Statement for Channel Island Power Station*, for the Northern Territory Electricity Commission, March 1983.

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.

Department of Environment and Heritage (DEH), 2004: *Assessment of the Ecological Condition of Freshwater Streams in the Darwin Region*; *Evidence from a survey of macroinvertebrate communities and water quality in the early dry season 2001*, Peter Dostine, Department of Environment and Heritage, permission from the Department of Insfrastructure, Planning and Environment (NT), 2004.

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.

Geoscience Australia, 1998: *Estuary Assessment Framework for Non-Pristine Estuaries* – Estuary 98 (Darwin Harbour), 1998.

GHD, 2005: *Darwin Wharf Project Coral Monitoring – Pre-Dredge Report*. Report prepared by GHD Darwin for Darwin Cove Consortium. August 2005.

Larson, H., 2003: T*he fishes of Darwin Harbour* from the Proceedings of the Darwin Harbour Public Presentations – February 2003.

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

McGuinness, K., 2003: *The Mangrove Forests of Darwin Harbour: A Review of Research on the Flora and Invertebrate Fauna*, from the Proceedings of the Darwin Harbour Public Presentations – February 2003.

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

NOAA: Oil Spills in Coral Reefs, Planning and Response Consideration, National Oceanic and Atmospheric Administration, National Ocean Service, Office of Response and Restoration.

Noske, R., 2003: *The Role of Birds in Mangroves: Pollination and Insect Predation*, from the Proceedings of the Darwin Harbour Public Presentations – February 2003.

Padovan, A., 2003: *Darwin Harbour Water and Sediment Quality*, from the Proceedings of the Darwin Harbour Public Presentations – February 2003.

Russell, B. C. & Hewitt, C. L., 2000: *Baseline Survey of the Port of Darwin for Introduced Marine Species* – A report to the Northern Territory Department of Transport and Works, September 2000.

Smit, N., 2003: *Marine Invertebrate Live in the Darwin Harbour Region and Management Implications* - from the Proceedings of the Darwin Harbour Public Presentations – February 2003.

The Environment Centre, NT, 2006: *Darwin Harbour – a precious Marine Environment*, The Environment Centre, Northern Territory, web site: www.ecnt.org.

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

Williams, D. and Wolanski, E., 2003: *Darwin Harbour Hydrodynamics and Sediment Transport*, from the Proceedings of the Darwin Harbour Public Presentations – February 2003.

Working Group to the Darwin Harbour Advisory Committee, 2003: *Management Issues for the Darwin Harbour Region,* June 2003.

Whiting, S., 2001: *Preliminary Observations of Dugongs and Sea Turtles Around Channel Island, Darwin*. Report to Power and Water Authority, Darwin, by Biomarine International, 2001.

Whiting, S., 2003: *Marine Mammals and Marine Reptiles of Darwin Harbour,* from the Proceedings of the Darwin Harbour Public Presentations – February 2003.

Limitations

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, Environmental and Heritage

Appendix B

Environmental Impact Statement Guidelines for Channel Island Proposed Aquaculture Farm

Appendix C

Aboriginal Areas Protection Authority, Authority Certificate Copy

Appendix D

Channel Island Bathymetry

Appendix E

Channel Island Baseline Report by Aquenal Pty Ltd

Appendix F

Port Hurd Biennial Report by Aquenal Pty Ltd

Appendix G

Paspaley Pearls Oyster Trials at Port Hurd

Appendix H

Greenhouse Gases Calculations

Appendix I

Fish Feed Residue Monitoring

Appendix J

Marine Harvest Port Hurd Standard Operating Procedures

Appendix K

Community Consultation Records