REPUBLIC OF MARSHALL IS

EIA REPORT

FISH FARMING

GFB Fisheries RMI Inc.

Majuro Aquaculture Farm

Majuro Lagoon

Environmental Impact Assessment

Draft/Revised/Final Report

January 2008

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LIST OF ABBREVIATIONS

Term	*Meaning / Definition*
GFB RMI	GFB Fisheries RMI Inc. – The proponent
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPA	Environmental Protection Authority
ML	Megaliters
RMI	Republic of Marshall Islands
MIMRA	Marshall Islands Marine Resources Authority

GLOSSARY OF TERMS

Environmental Management Plan (EMP) -- Either a stand-alone document or an attachment to an Environmental Impact Assessment Report, summarizing the mitigation measures and constraints identified in the EIA and identifying the actions required to implement them before, during and after construction. The EMP also sets out who has responsibility for implementing these actions and provides a mechanism to incorporate additional mitigation measures or modify specified action as required during the detailed design and construction of a project.

Environmental Impact Assessment (EIA) – Applied at the project level. It is a process intended to ensure that environmental impacts of schemes are identified prior to any work being carried out so that proposals can be modified or managed in such a way that adverse impacts are avoided or minimized.

Environmental Impact Assessment Report –The document that is formally required by EIA legislation as part of the EIA process.

Non-Technical Summary

Introduction and Background

GFB Fisheries RMI Inc. proposes to develop an aquaculture farm in Majuro for the production of marine fish. Species that are under consideration for farming in the RMI are humphead grouper (*Cromileptes altivelis*), leopard coral grouper (*Plectropomus leopardu*), giant grouper (*Epinephelus lanceolatus*), Tiger Grouper (*Epinephelus fuscoguttatus*), cobia (*Rachycentron canadum*), yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*) and tropical rock lobster (*Panulirus penicillatus*). Further species may be considered in the future depending on technological developments and the economics of production.

According to the United Nations Food and Agriculture Organization, 18.84 million metric tons of fish, crustaceans and mollusks were farmed globally in marine waters in 2005 with an additional 29.31 million metric tons farmed globally in freshwater. This compares with 93.25 million metric tons of fish, crustaceans and mollusks that were produced by the worlds capture fisheries (fresh and saltwater) in 2005. There is a general consensus that aquaculture production will continue to grow in importance compared to wild catch fisheries over the coming decades.

Seacage aquaculture is the most effective way of growing commercial quantities of high quality fish and the only technology suitable for significant levels of fish aquaculture in the Marshall Islands. Numerous studies have demonstrated that appropriately sited and sized seacage farms have minimal impacts on the environment.

Worley Parsons and GFB Fisheries RMI Inc. have prepared the following Environmental Impact Assessment for the production of up to 50,000 tons per annum of seafood in defined sites within the central parts of Majuro Lagoon. Impacts on the environment of this fish farm are minimized by the large water volumes and flush rates at the proposed sites. Mass balance modeling of the nutrient dynamics associated with full production of the farm reveals a level of impact on water quality well within environmentally sound levels. Minimal land-based impacts are associated with the farm due to most activities and infrastructure being located on the water.

All of the aquaculture activities will be located in less than 800 hectares, or 2% of the lagoon surface area. At full production the proposed farm would directly employ approximately 400 people, of which about 10 would be foreign. There will also be significant indirect employment from the operation through service activities, processing of production and flow-on economic impact.

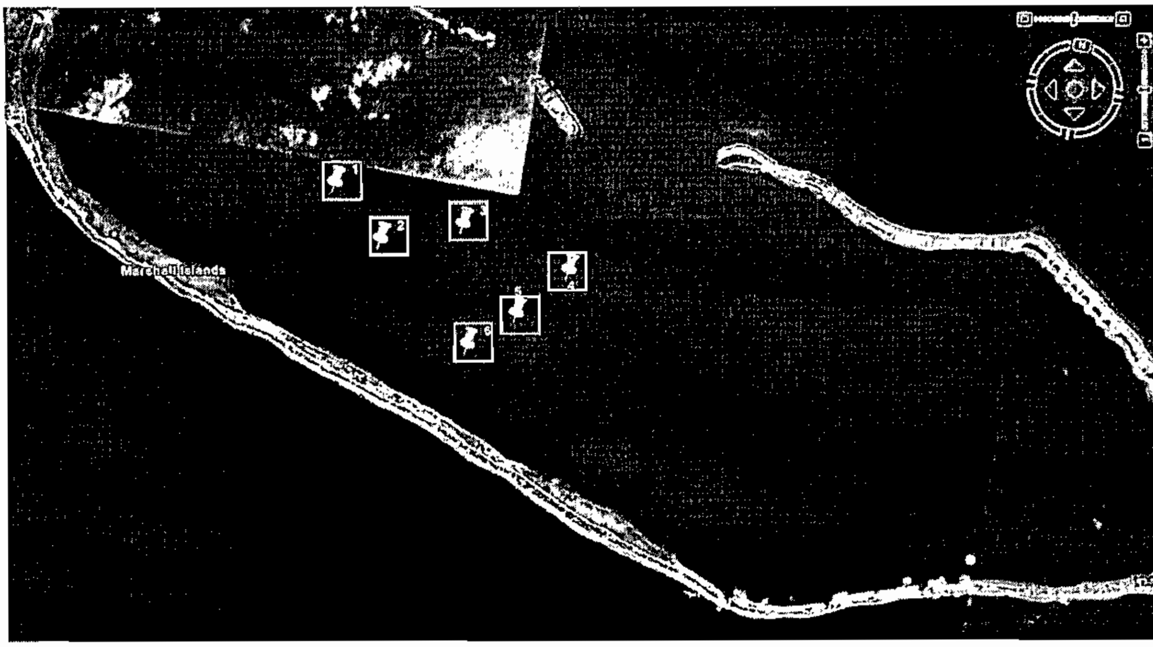
Summary of the Need for the GFB Fisheries aquaculture farm

1. Aquaculture is required to meet growing global demand for seafood in the face of static or declining wild fishery production.
2. Some of the species that will be farmed in Majuro by GFB Fisheries are highly threatened by over fishing – the farming of these species helps to reduce pressure on wild species.
3. The Republic of Marshall Islands currently has a weak and narrowly based economy and high unemployment – there are very few industries other than aquaculture that has the potential to bring this level of economic development to the RMI and employ large numbers of Marshallese.

Location

The proposed aquaculture cage sites will be located in a number of sites within Majuro lagoon. These sites will be accessed by boat, primarily from existing docks in the Uliga area, however potentially from other locations closer to the cage sites, such as the Woja area. It is also proposed that barges be permanently moored at the cage locations to provide storage, working areas and accommodation on site. This will minimize travel between the sites and docks.

The areas of Majuro Lagoon that are proposed for the location of the aquaculture farms are displayed in Figure 1.1.



Source: Google Earth 2007, GFB RMI Inc

Figure 0.1: Proposed Zones for GFB Fisheries Fish Cage Siting

These zones have been chosen as the optimal in terms of minimizing impacts on the environment, residents and other users of the lagoon. They were selected as the optimal solution to:

- **Flushing:** Modeling conducted by Kraines, Isobe and Komiyama (2001) indicates that these zones are the best flushed throughout the year to the open ocean through Calalin Channel;
- **Water circulation:** Nutrients added to these zones will have minimal impact on the relatively polluted and poorly exchanged far eastern corner of the lagoon;
- **Sensitive habitats:** The zones are located away from significant areas of coral habitat;
- **Depth:** The zones are exclusively in water greater than 30m in depth. The depth of water provides both a large buffer to water quality and a significant distance for waste remediation in the water column;
- **Visual impacts:** While all sites will be well marked for marine navigation, these zones are away from major shipping routes, population centers and recreational and tourist destinations;
- **Access:** While suitable areas exist closer to the main wharves in Majuro, these zones are acceptably accessible under most conditions by boat;

The data supporting these factors is discussed further in the EIA.

Summary of Proposal

Table 0.1: Key Characteristics Identifying the Details of the Proposal

Element	Description
Life of project	• Increase production over time to a maximum of 50,000 metric tons per annum. • Ongoing
Location	Majuro Atoll, Republic of Marshall Islands (See Attachment 1 for precise locations)
Species cultured	Species currently under consideration: • Cobia (*Rachycentron canadum*) • Humphead Grouper (*Cromileptes altivelis*) • Leopard Coralgrouper (*Plectropomus leopardus*) • Giant Grouper (*Epinephelus lanceolatus*)

	• Tiger Grouper (*Epinephelus fuscoguttatus*) • Yellow fin Tuna (*Thunnus albacares*) • Bigeye Tuna (*Thunnus obesus*) • Tropical Lobster (*Panulirus penicillatus*)
Source of fish fingerlings	• Australia – All species (bio-secure hatchery) • Marshall Islands - Tuna species only
Expected production • Maximum	• 50,000 tons/annum
Size of proposed aquaculture lease area • Maximum	• 750 hectares consisting of 6 x 125 hectare sites
Size of marine cages • Nursery • Growout	• Up to 6m (length) x 5m(width) x 5m (depth) • Between 50m and 130m circumference.
Volume of marine cages (dependent on circumference) • Nursery • Growout	• Up to 150 cubic meters • 1,200-13,454 cubic meters
Stocking density within marine cages • Nursery • Nursery maximum • Growout • Growout maximum (holding)	10-15 kg/m^3 25 kg/m^3 15-20 kg/m^3 40 kg/m^3
Feed input • Maximum	• 210 tons/day
Fish Excretions • Nitrogen Maximum • Increase in Nitrogen in Majuro lagoon water (Mass-balance point) • Phosphorus Maximum • Increase in Phosphorus in Majuro lagoon water (Mass-balance point)	10,470 kg/day Order of Magnitude 1/100 mg/liter 2,670 kg/day Order of Magnitude 1/1,000 mg/liter

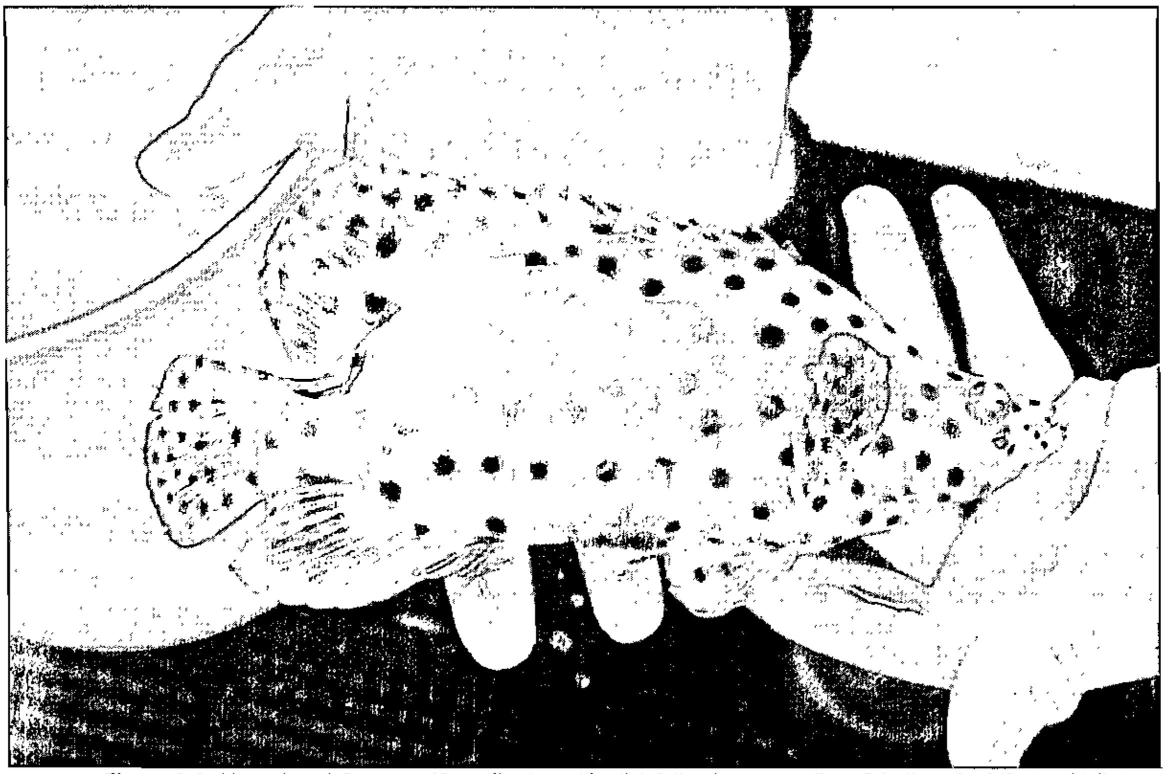


Figure 0.2: Humphead Grouper (Cromileptes altivelis) following 6 months of Culture in GFB RMI Pilot Seacage off Lobekerae Island, Majuro.

Alternative Options and Locations Considered

Alternative options and locations considered other than seacages in Majuro Lagoon are:

- The Do Nothing option;
- Alternative Atoll in the RMI;
- Cages located external to Majuro Atoll; and
- Land-based operation.

The Proposed Scheme

The proposed project involves the farming of fish in Majuro Lagoon for sale to markets in Asia, North America and Australia. A simplified account of the process is displayed in Figure 0.1.

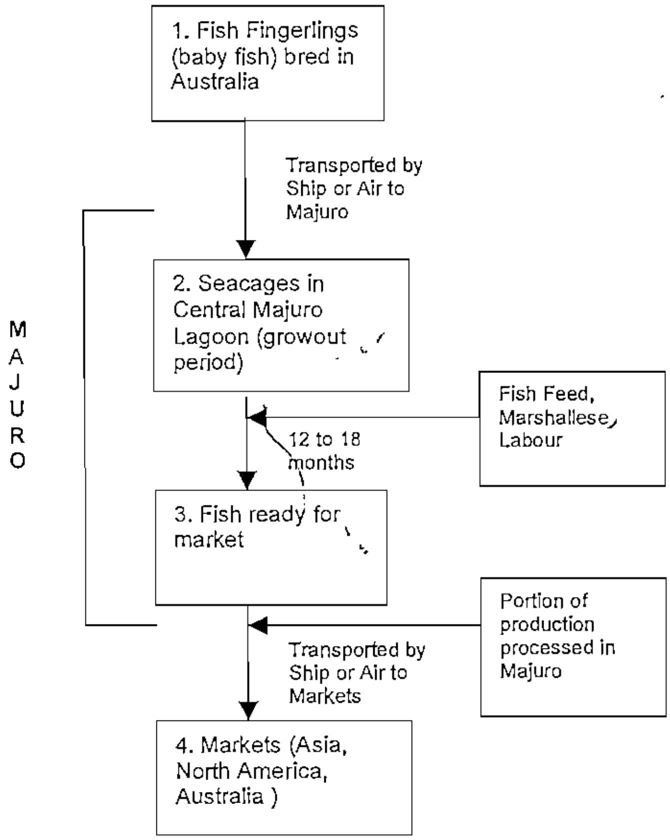


Figure 0.1: Schematic of the Proposed Project

The facilities to produce 50,000 metric tons per annum of fish production are to be situated in 6 x 125 hectare fish farming sites with central Majuro Lagoon (Figure 0.2).

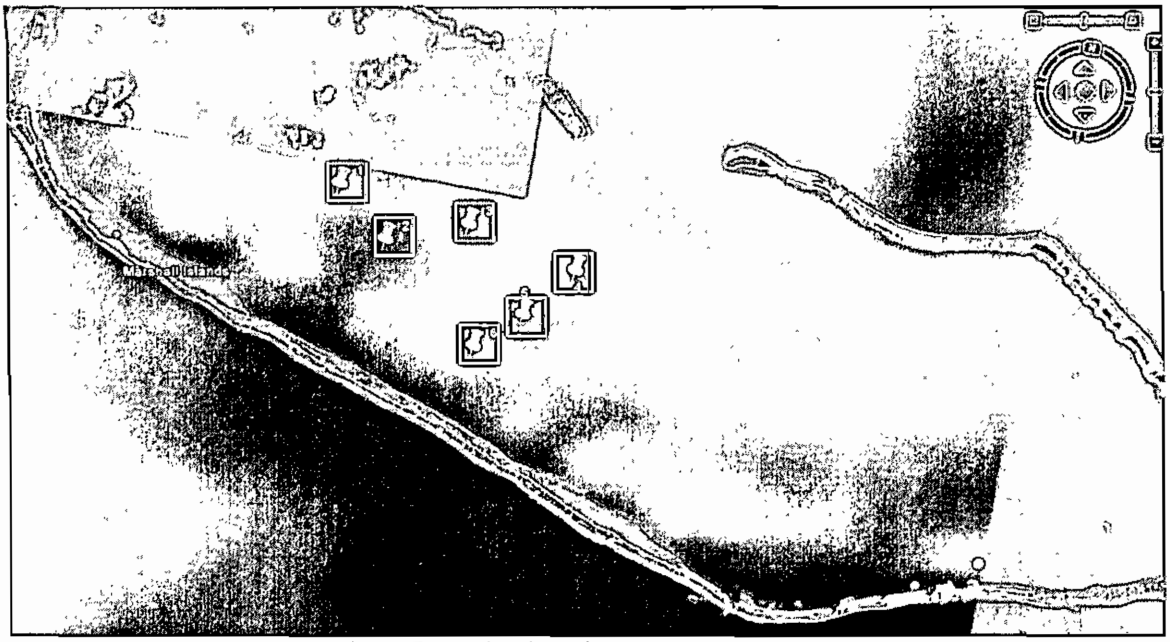


Figure 0.2: Proposed Fish Farm Sites in Majuro Lagoon

The scale of the infrastructure within each fish farm site is displayed in Appendix A: Figure 8.3.11. GFB RMI currently plans to expand production in three main stages. Between each stage GFB RMI will review the operation of the farm and the existing economic conditions before expanding to the next stage of production. These stages are:

Stage 1: Up to 6,000 to 10,000 metric tons per annum. This would require the operation of 1 x 125 hectare fish farm site. It is also proposed that the current pilot site at Lobekerae Island be continued with production of up to 500 metric tons per annum during this stage until sufficient infrastructure and security is located on the new sites to accommodate nursery functions;

Stage 2: Up to 30,000 to 35,000 metric tons per annum This would require the operation of 3 x 125 hectare fish farm sites; and

Stage 3: Up to 50,000 metric tons per annum. This would require the operation of 5 x 125 hectare fish farm sites. The sixth site is required is a potential 'spillover' site for seacages with fallowing movements at the other 5 sites.

It is aimed to accommodate as much of the fish farming infrastructure within the fish farm sites in central Majuro Lagoon as possible. As the operation grows barges and platforms on site will enable fish feed, fuel and equipment to be stored on site minimizing traffic and disturbance to the eastern portion of Majuro. Much of the construction and maintenance will be able to be conducted on the barges and sleeping quarters will enable staff to be present at the fish farm sites 24 hours per day, 7 days per week.

Key Features of the Environmental Baseline

The proposed fish farm will be located within Majuro lagoon. The relevant existing environment to the development is the Majuro Lagoon Aquatic environment. The lagoon consists of a large (324 square kilometer) area of water with an average depth of 46 meters of a relatively flat bottom consisting of coral aggregate. Key features of the environment with regards to the fish farm project are:

- Coral reefs on the rim of the atoll with the most pristine being those on the northern shore;
- Relatively low value environment of coral aggregate flats in the areas within and surrounding the proposed fish farm sites;
- Surrounding ocean of very low nutrient water and strong currents;

- Significantly degraded water quality in the far eastern portion of the lagoon with more pristine water quality in the central and western lagoon; and,
- Average lagoon exchange rate of 15 days, with lower exchange rates in the eastern lagoon and highest in the central lagoon through Calalin and Western Channels.

Majuro Lagoon has a number of physical features that make it well suited to minimize the environmental impacts of fish farming. Key to the ability of the lagoon to assimilate the impacts of fish farming are its sheer size and strong flush rates to the open ocean.

Environmental Impacts and Proposed Mitigation Measures

The potential environmental impacts associated with the proposed fish farming operations along with proposed mitigation measures outlined below in Table 0.2.

Table 0.2: Summary of Key Impacts and Mitigation Measures

Receptor / Environmental Resource	Description of Impact	Mitigation Measures
Human Beings and Land Use	**Construction impacts**	
	Increased boat traffic	GFB RMI aims to minimize the amount of boat traffic to and from the fish farm sites by: • Mooring large service barges on site to store feed, supplies and some equipment; • Ferrying farm workers to site on several large boats; • Providing accommodation on boats on site; and • Working with RMI authorities to develop procedures for import / customs / quarantine inspections at sea to avoid double transfer of goods and unnecessary use of the ports in Majuro.
	Employment generation	Nil, positive impact
	Increased skills of Marshallese	Nil, positive impact
	Operational impacts	
	Restricted access	Position fish farm sites in low use areas.
	Restriction of recreational fishing	Position fish farm sites in areas of low value to recreational fishing.
	Impact on other businesses	Position fish farm sites distant from other businesses.
	Restriction of boat traffic	• Position fish farm sites in areas of low boat traffic. • Allow passage between fish farm sites. • Ensure sites are clearly marked for marine navigation day and night.
	Increased skills of Marshallese	Nil, positive impact
	Employment generation	Nil, positive impact
Habitats and	**Construction impacts**	

Receptor / Environmental Resource	Description of Impact	Mitigation Measures
Species	Placement of mooring blocks	• Use of permanent moorings for boats in order to minimize the need for dropping anchors in various parts of the farm; and, • Sites where moorings are to be placed will be inspected to ensure any bommies or potential higher value habitat is avoided.
	Operational impacts	
	Aggregation of wild fish assemblages	Considered partly positive impact in mitigating fish waste.
	Changes to macrobenthic assemblages	Considered partly positive impact in mitigating fish waste. The location of the fish farm sites in relatively deep water will reduce the potential for this impact. Measures to mitigate impacts of changes to macrobenthic assemblages are: • Moving of cages around the lease area to provide fallowing ; • Use of pellets for food to minimize wastes; and, • Monitoring of feeding to minimize waste.
	Boat strike when traveling to site	Nil
	Disease and pathogen transfer to the wild	Measures to mitigate the risk of disease and pathogen transfer to the wild are: • Remove any dead fish from cages ASAP; • Use appropriate existing disease management protocols (stress management, sampling for disease where appropriate); • Do not overstock cages;
	Entanglement of megafauna	Measures to mitigate this risk are: • Separate predator nets not to be used; • Removal of any dead fish from cages ASAP to minimize attraction to cages; • Use of rigid netting material for cages; and, • Ensure all ropes/cables etc and cage material is taut.
	Escaped stock	Measures to mitigate this risk are: • Regular checking of cage material to ensure integrity • Ensure cage material and structures are engineered to withstand extreme weather events; • Ensure that species are endemic; and, • Ensure good site security.
	Food web changes	Food web changes in the near field are in positive in helping to mitigate fish wastes. Measures to mitigate this impact are:

Receptor / Environmental Resource	Description of Impact	Mitigation Measures
		• Moving of cages around the lease area to provide fallowing; • Use pellets for food to minimize wastes; • Use a feeding regime that minimizes waste; and, • Remove any dead fish from cages ASAP.
	Seabird interactions	Taught bird nets will be used over the cages and netting type reviewed in tangling of seabirds proves to be a problem.
	Sediment changes	Measures to mitigate this impact are: • Ensure cages are sited in an area with a high flushing rate; • Ensure cages are in relatively deep water; • Moving of cages around the lease area to provide fallowing if sediment deteriorates; • Use pellets for food to minimize wastes; • Use a feeding regime that minimizes waste; and, • Remove any dead fish from cages ASAP.
	Water quality (near field)	Measures to mitigate this impact are: • Ensure cages are sited in an area with a high flushing rate; • Use pellets for food to minimize wastes; • Use a feeding regime that minimizes waste; • Remove any dead fish from cages ASAP; and, • Monitor water quality parameters (Nitrogen, Phosphorus and Chlorophyll a).
	Water quality (intermediate field)	Measures to mitigate this impact are: • Ensure cages are sited in an area with a high flushing rate; • Use pellets for food to minimize wastes; • Use a feeding regime that minimizes waste; • Remove any dead fish from cages ASAP; and, • Monitor water quality parameters (Nitrogen, Phosphorus and Chlorophyll a).
	Translocation of species	Measures to mitigate this impact are: • Ensure cultured species are endemic; • Exchange ballast water at least 30 miles from Majuro; • Ensure all fish imported are from controlled hatcheries; and

Receptor / Environmental Resource	Description of Impact	Mitigation Measures
		• Prophylactically treat fish tanks during shipping to the RMI to kill any potential invertebrates in the tanks.
Geology and Coastal Processes	**Construction Impacts**	
	N/A	
	Operation Impacts	
	N/A	
Water	**Construction impacts**	
	Disturbance of sediments	• Use fixed mooring buoys for boat anchorage. • Use mooring blocks and anchors designed to 'dig and hold' rather than drag.
	Operational impacts	
	Increase in nutrient levels	• Feed formulated pellets only. • Avoid overfeeding. • Locate fish farm sites in high flush areas. • Cap fish production to levels within assimilation capacity of the environment. • Monitor water quality.
	Introduction of chemicals	Maintain equipment in good order to minimize the chance of fuel or oil leaks.
Waste	**Construction impacts**	
	Production of waste materials from construction and mooring of seacages	Utilize prefabricated seacages and equipment where possible.
	Mooring blocks and anchors	Nil.
	Operational impacts	
	Consumable goods waste	Utilize bulk feed containers (Reusable) where possible.
	Waste from Decommissioned Farm Materials	Either sell decommissioned materials on island where they are reusable, recycle, incinerate or take the materials off island.
Air, Climate, Noise and Vibration	**Construction impacts**	
	Increased noise from construction on land	Utilize existing industrial localities for land-based construction.
	Increased noise from construction on water	• Maximize distance of fish farm sites from residential areas; • Conduct farm construction activities between sunrise and 10pm.
	Increased boat traffic	Utilize barges / work platforms on site to minimize boat movements to site.

Receptor / Environmental Resource	Description of Impact	Mitigation Measures
	Operational impacts	
	Increased boat traffic	Utilize barges / work platforms on site to minimize boat movements to site.
Landscape and Visual Amenity	Construction impacts	
	Visual impact at component assemblage sites	Utilize existing industrial localities for land-based construction.
	Operational impacts	
	Visual impact of farm and service vessels	• Maximize distance of fish farm sites from residential and tourism areas. • Minimize lighting from 10pm to sunrise to that required for safety and navigation.
Cultural Heritage, Archaeology	Construction impacts	
	N/A	
	Operational impacts	
	N/A	
Traffic and Transport	Operational impacts	
	N/A	
	Construction impacts	
	N/A	

Conclusion

It is intended to accommodate the majority of equipment and activity associated with the construction and operation of the fish farm within the fish farm sites in central Majuro Lagoon. In this way, the proposed farm will have minimal negative impacts on the land areas of Majuro and on the more heavily utilized eastern portion of the lagoon.

The potential environmental impacts of fish farming are well understood with similar fish farms to that proposed operated throughout the world. Majuro lagoon is well situated to mitigate the environmental impacts of an appropriately sized, located and operated fish farm. The proposed fish farm sites have been selected to be distant from high value habitats and to maximize water exchange with the open ocean. All fish fingerling and feed inputs will be from controlled sources and water quality and nearby habitats will be monitored to ensure that the environmental impacts remain within acceptable parameters.

1 Introduction and Background

1.1 Purpose and Need of the Document

1.1.1 Document Purpose

The RMIEPA General Manager has determined that in order for GFB Fisheries RMI Inc. to proceed to commercial scale production of fish in Majuro Lagoon an Environmental Impact Assessment is required.

The Republic of the Marshall Islands Environmental Protection Authority Environmental Impact Assessment Regulations (1994) states that the purpose of the Environmental Impact Assessment (EIA) is as follows:

> *"EIA's are intended to help the general public and government officials make decisions with the understanding of the environmental consequences of their decisions, and take actions consistent with the goal of protecting, restoring, and enhancing the environment. These Regulations are designed to integrate the EIA process into early planning of projects to ensure timely consideration of environmental factors and to avoid delays, as well as to identify at an early stage the significant environmental issues facing the Republic."*

The EIA process is described as:

> *"An analytical system of assessing and reviewing environmental consequences that may result from proposed development activities, beginning at the inception and ending at the completion or decommissioning of a proposed development activity, during which various environmental analyses and documents are prepared, reviewed and approved, in accordance with these Regulations."*

The environment is defined as:

> *"The physical factors of the surroundings of human beings and includes the land, soil, water, atmosphere, climate, sound, odors, tastes, and the biological factors of animals and plants of every description situated within the territorial limits of the Republic including the exclusive economic zone."*

1.1.2 Report Structure

1. Introduction and Background:
2. Description of Proposed Works:
3. Consultation:
4. The Baseline Environment:
5. Environmental Impacts and Mitigation:
6. Conclusions and Recommendations:
7. List of Prepares:
8. Environmental Management Plan
9. References
10. Appendices

1.2 EIA process

GFB Fisheries RMI Inc. has previously submitted an Operations Brief and Environmental Management Plan to the RMI EPA for the conduct of pilot aquaculture operations. The RMI EPA reviewed the Environmental Management Plan (EMP) submitted by GFB Fisheries RMI Inc. for the pilot aquaculture production of up to 50 tons per annum of Humphead grouper (*Cromileptes altivelis*) in Majuro Lagoon, and approved the pilot for a three (3) year period effective from March 2007. The RMI EPA stated that it 'is satisfied that the construction, operating, decommissioning and monitoring procedures outlined in the EMP are adequate'.

The RMI standards for approval are (Section 32. Standards for approval, pp 6 – 17):

a) When an EIA has been submitted, the Authority shall not approve the EIA as proposed if the Authority finds omission or inadequate treatment of any practicable alternative or practicable mitigation measures, within its powers or the powers of the proponent, that may substantially lessen any significant impact the proposal may have on the environment to an acceptable level.

b) As used in this Regulation, the term "acceptable level" means that the EIA describes:

   i. all significant adverse environmental effects that may be avoided have been eliminated or substantially lessened;

   ii. any remaining, unavoidable significant impacts are acceptable considering the balance of the benefits of a proposal against its unavoidable environmental risks.

The EIA process that will conducted by GFB RMI in regards to the proposed fish farm will follow the standard procedures outlined in the RMI Environmental Legislation (Environmental Impact Assessment Regulations, 1994):

- Project Brief (submitted);
- Scoping Report (submitted);
- Stakeholder Consultation (Within this report);
- Environmental Impact Assessment Report (Within this report);
- Environmental Management Plan (Appendix to this report);
- Public Hearing (Pending);
- RMIEPA Board Approval Process; and
- EPA Monitoring of EMP for Compliance.

The EIA addresses the following legislation and regulations:

- National Environment Protection Act 1984;
- Coastal Conservation Act;
- MIMRA Act;
- EIA Regulations 1994;
- Marine Water Quality Regulations 1992; and
- Solid Waste Regulations.

The EIA process covers all regulation compliance and permits required from MIMRA and RMIEPA.

The approvals required by GFB RMI from the RMI EPA are:

- Approval of the Environmental Impact Assessment for the aquaculture of 50,000 tons per annum of fish in Majuro;

- Approval of the Environmental Management Plan for the aquaculture of 50,000 tons per annum of fish in Majuro;

- Permit for the establishment of fish farming infrastructure (cages and mooring) within the outlined cage sites;

The approvals required by GFB RMI from MIMRA are:

- Permit for exclusive use of the 6 proposed fish farm sites for fish farming activities and operations;

- Permit for import of the proposed species from Australia;

- Approval of quarantine protocol for import of proposed species from Australia.

1.3 Background to the Project

1.3.1 Introduction

GFB Fisheries, an Australian company, was formed in 2002. The company has recorded a number of important achievements in this time including:

- Growth to Australia's largest barramundi producer;

- Australia's, and one of the world's, largest marine finfish hatchery's;

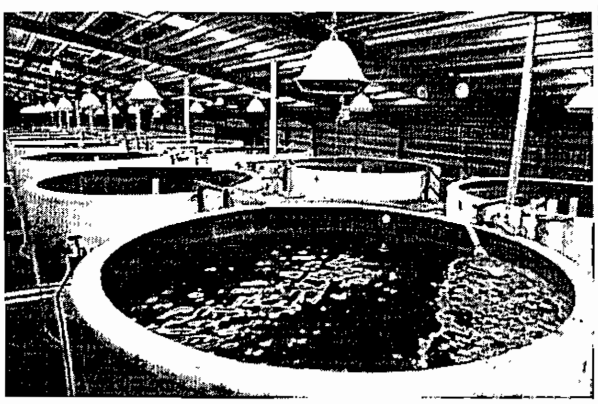
- The world's first regular hatchery production of humphead grouper;

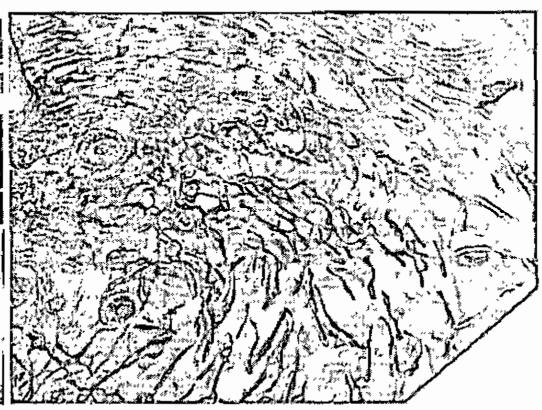
- Successful hatchery production of a number of difficult reef fish species; and

- Australian first production of species such as cobia and humphead grouper.

The company operates several sites in Australia, supplies fish fingerlings to growers across Australia, is involved with major collaborative research projects (such as world-first attempts to breed southern blue-fin tuna) and is investigating options to expand production in other countries such as India.

Some images of the company's facility at Bowen, Queensland, are show below.





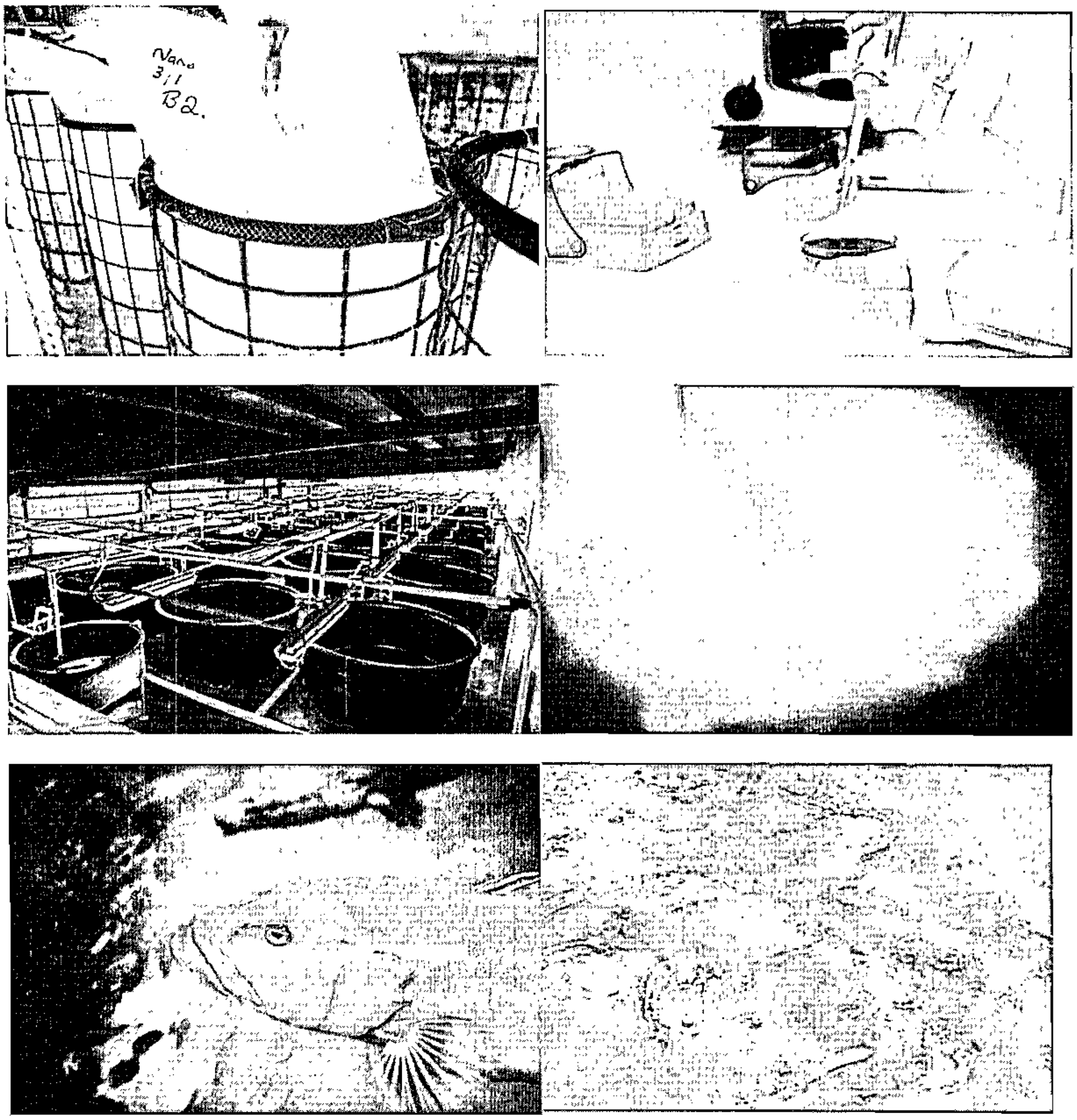


Figure 1.3.1: Collage of Images of GFB Fisheries Australian Hatchery Facility

In Australia GFB Fisheries has become limited with available sites to grow the fish that its hatchery produces. Australia is limited in good quality tropical marine aquaculture sites. Those areas sufficiently close to a population base suffer from variable water quality and winters that cool enough to increase the disease risk to the fish. While these constraints are not a major problem for hardier species such as barramundi, they impact on the viability of production of sensitive species such as the groupers.

In addition, Australia is currently experiencing a very tight labor market and any expansion of production is limited by the ability to find suitable people to care for the fish.

In 2005 GFB Fisheries began to investigate the potential for producing fish in India, Indonesia and the Philippines. The primary considerations were:

- Excellent, consistent water quality (to enable the economical growout of the high value reef fish species);
- Consistent, warm water temperatures;
- Political and financial stability;

- Suitable logistics (sea and air) particularly to Asia and North America; and
- Sufficient labor supply.

In 2006 GFB Fisheries became aware of Majuro as a potential production site. Majuro had the advantage of particularly good water quality and scored well in all objectives except for the cost and difficultly of logistics. In early 2007 GFB Fisheries RMI Inc. was registered in the Republic of Marshall Islands and approval for pilot scale production of humphead grouper granted by the RMI EPA. Small numbers of humphead grouper were flown to Majuro from the end of the hatchery season in Australia. Despite a number of delays with shipping equipment to the Majuro and problems in the quarantine system the fish responded the excellent water quality conditions and performed well. Continued investigations on the viability of the Majuro site indicated that the logistic problems could be mostly overcome as the farm achieved economies of scale, by operating dedicated ships for the transport of fish, feed and some equipment. The board decided to upscale the project in Majuro, ahead of other potential sites in Asia.

1.4 Project Objectives

Economic Objectives

The project is being established by a private company for the purpose of business profit. In the process, the project will bring very substantial economic benefits to the Republic of Marshall Islands. Expected benefits include:

- The creation of approximately 400 full time jobs directly through the farming activities. About 10 of these positions are anticipated to be filled by foreign staff, the rest will be sourced from the local population of Majuro. Further full-time jobs will be created in support industries and processing in Majuro;
- At full production the operation will turn over many millions of dollars in the RMI, generating significant tax revenues for the RMI government. The RMI currently has a heavy reliance on foreign aid and few industries that it can pursue to grow the local economy;
- The project will significantly increase the amount of freight between the RMI and other countries. This increase in volume will improve economies of scale in freight to the RMI and should result in a lower freight component being paid for a variety of goods by the Marshallese people.

Technical Objectives

The technical objectives of the project are:

- To produce a variety of fresh fish for markets in Australia, the USA and Asia;
- To develop and maintain infrastructure for the farming of up to 50,000 tons per year of fish.

Environmental Objectives

The environmental objectives of the project are:

- Maximize the amount of work that can be conducted within the sites by the use of barges and platforms;
- Maintain production limits within the capacity of Majuro lagoon to assimilate and flush wastes;
- Not significantly contribute to the degradation of the far eastern lagoon;
- Maintain the quality of the production sites for the ongoing production of healthy fish; and,
- Produce no significant adverse environmental impacts beyond the intermediate field (1000 meters from the fish farm sites).

2 Description of the Proposed Works

2.1 Site Location

The project is proposed to be located in central Majuro Lagoon in the Republic of Marshall Islands. The site is displayed in detail in Appendix A: , Figure 8.3.1. The location of the proposed sites within Majuro Lagoon are also displayed below in Figure 2.1.1.

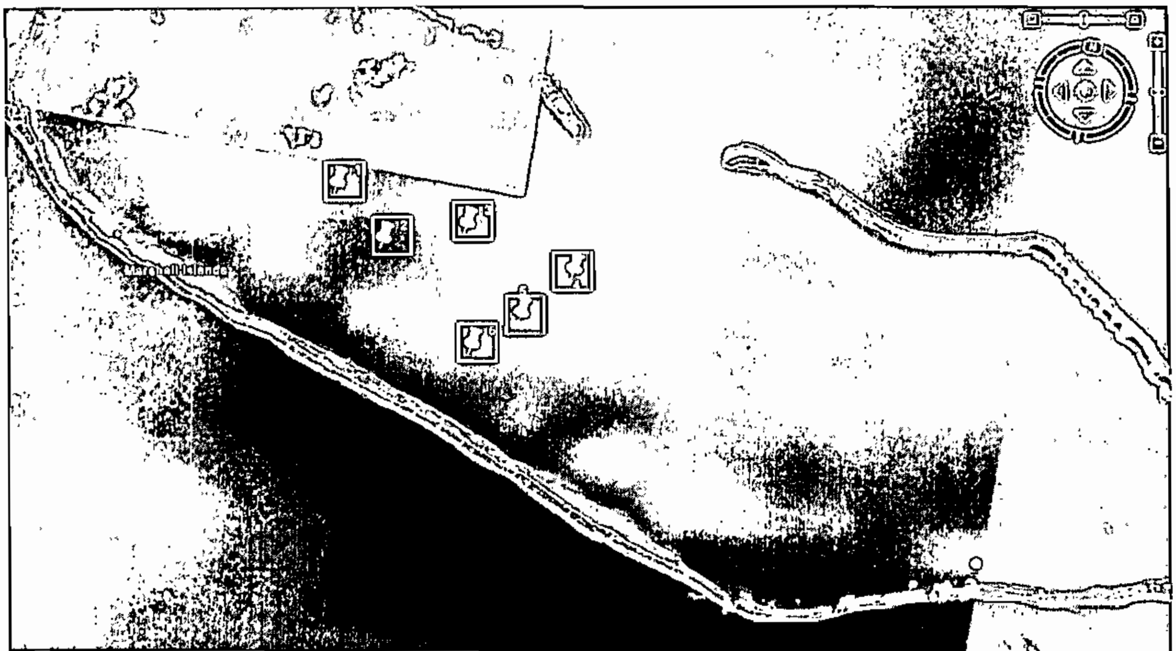


Figure 2.1.1: Proposed Location of Fish Farm Sites within Majuro Lagoon (White Squares)

The sites are numbered and displayed to scale, latitude and longitude in Figure 2.1.2.

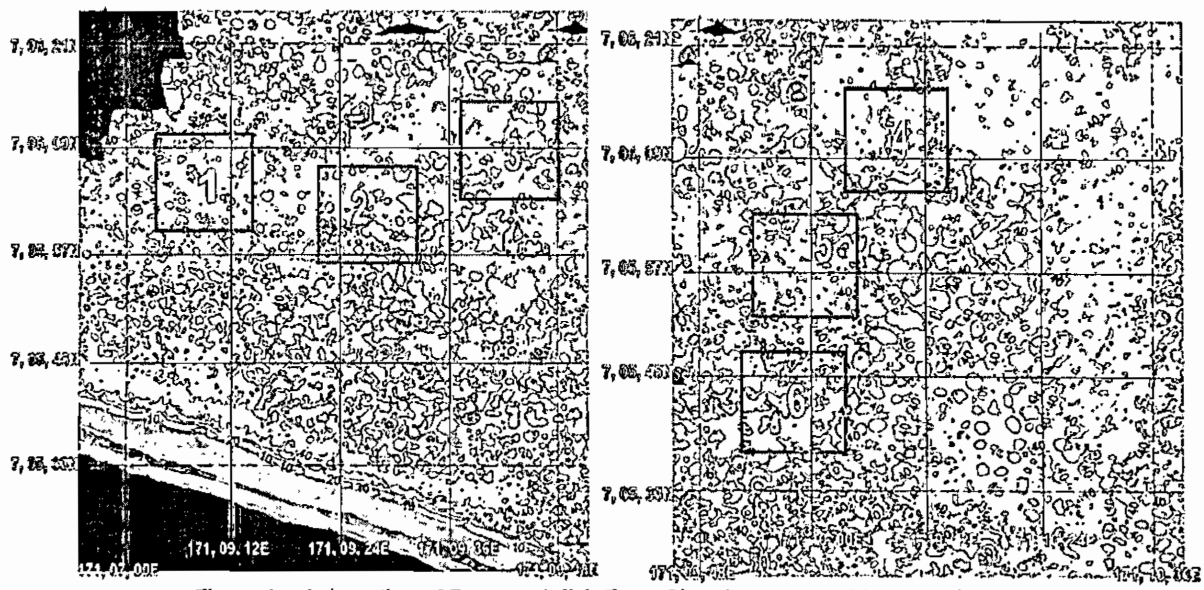


Figure 2.1.2: Location of Proposed Fish Farm Sites (to scale and true location)

The coordinates of the proposed sites based on Lat / Long WGS 84 estimates from Google Earth are (center points):

Site	Google Earth	Garmin GPS on Site
Site 1	7° 8' 4.97"N 171° 6' 56.73"E	7° 9' 0.67"N 171° 7' 20.91"E
Site 2	7° 7' 24.74"N 171° 7' 43.11"E	7° 8' 11.81"N 171° 7' 57.36"E
Site 3	7° 7' 49.29"N 171° 8' 51.39"E	7° 8' 20.34"N 171° 8' 52.09"E
Site 4	7° 7' 25.61"N 171° 10' 27.76"E	7° 7' 22.5"N 171° 10' 24.06"E
Site 5	7° 6' 41.17"N 171° 9' 49.99"E	7° 6' 50.05"N 171° 9' 47.56"E
Site 6	7° 6' 7.93"N 171° 9' 12.16"E	7° 6' 31.96"N 171° 9' 14.34"E

Site 3 will be the first site to be developed by GFB.

Furthermore, it is proposed that the current pilot farm location off Lobekerae Island (Figure 2.1.3) be utilized in the early stages for up to 500 metric tons per annum production primarily due to the favorable security characteristics of the site for small levels of production. The site would be made redundant once expansion to 6,000 to 10,000 metric tons per annum at the above sites was reached.

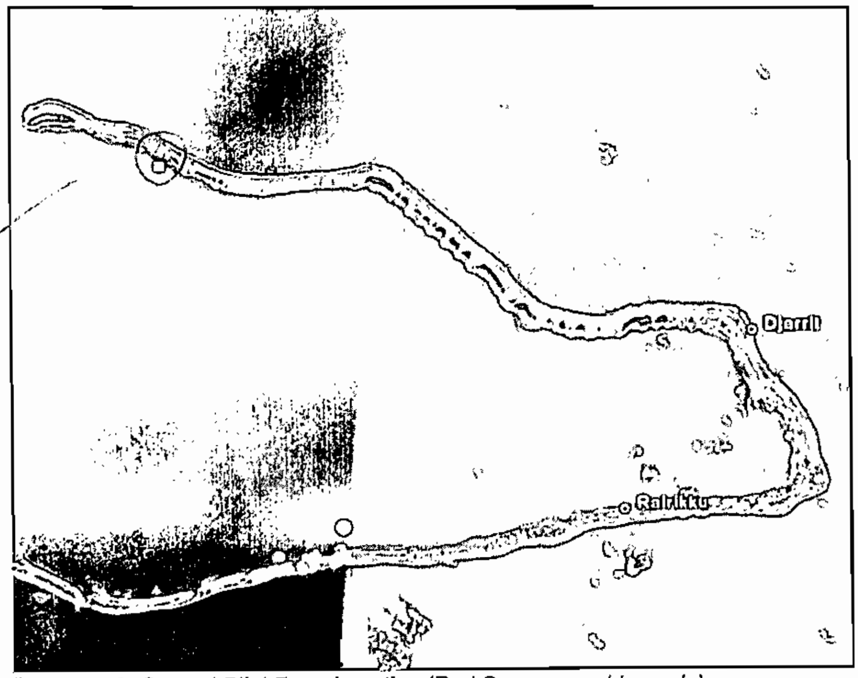


Figure 2.1.3: Current Pilot Farm Location (Red Square – not to scale)

The current site is located at approximately 7° 14' 59.41"N, 171° 14' 06.65" E (Lat / Long WGS 84 estimate from Google Earth).

2.2 Physical Characteristics of the Project

For each fish farm site the following equipment shall be located (see Appendix A: , Figure 8.3.11):

- Marker buoys surrounding the extent of the site;
- Mooring buoys for boats and ships;
- One or more work barges, which will be semi-permanently moored on the site. The barge will be used for storing feed, equipment and supplies on site and as overnight accommodation for some staff;
- A number of small work boats;
- Nursery seacages. At this stage a raft of small cages close to the barge is the preferred design;

- Growout seacages. At this stage polar circle type cages (see below) are the favored design. These cages would be moored in a number of arrays within the site. The position of these arrays will be moved after a number of years to allow the seabed under the cages to fallow.

The cage type currently preferred (in this paper referred to the *polar circle* seacage) involves main collars of the floatation device, handrail and stanchions constructed of high-density polyethylene (HDPE) (Figure 2.2.1).

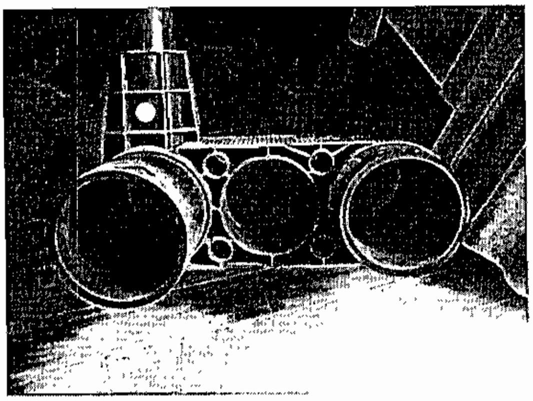


Figure 2.2.1: Cut Section of a Polar Circle Seacage

Polar circle type seacages are the most popular for fish farming around the world (Figure 2.2.2). Those that will be used in Majuro are engineered to withstand seas associated with typhoon conditions in Majuro Lagoon. Polar circle seacages to be utilized in Majuro will range between 16 and 42 meters in diameter and the net will have between 7 and 20 meter deep sidewalls. Assuming a 42 meter diameter this would have a volume of approximately 13,454 cubic meters and a carrying capacity of 538 metric tons of fish (assuming a stocking density of 25 kg per cubic meter). The volume of the smaller cage (16 meter diameter) is approximately 1,200 cubic meters with a carrying capacity of 30 metric tons of fish (assuming a stocking density of 25 kg per cubic meter).

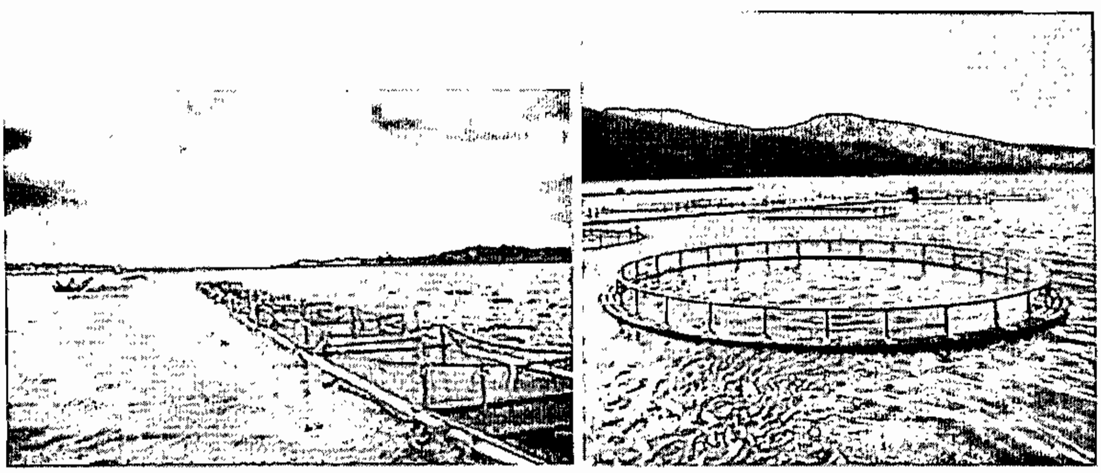


Figure 2.2.2: Polar Circle Seacages (similar to those proposed for Majuro): left – nursery cages; right – grow-out cages

Other cages designs under consideration are *geodesic dome* seacages (Figure 2.2.3) and *raft/float* seacages (Figure 2.2.4). GFB RMI's current pilot cages in Majuro are small raft/float and polar circle type designs.

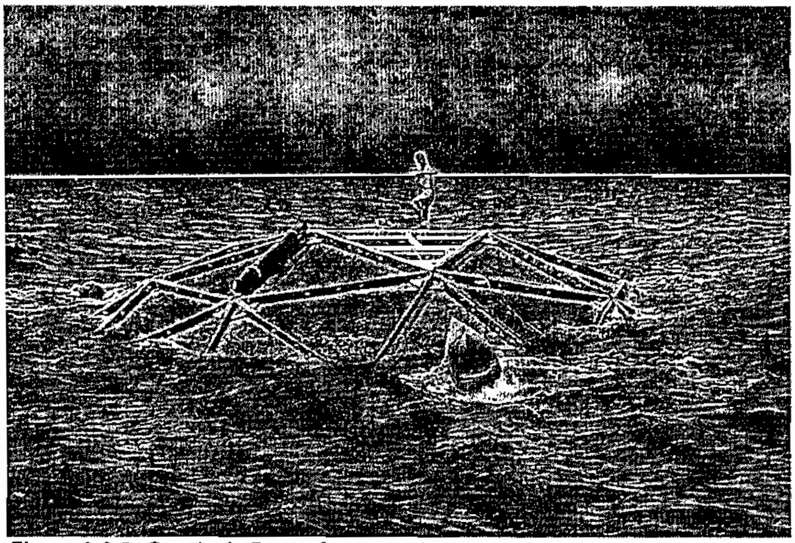


Figure 2.2.3: Geodesic Dome Seacage

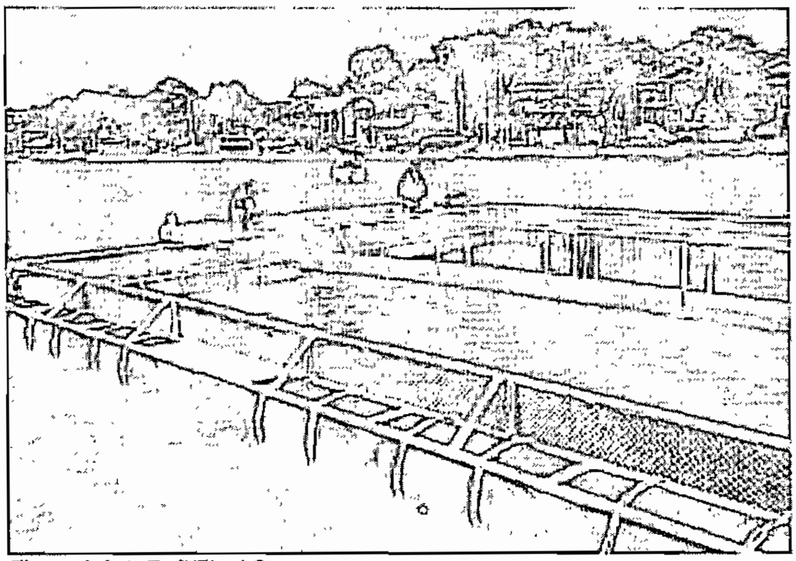


Figure 2.2.4: Raft/Float Seacage

Nets utilized will be constructed using a predator resistant material. Currently trials are being conducted utilizing both a heavy galvanized steel mesh (Appendix A: ,Figure 8.3.4) and a PVC coated semi rigid cross ply polyester fiber (see Appendix A: , Figure 8.3.3). The nets are secured to the collars at close intervals using 25-50mm wide webbing straps, or polyester double braid rope and galvanized D-shackles.

The cages will be anchored within a mooring grid designed to withstand cyclonic conditions (Figure 2.2.5). Bird exclusion nets will be utilized for each individual cage.

Any loss of fish is a major financial cost to GFB RMI and hence the company has a strong motive to avoid them.

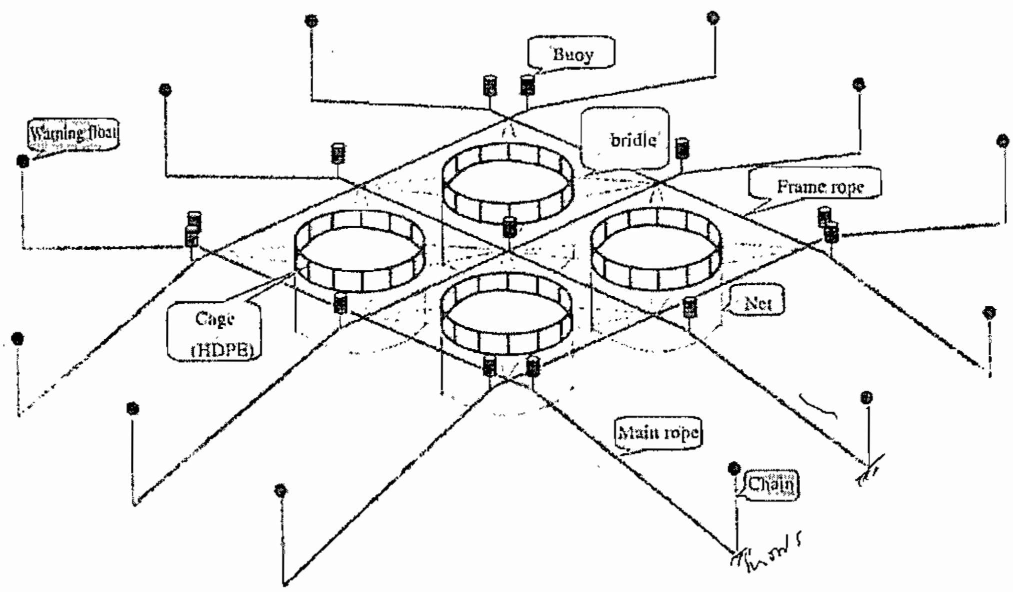


Figure 2.2.5: Mooring System for Polar Circle Cages

Construction

Construction impacts are minimal, as the project requires no earthmoving or construction of buildings.

Construction of the fish farms will involve:

- Assembly of cages (these are shipped prefabricated);
- Placements of mooring blocks, anchors and buoys;
- Running of mooring lines and attachment of cages.

The fish farm is mostly a floating structure. The only permanent construction impact on the sites will be the placement of the mooring blocks. Mooring blocks and anchors, which are constructed of concrete and/or steel will not be recovered from the seabed at the end of their working lives.

Some construction activities (eg. Assembly of seacages) will occur on land in Majuro, particularly in the early phase of scaling up of operations (prior to large work barges being moored on site). These construction activities are relatively low impact assembly operations and will be conducted in existing industrial areas during normal hours.

Operation

The operation of the fish farms is a relatively simple process.

The fish are brought to the farm at a small size (0.5 to 2.0 grams each) and grown in a series of cages for a period of 1 to 2 years after which they are harvested for live, fresh and frozen fish markets as would be wild caught fish.

Fish are fed sterilized manufactured pellets ranging in size between 2.0mm and 20.0mm dependent on the size of the fish. The data sheets for these feeds are provided in Figure 8.3.12 and Figure 8.3.13. It is estimated that a maximum of 75,000 metric tons of feed will be required per annum at the total maximum production of 50,000 metric tons of fish per year. Feeding regimes and behavior will be closely monitored to prevent overfeeding and wastage. Fish size data will be regularly collected and utilized to calculate growth rates and feed conversion ratios to analyze operational efficiency.

Harvesting will be conducted using a "Seine" net and fish pump or wet brail, depending on the species and end use. Depending on species harvested fish will either be shipped to Majuro for further processing or transported live to markets in Asia. The majority of fish will be transported to market by ship although some product may also be air-freighted (as is currently the case for tuna processed in Majuro).

Cages will be serviced from existing dock facilities and from service vessels located within the aquaculture sites. By moving the majority of storage and activities to barges and vessels within the fish farm sites, the impact of operations on the rest of Majuro will be minimized.

Landowner Agreements

Legally, all seabed use leases are permitted by the local government. The Local Government Act designates the coastal waters as areas where the local government has authority in addition to any overlapping jurisdiction by the national agencies. Coastal waters are the sea and seabed of the atoll lagoons in the RMI as well as 5 miles seaward of the low water mark on the ocean side.

GFB RMI has signed an agreement with the Iroij of Majuro (the Zedkaia family) for the development of the current pilot project off Lobekerae Island. Discussions have held with the Zedkaia family regarding the GFB's plans for commercial scale aquaculture in Majuro Lagoon. The Iroij of Majuro has expressed support of GFB's RMI's plans for fish farming in Majuro.

Formal approval from the local government of Majuro for the use of the fish farm sites is sought as part of this EIA.

2.3 Project Processes

2.3.1 During Construction

Time on Site

The construction of fish farming structures on the fish farm sites will be ongoing through the life of the project. Construction activities will only take place during daylight hours.

Plant and Vehicle Requirements

The exact plant and vehicle requirements for construction activities are difficult to define due to much machinery being shared between construction and operation. In general construction requirements are limited, as the project requires no earthmoving or construction of buildings. A list of the major equipment that is expected to be required by the fully operational farm is detailed in the 'When Operational' section below.

Storage of Materials and Equipment

At this stage a need to create new land-based facilities for the storage of materials and equipment is not anticipated. At present, the limited storage needs are met through the lease of existing facilities.

In the longer run barges moored on the fish farm sites will be used for the storage of the limited materials and equipment for establishment and operation of the fish farm sites.

Access Arrangements

The fish farm sites will only be able to be accessed by boat. The waters within each 125 hectare fish farm site will be designated as no public access.

Security during construction will overlap with operational security (see below). The sites are relatively remote and the initial construction (placement of mooring blocks/anchors, mooring lines and buoys) is not expected to be subject to significant security concerns. As production increase at the central Majuro sites, staff will be present on site 24hours per day, 7 days per week.

2.3.2 When Operational

Time on Site

Once operational the fish farm sites will be continually staffed, 24 hours per day, 7 days per week, 365 days per year for the life of the project.

Plant and Vehicle Requirements

For each 125 hectare fish farm site when fully operational the following machinery and vehicles are anticipated:

- 1 large barge / pontoon with living quarters, office areas, feed and water storage, fuel storage, net cleaning equipment, diving equipment, generator, crane and minor repair tools and equipment similar to a typical ship (see Appendix A: Figure 8.3.10);

- 1 live fish carrier ship, for transporting fingerlings from Australia and live fish to markets in Asia. This ship would only be on site periodically for short periods, with the rest of the time spent traveling to and from ports in Australia and Asia;

- Approximately 20 small work boats for general activities (see Appendix A: Figure 8.3.9);

- 2 larger work boats with fish pumps, live fish tanks and fish graders; and

- 2 transport boats for transport of people and supplies from the dock areas in eastern Majuro.

GFB RMI will also operate a small number of utility vehicles and light trucks on Majuro for transport of goods to docks etc.

Storage of Materials and Equipment

In order to minimize movements between the fish farm sites and the docks in eastern Majuro it is aimed that where possible materials and equipment be stored on the fish farm sites. Equipment such as seacages not in use and boats are able to be moored on site while other equipment will be stored on barges / pontoons.

Some land-based storage will be required, particularly during the earlier stages. The lease or purchase of existing facilities in Majuro is expected at this stage to be adequate for all of GFB RMI's land based needs.

Access Arrangements

The fish farm sites are only be able to be accessed by boat. The waters within each 125 hectare fish farm site will be designated as no public access. GFB staff, relevant public servants and government of the RMI shall have normal access to the sites.

Security arrangements are detailed below.

2.3.3 Security

Any loss of fish or equipment represents a direct financial cost to GFB RMI and hence the company has a strong vested interest in minimizing sabotage, vandalism and theft. GFB RMI's current pilot site is located close to Lobekerae Island primarily due to the security the site offers.

Measures to support the security of the sites in central Majuro lagoon are:

- The relatively remote nature of the sites reduces the potential for 'nuisance' type theft and vandalism. Access to the sites requires boats and a significant trip for the majority of the population;

- Limited access to the fish farm sites in central Majuro lagoon (no additional access restriction proposed for Lobekerae Island). For this purpose each site will be a 125 hectare square marked with buoys and restricted for access accept for GFB staff and relevant public servants and government. The 125 ha area is substantially larger than required for the fish farm infrastructure – it is as much to provide a security buffer surrounding the site;

- 24hr staffing of the sites with live-on boats and barges moored within the farm sites. This will not be achievable while the farm is small hence the need to continue to utilize Lobekerae Island for a period;
- Storage of fish feed and some other materials on barges moored within the farm sites. This will limit the potential for theft;
- Advertisement of the restricted access nature of the sites as they are commissioned in the Yokwe Paper and cooperation with the RMI Ports Authority to ensure they are included in relevant future documents produced by the RMI.

Any significant security breaches will be reported to the RMI police and the security measures reviewed regularly for performance.

2.3.4 Decommissioning

GFB RMI intends at this stage to operate the fish farms in Majuro Lagoon for an indefinite period.

Were the farm to be decommissioned all materials and equipment on the fish farm sites placed there by GFB RMI other than the mooring blocks / anchors and associated metal mooring chains shall be removed. These materials shall either be:

- Sold for reuse or recycling to other parties in the RMI;
- Removed from the RMI.

The fish farming equipment and associated machinery has a limited life. At the end of the working life all materials and equipment on the fish farm sites placed there by GFB RMI other than the mooring blocks / anchors and associated metal mooring chains shall be removed. These materials shall either be:

- Sold for reuse or recycling to other parties in the RMI;
- Removed from the RMI.

2.4 Alternative Options Considered

Relative to other locations Majuro Lagoon is favored by GFB RMI for aquaculture as:

- The lagoon displays relatively consistent water temperature and quality throughout the year which favors the best outcomes with regards to fish growth and health;
- Large parts of the lagoon are well flushed to the open ocean ensuring that impacts are minimized;
- The lagoon provides protection from large seas enabling regular activity on the seacages;
- Majuro is relatively well serviced with sea and air linkages and a workforce compared to other tropical atolls with similar favorable technical attributes;
- Majuro is relatively centrally located between the project's major trading partners of Australia, Asia and the USA.

The alternative options for fish farming in the RMI are considered below. Option 5 is the viable option that is considered in detail in the EIA.

2.4.1 Option 1 - Do Nothing

The Do Nothing option involves:

- The loss of an opportunity to establish a major investor in the RMI with associated job creation, economic stimulus and tax revenue;

- No additional environmental impacts from the fish farming activity;
- The loss of an opportunity to conduct significant ongoing environmental monitoring of Majuro lagoon at no cost to the RMI Government;
- The loss of an opportunity to establish an industry in Majuro lagoon with a vested interest in maintaining the quality of the aquatic environment;
- The creation of a negative signal to other potential investors in the Marshall Islands;
- The loss of the opportunity to train Marshallese in aquaculture and aquatic sciences.

2.4.2 Option 2 - Alternative Atoll in the RMI

Other atolls in the RMI are currently unviable due to their remoteness and subsequent difficulty with logistics and size of workforce. On establishment of scale operations in Majuro other atolls may be more viable.

2.4.3 Option 3 – Cages Located external to the Atoll

Offshore cage systems are an emerging technology that currently involve considerable additional cost and risk. Furthermore the water depth off the Majuro atoll increases rapidly to over 6000 feet - at this stage there is no technology available for these conditions.

2.4.4 Option 4 -- Land-based Operation

Land based systems require three main commodities to ensure a viable facility:

1. Clean abundant high quality water supply.
2. High capacity reliable energy supply
3. Large suitable land area available.

The Majuro area has an abundant supply of high quality water for the operation, however the second and third commodities are in poor supply. The cost and risk associated with operating a land-based facility in Majuro would not be economically viable and the loss of significant areas of land (hundred's of hectares) is unlikely to be acceptable.

2.4.5 Option 5 – Location within Majuro Lagoon

The physical conditions within Majuro Lagoon are well within those experienced by inshore seacage fish farms in other parts of the world. As such the technical requirements for aquaculture in this environment are understood and commercially viable using existing technologies.

There are potential impacts associated with this option (as there are with all of the options) however these can be minimized by:

- Locating the aquaculture sites in areas that do not interfere with other activities in Majuro and that have minimal visual impact;
- Ensuring that total production levels are such that associated nutrient production is appropriate to the level of flushing and tolerance of the natural environment; and
- Ensuring that aquaculture sites are located where flushing is greatest and distances from the most sensitive environments is maximized.

The location within Majuro Lagoon is associated with the least infrastructure requirements with the only fixed infrastructure required being the actual sea cages and associated mooring systems.

2.4.6 Conclusion on Options

The options for fish aquaculture in the Marshall Islands at Majuro atoll are reduced due to then limited area of land available and the great depths very close to the atoll rim. Sea cages located within the high flushing protected environment of the central inner lagoon provide the best balance of commercial viability and environmental risk.

3 Consultation

The scoping report preceding this EIA has been distributed to a list of stakeholders as agreed with the RMI EPA. Further discussions with most of the stakeholders have also been conducted by GFB RMI staff. A summary of stakeholder consultation outcomes is presented below in Table 3.1.

Table 3.1: Summary of Stakeholder Consultation Outcomes

Date of Consultation	Consultee(s)	Method of Consultation	Summary of Consultation
	Ministry of Marine Resources Authority – Director, Glen Joseph	Meetings, Scoping Report	Supportive of Project providing project meets all relevant laws of the RMI
	Republic of the Marshall Islands Environmental Protection Authority	Meetings, Scoping Report	Need to ensure that the project does not involve unacceptable environmental risk to the RMI
	Ministry of Resources and Development – Quarantine Department, Henry Capelle	Scoping Report	?
	Ministry of Foreign Affairs – Secretary	Scoping Report	?
	Office of Environment, Planning, Policy and Coordination – Director, Yumiko Crisostomo	Scoping Report	?
	Office of the President – Minister in Assistance, Witten Philippo	Scoping Report	Presidents office (Tomeing administration) has indicated verbally that they are supportive – awaiting written response
	College of the Marshall Islands Marine Studies Department – Don Hess & Dean Jacobsen	Scoping Report	Supportive of project depending on scale. Concerns are number and type of species and nitrogen loading.
	College of the Marshall Islands Land Grant – Director, Diane Myazoe	Scoping Report	?
	SPC – Lindsay Chapman, Ben Ponia, Johann Bell	Scoping Report	?
	SPREP – Dominque Benzaken, Coastal Management Advisor	Scoping Report	?
	SOPAC – Arthur Webb, Coastal Advisor	Scoping Report	?

Date of Consultation	Consultee(s)	Method of Consultation	Summary of Consultation
	Majuro Atoll Local Government – Mayor	Scoping Report	
	RMI Ports Authority – Director, Jack Chong-Gum	Scoping Report	Confirmed project will not conflict with shipping. Ask that GFB consult with them on type of navigational lighting used in the project.
	Majuro Atoll Waste Company – Roger Cooper	Scoping Report	
	Zedkaia Family (Traditional Landowners)	Meetings	Have been supportive of the project in discussions since the pilot project was initiated.
Pending	Public Meeting		

4 The Baseline Environment

4.1 Introduction

The proposed fish farm will be located within Majuro lagoon. The relevant existing environment to the development is the Majuro Lagoon Aquatic environment. The lagoon consists of a large (324 square kilometer) area of water with an average depth of 46 meters of a relatively flat bottom consisting of coral aggregate. The rim of the lagoon consists of a number of islets (wetos), which have been joined on the southern and eastern sides of the island. The shallower water surrounding the island supports coral reefs, both on the lagoon and ocean side (Figure 4.1.1). The most pristine reefs are found on the northern shore of the atoll. Those reefs on the lagoon side of the heavily populated south-eastern corner of the lagoon are relatively degraded. The cause of the degraded state of these reefs is likely to be a combination of unregulated organic and chemical pollution, overfishing, poor water exchange and physical damage.

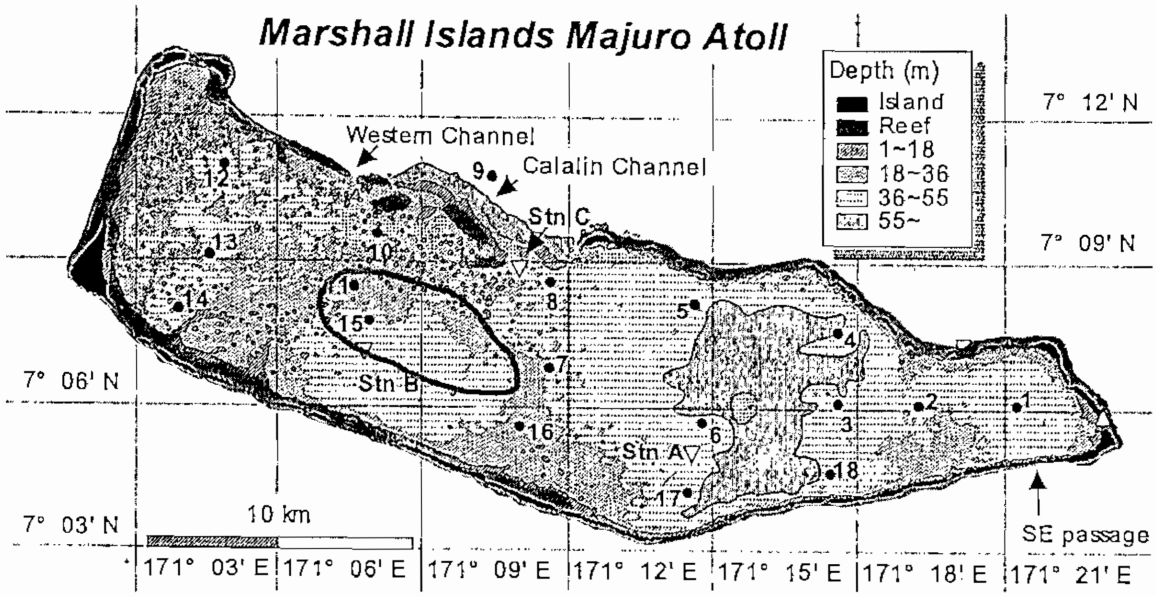


Figure 4.1.1: Coral Reef Areas in Majuro and Area of Proposed Fish Farms (circled in red)

The west-central Pacific Ocean surrounding Majuro Atoll is deep (from about 150 meters to over 500 meters directly offshore from the atoll to over a kilometer deep within 10 kilometers of the atoll). The closest land to Majuro is Arno Atoll, approximately 18 kilometers at the closest point to Majuro. Aside from other atolls in the Marshall Islands, Kiribati and Micronesia the closest land to Majuro is the Solomon Islands at approximately 2,050 kilometers to the south-west, and Hawaii at approximately 3,740 kilometers to the north-east. Due to this distance from land the ocean surrounding Majuro is very low in nutrients.

4.2 Methods of Assessment

4.2.1 Baseline Information

Information for the EIA has been collected from the following sources:

- Field Surveys;
- Consultations (see Table 3.1 above); and,
- References in Section 10.

4.3 Legislative and Administrative Framework

4.3.1 Baseline Conditions

The following legislative and administrative framework conditions for aquaculture in the RMU are summarized from the draft RMI Mariculture Policy (2004).

1.1.1.1 Traditional and Customary Rights

All land in the RMI is private land, at least for that portion above the high water shoreline. The RMI Attorney General asserts that the land below the high water mark belongs to everyone. Ownership property rights do not necessarily need to be resolved before mariculture development takes place as long as proper protocol for permissions are followed. Legally, all terrestrial land and seabed use leases are permitted by the local government. In practice, local governments will be reluctant to issue any permits unless proponents can demonstrate that all affected landowners as well as the Iroij or Leroij —Atoll Chiefs— have given their blessing.

Permits Required

1. Permit from Majuro Local Government for the establishment of fish farm infrastructure within the proposed fish farm sites.
2. Agreement with the Majuro Iroji for the conduct of the proposed aquaculture activities in Majuro Lagoon.

1.1.1.2 National Government Policy

There is no independent national policy on mariculture in the RMI. However, there are two national policy and planning documents that are relevant. They include the National Fisheries Policy (1997a) and the National Fisheries Development Plan (1997b). Both of these contain direction pertaining to mariculture but neither one significantly addresses the type of instrument (regulation, economic incentive, and/or information) necessary to achieve the stated objectives.

The National Fisheries Policy (1997) sets out strategic direction for the development of industrial, island and atoll, and culture fisheries. Overall objectives of fisheries development include:

- to improve economic benefits from fisheries sectors within sustainable limits;
- to strengthen institutional capacity to facilitate the responsible development and management of fisheries resources;
- to support legitimate, responsible, private sector enterprise as the primary vehicle for fisheries development, and;
- to support the preservation of coastal, reef, and lagoon resources for nutrition, food security, and small-scale sustainable income earning opportunities for the community.

The National Fisheries Policy recognizes that "culture fisheries demonstrate potential to make a valuable contribution to economic development in the Republic" and mandates MIMRA to encourage applied research and culture fisheries development activities initiated by the private sector, agencies, and donors.

Permits Required

1. Nil.

1.1.1.3 Agencies and Enabling Legislation

MIMRA was established under the Marshall Islands Marine Resources Authority Act (1988), and is the primary agency responsible for the conservation, management, and sustainable development of marine resources in the Marshall Islands. The MIMRA Act was complemented with the Marine Resources Act (1997) to give MIMRA more autonomy in performing its responsibilities effectively.

The MIMRA and Marine Resources legislation establish and reinforce MIMRA's authority with respect to capture fisheries and aquaculture. They led to the formulation of the National Fisheries Policy described previously.

Coastal waters are the sea and seabed of the atoll lagoons in the RMI as well as 5 miles seaward of the low water mark on the ocean side. The Local Government Act designates the coastal waters as areas where the local government has authority in addition to any overlapping jurisdiction by the national agencies. However, the low water boundary apparently only applies to the RMI baseline on the ocean side; the atoll lagoons encompass all land and water up to the high water mark. As discussed previously, the inclusion of intertidal lagoon areas under local government jurisdiction do not necessarily diminish landowner influence on development.

Permits Required

1. Permit from MIMRA for exclusive use of the 6 proposed fish farm sites for fish farming activities and operations.

1.1.1.3.1 National Environmental Protection Act (1984)

The RMI Environmental Protection Authority (RMIEPA) is a national statutory body under the Office of the President, established under the National Environmental Protection Act (NEPA 1984).

Main functions of the Authority as stated in the NEPA include the following:

- to study the impact of human activity including population growth and redistribution, cultural change, exploitation of resources and technological advances on the environment;
- to improve and coordinate consistently with other essential considerations of national policy, governmental plans, functions, and programs and resources, so as to prevent, as far as practicable, any degradation or impairment of the environment;
- to regulate individual and collective human activity in such manner as will ensure to the people safe, healthful, productive, and aesthetically and culturally pleasing surroundings, and;
- to attain the widest possible range of beneficial uses of the environment without degradation or impairment thereof and other undesirable consequences to the health and safety of the people.

Mariculture development in the RMI in terms of EPA interest is encapsulated in the last objective where it recognizes the importance of the "widest possible range of beneficial uses of the environment without degradation."

Permits Required

1. Approval from the RMI EPA of the Environmental Impact Assessment for the aquaculture of 50,000 tonnes per annum of fish in Majuro;

2. Approval from the RMI EPA of the Environmental Management Plan for aquaculture of 50,000 tonnes per annum of fish in Majuro;

3. Permit from the RMI EPA for the establishment of fish farming infrastructure (cages and mooring) within the outlined cage sites.

1.1.1.3.2 Coast Conservation Act (1988)

The Coast Conservation Act places the responsibility of planning and management of development activity within the coastal zone with the EPA. Under the Act, development activity is any activity likely to alter the physical nature of the coastal zone in any way. The coastal zone is defined as the area lying within twenty-five feet landward of the mean high water line and two hundred feet seaward of the mean low water line. This definition is broad enough to include most of the usable land area available in the RMI, whether for mariculture facilities on terrestrial land or anchored to, or in some way affecting the seabed.

Permits Required

1. Nil.

1.1.1.3.3 Planning and Zoning Act (1987)

This Act requires every Local Government Council to establish a Planning Commission and subsidiary Planning Office. The Act is specifically directed at the local governments of Majuro and Kwajelein, two of the most heavily populated atolls of the RMI. The objective of zoning is to promote harmonious interrelationships of land use, preservation of the natural landscape and environment, and identification of appropriate locations for recreational areas and parks. Traditional land tenure systems in the RMI continue to present the biggest challenge to implementation of the Planning and Zoning Act. Such an Act would have significant positive implications for mariculture in terms of clarity of future land uses in surrounding areas.

Permits Required

1. Nil.

1.1.1.4 Regulations

There are no regulations for mariculture activities issued under the Marine Resources Act or any other statute. To establish a mariculture facility or project requires the approval from the Director of MIMRA and clearance from the Manager of the EPA as to possible environmental impacts.

The EPA is responsible for ensuring compliance and enforcement of the Earthmoving Regulations (1989), Environmental Impact Assessment Regulations (1994), and Marine Water Quality Regulations (1992) and for the development of a Coastal Zone Management Plan for the Marshall Islands. Under the Coast Conservation Act, the EPA is mandated to draft regulations for the sustainable development of the coastal zone and coordinate with other relevant stakeholders in the development of a Coastal Zone Management Plan.

1.1.1.4.1 Environmental Impact Assessment Regulations (1994)

The Environmental Impact Assessment Regulations were established to implement EPA obligations under Part IV of the National Environmental Protection Act and Section 11 of the Coast Conservation Act. The EIA regulations establish standard procedures for the preparation and evaluation of an EIA for proposed public and private development activities that may affect the quality of the environment of the RMI. The EIA regulations are designed to integrate the EIA process into early planning of projects to ensure timely consideration of environmental factors and to avoid delays, as well as to identify at an early stage the significant environmental issues facing the RMI.

Permits Required

1. Approval from the RMI EPA of the Environmental Impact Assessment for the aquaculture of 50,000 tonnes per annum of fish in Majuro;

1.1.1.4.2 *Marine Water Quality Regulations (1992)*

The Marine Water Quality Regulations are established to identify appropriate uses of the marine waters of the RMI, to specify the water quality standards required to maintain designated uses, and to prescribe regulations necessary for achieving and maintaining the specified marine water quality. The regulations state that no waters shall be lowered in overall quality unless it has been demonstrated to EPA that such a change is a necessary result of economic or social development, is in the best interest of the people of the RMI, and will not permanently impair any marine resource or beneficial use assigned to the waters in question.

Permits Required
1. Approval from the RMI EPA of the Environmental Impact Assessment for the aquaculture of 50,000 tonnes per annum of fish in Majuro;
2. Approval from the RMI EPA of the Environmental Management Plan for aquaculture of 50,000 tonnes per annum of fish in Majuro;

1.1.1.5 *International Legislation*

1.1.1.5.1 *National Biodiversity Strategy and Action Plan*

The RMI signed the United Nations Conventions on Biological Diversity in 1992. Ratification soon followed in 1993. In 1997, the Republic of the Marshall Islands with the assistance of UNDP prepared a National Biodiversify Strategy and Action Plan (NBSAP) as part of its obligations under the Convention on Biological Diversity. The NBSAP provides key actions and strategies for addressing the threats to biodiversity in the RMI. It has involved wide consultation with many sectors of the community and has resulted in a strategy and plan, with a high level of community ownership. Conservation of native species particularly for the protection of marine biodiversity is a key area of concern in relation to intentional or accidental release of non-native species into the environment.

Permits Required
1. Permit from MIMRA for import of the proposed species from Australia.

1.1.1.5.2 *National Biosafety Framework*

A number of biosafety issues are highlighted in the NBSAP-the most urgent being quarantine. The introduction of exotic species or native species that have been modified outside the country and reintroduced pose a serious threat to the sustainability of marine and land biodiversity. In the Marshall Islands, MIMRA is responsible for the quarantine of imported marine species.

Permits Required
1. Approval by MIMRA of the import quarantine protocols.

Human Beings and Land Use

4.3.2 Baseline Conditions

Population and Residential Areas

The proposed project is entirely marine based and is not adjacent to residential areas or landholdings. The only exception to this is the current site adjacent to Lobikaere Island. Lobikaere Island is owned by the Zedkaia family and written agreements exist between the Zedkaia's and GFB RMI Inc. for the utilization of the sea adjacent to the island.

Land tenure in the Marshall Islands does not extend to the water, which is controlled by the Marshall Islands Government primarily through the Marshall Islands Marine Resources Authority (MIMRA) and local governments.

At the atoll scale Majuro is estimated to have a population of 28,000 in 2006 (Office of the President, 2006). The majority of the population lives in the urbanized eastern shore of the lagoon.

Businesses

No private or public businesses currently operate in the area of the proposed farm site.

Fishing Grounds

The proposed farm site is not regarded as a significant fishing site although it is possible that incidental fishing occurs in the area. The area is relatively remote from the majority of the population and does not contain structure or habitat to distinguish itself as a fishing location.

no coral reefs / reef flats?

Economics

According to the World Bank (2006) the RMI has one of the highest unemployment rates in the Pacific:

"*Up to 50 percent of Marshallese of working age are not participating in the workforce. The unemployment rate, which was 7.6 percent in 1999 and almost three times that for young people — one of the higher such rates in the Pacific— tells only a small part of the story. Looking at male joblessness, for example, about five times as many Marshallese men are not even in the workforce as are unemployed (see figure 5). A very large group of Marshallese are idle.*"

The Office of the President (2006) RMI 2006 Community Survey found:

- The median age in Majuro is 21;
- 40% of the population is below the age of 15;
- Average household size was 7.5;
- Home ownership was 87%, with 15% making mortgage repayments;
- Unemployment in Majuro is estimated at 26% to 39% in 2006 however nearly 60% of working age people were unemployed but not looking for work;
- Nearly one-third of Majuro households claimed that their overall quality of life has deteriorated in the past three years, closely matching the percentage (35%) of households that claimed they sometimes or often did not have enough to eat; and
- Applying US poverty thresholds to Majuro families reveals that the percentage of families below the poverty line increased from 75 to 80 percent from 1998 to 2006.

The U.S. Department of State (June 2007) information on the Marshall Islands economy is:

- GDP of $135.3 million in 2004. GDP is derived mainly from payments made by the United States under the terms of the Compact of Free Association. Direct U.S. aid accounted for 60.2% of the Marshall Islands' $124.6 million budget for FY 2007;
- Natural resources: Marine resources, including mariculture and possible deep seabed minerals. Agriculture: Products--Copra (dried coconut meat); taro and breadfruit are subsistence crops;
- Industry: Types--Copra processing, fish processing, tourism, pearl farming, handicrafts; and
- Trade: Major trading partners--U.S., Japan, Australia, China, Hong Kong, New Zealand, Taiwan;
- The government is the largest employer, employing 64% of the salaried work force.

The Marshall Islands Government and the Marshall Islands people are clearly in need of reducing their reliance on aid and improving the infrastructure and living standards in the country.

Recreation and Tourism

The area proposed for the farm site is not know to hold any existing or likely future value for tourism. Current tourism in Majuro is primarily centered around the urban areas on the eastern side of the atoll and on the islands and reefs on the northern side of the atoll. Some popular dive locations are found around Calalin channel on the northern side of the atoll. These dive areas are approximately 3 kilometers to the nearest proposed fish farm site.

The proposed fish farm sites are located in areas remote from the majority of the population and not considered to have significant recreational value.

4.4 Habitats and Species

4.4.1 Baseline Conditions

General Habitat Overview

The area within immediately surrounding the proposed fish farm sites consists of a relatively uniform depositional surface of decomposed coral aggregate built up by lagoon sediment transport and deposition.

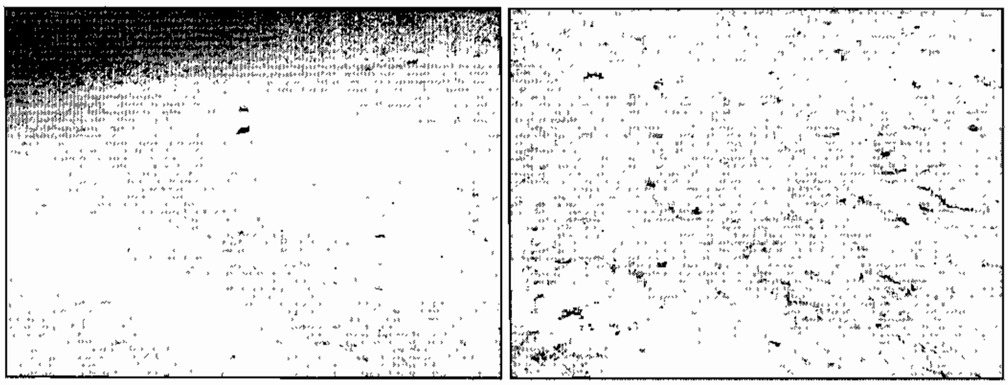


Figure 4.4.1: Typical Decomposed Coral Aggregate Bottom of Central Majuro Lagoon

The water depth in the proposed fish farm sites is approximately 40 meters.

Marine

The most significant marine habits in Majuro Atoll are the coral reefs, some of which are relatively pristine. The extent of coral reefs is displayed in Figure 4.4.2.The highest quality reefs occur on the Northern shore of the atoll (Pinca et al.2004).

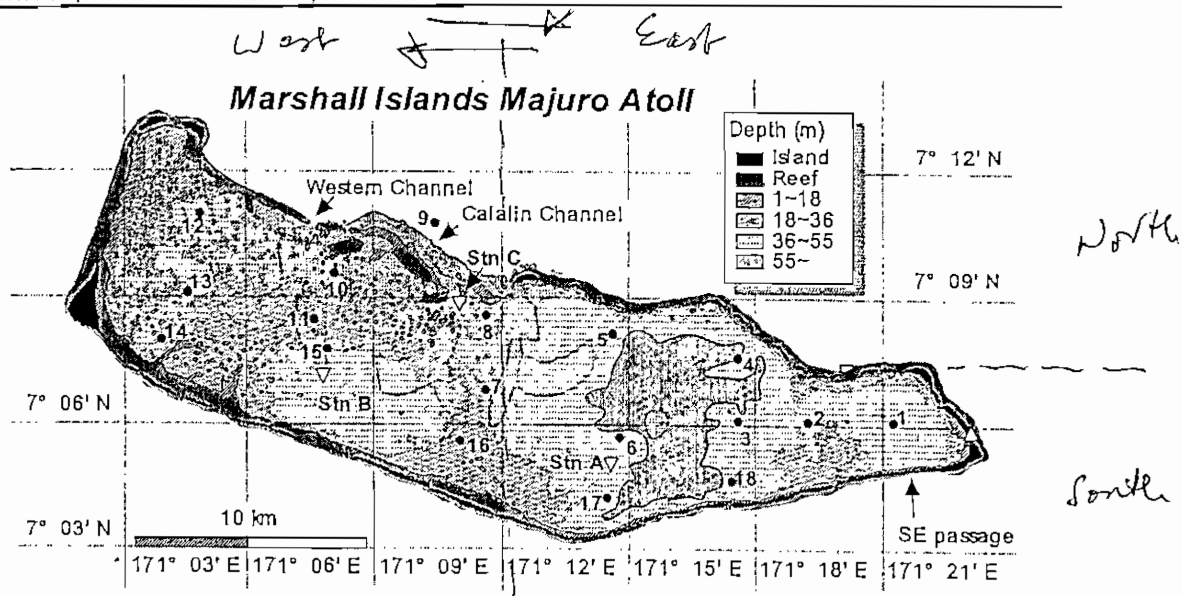


Figure 4.4.2: Coral Reef Areas in Majuro Lagoon (Highlighted in Purple).

In general, the most apparent impacts to the reefs of the Marshall Islands are lifestyle change, loss of traditional conservation knowledge, and urbanization (Turgeon et al. 2002). Lack of proper trash disposal results in occasional dumping in the lagoon or ocean, which, at the very least, causes aesthetic damage. Periodically, fishing vessels have broken loose from their anchor and hit the reef, damaging the coral structure as well as spewing fuel over a large area.

Poaching of reef species is known of and surveillance is limited.

Fouling marine invertebrates have been introduced, especially in ports where they probably arrived on ship hulls. Non-native algae and fishes have been documented, but the full impact of their presence has not been studied. Indications are that invasive species have the highest potential to damage coral reefs.

Coral reefs are recognized as sensitive habitats. For the purpose of this EIA the coral reef environment is considered as a single sensitive ecosystem (as it is in the majority of relevant scientific publications) rather than considering the sensitivity of the individual constituent species.

The proposed aquaculture farm sites are located at distances in excess of 3 kilometers from any significant reef sites in Majuro. At this distance, the potential impact of the aquaculture operation is limited to indirect effects of increased nutrient levels of the water in the lagoon.

Despite the lack of unequivocal evidence of the effect of nutrient enrichment on coral it is considered that a conservative approach be taken to aquaculture production limits and subsequent nutrient loadings.

Site Specific Habitats

There are two habitat types of relevance to the proposed project:

a. The decomposed coral lagoon bottom ('Lagoon Flat'). This is a relatively poor species habitat. The proposed fish farm sites consist of this habitat type under 30 to 40 meters of water; and,

b. Coral reefs located on the fringes of the atoll (lagoon side) and on some scattered bommies in shallower parts of the lagoon ('Coral Reef'). This is a relatively rich habitat with high ecological and local values.

Examples of these habitat types are displayed below.

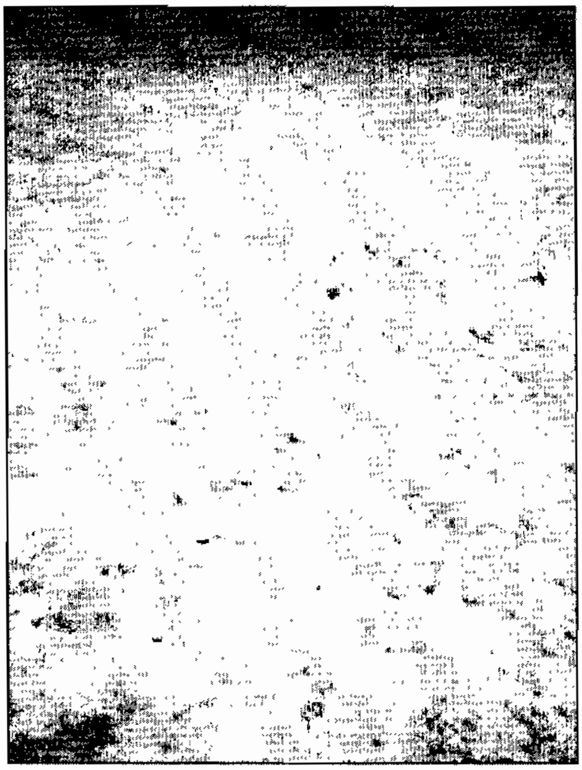


Figure 4.4.3: Typical Lagoon Flat Habitat that is the dominant habitat type below about 15 to 20 meters in Majuro Lagoon

Figure 4.4.4: Typical Coral Reef Habitat. This is a relatively pristine reef at Calalin Pass

Species

According to Turgeon et al (2002) the RMI has recorded:

- At least 362 species of corals and other cnidarians, 40 species of sponges, 1,655 species of mollusks, 728 species of crustaceans, and 126 species of echinoderms on the coral reefs of the RMI;
- Five species of sea turtles and 27 species of marine mammals have been observed in the Marshall Islands;
- There are at least 860 species of reef fishes recorded throughout the country. Seven species of fishes are endemic to the Marshalls;
- 238 species of green, brown, red and blue-green algae. There are several beds of sea-grasses.
- *Endangered Species: Blue whale, sperm whale, micronesian pigeon, leatherback turtle, hawksbill turtle.*

Surveys at the proposed fish farm sites have noted minimal sea life with low numbers of mollusks and echinoderms most prominent.

Terrestrial

N/A

Site Specific Habitats

N/A

Species

It is expected that seabirds will visit the farm sites. According to the RMI US Embassy 31 species of seabirds are found in the RMI although none of these are noted as endangered.

4.5 Geology and Coastal Process

4.5.1 Baseline Conditions

Natural Aggregate Resources

According to the SOPAC report Sand and Gravel Resources of Majuro Atoll, Marshall Islands (Smith & Collen, 2004) the nearest potential natural aggregate resources are found to the east of Lobikaere Island. A potentially suitable resource was found within the perimeter of the basin in Arrak Sub-district (east of Laura) – within about 5.5 kilometers of one of the proposed farm sites. However this area is a historical-cultural site and unlikely to be utilized. It is also sufficiently distant from the proposed farm site to present minimal impact to the fish farm if operated.

Geology

The proposed farm sites consist of flat lagoon bottom consisting of decomposed coral aggregate. According to the Smith & Collen (2004) sediments in Majuro Lagoon are composed primarily of clasts derived from coral and calcareous red algae and of the tests of the larger foraminifer *Calcarina gaudichaudi*. Fragments of mollusks and *Halimeda Halimeda*, and the tests of other larger foraminifera, are important minor components.

Coastal Processes (sediment transport)

The proposed farm sites are in an area of upwelling of water flows from both the east and west lagoons prior to discharging to the open ocean through Calalin and Western Channels (this is further described in Section 4.6.1 below). As such any sediment in the water column from other parts of the lagoon has the potential to be transported to the site. There is little scope for sediment from the site to be transported to other parts of the lagoon other than the Calalin and Western Channel Areas.

Due to the proposed development being distant from coastal areas and in relatively deep waters there is no significant erosion and deposition processes in the area.

Coastal Geomorphology

Coastal geomorphology is of no relevance to the proposed project other than to how it influences the hydrodynamics of the entire lagoon and hence the project. Published studies have incorporated the coastal geomorphology into marine hydrodynamic models of the lagoon. These hydrodynamic models are discussed in Section 4.6.1 below.

Contaminated Land

The proposed fish farm sites are not known to contain contaminated marine substrates.

4.6 Water

4.6.1 Baseline Conditions

Marine Water Quality

Marine water quality is poorly understood in Majuro due to the lack of water quality monitoring. Visual evidence (algal growth, coral disease, faunal distributions) suggests significant variability in water quality between sections of the lagoon.

The eastern section lagoon suffers from water quality problems due to:

- Relatively poor water exchange;
- Unregulated sewerage outfalls;
- Unregulated dumping and waste discharge;

Evidence of eutrophication is noted from the eastern section of Majuro lagoon, however, the level of nutrient inputs is unknown. Evidence suggests that the water quality in the eastern section is also significantly polluted with heavy metals and / or other toxins.

The northern and western portions of the lagoon are relatively pristine. Given the pollution in the eastern portion of the lagoon and the water exchange dynamics outlined in Kraines et al (1999; 2001), this is likely primarily due to much better flushing with the open ocean in these areas.

The water quality in the area of proposed aquaculture sites is unknown. The water exchange dynamics outlined in Kraines et al (1999; 2001) suggest that the area should be relatively pristine due to high flushing with the outside ocean, however, the area experiences significant upwelling and outflow of water deriving from the relatively polluted eastern lagoon.

Table 4.1: Water Quality Measurements from Majuro Lagoon

Parameter	Baseline Water Quality	Sample Location and Source of Data
Total dissolved nitrogen	0.028–0.038mg/l	Lobekerae Island, Majuro. (GFB pilot water quality testing 2007-08)
Phosphorous	0.035 - 0.036mg/l	Lobekerae Island, Majuro. (GFB pilot water quality testing 2007-08)
pH	8.264 – 8.350	Various within Majuro Atoll (Suzuki, Kawahata and Goto, 1997)
Salinity	33.70 – 33.90 ppt	Various within Majuro Atoll (Suzuki, Kawahata and Goto, 1997)

A number of studies that have measured water quality parameters in Majuro Lagoon indicate relatively pristine water quality consistent with high exchange rates with the open ocean. The high phosphorous to nitrogen ratio agrees with results from the south central Pacific (Tuamotu Atoll) where nitrogen availability was found to be much more limiting than phosphorous availability (Dufour & Berland,1999).

Marine Hydrodynamics

The Majuro Lagoon has an area of 324 km^2 with an average depth of 46m increasing to 67m in the deepest parts of the lagoon.

Winds

Majuro Atoll is affected by easterly trade wind waves and the north Pacific swell. The prevailing winds at Majuro Atoll are east-northeast trade winds and occur 85% of the time. The average speeds of these prevailing winds are approximately 18.5 km/hr. Tropical storms and typhoons can also generate significant wave action in the waters surrounding Majuro Atoll and Lagoon although they are relatively rare.

Consistent with the seasonality of the trade winds, most trade wind wave action occurs between December and April. Although, trade winds are not as prevalent in May to November significant trade wind wave action can occur. Trade wind waves generally have a frequency of 5-8 seconds and heights of less than 1.8 meters.

Waves

The South Pacific swell is most prevalent between April and October to correspond with the southern hemisphere winter. The swell is characterized by long low waves from the southeast and southwest. Wave frequency ranges from between 12 to 20 seconds with heights between 0.6 to 1.8 meters. October through to March sees the Pacific swell come from the north to correspond with the northern hemisphere winter. The North Pacific swell has a greater frequency and intensity with wave periods of 10 to 16 seconds and heights of 4.5-5 meters.

Ocean swells have the potential to do considerable damage to low lying atolls, such as Majuro, as a result of wave run-up and overtopping. Severe swells of this nature are infrequent in Majuro.

Prevailing northeast-east winds generate lagoon waves, which are important to the sedimentation, erosion and accretion of the lagoon coast on the south rim of the lagoon and coastline to the southwest of Majuro. The trade winds are most prevalent throughout December to April generating moderate speeds. May to November sees the trade winds become weaker.

Tides

The tides at Majuro Atoll are semi-diurnal with pronounced diurnal inequalities meaning that the two tidal cycles per day have unequal tidal ranges. The predicted mean tidal range for Majuro is 1.13 meters. The mean spring tide range is 1.62 meters.

Water Exchange

Water exchange dynamics of Majuro lagoon has been extensively studied. Kraines et al (1999) studied the effect of wind, waves and tide on the water exchange of Majuro lagoon. They found that wave induced exchange (radiation stress) was the primary driver of water exchange with tidal exchange only important around the main channels (eg. Calalin channel). On average the entire lagoon volume of Majuro was determined to exchange completely with the open ocean every 15 days, with a range of 12 to 20 days. However water exchange in Majuro Lagoon is not uniform across the lagoon with the eastern portion being relatively poorly exchanged and the central portion being the most frequently exchanged.

From Kraines et al (1999):

"The current vectors 10m from the surface averaged over 28 cycles of the M2 tide, i.e., approximately the M2-S2 spring-neap tidal cycle, show a flow pattern from the east and west lagoons through the Calalin Channel and out to the ocean"

The flow patterns of Majuro lagoon are also examined in Kraines, Isobe & Komiyama (2001). While variations exist across seasons and water depth the overall pattern is consistent with the above comment. The general water exchange pattern of Majuro Lagoon is displayed in Figure 4.6.1. Additional water exchange occurs around point B with tidal exchange through Calalin and the Western Channels.

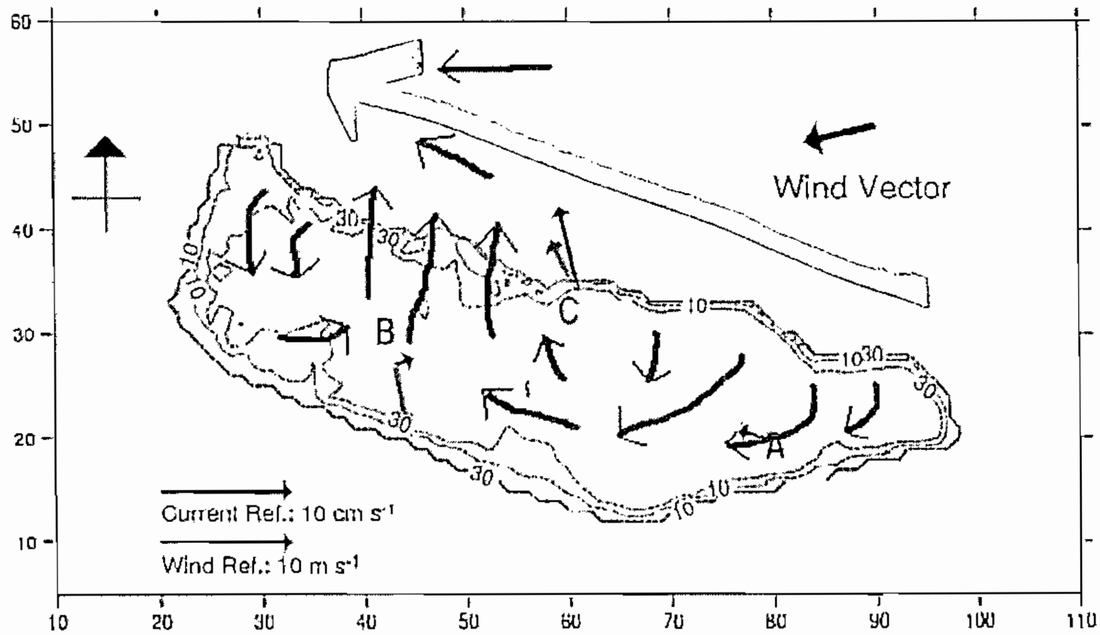


Figure 4.6.1: Dominant Water Flow Pattern in Majuro Lagoon (adapted from Kraines et al, 1999 and Kraines, Isobe & Komiyama, 2001))

It was also noted that water mixing in Majuro lagoon was strong with no indications of thermocline or halocline structures during the study.

Kraines, Isobe & Komiyama (2001) further investigated the hydrodynamics of water exchange in Majuro lagoon with models of flow fields by three-dimensional numerical simulation to clarify the mechanisms controlling the exchange of water and water-borne particles (Lagrangian type particle-tracking model) between the lagoon and open ocean. Water exporting the lagoon was assumed to be rapidly swept away from the atoll by the strong currents observed in the ocean surrounding Majuro.

The results in Kraines, Isobe & Komiyama (2001) demonstrate that the central portion of Majuro lagoon has the most rapid export of water and particles. Figure 4.6.2 displays the export of particles in Majuro lagoon across seasons.

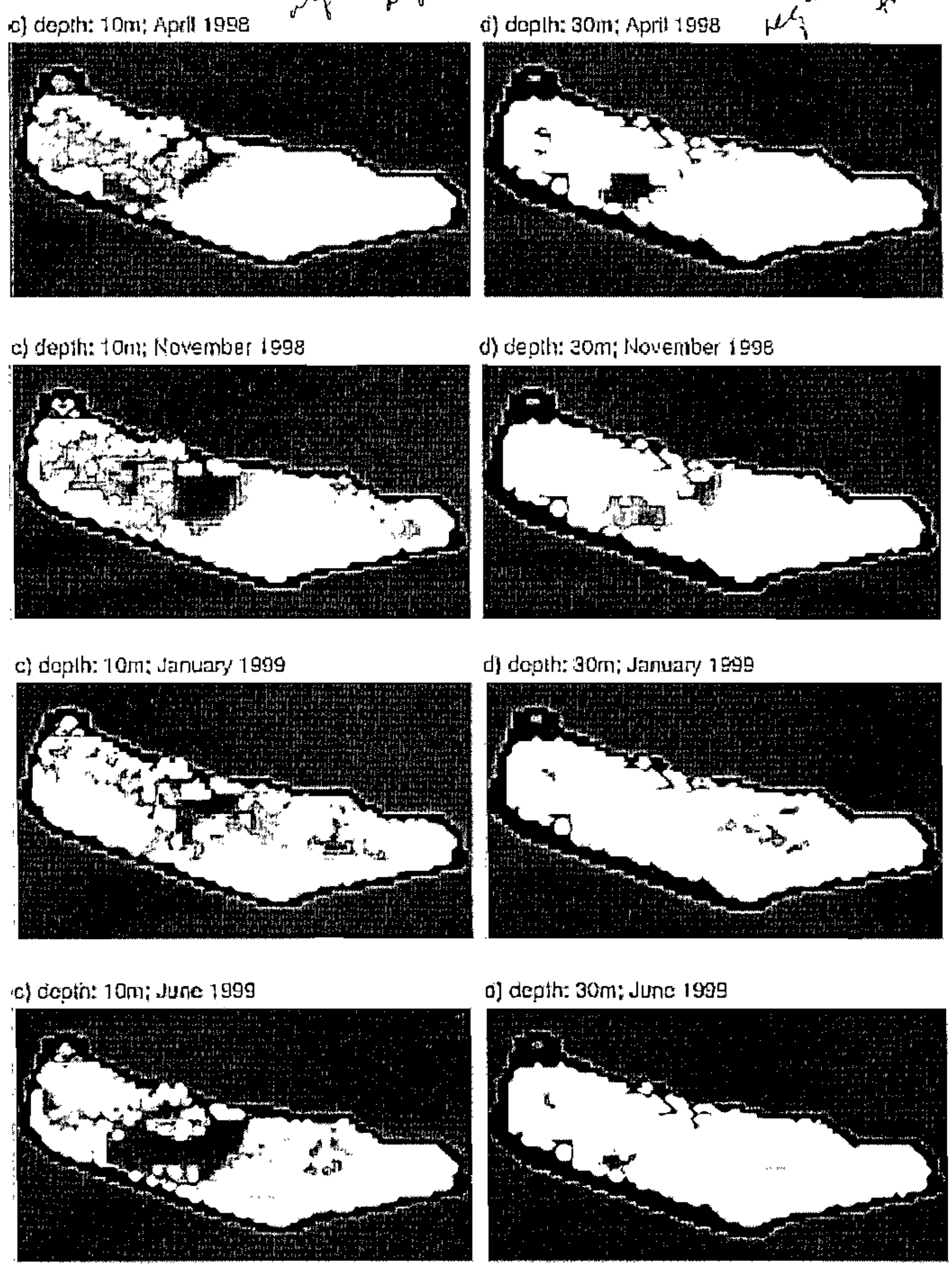


Figure 4.6.2: Particle Export Times from Majuro Lagoon (Taken from Kraines, Isobe & Komiyama, 2001). Variations in the time for particles from different areas of the lagoon to be exported are shown with a continuous shading scale going from less than 1 day (shaded areas) to greater than 21 days (unshaded areas).

The water exchange of Majuro lagoon is relatively high. The average total exchange of 15 days in Majuro compares to Christmas Island and Cantonne Atoll exchange rates of 50 days and Shark Bay (Australia) every 400 days.

Sea Currents

It is observed that there are relatively strong currents in the sea surrounding Majuro Atoll sweeping in a generally easterly direction. Kraines, Isobe & Komiyama (2001) assumed that these currents were strong enough to sweep all water or particles exported from Majuro lagoon away from the atoll.

Fresh Water Quality

N/A

4.7 Waste

4.7.1 Baseline Conditions

This section will provide the current status of waste production and disposal in the area so to assess the impact on the current situation in Section 5.

Solid Waste

There is no solid waste disposed of in the area.

Hazardous Waste

There is no hazardous waste disposed of in the area.

Waste Water

There are no wastewater treatment outfalls in the area of the proposed farm sites.

4.8 Air, Climate, Noise and Vibration

4.8.1 Baseline Conditions

Air Quality

There are no significant anthropogenic air quality issues at the proposed farm sites.

Climate Change

Climate change has the potential to increase the sea levels at the proposed farm sites. As the existing depth of water at the sites is quite deep (30-40 meters), moderate sea level rises will not have a significant impact on the operation of the farm.

Noise and Vibration

There are no anthropogenic noise or vibration issues at the proposed farm sites.

4.9 Landscape and Visual Amenity

4.9.1 Baseline Conditions

The proposed aquaculture site locations are a significant distances from land (almost central in the lagoon). At present the visual amenity of the location relates to the clear view across the water. The visual amenity of the site as seen from Woja is displayed in Figure 4.9.1.

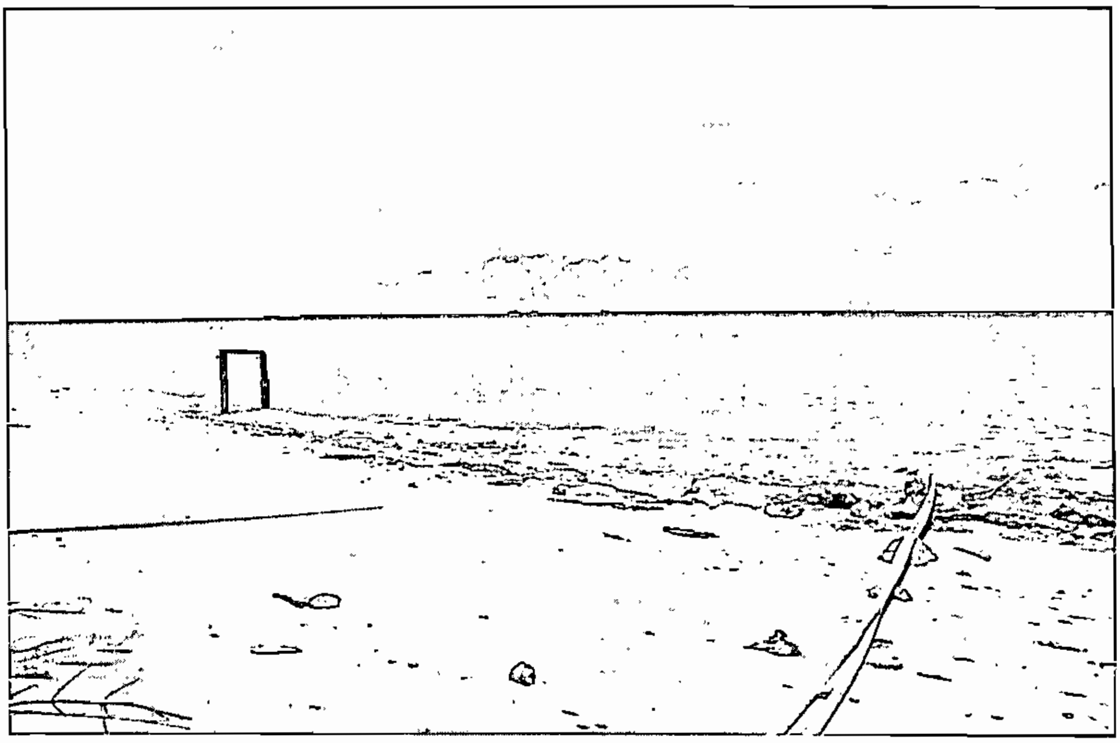


Figure 4.9.1: View from Woja Towards the Proposed Farm Site

4.10 Cultural Heritage, Archaeology and Material Assets

4.10.1 Baseline Conditions

It is understood that the site has no significant cultural or archaeological fabric and no particular material assets. A letter confirming the sites character is being sort from the Historic Preservation Office at Ministry or Internal Affairs.

4.11 Traffic and Transport

4.11.1 Baseline Conditions

Navigation

The shipping lanes in Majuro lagoon extend from Calalin Channel to the Delap area in the eastern lagoon (Figure 4.11.1). All proposed aquaculture sites are west of the shipping lane at Calalin Channel and will not interfere with shipping.

It is understood that the proposed location of the aquaculture site is not a popular boating routes within the Majuro Atoll. The RMI Ports Authority has confirmed that the proposed sites are remote from any shipping lanes in Majuro.

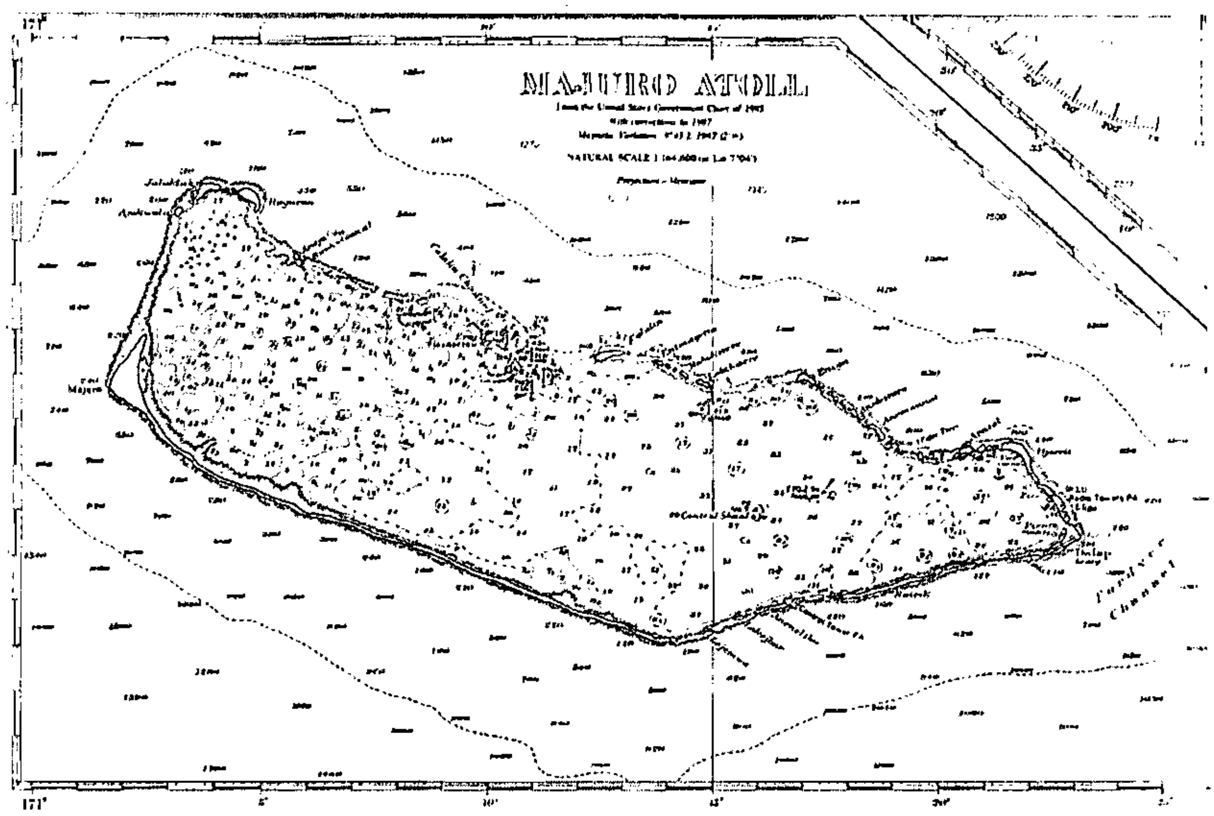


Figure 4.11.1: Shipping lanes within the Majuro Atoll.

Land Traffic and Transport

N/A

5 Environmental Impacts and Mitigation

5.1 Impact Assessment Methodology

The significance of impacts is evaluated by taking account of the status and level of importance of 'receptors' and the magnitude of any impacts. Importance is defined in relation to:

- Worldwide and Pacific Region;
- Republic of the Marshall Islands;
- Atoll; and
- Wetos.

For the purpose of this EIA the receptor 'Wetos' is also used to represent impacts within the lagoon that are limited to the proposed aquaculture areas.

Magnitude is determined on the basis of accepted EIA methodology and comprises of the relative scale / size / severity of impacts. This is considered against the importance / value / sensitivity of the receptor, spatial and temporal incidence of any impacts and ability of receptors to recover.

In determining the significance of an impact, 'magnitude' is assessed against 'importance' to provide a range of significance from 'negligible' to 'major' as shown in Table 5.1.

Table 5.1: Matrix to Assess Significance of Impacts

		Magnitude of impact			
		Negligible	Low	Medium	High
Level of importance of receptors	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

For this Environmental Impact Assessment a significant impact is considered to be "Moderate/Major" or "Major" significance. However, where feasible, mitigation is set out for impacts at all levels of significance to minimize or remove effects. These are identified under each discussion of impacts and summarized in the Environmental Action Plan (EAP).

In addition, the nature of impact is defined in relation to duration and permanence:

- Short-term 0 – 3 years;
- Medium-term Extending from end of construction to 5 years from the start of works;

- Long-term — Extending beyond 5 years from the start of works;
- Reversible — Impact can be reversed by impact reduction/mitigation measures or by natural environmental recovery within reasonable timescales (within a maximum of five years following cessation of operations); and
- Irreversible — Impact cannot be reversed.

The above impact assessment methodology is used to determine impacts associated with all aspects of the scheme so to provide a consistent approach. The impact assessment sets out an assessment of the key impacts related to taking forward the preferred option only. The impacts considered raised in the Scoping Report.

In regards the magnitude of impact levels displayed in Table 5.1 the definitions displayed in Table 5.2 have been utilized.

Table 5.2: Qualitative Measure of Consequence

Level	Descriptor	Description: Benefits	Description: Costs
	Negligible	Very insignificant impacts. Unlikely to be measurable against benchmarks.	Very insignificant impacts. Unlikely to be measurable against benchmarks.
	Low	Possibly detectable impacts but minimal changes to the established structure and function. The impact and its magnitude are small relative to the wider context of the population / area being impacted. Benefits maintained over the short term without extended management and / or works	Possibly detectable impacts but minimal changes to the established structure and function. The impact and its magnitude are small relative to the wider context of the population / area being impacted. Return to pre impact levels achievable and expected to occur over the short term once management initiatives are implemented.
	Medium	Detectable impacts, characterized by significant changes in structure, composition and function. The benefit is maintained over the medium term with minimal management and / or works.	Detectable impacts, characterized by significant changes in structure, composition and function. Recovery from impacts is achievable over the medium term once management initiatives are implemented.
	High	Wider and longer term impacts occurring and likely to result in a highly changed structure, composition and function. The benefit is maintained over the longer term without management and / or works.	Wider and longer term impacts occurring and likely to result in a highly changed structure, composition and function. Return to pre impact levels unlikely to occur even with mitigation and intervention.

Source: Modified from Crawford (2003) and Fletcher et al. (2004)

5.2 Human Beings and Land Use

5.2.1 Assessment of Impacts and Mitigation Measures

Table 5.3: Summary of Impacts

Impact	Activity and Description	Assessment
Costs		
Increased Boat Traffic	Construction and operation of the fish farms will increase boat traffic between eastern Majuro and the fish farm sites.	Minimal impact in Majuro Lagoon which is a relatively busy shipping and boat activity area. Impacts of increased boat activity due to construction activities are short-term (associated with the activity only) and reversible with an overall of **minor / moderate** significance.
Restricted Access	Access to the fish farm areas by the public will be restricted.	Currently the area is not heavily utilized by members of the public. Overall, the impact of restricted access by the public is considered to be of **minor / moderate** significance.
Restriction of Recreational Fishing Area	Access to the fish farm areas by the public for fishing will be restricted.	Currently the area is not used for recreational fishing. Previous experience suggests that wild fish will aggregate around sea cages as they do around most floating structures. Excluding recreational fishing around the cages results in a de-facto marine sanctuary with conservation and fisheries benefits. The impact is considered to be of **minor / moderate** significance.
Impact on other Businesses	Other potential business activities in the vicinity of the fish farm sites may conflict with the aquaculture operation.	The areas considered for the fish farm sites are relatively remote and other businesses are not known to operate in the vicinity. The seafood industry in general is an established type of industry in RMI. Impacts on other businesses are considered to be of **minor** significance.
Restriction of Boat Traffic	Boat navigation through the fish farm sites will be restricted.	The proposed fish farm sites are not located in or near any shipping lanes in Majuro and will not pose a navigation hazard to shipping. Boats that do wish to travel through the central part of Majuro Lagoon shall be free to travel between and adjacent to the fish farm sites. The resultant significance of the impact is **minor.**
Benefits		
Employment Generation (Construction)	The construction and operation of the fish farms will generate new employment for the RMI.	A significant number of new jobs (around 400) will be directly created by the development although it is difficult to separate construction and operational employment. There will also be significant indirect and flow-on employment created (estimated additional 920 jobs). The impact is

		considered to be of moderate / major significance.
Increased Skills of Marshallese (Construction)	Marshallese will gain new skills in the construction of the aquaculture facilities.	The skills developed by employees of GFB in assembling and mooring fish farms is considered of being major significance.
Employment Generation (Operation)		A significant number of new jobs (around 400) will be directly created by the development although it is difficult to separate construction and operational employment. There will also be significant indirect and flow-on employment created (estimated additional 920 jobs). The impact is considered to be of moderate / major significance.
Increased Skills of Marshallese (Aquaculture)	Marshallese will gain new aquaculture skills through the operation of the venture.	The skills developed by employees of GFB in fish husbandry and fish farm maintenance is considered of being major significance.

1.1.1.6 Construction Impacts

Increased Boat Traffic

Construction activities will involve an increase in boat traffic in Majuro lagoon associated with the transport of equipment and staff to and from the fish farm sites.

An increase in boat traffic is considered negative due to potential for increased noise and activity. However the level of impact is considered to be minimal in the established structure and function of Majuro Lagoon which is a relatively busy shipping and boat activity area. Impacts of increased boat activity due to construction activities are short-term (associated with the activity only) and reversible. Return to pre impact levels are expected to occur in the longer term with reduced construction activities and less movement between the fish farm sites and Majuro docks with more equipment and construction activities confined to barges within the fish farm sites. Consequently the magnitude of the impact is assessed as being **low** at the **atoll** level, providing a **minor / moderate** significance of the impact.

Assessment of Impact – Summary

Positive	Negative

Level of importance of receptors	Magnitude of impact: Negligible	Low	Medium	High
Wetos	Negligible	Minor	Minor/Moderate	Major
Atoll	Minor	Minor/Moderate	Moderate/Major	Major
Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Employment Generation

Additional employment generation will be created by the construction phases of the fish farms. Differentiating between employment generated by construction activities on the farm and operational activities associated with producing fish is not easy as many staff will be required to work on both types of activities.

Given the high rate of un and under employment in Majuro it is considered that employment generation due to construction will generate positive detectable impacts with significant changes is structure, composition and function. The employment generated by construction, although likely to translate into further operational jobs for the employees, is best considered as short-term. It is also reversible on the cessation of construction activities. Overall construction employment generation is assessed as being of **medium** impact at the **atoll** level and of **moderate / major** significance.

Assessment of Impact – Summary

Positive	Negative

		Magnitude of impact			
		Negligible	**Low**	**Medium**	**High**
Level of Importance of receptors	**Wetos**	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Increased Skills of Marshallese

The construction activities associated with the development the fish farms will bring significant new skills to those Marshallese working on the project. New construction skills include plastic welding, calculation and placement of complex mooring systems, net and rope skills and commercial diving.

These skills will be retained by staff on leaving GFB RMI and will be able to be utilized for the construction of other marine-based projects in the RMI, including other aquaculture developments. The skills impacts are long-term and essentially irreversible. As such the impact is assessed as being **high** and of relevance to the entire **RMI**. The positive impacts associated with skills generation during construction are therefore of **major** significance.

Assessment of Impact – Summary

Positive	Negative

Level of importance of receptors		Magnitude of impact			
		Negligible	**Low**	**Medium**	**High**
	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

1.1.1.7 Operational Impacts

Restricted Access

GFB RMI seeks to restrict access to the fish farm sites for security reasons. Officials and employees of relevant RMI Authorities will be permitted access however access by the general public will require prior permission from GFB RMI management.

The proposed fish farm sites occupy less than 2% of the surface area of Majuro lagoon and are located in a relatively remote and low use area. The general public will be free to move up to the boundaries of the sites. However the fish farm sites will present a minor navigational constraint.

In the context of the current use and value of the proposed fish farm areas it is considered that the impact of restricted access to the public will be **low** at the **atoll** level. There will possibly be detectable impacts but these are considered minimal in the established structure and function. The impact is reversible however will be preserved for the life of the project. The impact of the restricted access by the public is considered to be of **minor / moderate** significance.

Assessment of Impact – Summary

Positive	Negative

		Magnitude of impact			
		Negligible	**Low**	**Medium**	**High**
Level of Importance of receptors	**Wetos**	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Restriction of Recreational Fishing Area

The proposed fish farm sites will be closed to all public access including for fishing purposes. The area of the proposed fish farm sites is not know to be considered as having significant value for recreational fishing. Furthermore the remaining 98% of Majuro lagoon that contains the higher value fishing areas will not be impacted in terms of access.

Restriction of recreational fishing in the fish farm sites also needs to be balanced against slight benefits with the restricted areas providing a form of 'marine sanctuary' to preserve breeding stocks of some fish species (thereby improving long-term fishing prospects in surrounding areas). The fish farm sites are not currently areas of significant fish assemblage however the establishment of the fish farming infrastructure will improve the fish habitat value to a limited degree. Overall the positive impacts of the 'marine sanctuary' effect are considered to be minimal in the overall context of the lagoon. The positive long-term fisheries and conservation benefits from excluding fishing adjacent to sea cages is documented in the scientific literature (Dempster et al., 2007).

The magnitude of the impact of restriction of recreational fishing is considered negligible at the atoll level. Overall the impact is considered unlikely to be measurable against benchmarks. The impact is reversible on cessation of farming. However GFB RMI is intending to restrict access to the site for the life of the project. In summary the restriction of recreational fishing area is assessed as being of minor consequence.

Assessment of Impact – Summary

Positive	Negative

Level of importance of receptors	Magnitude of impact: Negligible	Low	Medium	High
Wetos	Negligible	Minor	Minor/Moderate	Major
Atoll	Minor	Minor/Moderate	Moderate/Major	Major
Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Impact on Other Businesses

Impact on other businesses due to the establishment of the fish farm is possible through:

- Restriction of access of other businesses;
- Restriction of the activities of other businesses;
- Visual impact on tourism related businesses.

The areas considered for the fish farm sites are relatively remote and other businesses are not known to operate in the vicinity. As such it is understood that there are no current issues with the restriction of access of other businesses. The seafood industry in general is not a new type of industry for the RMI.

Sand mining in the lagoon does not overlap spatially with the current proposal. The identified aggregate resources in Majuro are all at the periphery of the lagoon and too distant to potentially impact the fish farm operation and vice versa.

Owing to the need to have good water quality for sea cage production, the project can provide a positive business impetus for maintaining water quality in the lagoon, and an early warning of any emerging impacts.

Tourism operators in Majuro are known to take diving tours to areas in Calalin pass, within about 4 kilometers of the nearest proposed fish farm site. The fish farm will be visible from these areas. However the visual impact of the fish farm is low (see visual impact section below) and the primary interest of the tourists in this case is the underwater visual amenity. These tourist tours are not currently operational any closer to the proposed fish farm sites and are unlikely to do so due to the limited recreational value of the area surrounding the fish farm sites.

While the overall impact of restriction of other businesses is best classed as negative the magnitude of the impact will be **negligible** at the **atoll** level and unlikely to be measurable against benchmarks. The impact is reversible on cessation of the project. The overall assessment is that the impact on other businesses of the operation of the fish farm will be of **minor** significance.

Assessment of Impact – Summary

Positive	Negative

		Magnitude of impact			
		Negligible	Low	Medium	High
Level of importance of receptors	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Restriction of Boat Traffic

The proposed fish farm sites will be closed to general boat traffic.

The proposed fish farm sites however, are not located in or near any shipping lanes in Majuro and will not pose a navigation hazard to shipping. Ships enter Majuro through Calalin Channel and move in the section of the lagoon east of the channel whereas all of the fish farm sites are west of Calalin Channel.

Smaller boats and vessels that travel in the western portion of Majuro Lagoon (for example to Rongrong) tend to do so by keeping close to the lee of the northern rim of the atoll. The fish farm sites in the central part of the lagoon are a minimum of 2.5 kilometers from this route.

Boats that do wish to travel through the central part of Majuro Lagoon shall be free to travel between and adjacent to the fish farm sites. All fish farm sites in use shall be clearly marked with buoys and navigation lights. The RMI Ports Authority and MIMRA will be notified of any restricted boating areas.

In the context of the usual shipping and boating routes in Majuro and the small area of the lagoon that will have altered navigation routes the magnitude of the impact on restricting boat traffic is assessed as being **negligible** at the **atoll** level. The impact is considered to be insignificant and unlikely to be measurable. The resultant significance of the impact is **minor.**

Assessment of Impact – Summary

Positive	Negative

Level of importance of receptors	Magnitude of impact: Negligible	Low	Medium	High
Wetos	Negligible	Minor	Minor/Moderate	Major
Atoll	Minor	Minor/Moderate	Moderate/Major	Major
Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Increased Skills of Marshallese

Operation of the fish farms will require a large number of Marshallese employees who will require training in a variety of skills for the husbandry of the fish and maintenance and operation of the fish farming equipment. GFB RMI is investigating options for a scheme to bring some Marshallese to Australia for training on GFB Fisheries farms in Australia as well as some possible short course work at an Australian University in Aquaculture and Marine Science.

Aquaculture is recognized by the RMI Government as one of six industries with the potential for major development in the Marshall Islands in order to achieve employment generation, human resource development, generation of foreign exchange, and import substitution (www.rmiembassyus.org/Economy.htm). The development of aquaculture development and husbandry skills for a large number of Marshallese will be of lasting benefit to the RMI. The pool of skilled Marshallese aquaculture workers will make further aquaculture developments, both by local and foreign investors, easier in the RMI.

The magnitude of the increased skills of Marshallese is assessed as high at the RMI level, with wider and longer term impacts occurring. The benefit will be maintained over the longer term even if the operation is discontinued. The resultant significance of the impact of increased skills of Marshallese is major.

Assessment of Impact – Summary

Positive	Negative

Level of Importance of receptors	Magnitude of Impact: Negligible	Low	Medium	High
Wetos	Negligible	Minor	Minor/Moderate	Major
Atoll	Minor	Minor/Moderate	Moderate/Major	Major
Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Employment Generation

GFB RMI believes that it will require approximately 400 full-time staff directly employed at full production (50,000 metric tons per year) of which about 10 would be foreign technicians. The operation would also generate significant indirect employment, for example through the processing of fish in Majuro prior to export, and the boost to the RMI economy would help to create additional employment through economic impact (due to the spending of the additional incomes of the direct and indirect employment positions). In all AEC*group* estimates that the total employment impact of the full-scale proposed aquaculture operation would be 1,320 full-time jobs in Majuro.

Up to 50% of Marshallese of working age are not currently participating in the workforce. The total workforce of the RMI was estimated at 9,810 in 2006 (http://www.spc.int/prism/country/mh/Stats/Economic/LaborMarket/EmpInd.htm). The establishment of the GFB RMI fish farm therefore has the potential to increase the Marshall Islands workforce by over 10%.

The magnitude of the impact of increased employment of Marshallese will create wider impacts likely to result in a highly change structure, composition and function. Although the GFB RMI investment is intended for the long term, the employment benefits would rapidly reverse with the cessation of the operation. As such the magnitude of the benefit is best assessed as medium at the atoll level. This results in a moderate / major significance for the impact.

Assessment of Impact – Summary

Positive	Negative

Level of importance of receptors	Magnitude of impact: Negligible	Low	Medium	High
Wetos	Negligible	Minor	Minor/Moderate	Major
Atoll	Minor	Minor/Moderate	Moderate/Major	Major
Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

1.1.1.8 *Mitigation Measures*

Increased Boat Traffic

The impact of increased boat traffic due to the construction and operation of the fish farms is assessed as being of minor / moderate significance.

GFB RMI aims to minimize the amount of boat traffic to and from the fish farm sites by:

- Mooring large service barges on site to store feed, supplies and some equipment;
- Ferrying farm workers to site on several large boats;
- Providing accommodation on boats on site; and
- Working with RMI authorities to develop procedures for import / customs / quarantine inspections at sea to avoid double transfer of goods and unnecessary use of the ports in Majuro.

Restricted Access

The impact of restricted access of the fish farm sites when in operation is assessed as being of minor / moderate significance. The fish farm sites have been selected partly due to their relatively low value to other uses. GFB RMI does not propose any other measures to mitigate the impact of restricted access to the fish farm sites as this is an important component of farm security.

Restriction of Recreational Fishing Area

The impact of restriction of recreational fishing area due to restricted access of the fish farm sites when in operation is assessed as being of minor significance. The fish farm sites have been selected in part due to their relatively low value as fishing areas. No other mitigation measures are proposed for this impact.

Impact on Other Businesses

The impact on other businesses from the operation of the fish farm areas by GFB RMI is assessed as being of minor significance. The fish farm sites have been selected in part due to their remoteness from other business activities. No mitigation measures are proposed for this impact.

Visual Impact on Residents

The visual impact on residents of the fish farms is assessed as being of minor / moderate significance. The fish farm sites have been selected in part due to their relative remoteness to most residential areas. Other measures to minimize the visual impact will be:

- Position work barges and ships in most distant part of the fish farm sites to the atoll shorelines; and
- Restrict lighting on boats and ships between 10pm and dawn to the minimum needed for safety and navigation.

Restriction of Boat Traffic

The impact of the fish farm sites on restricting boat traffic is assessed as being of minor significance. The fish farm sites have in part been selected due to the remoteness from usual boating and shipping routes. Furthermore, the sites will be clearly marked for marine navigation day and night.

Increased Skills of Marshallese

The impact in increasing the skills of Marshallese is assessed as being of major significance for construction associated skills and major significance of aquaculture operation skills. GFB RMI intends to maximize the skills base in the Marshallese workforce and further this positive impact through onsite and possibly overseas training.

Employment Generation

The impact on employment generation in the RMI is assessed as being of moderate / major employment. GFB RMI intends to maximize the long-term viability of the project in economic, environmental and social terms to ensure that the employment generation benefits continue into the longer term.

5.3 Habitats and Species

Table 5.4: Summary of Impacts

Impact	Activity and Description	Assessment
Costs		
Placement of Moorings	Placement of the moorings will involve some disturbance of the seabed.	The very small areas of seabed to be affected by the placement of the moorings and its relatively low ecologicial value result in this impact being considered to be of **negligible** significance.
Aggregation of Wild Fish Assemblages	Wild fish will tend to aggregate around the structures provided by the fish cages and farm infrastructure.	Fish aggregation has been observed at the pilot site and will occur at the proposed fish farms. There are positive implications for improved assimilation of wastes with fish aggregations. This impact is considered to be of **minor / moderate** significance.
Changes to Macrobenthic Assemblages	Macobenthic assemblages under and directly adjacent to the seacages are likely to undergo changes in composition.	Changes to macrobenthic assemblages (such as seacucumbers) under the fish cages is considered to be of little impact in the relatively low value habitat of the fish farm sites and of benefit in assimilating wastes and maintaining sediment quality. The impact is considered to be of **minor / moderate** significance and highly restricted in area (within 10s of meters of the cages).
Boat Strike When Traveling to Site	Boats traveling to the fish farm sites may strike marine macrofauna such as turtles.	The chance of boat strike is greatly reduced in Majuro due to the deepa and clear lagoon waters. This impact is considered to be of **minor** significance.
Disease and Pathogen Transfer to the Wild	Cultured fish may develop diseases and transfer them to wild stock.	Disease in the cultured fish is expected to be minimal and restricted to opportunistic infections by organisms already present in the environment. The potential for disease and pathogen transfer is considered to be of **minor / moderate** significance.
Entanglement of Megafauna	Marine megafauna may become entangled in some types of fish farm infrastructure.	Potential entanglement of megafauna is relatively easily avoided by utilizing the appropriate types of nets. The resulting impact is considered to be **minor** and manageable with further changes to technology if it does occur.
Escaped Stock	Stock may escape through damaged seacages or grading or transfer accidents and interact with wild fish and ecosystems.	The proposed species for culture are all endemic. Escapees are often domesticated and perform poorly when they escape although those that do adapt will assimilate as part of the natural ecosystem. The impact is considered to be of **minor / moderate** significance.

Food Web Changes	Changes to food webs in the vicinity of the fish farms are likely due to excretion of organics and nutrients from the fish cages.	Food web changes with increases in some types of fish, plankton and macrobenthos will occur in the near field as part of the natural assimilation response. The overall impact is considered to be of minor / moderate significance.
Seabird Interactions	Seabirds may become entangled in some types of seacage coverings.	It is considered unlikely that seabirds will become entangled in the fish farm infrastructure and modifications can easily be made if this becomes and occurrence. The potential for the impact is assessed as being of minor significance.
Sediment Changes	Sediments under and directly adjacent to the seacages may become anoxic after a period of time under certain conditions.	Some sediment impacts are possible but will be lower than noted in studies of many other farms due to the water depth and flushing rates. The impact is short-term and easily managed by moving cages to allow for fallowing; as such the impact is considered to be of minor significance.
Water Quality (near field)	Nutrients excreted by fish (primarily nitrogen and phosphorus) may result in measurable water quality changes in the near field (within 1,000 meters) of the fish farm sites.	The near field water quality will be impacted at levels that may be measurable, as this is where the major assimilation occurs. Calculations and baseline water quality results suggest that the level of impact is likely to be unmeasurable against natural variability. The impact is considered to be of minor / moderate significance and rapidly reversible.
Water Quality (intermediate field)	Nutrients excreted by fish (primarily nitrogen and phosphorus) may result in measurable water quality changes in the intermediate field (beyond 1,000 meters of the fish farm sites but within Majuro Lagoon).	Mass balance modeling indicates that water quality in the lagoon will not be significantly altered from background levels due to the fish farming with changes unlikely to be measurable. The impact is considered to be minor / moderate and rapidly reversible.
Translocation of Species	Importing of fish from overseas may result in the inadvertent transfer of non-endemic species in the seawater or on ships surfaces.	Protocols for the importation of fish fingerlings from Australia will reduce the risk of translocation of species to a similar or lower level than that associated with existing ship movements. The potential for translocation of species is considered to be of minor significance.

5.3.1 Assessment and Mitigation of Effects

1.1.1.9 Construction Impacts

Placement of Moorings

Placement of moorings (which consist of concrete blocks or metal anchors with metal chains) involves some disturbance to the seabed. The moorings may travel a short distance before bedding properly into the sediment and the chains may move about with heavy seas causing small areas of scouring of the seabed. Any benthic fauna in the areas impacted by the block and chain have the potential to be damaged. A mooring block and chain used at the current pilot site at Lobekerae Island by GFB RMI is displayed in Figure 5.3.1.

Figure 5.3.1: Mooring Block and Chain in Use off Lobekerae Island (Majuro)

Dive surveys of the proposed fish farm sites indicated that the benthic ecosystem is relatively impoverished, with consistent flat, decomposed coral aggregate with very little coral or macroflora. The quantum of seabed that has the potential to be impacted through damage is minimal in terms of the lagoon size. The fish farm sites occupy less than 2% of the Majuro lagoon area with the actual cages occupying about 2% of the fish farm site areas. The area of seabed subject to impact is almost negligible in the context of the total Majuro lagoon seabed area.

Consequently the magnitude of the impact is considered to be **negligible** (unlikely to be measurable against benchmarks) at the **weto** level. The impact is expected to be long-term (for as long as the moorings are in use) but rapidly reversible on decommissioning on the site. The impact of the placement of the moorings on the seabed environment is assessed as being of **negligible** significance.

Assessment of Impact – Summary

Positive	Negative

		Magnitude of impact			
		Negligible	Low	Medium	High
Level of importance of receptors	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

1.1.1.10 *Operational Impacts*

Aggregation of Wild Fish Assemblages

Various fish species are typically attracted to sea cages principally because it provides a high level of structural diversity in an otherwise low structure environment. This is an unavoidable issue in the operation of sea cage aquaculture.

As recreational fishing will be prohibited directly adjacent to the sea cages, the aggregated fish populations will be provided with refuge from fishing mortality. The aggregation effects and protection will only last for as long as the seacages are in operation. Furthermore the aggregations have some positive environmental impacts with the aggregated fish populations demonstrated in some studies to significantly improve assimilation of the wastes from the fish farms. Wild fish populations can consume up to 40% to 60% of the cage derived nutrients, resulting in an important nutrient removal or redistribution mechanism in certain marine environments (Felsing et al. 2004; Fernandez-Jover et al. 2007). Fernandez-Jovier et al. (2007) reported up to 80% reduction in total organic wastes due to wild fish populations at one Mediterranean farm.

At GFB's pilot aquaculture site in Majuro fish aggregation aggregation effects on the following species have been noted:

- *Scarus sp.* (parrot fish);
- *Epinephelus cyanopodus* (Grouper);
- *Gymnosarda unicolor* (dogtooth tuna);
- *Caranx melampygus* (trevally); .

- *Lutjanus bohar* (red snapper);
- *Acanthurus sp.* (surgeon fish);
- *Elagatis bipinnulatus* (rainbow runner); and,
- Unidentified small pelagic 'bait fish' schools surround the cages.

Figure 5.3.2: Small Pelagic Fish Aggregating Around Existing Sea Cage off Lobekerae Island (Majuro)

Fish assemblages through aggregation around the fish cages is considered to be of **medium** magnitude at the **weto** level (to reflect the impact being within the fish farm sites). The impacts will be detectable with significant changes in structure, composition and function. It is unclear as to whether the impact should be considered as primarily a negative or positive impact. The impact is reversible in the medium term on discontinuation of operation of the fish farms. The impact is assessed as being of **minor / moderate** significance.

Assessment of Impact – Summary

Positive	Negative

Level of importance of receptors	Magnitude of impact: Negligible	Low	Medium	High
Wetos	Negligible	Minor	Minor/Moderate	Major
Atoll	Minor	Minor/Moderate	Moderate/Major	Major
Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Changes to Macrobenthic Assemblages

The structure of macrobenthic assemblages (e.g. marine worms, snails, sea cucumbers) can be altered by sea cage farming activities. This is a well-documented impact from sea cage aquaculture. At this stage changes to the macrobenthic assemblages at the pilot sites in Majuro have not been noted. This may be due to:

- The level of production being insufficient at present to achieve such an impact;
- The depth of the water, which is greater than many similar fish farms, may be assimilating the wastes before they are able to impact the benthos. This has been suggested for the findings of little benthic impact of fish farms in the Mediterranean by Maldonado et al., (2005); and / or
- Relatively high levels of natural marine life may be assimilating any fish cage outputs before they have an impact on the environment. Field experiments in Vita et al. 2004 have revealed that about 80% of particulate organic matter escaping from the cages may be consumed by wild fish before reaching the seafloor (Vita et al., 2004).

The impact of fish farms on macrobenthic assemblages can be managed and mitigated, but the vast body of literature documents that it cannot be avoided entirely at most sites. The scale of the impact is generally restricted to the areas under and adjacent to (10s meters) the seacages. Changes in macrobenthic assemblages is an important natural mitigation method for sediment impacts of aquaculture – for example sea cucumber populations developing under a seacage will consume organic wastes and reduce the magnitude of the near field impact.

A summary of some studies on macrobenthic assemblages are:

- Hoskin and Underwood (2001) investigated the impacts of snapper farming at Port Stephens (NSW, Australia) and found minor changes in the patterns of abundance of existing animals. At the scale of annual production planned by the farm, despite some evidence for impacts, it is unlikely the farm could cause any major, irreversible environmental or ecological changes on the seabed;

- Karakassis et al. (2000) in the Greek Islands identified that abundance and biomass of macrobenthos was up to 10 times higher at impact compared to control sites and this impact extended to 25 meters beyond the cage, although clear attenuation of the impact was evident. These authors did not survey areas further than this from the cages; and

- Brown et al. (1997) reported a clear dominance of the macrofaunal community by the pollution tolerant *Capitella* cf. *capitata,* but the impact could not be detected 15 meters beyond the cages.

There is a significant amount of information on the impacts of sea cages on benthic assemblages. This information demonstrates that the impacts of sea cage aquaculture on benthic assemblages is localized to the areas directly proximate to the seacages and mitigated by fallowing impacted areas. The impacts are also reduced in deeper sites with flushing rates such as those selected for this proposed development.

In terms of the impact of the proposed aquaculture farm in Majuro lagoon, it is expected that changes to macrobenthic assemblages will be detectable at the near field (within 10's of meters of the cages) at higher levels of production. Increases in various invertebrates (e.g. beche de mer) feeding on the increased organic matter falling from the cages are also considered highly likely.

The impacts are not considered to be long-term. Aquaculture sites that are fallowed typically return to pre-impact conditions within months or years. The impacts are reversible in the short term (less than three years) on cessation of the aquaculture activities in the area or the fallowing of a site.

While the changes to the macrobenthic assemblages are assessed as being negative the increase in macrobenthic fauna has an important function in mitigating the organic fallout produced by the aquaculture and maintaining the health of the sediments.

The magnitude of the impact is best classified as **medium** with detectable impacts characterized by significant changes in structure, composition and function at a local level measured in 10s meters. Evidence is abundant that the impacts are confined to relatively small areas around the cages and hence the atoll receptor is not appropriate with the **wetos** level of importance considered the best representation of the scale. The overall significance of the impact on macrobenthic assemblages is therefore assessed as **minor / moderate.**

Assessment of Impact – Summary

Positive	Negative

		Magnitude of impact			
		Negligible	Low	Medium	High
Level of importance of receptors	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Boat Strike When Traveling to Site

Boat traffic, through boat strike, can kill or injure animals such as marine turtles. In the case of Majuro, it should be noted that the speed of recreational and commercial fishing vessels are not limited and that boat strike is not documented as an issue. Boat strike is generally an issue in turbid narrow channels but not in broad expanses of navigable clear water such as those to be traversed by vessels associated with this proposal. The additional boat traffic generated by the operation of the fish farm in not expected to be significant within the context of the usual boat traffic on the lagoon. Boat traffic within the sites for fish husbandry activities will be relatively slow and pose little risk of boat strike. The impacts are short-term and reversible on the cessation of traffic associated with the farm however may occur for as long as the farm is in operation.

The level of risk of boat strike due to the operation of the farm is considered to be **negligible** (unlikely to be measurable against benchmarks) although impacts are possible over much of the atoll (with travel from Uliga to the aquaculture sites). The significance of the impact as assessed is considered to be **minor**.

Assessment of Impact – Summary

Positive	Negative

		Magnitude of impact			
		Negligible	Low	Medium	High
Level of Importance of receptors	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Disease and Pathogen Transfer to the Wild

Sea cage farming has been implicated in the spread of fish diseases and pathogens. This is an issue that can be managed, although the risk cannot be reduced to zero.

The activity of sea cage aquaculture poses a low risk to disease and pathogen issues for adjacent wild stocks. Cultured stocks may be impacted by natural diseases that do not manifest acute symptoms in wild fish. The diseases impacting the cultured stock are almost always ubiquitous in the natural environment, however do not cause significant problems in the wild fish due to much lower densities and the lack of stressors such as grading and other handling activities.

The high water quality and stable water temperatures in Majuro are anticipated to minimize the occurrence of diseases in the fish under production. There has been no disease recorded in the current grouper in the pilot cages despite the fish being repeatedly exposed to heavy stress in quarantine due to power outages.

Much of the disease work that has demonstrated a linkage between diseases in aquaculture stock transferring to wild fish refers to salmon and salmon lice (e.g. Bjorn et al., 2001 and reference therein). Other species in production have not been demonstrated to increase disease risk to wild stocks.

There is a possibility of introducing fish diseases through the feeding of baitfish in aquaculture. However the fish farm in Majuro will exclusively utilize heat-sterilized pelletized feed with no disease transmission risk.

The introduction of any new diseases or pathogens is always a potential concern when translocating fish. All fish grown in the Marshall Islands shall either:

- Be sourced from the Marshall Islands. This is associated with no risk of disease introduction; or
- Be sourced from high-health hatcheries in Australia. Australia is a relatively disease free locality as a result of its geographical isolation together with the strictest biosecurity laws and procedures in the world (bar New Zealand). Australia has recorded two fish diseases of international concern however these are both freshwater diseases of no risk of transmission through the saltwater species to be sent to the Marshall Islands (Table 5.5).

Table 5.5: Fish Diseases of International Concern and Relevance in Australia

Fish Disease	Relevance in Australia	Risk to the RMI
Epizootic haematopoietic necrosis	Reported in freshwater fish in Australian States of ACT, NSW, SA and VIC. It has not been recorded in Queensland (the location of GFB's hatchery) and does not infect saltwater fish	No risk to RMI fish as freshwater disease only. No risk of transfer to the RMI by GFB as freshwater disease only.
Infectious haematopoietic necrosis	Not known to exist in Australia	N/A
Spring viraemia of carp	Not known to exist in Australia	N/A
Viral haemorrhagic septicaemia	Not known to exist in Australia	N/A
Infectious pancreatic necrosis	Not known to exist in Australia	N/A
Infectious salmon anaemia	Not known to exist in Australia	N/A
Epizootic ulcerative syndrome	Epizootic ulcerative syndrome is endemic in many freshwater catchments and estuaries in Australia and has been officially reported from NSW, NT, QLD, VIC and WA. It is only present in freshwater and estuarine (when under freshwater stress) habitats.	No risk to RMI fish as freshwater disease only. No risk of transfer to the RMI by GFB as freshwater disease only.
Bacterial kidney disease (*Renibacterium salmoninarum*)	Not known to exist in Australia	N/A
Gyrodactylosis (*Gyrodactylus salaris*)	Not known to exist in Australia	N/A
Red sea bream iridoviral disease	Not known to exist in Australia	N/A

Sources: OIE, www.disease-watch.com (Australian Government Department of Agriculture, Fisheries and Forestry

It is impossible to assign a level of no risk of translocation of disease. However the level of risk is considered to be acceptable throughout the world with hundreds of millions of aquarium fish imported into Australia, the USA and Europe each year. For Australia, which has some of the strictest quarantine procedures in the world, a quarantine period of 7 days is applied to marine fish imports.

The magnitude of impact associated with transfer of endemic diseases to wild fish stocks is considered to be negligible, given that no fish farming apart from salmon has been implicated for this impact anywhere in the world. The risk of introduction of new fish diseases from the importation of fish from Australia is considered to be very low given the relatively disease free status of Australia, the status of the hatchery from which they will be sourced, and the import quarantine procedures that will be followed. On the balance, the appropriate assigned impact assessment is considered to be low.

A comprehensive risk mitigation protocol is outlined in the Mitigation Measures section below to minimize the risk of disease transfer. As mentioned, these procedures are precautionary in view of other procedures utilized by other countries around the world.

Assessment of Impact – Summary

Positive	Negative

Level of importance of receptors		Magnitude of impact			
		Negligible	**Low**	**Medium**	**High**
	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Entanglement of Megafauna

Fauna such as dolphins and turtles may become entangled or trapped in sea cage equipment. The potential for this impact depends on the type of sea cage equipment used.

Dolphins and turtles are known to exist in Majuro lagoon. Potentially there are 5 species of sea turtle in the RMI with the leatherback turtle and hawksbill turtle endangered. Anecdotal evidence is that only one species of marine mammal (a dolphin species) enters the lagoon.

Dolphin interactions with sea cages in Australia is best quantified for tuna feedlots in South Australia (Kemper and Gibbs, 1997; 2001) who recorded that approximately three dolphins deaths per year (between 1990 and 1999) were confirmed from the sea cages, however this figure could have been as high as six. Dolphins became entangled and drowned in the large mesh (> 15 cm) predator nets that were used at the time on the sea cages.

Such large mesh predator nets are not used in sea cages elsewhere in Australia (e.g. Tasmania, Pt Stephens) and their use in general is considered unnecessary and undesirable and will not be used on the fish farm in Majuro.

There are no published accounts of interactions between sea cage aquaculture and marine turtle populations.

The net types that will be used in Majuro are rigid or semi-rigid and do not present an entanglement risk to dolphins or turtles.

The nets of sea cage aquaculture will pose a **negligible** magnitude of impact in terms of risk to dolphin and marine turtle populations. With populations of megafauna quite mobile the potential impact is best considered to be possible at the atoll level. Any possible interaction problems, if they emerge, should be able to be rapidly overcome by adopting new netting types and reversible on cessation of the aquaculture operation. In summary the significance of the impact of entanglement of marine megafauna is assessed as minor.

Assessment of Impact – Summary

Positive	Negative

Level of importance of receptors	Magnitude of impact			
	Negligible	Low	Medium	High
Wetos	Negligible	Minor	Minor/Moderate	Major
Atoll	Minor	Minor/Moderate	Moderate/Major	Major
Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Escaped Stock

Sea cages may fail liberating cultured stock into the wild. A key mitigation strategy is to ensure that species being farmed are endemic. The occurrences of the species to be farmed are outlined in Appendix D: . It should also be noted that any loss of fish is a direct commercial cost to the fish farm business and hence the proponent has a strong vested interest in utilizing technology and systems to minimize such an occurrence. However occasional individual fish escapees are likely during activities such as sampling and grading.

Vandalism, theft and sabotage may also liberate stock. Once again the proponent obviously has a strong vested interest to minimize such occurrences. The proponent's current pilot production site was sited off Lobekaere Island primarily due to the site's security benefits.

It should be noted that the impact of fish escaping is not significantly different from that resulting from the deliberate stocking of waterways with fish for the purpose of enhancing recreational fisheries. However fish that escape from fish farms at a larger size are conditioned for captivity and often exhibit low vigor in the wild environment.

An additional risk assessment of the impact of escaped stock on the environment is presented in 10Appendix D: The only species considered to present any risk of unnatural ecological pressure in the event of escapees is the giant grouper (*Epinephelus lanceolatus*) if large numbers escape and recruit to very large sizes. As giant grouper are relatively uncommon in Majuro a large number of very large fish is postulated to have the potential to exert unnatural predatory stress on reef habitats however no evidence is available to confirm this.

The magnitude of impact of escaped stock and interaction with wild resources is considered to be low in the worse case scenario of large-scale escapees with potential impacts at the atoll level. Any impacts are relatively short-term (escaped fish die, are predated upon and fished) and reversible on cessation of the aquaculture activities. The significance of the impact is therefore assessed as being minor / moderate.

Assessment of Impact – Summary

Positive	Negative

Level of importance of receptors		Magnitude of impact			
		Negligible	Low	Medium	High
	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Food Web Changes

The outputs associated with sea cage farming have the potential to alter food webs in areas directly adjacent to farms. Changes to the structure of food webs as a result of seacage farming have been documented. Changes to phytoplankton and zooplankton assemblages, as well as benthic assemblages occur which can flow on through trophic interactions to other components of the ecosystem.

The primary food web impacts will be generated through:

- Changes to macrobenthic assemblages which are then consumed by fish. These fish are most likely to remain around the fish cages (and food source) although some are likely to migrate to other areas; and

- Water quality impacts that potentially generate changes to the structure of phytoplankton and bacteria floc assemblages in the intermediate field which then flow through grazers (zooplankton) to predators.

Thus, the risk of food web changes at a far field and near field level is relative to water quality impacts (discussed elsewhere in this report) and changes to benthic macro-invertebrate assemblages.

Macrobenthic assemblage changes have been described in a previous section. There will almost certainly be an increase in the biomass of benthic and pelagic fish in the immediate vicinity of the aquaculture sites in response to changed macrobenthic assemblages (Valle et al. 2007 and references therein). It is not considered that this increase is likely to have a significant impact on the lagoon environment outside of the aquaculture areas. Further and as discussed by Dempster et al. (2007), such an impact maybe beneficial in terms of providing a defacto marine sanctuary that may have long term benefits for fishing in the area.

Increased phytoplankton in a plume from the fish farm sites is possible. A study of phytoplankton nutrition at Tuamotu atoll (with similar water parameters to Majuro) demonstrated that phytoplankton in the central Pacific is most severely limited by nitrogen availability (Dufour & Berland, 1999). Most phytoplankton was found to be unable to utilize nitrogen below 1uM/liter (Dufour & Berland, 1999). Dissolved Inorganic Nitrogen (DIN) levels of about 0.5uM/liter were found to be usable for growth of some phytoplankton species in studies of 12 atoll lagoons in the South Pacific (American Society of Limnology and Oceanography, Inc. 2001), lower than previous studies. It was found that very small phytoplankton (<3um in diameter) were more dominant in the oligotrophic conditions and may be better able to utilize DIN concentrations in the range of 0.5uM/liter to 1.0uM/liter. However it was also noted that a large part of N and P is sequestered in bacterial biomass (which have a higher N to C requirement) and is not likely available to phytoplankton.

Lagoon DIN levels varied significantly between seasons from a low of 0.03uM/liter to 1.0uM/liter in the South Pacific depending on season and location (American Society of Limnology and Oceanography, Inc. 2001). Oceanic levels of DIN were 0.02 uM/liter.

The proposed aquaculture production of 50,000 tons per annum has the capacity to raise total nitrogen levels in Majuro lagoon by around 0.4uM/liter (see section 1.1.1.13 below) although due to the flushing characteristics at the proposed sites the modeled outcome is that nitrogen levels will be raised by about 0.1uM/liter. Background levels of total nitrogen in Majuro (measured at a relatively pristine area near Lobekerae Island) are 2.0 to 2.7 uM/liter. The most likely impact of the nitrogen inputs from the fish farm will be in the order of $1/20^{th}$ of natural nitrogen levels. Based on research on the nitrogen cycle at Enewetak Atoll in the RMI (Webb et al. 1975) dissolved nitrogen levels (DIN) are likely to be about $1/10^{th}$ of the total nitrogen level i.e. 0.20 to 0.27uM/liter during the period sampled at Lobekerae Island. At these levels phytoplankton growth is unknown.

With seasonal fluctuations it is possible that nitrogen levels will reach a level at times where minor increases in phytoplankton biomass can be expected. Under the usual conditions in Majuro it is considered far more likely that the majority of nitrogen will be sequestered in the intermediate field (within 1,000 meters of the fish cages) by bacteria floc and be consumed by zooplankton and/or small pelagic fish or exported through water exchange through Calalin Channel.

The fish farm sites are located at a minimum of 2.5km – 3.0km from any significant coral reef areas. Numerous studies as discussed elsewhere in this report indicate that the impacts of fish farms are greatly attenuated at these distances. Food web changes will be mostly confined to those environments within 100m to 1km of the fish farm sites.

In summary the impacts on food webs due to the operation of the fish farm are anticipated to be:

1. Near Field (within 100 meters of the fish cages): Significant localized changes to macrobenthic assemblages in small areas (10s meters of cages) with resultant increases in benthivorous fish species;

2. Intermediate Field (with 1000 meters of the fish cages): Increased pelagic activity possible at times due to limited increases in some phytoplankton (and subsequent zooplankton) and organic floc. Zone of most significant assimilation of nutrients through mineralization, utilization by phytoplankton and bacterial floc, volitization and sedimentation. Increases in the biomass of small planktivorous fish may then result.;

3. Far Field (beyond 1,000 meters of the site but within the atoll): Possibly some measurable increases in inorganic or organic forms of nutrients such as nitrogen and phosphorus but

modeling indicates that levels will be near the level of detection (≈0.1uM nitrogen and ≈0.004uM phosphorus);

4. Very Far Field (outside of atoll): No impacts will occur. Huge water volumes and strong currents will rapidly dilute any impacts to undetectable levels.

Any impacts on the food webs in Majuro will be rapidly reversible in the event of discontinuation of the fish farm due to the high flushing of the lagoon (particularly in the central portion). The overall magnitude of the impact on changing food webs at the **atoll** level is considered to be **low** (possibly detectable changes but minimal to the established ecological structure and function of the area. A return to pre impact levels is achievable and expected to occur in the short term once inputs are discontinued however will exist for the life of the project.) The significance of the impact is therefore assessed as **minor / moderate**.

Assessment of Impact – Summary

Positive	Negative

		Magnitude of impact			
		Negligible	Low	**Medium**	**High**
Level of importance of receptors	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Seabird Interactions

Some seabird species may be attracted to a sea cage area due to fish farming activities (e.g. feeding) or to the cages as a roosting area. This is not a well documented issue but has been observed by the authors at other sites. Evidence of seabirds roosting on the seacages at Lobekerae Island has been noted by GFB. According to the RMI US Embassy 31 species of seabirds are found in the RMI although none of these are noted as endangered.

The typical non-lethal mitigation measure is to cover the top of the cages with taught netting that does not entangle birds. This is required from a commercial perspective to prevent seabird predation. For most types of netting there will remain a risk that seabirds may occasionally become entangled in the net. The impact of seabirds roosting on the seacages is not considered to be significant.

The magnitude of impact of interactions of the fish farms with seabirds is considered to be **negligible** at the **atoll** level. The potential impact if experienced should be able to be rapidly reduced by altering bird netting systems and is also reversible on cessation of fish farming activities. The significance of the impact is assessed as being minor.

Assessment of Impact – Summary

Positive	Negative

		Magnitude of impact			
		Negligible	Low	Medium	High
Level of importance of receptors	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Sediment Changes

Through the addition of feed and fish excretion and egestion, sea cage aquaculture can result in organic enrichment of the sediment and changes to sediment chemistry. In the best case mild organic enrichment will lead to changes in the macrobenthic assemblages and increased potential for denitrification, in the worst case the sediment may become anaerobic leading to a poorer environment for waste assimilating organisms and the release of sulfides and other toxic metabolites. This is a well documented impact from sea cage aquaculture. The impact can be relatively easily managed and mitigated through fallowing and ensuring the feeding regime is optimal, although not avoided entirely. The scale of the impact is generally restricted to the areas under and adjacent to (10s meters) the sea cages.

Maldonado et al., (2005) studied fish farms in the Mediterranean that were in a greater depth of the water (20 meters to 40 meters) than those generally studied (5 to 10 meters). They found a much lower level of change in the sediment and in some cases, no significant difference between fish cage sites and control sites. It has also been noted in a number of studies that wild fish populations can assimilate large quantities of fish farm waste before it impacts on the sediment.

Due to the water depth (35 meters to 40 meters) of the proposed fish farm sites in Majuro, the relatively high water exchange, the tropical conditions (facilitating faster waste breakdown and mineralization), high water quality, nature of the sediment (relatively porous, buffered and aerobic) and the native macobenthos (e.g. Seacucumbers – with the ability to physically turnover and filter sediment) it is considered that sediment changes due to the fish farms will be at the lower end of those noted at other sites around the world. Sediment quality will be monitored throughout the operation of the sites, and seacages moved to allow sites to fallow if sediments impacted by the seacages become anaerobic (as determined by black, reduced sediments) less than 10 centimeters below the sediment-water interface.

Fresh feed and faeces from the fish cages at Lobekeare Island has been observed reaching the bottom in about 20 meters of water. However this waste appears to have assimilated rapidly with no build up or change to sediment quality observed thus far.

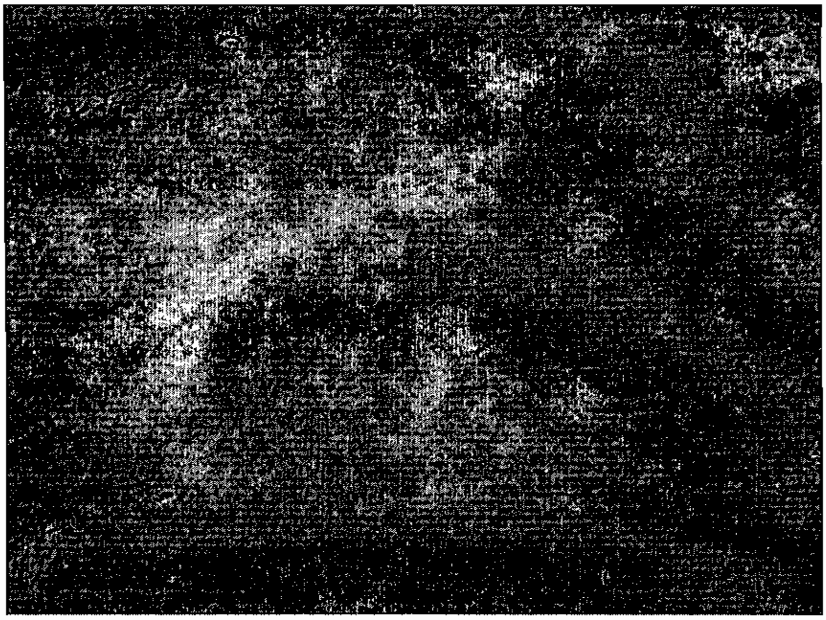


Figure 5.3.3: Sediment directly under current seacages at Lobekeare Island after six months of fish culture.

The magnitude of the impact of sediment chemistry changes is expected to be low (possible detectable impacts but minimal changes to the established structure and function) given the conditions in Majuro Lagoon and is best assessed as a **we**to level impact (due to impacts being very restricted in the area directly surrounding the fish cages). The impacts are rapidly reversible on the cessation of fish farming within close proximity to the impacted sediment, for example by fallowing sites. The significance of the impact is assessed as being minor.

Assessment of Impact – Summary

Positive	Negative

		Magnitude of impact			
		Negligible	Low	Medium	High
Level of importance of receptors	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Water Quality (near field)

The near field (within 1,000 meters of the sea cages) impacts of sea cages on water quality are well documented. Through the addition of feed and fish excretion and egestion, sea cage aquaculture can result in elevated nutrient levels – nitrogen and phosphorus most significantly - and in extreme cases low dissolved oxygen. Appropriate siting, together with best practice husbandry techniques (feed type and feeding methods) can mitigate, but not avoid this impact.

When taking into consideration the oligotrophic nature of central Majuro Lagoon, the level of impact in the near field may be measurable. The near field habitat of the proposed fish farm sites is almost uniform open lagoon water of 35 to 55 meters depth over bare decomposed coral aggregate sediment. If it is considered that the near field area is an average of 40 meters in depth and an area of 1000 meters surrounding the fish farm sites the surface area of the near field impact zone is 30.38 square kilometers. The daily impact on water quality in the area is modeled as 0.006mg/ liter nitrogen and 0.002 mg/ liter phosphorus. These levels are an order of magnitude lower than those (around 0.04mg/ liter nitrogen and 0.025mg/ liter phosphorus) which are considered an appropriate quality for coral reef areas.

The fate of these nutrients is that a portion will be rapidly assimilated in the near field by processes of mineralization, utilization by phytoplankton and bacterial floc, volitization and sedimentation (as discussed in more detail in the Water Quality section below) and the remaining portion will mix with the intermediate field (entire Majuro Lagoon) and be exported via water exchange to the open ocean. It is considered certain that subtle changes to the near field ecosystem will occur as part of a natural response to assimilating the outputs from the fish farm. The type of habitat impacted is not considered to of high ecological value or restricted quantity. While subtle changes to the near field ecosystem will occur there is no evidence to suggest that this will adversely affect any species in Majuro in the context of the whole atoll.

The available literature demonstrates that impacts are likely to attenuate very rapidly with distance from the cage and are influenced by siting and husbandry factors. Specific studies include:

- Wu et al. (1994) in Hong Kong observed decreases in dissolved oxygen at all sea cage sites studied while increases in ammonia, inorganic phosphate, nitrate and nitrite were observed only at sites with poor tidal flushing and high stocking density. The impacts on water quality were localized and did not appear to extend beyond a distance of 1 – 1.5 km from the cages. The authors identified that their study did not support the suggestion that marine fish farming activities have caused eutrophication on a large scale;

- Arulampalam et al., (1998) in Malaysia identified water quality impacts in the Kelang region where approximately 30 cage farms are present. Specifically, increases in ammonia, nitrate, phosphate and nitrite were observed and attributed principally to a sub-optimal feeding regime of using whole trash fish, with the transition to dry pellets being a potentially effective way of mitigating (in part) the impact. This study did not differentiate near and far field effects;

- Enell (1995) provided estimates of nutrient loads, but not their impacts on water quality parameters for fish farming in the Baltic Sea where approximately 250,000 tons/year of fish were grown at the time of their study. He concluded that the nutrient input from this very large volume of production was negligible at a large scale compared to other impacts but that fish farms in certain coastal areas can be significant at an (undefined) local scale and needs to be considered in impact assessment;

- La Rosa et al., (2002) identified that sea cages in the western Mediterranean resulted in the waters overlaying the fish farms having significantly higher levels of dissolved organic carbon, but not chlorophyll a. This study did not differentiate near and far field effects;

- Papoutsogolou et al., (1996) identified water quality concerns (ammonia and dissolved oxygen levels) from two fish farms in Greece but considered changes in farm management, such as reducing stocking densities below 16 kg/m3 could potentially mitigate these impacts to a large degree;

- Maldonado, Carmen, Echeverria and Riesgo (2005) studied the impact of fish farms in the Mediterranean which tend to be located in deeper (20m to 40m), better flushed and warmer areas than salmonid farms. They found nutrient, chlorophyll and benthic parameters were little or not at all different between fish farm and control sites and differences tended to be better explained by variations in depth, tides and season than the presence or not of fish farms.

It should be noted that the water exchange dynamics of Majuro Lagoon are unique in the high turnover of the lagoon and exit of the exchange of water directly to the open ocean. As noted by Szmant (2002), mid-ocean atolls and offshore barrier reefs, which are exposed to high ocean energy and much flushing, would not be expected to be as easily affected (by anthropogenic nutrient enrichment) as the more frequently studied inshore continental reefs. However tempering this to some extend is the need to be more conservative with the nutrient impacts in Majuro due to the coral reef ecosystems.

The near field water quality impacts on habitats and species are assessed as medium (detectable impacts with significant changes to the established structure, composition and function). Near field water quality impacts are, by definition, best assessed at the sub-atoll level so the level of weto has been assigned. Impacts are reversible in the short-term on the cessation of fish farming activities however need to be considered for the life of the project. The overall assessment of the impact is therefore minor / moderate.

Assessment of Impact – Summary

Positive	Negative

		Magnitude of Impact			
		Negligible	Low	Medium	High
Level of Importance of receptors	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Water Quality (intermediate field)

Available evidence suggests that water quality impacts reduce rapidly with distance from the sea cages (between 100s m and 1 km). Intermediate field water quality impacts are defined for the purpose of this study to mean those beyond 1000 meters from the fish farm sites but within Majuro Atoll.

The most important intermediate field habitat to consider in Majuro in terms of water quality are the coral reefs on the fringes of the atoll. Coral reefs are generally regarded as being sensitive to increased nutrient levels. The natural environment in which coral reefs exist is very low in nutrients. However coral reefs are some of the most biologically productive environments on earth, primarily due to the ecosystems ability to efficiently recycle nutrients and fix atmospheric nitrogen (Froelich, 2002). Coral reefs are significant exporters of nitrogen due to fixation by benthic and epiphytic cyanobacteria (Webb et al. 1975).

There remains significant debate as to the reason for water quality impacts on coral reefs with some scientists maintaining that overfishing (particularly reduction of herbivorous fish), sedimentation and global warming are more important in most coral reef degradation. For example McCook (1999) states:

"*I conclude that nutrient overloads can contribute to reef degradation, but that they are unlikely to lead to phase shifts simply by enhancing algal growth rates and hence allowing overgrowth of corals, unless herbivory is unusually or artificially low. Concentrations of dissolved inorganic nutrients are poor indicators of reef status, and the concept of a simple threshold concentration that indicates eutrophication has little validity.*"

However despite some uncertainty it is considered prudent to maintain loading for fish farming to a conservative limit that ensures water quality remains well within levels raised as the limits for impacts for coral reef environments.

The conservative safe limit for Dissolved Inorganic Nitrogen (DIN: NH_3, NH_4+, NO_2-, NO_3-) in coral reef waters as reported from various sources (Bell, 1992; Lapointe, 1992 in Goreau & Goreau, 1997; Lapointe et al 1992, 1993; Goreau and Thacker, 1994) is 0.014mg/ liter. Total nitrogen (including nitrogen in suspended and dissolved organic forms) will be higher. Research on the nitrogen cycle at Enewetak Atoll in the RMI (Webb et al. 1975) found total nitrogen levels across a variety of sample points were approximately 10 times the level of DIN.

The RMI Marine Water Quality Regulations (1992) outlines total nitrogen levels of a maximum 0.40mg/l for Class AA waters. This is a conservative and appropriate limit based on the evidence in the literature. The water quality monitoring at the relatively pristine Lobekerae Island revealed total nitrogen levels of 0.032mg/ liter to 0.038mg/ liter. The modeling of nutrient loading due to the operation of the full 50,000 metric ton per year proposed fish farm suggests an increase of total nitrogen of 0.001mg/ liter to 0.004mg/ liter at mass balance (see water quality section). This is an order of magnitude lower than the level considered to be safe limit for coral reef waters and will likely result in an unmeasurable change to the water quality in the lagoon.

The conservative safe limit for phosphate (P as PO_4) in coral reef waters as reported from various sources (Bell, 1992, Lapointe, 1992 in Goreau & Goreau, 1997 Lapointe et al 1992, 1993, Goreau and Thacker, 1994) as 0.003mg/ liter. Total phosphorus (including phosphorus in suspended and dissolved organic forms) will be higher. Research on the phosphorus cycle in Tikehau Atoll, French Polynesia (Charpy and C.J. Charpy-Roubaud, 1988) indicated total phosphorous levels were approximately 4 times higher than phosphate levels.

The RMI Marine Water Quality Regulations (1992) outlines total phosphorus levels of a maximum 0.025mg/l for Class AA waters. This is a conservative maximum level for total phosphorus. The water quality monitoring at the relatively pristine Lobekerae Island revealed total phosphorus levels of 0.032mg/ liter to 0.036mg/ liter – higher than the RMI Class AA waters guidelines and about 3 times greater than those measured at Tikehau Atoll, French Polynesia (Charpy and C.J. Charpy-Roubaud, 1988). The site at Lobekerae Island receives oceanic water across the reef flats and is essentially free of any anthropogenic water quality impacts. This higher than expected phosphorous level (although still relatively low) may be due to open ocean upwelling near to Majuro Atoll. The modeling of nutrient loading due to the operation of the full 50,000 metric ton per year proposed fish farm suggests an increase of total P of 0.0003mg/ liter to 0.001mg/ liter at mass balance (see water quality section below) using conservative estimates for phosphorous excretion and sediment absorption. This is an order of magnitude lower than the level considered to be safe limit for coral reef waters and will likely result in an unmeasurable change to the water quality in the lagoon.

Potential water quality impacts from the fish farm are minimized by the high flush rates in central Majuro lagoon and the distance of the sites from sensitive habitats. Szmant (2002) notes that coral reefs generally require high water flow and turbulence, and only reefs in embayments with restricted with restricted circulation are likely to experience nutrient build-up. In Scotland, Tett and Edwards (2002) concluded that there was no confirmed connection between harmful algal blooms and finfish farming, and suggested that nutrient enrichment by fish farms would be insignificant unless the farm was located in an enclosed basin where water exchange was poor.

Intermediate field water quality impacts on habitats in Majuro, most notably coral reefs, are best assessed as being of low magnitude (possibly detectable impacts but minimal changes to the established structure and function) at the atoll level. Impacts are rapidly reversible on the cessation of fish farming activities however need to be considered for the life of the project. The overall significance of the impact is assessed as being **minor / moderate.**

Assessment of Impact – Summary

Positive	Negative

		Magnitude of impact			
		Negligible	Low	Medium	High
Level of importance of receptors	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Translocation of Species

As detailed in 10Appendix D: all of the species proposed for farming in the project are endemic to the RMI. This conclusion is drawn from published records of collections and signed declarations from experienced local fisherman. The scientific record for collections in the RMI is limited with described collections of even common commercial species such as yellowfin and bigeye tuna being almost non-existent.

It is possible for translocation of species to unintentionally occur in the water used to transport fish fingerlings to the RMI or on the hulls or ballast water of ships traveling to the RMI carrying fish. This issue can be managed; A biosecurity management plan for imports into the RMI is attached to this document (10Appendix B:). Through these procedures the risk of inadvertent translocation of species due to the movements of the live fish vessels is reduced to be equivalent to the risk associated with other ship and boat movements to the RMI.

With appropriate management the level of risk of translocation of species is very low. Through these procedures the risk of inadvertent translocation of species due to the movements of the live fish vessels is reduced to be equivalent to the risk associated with other ship and boat movements to the RMI.

The magnitude of impact assigned needs to consider the level of risk in the context of the management protocols that will be in place and the background level of risk due to other activities. As such a magnitude of **negligible** (unlikely to be measurable against benchmarks) at the RMI level (translocated species may, over time and depending on their biology, migrate to other atolls) is considered most appropriate. The impact if it was to occur is long-term and beyond the life of the project and most likely irreversible. The overall assessment of the significance of the impact is **minor**.

Assessment of Impact – Summary

Positive	Negative

		Magnitude of impact			
		Negligible	Low	Medium	High
Level of importance of receptors	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

1.1.1.11 *Mitigation Measures*

Placement of Moorings

The impact of the placement of moorings on habitats and species is localized at the scale of meters and has been assessed as minor. Further measures to mitigate impacts of placement of moorings will be:

- Use of permanent moorings for boats in order to minimize the need for dropping anchors in various parts of the farm; and,
- Sites where moorings are to be placed will be inspected to ensure any bommies or potential higher value habitat is avoided.

Aggregation of Wild Fish Assemblages

The impact of aggregation of wild fish assemblages has been assessed as minor / moderate. Aggregation of wild fish assemblages is also associated with some positive impacts in terms of mitigating farm waste and no attempt is proposed to reduce its occurrence. These aggregations will be protected from fishing by a defacto marine sanctuary which may provide a source of recruits for some species for the benefit of the atoll fishery as a whole.

Changes to Macrobenthic Assemblages

The impact of changes to macrobenthic assemblages is assessed as minor / moderate. Some changes in macrobenthic assemblages have a positive impact in maintaining sediment quality and mitigating fish wastes. The location of the fish farm sites in relatively deep water will reduce the potential for this impact. Measures to mitigate impacts of changes to macrobenthic assemblages are:

- Moving of cages around the lease area to provide fallowing·;
- Use of pellets for food to minimize wastes; and,
- Monitoring of feeding to minimize waste.

Boat Strike When Traveling to Site

The impact of boat strike on macrofauna when traveling to the sites has been assessed as **minor.** There are no specific measures proposed to mitigate this risk beyond those associated with vigilant and safe boat driving.

Disease and Pathogen Transfer to the Wild

The impact of disease and pathogen transfer to the wild has been assessed as **minor / moderate.**

Measures to mitigate the risk of disease and pathogen transfer to the wild are:

- Remove any dead fish from cages ASAP;
- Use appropriate existing disease management protocols (stress management, sampling for disease where appropriate);
- Do not overstock cages;

Figure 5.3.4: Humphead Grouper Fingerlings in Quarantine at MIMRA's Woja (Majuro) Facility

Entanglement of Megafauna

The potential for entanglement of megafauna has been assessed as **minor.** Measures to mitigate this risk are:

- Separate predator nets not to be used;
- Removal of any dead fish from cages ASAP to minimize attraction to cages;
- Use of rigid netting material for cages;
- Ensure all ropes / cables etc and cage material are taut; and,

- Not 'predator nets' are proposed to be used.

Escaped Stock

The impact of escaped stock is assessed as **minor / moderate**. GFB obviously has a strong commercial incentive to ensure that escaped stock is minimized. Measures to mitigate this risk are:

- Regular checking of cage material to ensure integrity and any necessary repairs are promptly undertaken;
- Ensure cage material and structures are engineered to withstand extreme (but rare) weather events;
- Ensure that cultured species are endemic; and,
- Ensure good site security.

Food Web Changes

The impact of food web changes has been assessed as **minor / moderate**. Food web changes in the near field are likely to help assimilate fish waste. Measures to mitigate this impact are:

- Moving of cages around the lease area to provide fallowing·;
- Use pellets for food to minimize wastes;
- Use a feeding regime that minimizes waste; and,
- Remove any dead fish from cages ASAP.

Seabird Interactions

The impact of the proposed fish farm with regard to seabird interactions has been assessed as **minor**. In order to mitigate this impact taught bird nets will be used over the cages and netting type reviewed if tangling of seabirds proves to be a problem.

Sediment Changes

The impact of sediment changes has been assessed as **minor**. Measures to mitigate this impact are:

- Ensure cages are sited in an area with a high flushing rate;
- Ensure cages are in relatively deep water;
- Moving of cages around the lease area to provide fallowing;
- Use pellets for food to minimize wastes;
- Use a feeding regime that minimizes waste; and,
- Remove any dead fish from cages ASAP.

Water Quality (near field)

The impact of the fish farm on near field water quality has been assessed as **minor / moderate**. Measures to mitigate this impact are:

- Ensure cages are sited in an area with a high flushing rate;
- Use pellets for food to minimize wastes;
- Use a feeding regime that minimizes waste;

- Remove any dead fish from cages ASAP; and,
- Monitor water quality parameters (Nitrogen, Phosphorus and Chlorophyll a)

Water Quality (intermediate field)

The impact of the fish farm on intermediate field water quality has been assessed as **minor / moderate**. Measures to mitigate this impact are:

- Ensure cages are sited in an area with a high flushing rate;
- Use pellets for food to minimize wastes;
- Use a feeding regime that minimizes waste;
- Remove any dead fish from cages ASAP; and,
- Monitor water quality parameters (Nitrogen, Phosphorus and Chlorophyll a)

Translocation of Species

The impact of the proposed operations on translocation of species has been assessed as **minor.** Measures to mitigate this impact are:

- Ensure cultured species are endemic;
- Exchange ballast water in the open ocean at least 30 miles from Majuro;
- Ensure all fish imported are from controlled hatcheries; and
- Prophylactically treat fish tanks during shipping to the RMI to kill any potential invertebrates or fish larvae in the tanks.

5.4 Geology and Coastal Process

N/A

5.5 Water

Table 5.6: Summary of Impacts

Impact	Activity and Description	Assessment
Costs		
Disturbance of Sediments	Placement of moorings and anchors may displace and suspend sediment in the water column.	The small areas of sediment effecting and the rapid settling characteristics of the sediment in question result in this impact being considered to be of **negligible** significance.
Increase in Nutrient Levels	Wastes from the fish farmed will add nutrients to the water column, most notably nitrogen and phosphorus.	Mass balance modeling of the nutrient impacts of the fish farm indicates a very low potential impact. The significance of the impact is considered to be **minor / moderate.**
Introduction of Chemicals	Operation of boats and machinery at the fish farm sites run the risk of accidents and fuel and / or oil spillages.	GFB does not intend to use chemicals for fish treatments. The risk of fuel spillages and similar events can be managed by maintaining equipment in good working order. The impact is considered to be of **minor** significance.

5.5.1 Assessment and Mitigation of Effects

1.1.1.12 Construction Impacts

Disturbance of Sediments

The placement of moorings associated with the construction of the fish farm has the potential to disturb sediments where the moorings may drag for short distances. In shallower waters the operation of boats and ships may disturb sediments with propeller currents.

The amount of sediment likely to be disturbed is very low in the context of the lagoon. The sediment in the areas of the proposed fish farm sites is granular, relatively large, and from visual observation during dives settles rapidly if disturbed. Observation during dives suggests that all appreciable quantities or any disturbed sediment will settle within meters of the original disturbance point.

Disturbance of sediments through the activity of ships and boats at the fish farm sites is not possible due to the depth of the water (over 35 meters).

The magnitude of the impact is considered to be **negligible** (unlikely to be measurable against benchmarks) and highly localized (so best considered at the **weto** level). Impacts are short-term and reversible (in terms of impact on water quality). The magnitude of the impact is therefore assessed as being **negligible.**

Assessment of Impact – Summary

Positive	Negative

		Magnitude of impact			
		Negligible	Low	Medium	High
Level of importance of receptors	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

1.1.1.13 *Operational Impacts*

Increase in Nutrient Levels

Fish farming results in the output of organic nutrients. While fish are far more efficient in converting what they consume than warm-blooded animals, a significant proportion of nutrients consumed is excreted. An example of a typical nutrient flow is displayed in Figure 5.5.1.

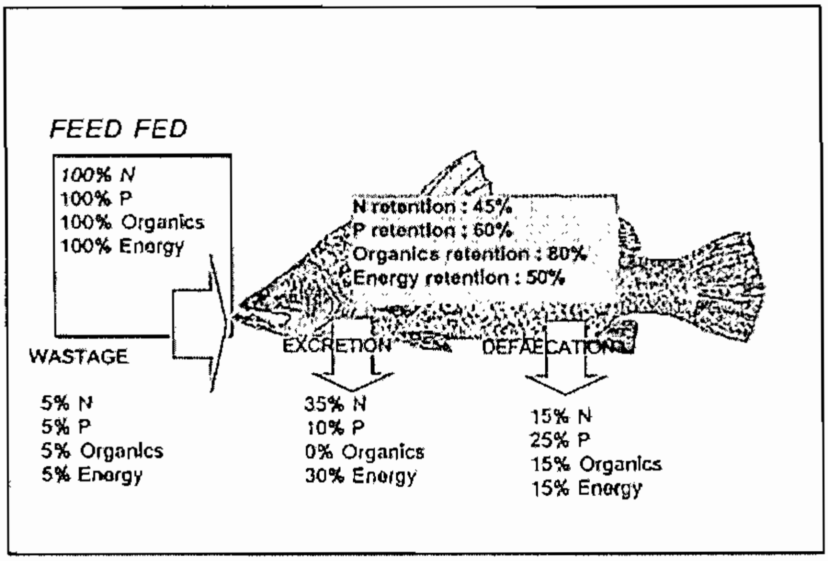


Figure 5.5.1: Nutrient and energy partitioning and utilization by a fish (source: McClure, 2001)

The amount of nutrients produced by aquaculture is relatively easily understood in that all nutrients fed are either converted into fish or excreted. Hence subtracting the nutrients accounted for by the harvest of fish from the total nutrients fed provides the quantity of nutrients excreted.

The forms of nutrient excretion are more difficult to understand with a proportion lost through wasted feed (this should be minimized through management), a proportion excreted directly from the fish via the gills and a proportion excreted as faeces. In terms of bulk nutrient dynamics in the environment the forms of excretion do not change to overall results.

Mass balance approach:

Mass balance modeling is the preferred method for modeling nutrient dynamics in semi-enclosed systems such as Majuro.

Where:

A = Level of substance in the lagoon water column after period

I = Existing level of substance in the lagoon water column before period

O = Substance lost to outflow of water from the lagoon and volitization during the period

G = Total input of substance into the system

C = Substance mineralized or assimilated to an inert form

$A_1 = (I - O) + (G - C) \rightarrow$

$A_2 = (A_1 - O) + (G - C) \rightarrow$

$A_3 = (A_2 - O) + (G - C) \rightarrow$

The cycle is repeated for indefinite cycles until I + G = O + C and the system is balanced. This is possible as O is a proportion of I. The balance point represents the maximum level of nutrient accumulation within the system.

For the mass balance model for Majuro Lagoon used in this study the period used has been one day. This is slightly more conservative than the actual exchange of the lagoon which peaks on a twice daily basis with the tides. Furthermore the model assumes a volume of 2/3rds of the actual lagoon model and relatively conservative estimates are used for near-field assimilation. As such the intention of the results is to present the *maximum potential impact.* Based on the results of water quality measures at existing fish farms around the world the water quality impacts beyond the near-field area is likely to less then modeled below.

It is estimated from hydrodynamic models of Majuro Lagoon (Kraines, Isobe & Komiyama, 2001; Kraines et al. 1999) that the average exit time for water in the central portion of Majuro Lagoon where the fish farm sites are proposed will vary between 1day and 10 days depending on the season and prevailing conditions, with a tendency towards exit times of less than 5 days. The results below present the impacts on average water exchange rates from 2 to 20 days.

Nitrogen Mass Balance Model

Table 5.7 outlines the assumptions to the nitrogen model. These parameters are considered to be conservative in order to provide a large safety margin.

Table 5.7: Assumptions for Nitrogen Mass-Balance Model

Measure	**Parameter for Model**
Feed input	205 metric tons per day
Average Protein Content of Feed	45.5%
Average Nitrogen Content of Feed	7.28%
Average Food Conversion Ration	1.5kg feed fed = 1.0kg fish produced
Nitrogen Retained in Fish	4.49 metric tons per day
Excreted Nitrogen per day	10.47 metric tons per day
Loss to denitrification, volitization, macroplankton and fish assimilation in near-field.	3.49 metric tons per day
Lagoon Volume	7.96 billion m^3 (2/3rds of actual estimated volume as an additional margin of safety)

It needs to be noted that the average protein content of 45.5% applies as around 80% of the feed volume fed is of 45%. Higher protein feed (up to 48%) is fed only in the early stages of the fishes growth.

The figure for loss to denitrification, volitization, macroplankton and fish assimilation in near-field may prove to be too conservative. Studies on denitrification in coral reef environments (Smith ,1984; Seitzinger & D'Elia, 1985; Corredor & Capone, 1985, Capone et al. 1992) suggest that Majuro lagoon would have a background denitrification capacity of around 2 to 6 metric tons of nitrogen per day even without anaerobic conditions in the sediments. Numerous studies (eg. Wu et al. 1994; Enell, 1995; Maldonado, Carmen, Echeverria and Riesgo, 2005) have demonstrated that nitrogen inputs from large scale fish farms are assimilated to levels below detection within a kilometer or two of the source.

The results of the mass-balance model in relation to the maximum total nitrogen impact for Majuro lagoon is displayed in Figure 5.5.2.

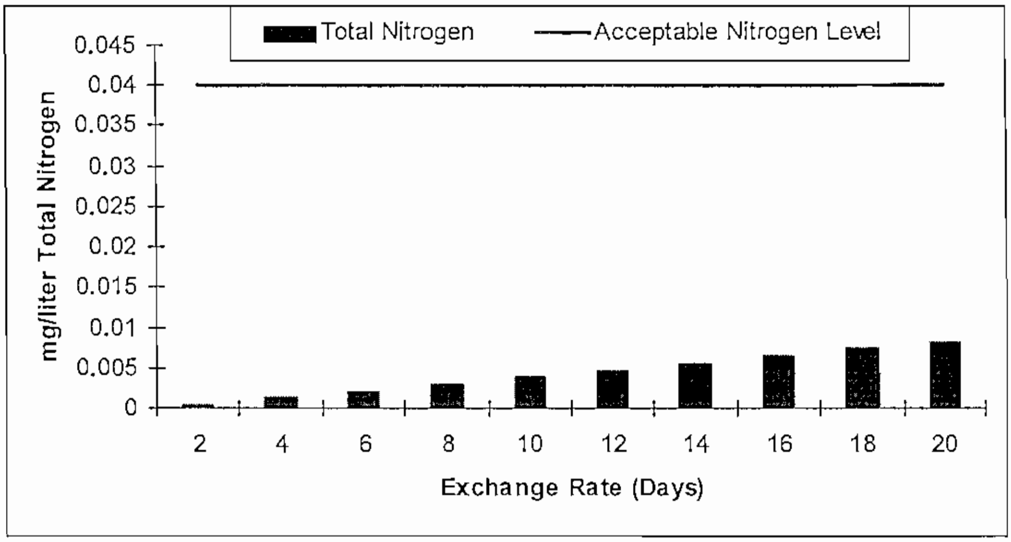


Figure 5.5.2: Maximum Total Nitrogen Impacts in Relation to Exchange Rates for 50,000 Metric Tonnes Fish Production

Phosphorus Mass Balance Model

Table 5.7 outlines the assumptions to the phosphorus model. These parameters are considered to be conservative in order to provide a large safety margin.

Table 5.8: Assumptions for Phosphorus Mass-Balance Model

Measure	Parameter for Model
Feed input	205 metric tons per day
Average Phosphate (H_2PO_4) Content of Feed	3%
Average Phosphorus (P) Content of Feed used in model	1.35%
Average Food Conversion Ration	1.5kg feed fed = 1.0kg fish produced
Phosphorus Retained in Fish	0.56 metric tons per day
Excreted Phosphorus per day	2.20 metric tons per day
Loss to sedimentation and precipitation	0.97 metric tons per day
Re-release to water from sediments	0.13 metric tons per day
Lagoon Volume	7.96 billion m^3 (2/3rds of actual estimated volume as an additional margin of safety)

The phosphate content of the fish feed as provided by the manufacturer (Appendix A: Figure 8.3.12 and Figure 8.3.21) translates as a phosphorus content of 0.95%. Holby & Hall (1991) analyzed a variety of fish feeds and found phosphorus contents of 1.13% to 1.57% (dry w/w). The average of this figure (1.35% dry w/w) has been applied in this analysis rather than the manufacturers figure to ensure phosphorus output is not underestimated.

The assumed loss of phosphorous into the sediment is more conservative than the work of Holby & Hall (1991) who found sediment accumulation of 59% to 66% of excreted phosphorus. The work of Holby and Hall (1991) was conducted on non-calcium carbonate sediments that were high in organic matter and very sulphidic. The sediment type in Majuro (calcite and aragonite) is known to have a significantly greater capacity for phosphorous binding (Boyd, 1994; Corredor et al. 1999) than organic sediments. Once in the sediment phosphorus tends to be relatively insoluble, particularly in aerobic conditions. In waters of high calcium concentrations and elevated pH, phosphorus may precipitate directly as calcium phosphate, tricalcium phosphate or apatite (Boyd, 1994). The consistent oceanic water quality in Majuro will favor this pathway over the estimates derived in Holby & Hall, 1991.

The results of the mass-balance model in relation to the maximum total phosphorus impact for Majuro lagoon is displayed in Figure 5.5.2.

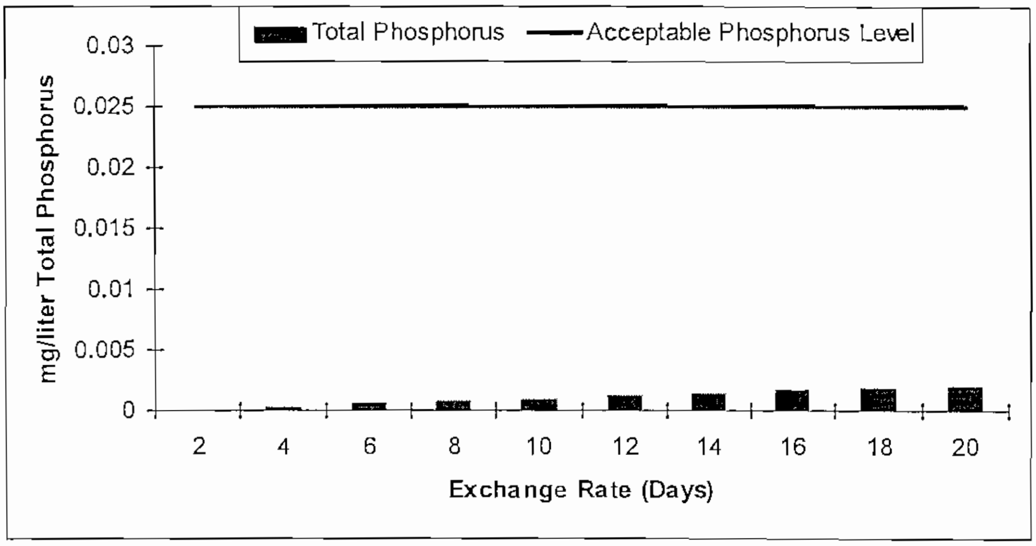


Figure 5.5.3: Maximum Total Phosphorus Impacts in Relation to Exchange Rates for 50,000 Metric Tonnes Fish Production

Summary

Mass balance modeling of the key indicator nutrients nitrogen and phosphorus demonstrate that the maximum impact of the proposed fish farm at full production on water quality will be minimal and well below levels of concern. The principal determinant of the capacity of Majuro Lagoon for fish farming is the high water exchange rates with the open ocean. This prevents the accumulation of significant levels of nutrients in the majority of the lagoon.

Numerous studies have demonstrated that water quality impacts from large fish farms in reasonably flushed sites are almost entirely assimilated within 1 to 1.5 kilometers of the farm sites. The water quality impacts from the proposed fish farm in Majuro could well be lower in practice with the modeling based on conservative assumptions.

While the results indicate that the water quality impacts will be near to negligible given the potential sensitivity of coral reefs it is prudent to assign a low (possibly detectable impacts but minimal changes to the established structure and function) magnitude of impact at the atoll level. The impact is reversible in the short-term on cessation of fish-farming activities however should be considered for the life of the farm. The significance of the impact is assessed as minor / moderate.

Assessment of Impact – Summary

Positive	Negative

		Magnitude of Impact			
		Negligible	Low	Medium	High
Level of importance of receptors	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Introduction of Chemicals

Various chemicals can be used to prevent or treat diseases, which may remain present in the environment for a period of time after treatment occurs. Some aquaculture ventures use antifoulants on the nets to reduce the need for net changing. There is also a risk of fuel and oil spills associated with the general operation of boats and other equipment around the fish farm sites.

GFB expects that it will be able to avoid treatable disease during culture in Majuro through good management and due to the quality of the water and culture conditions. The company does not intend to use any chemicals in the culture process in order to be able to preserve its 'clean and green' image in the marketplace.

The level of marine fouling observed on marine structures in pilot sea cages in Majuro (Figure 5.5.4) is very low by the standards of other parts of the world. Due to this and the types of cage net materials to be used in Majuro the use of antifoulants on the nets is not required. Nets will be cleaned by sun-drying and water cleaning.

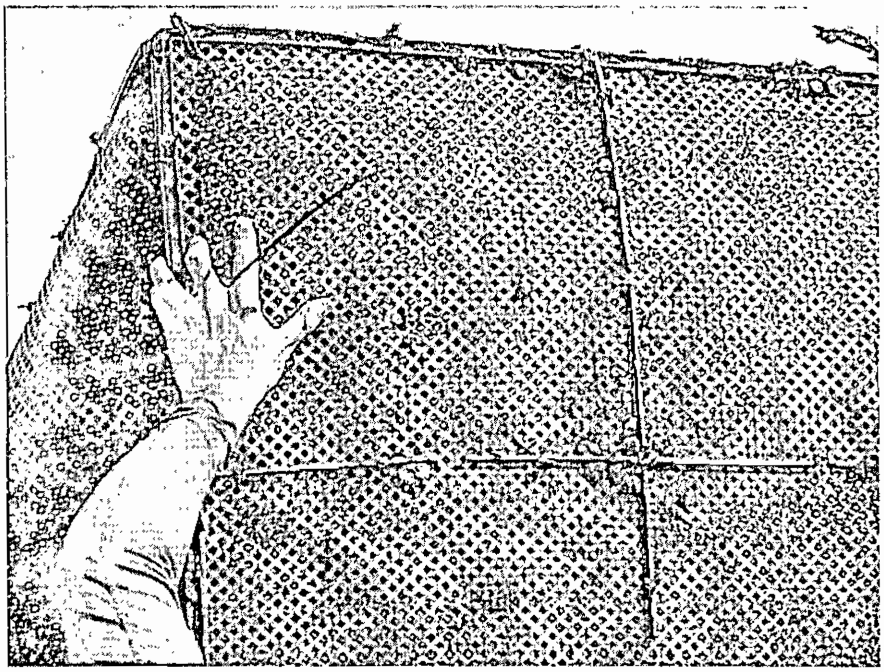


Figure 5.5.4: GFB RMI Pilot/ Experimental Seacage after 6 months of Culture off Lobekerae Island. Level of fouling is very low relative to time in water, water temperatures and type of mesh material.

There exists a low unavoidable level of risk of minor fuel and oil spillage due to the operation of boats and equipment at the fish farm sites. Large numbers of vessels are moored or operate in Majuro lagoon at present presenting similar levels of risk. While all equipment will be maintained in good working order and zero spillages targeted, the environmental impact of trace hydrocarbon spillages in central Majuro lagoon is not considered to be great.

The magnitude of a minor hydrocarbon spill associated with an accident on the fish farm is considered **negligible**, considering the number of other vessels operating on the lagoon who would occasionally have similar accidents and the high flush area in which the fish farms will be located. Some spills may be relatively persistent (days or even weeks) and hence it is most appropriate to consider the impact at the **atoll** level. The significance of the impact is therefore assessed as **minor.**

Assessment of Impact – Summary

Positive	Negative

		Magnitude of impact			
		Negligible	Low	Medium	High
Level of Importance of receptors	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

1.1.1.14 *Mitigation Measures*

Disturbance of Sediments

The impact of disturbance of sediments during construction is assessed as being **negligible**. Measures to mitigate the impacts are:

- Use fixed mooring buoys for boat anchorage; and
- Use mooring blocks and anchors designed to 'dig and hold' rather than drag.

Increase in Nutrient Levels

The impact of increased nutrient levels as determined by modeling the key nutrients of nitrogen and phosphorus is assessed as **minor / moderate**. Key to the mitigation of increase in nutrient levels is the farm location in a well flushed, deep water site. Other measures to mitigate this impact are:

Ensure cages are sited in an area with a high flushing rate;

Use pellets for food to minimize wastes;

Use a feeding regime that minimizes waste;

Remove any dead fish from cages ASAP; and,

Monitor water quality parameters (Nitrogen, Phosphorus and Chlorophyll a).

Introduction of Chemicals

The impact of potential introduction of chemicals in the environment due to the activities of the fish farm is assessed as minor. GFB will endeavor to maintain equipment in good order at all times to minimize the chance of fuel or oil leaks.

5.6 Waste

Table 5.9: Summary of Impacts

Impact	Activity and Description	Assessment
Costs		
Production of Waste Materials from Construction and Mooring of Seacages	Construction of seacages will result in some level of waste offcuts and scrap material.	The majority of components and equipment for the fish farm are purchased prefabricated resulting in nil or very little waste. The significance of this impact is considered to be minor.
Mooring Blocks and Anchors	Mooring blocks and anchors will be left in situ at the end of their useful lives	The leaving of the mooring blocks and anchors at the bottom of central Majuro lagoon will have no impact on surrounding areas and will essentially be unnoticed. The impact is considered to be of **negligible** significance.
Consumable Goods Waste	Some types of packaging for feed for the fish is disposable.	The fish farming operations will produce very little consumable waste. The majority of fish feed (The major consumable) will be imported in reusable bulk packaging and disposable packaging is easily incinerated. The impact is considered to be of minor significance.
Waste from Decommissioned Farm Materials	Farm materials and structures have a limited life and will thereafter need to be disposed of.	Decommissioned farm materials will either be reused, recycled or taken off island. The resulting impact is considered to be of minor significance.

5.6.1 Assessment and Mitigation of Effects

1.1.1.15 Construction Impacts

Production of Waster Materials from Construction and Mooring of Seacages

The construction of seacages, nets, moorings and other equipment for use on the fish farms will generate some level of waste due to off-cuts etc.

The majority of seacages, nets, floats and some moorings will be imported into Majuro as prefabricated designs (Figure 5.6.1). These require assembly in Majuro however produce minimal wastes. Boats and other equipment will be imported as finished products.

The limited off-cuts of plastic and rope will be disposed of through the Majuro Atoll Waste Company. GFB has made contact with the Majuro Atoll Waste Company and will confirm their position with regard to projected waste from GFB.

Packaging materials such as cardboard boxes and wooden pallets will be reused or incinerated after use.

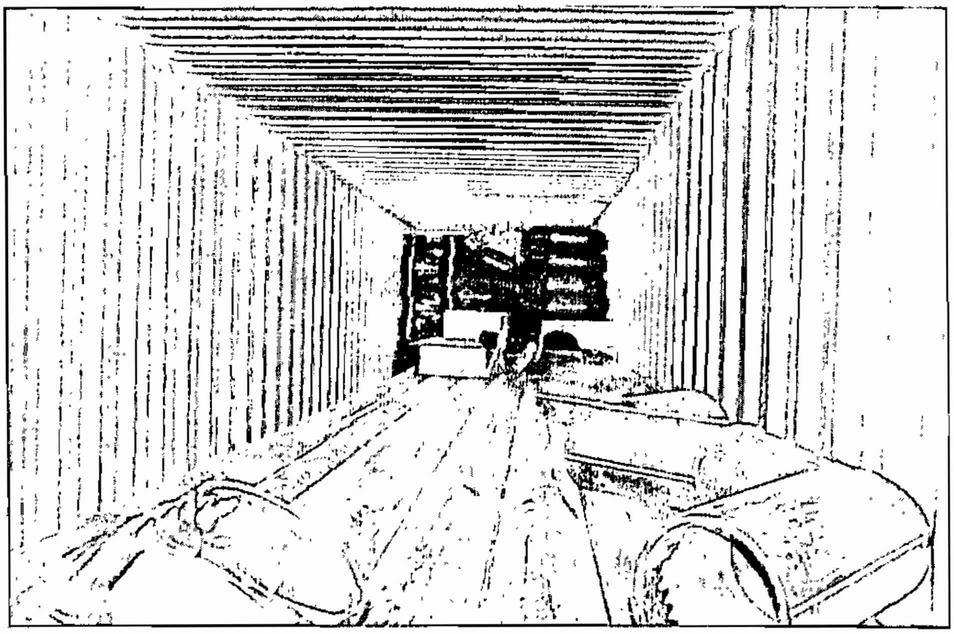


Figure 5.6.1: Prefabricated Seacage Materials Ready for Assembly in Majuro

The level of waste produced due to the construction of the fish farm project is considered to be of negligible magnitude at the atoll level. Any impact is long-term and irreversible. The significance of the impact is assessed as being minor.

Assessment of Impact – Summary

Positive	Negative

Level of importance of receptors		Magnitude of Impact: Negligible	Low	Medium	High
	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Mooring Blocks and Anchors

Mooring blocks and anchors will be used for mooring the fish cages, barges, permanent mooring buoys for ships and boats and for market beacons.

The moorings consist of a concrete block or steel anchor and a length of chain. The moorings are designed to dig into the bottom of the lagoon to increase drag and reduce movement. For this reason the moorings are difficult and costly to move once established in place.

GFB proposes to leave any moorings and mooring chains in situ at the end of their working lives (10-20 years). All ropes used for the moorings and other gear will be removed. The concrete moorings can be considered as indefinite structures while the steel moorings and chains will gradually corrode in the marine environment. There are no toxic compounds associated with the concrete or steel.

The disused moorings will be located in deep (greater than 35m) water in central Majuro lagoon. This area has no know diving value. The moorings will not interfere with any activities in the lagoon.

In the context of the size of Majuro lagoon, the depth of the fish farm sites and the use of central Majuro lagoon the magnitude of the impact is considered to be negligible at the weto level (to reflect the impact being contained within the fish farm sites). The impact will be long-term and should be considered irreversible in a reasonable time-frame. The significance of the impact is assessed as negligible.

Assessment of Impact – Summary

Positive	Negative

Level of importance of receptors		Magnitude of impact			
		Negligible	Low	Medium	High
	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

1.1.1.16 Operational Impacts

Consumable Goods Waste

The operation of the proposed fish farm will require very little consumable goods. The major consumable good will be fish feed. The transport of fish fingerlings by air requires packaging in plastic bags and foam boxes. Fuel, the other consumable good, is transported in reused bulk containers and is not associated with packaging waste.

In full operation the operation will use approximately 75,000 metric tons of feed per year. Fish feed is transported in a number of packaging forms:

- In 20kg or 25kg paper, light plastic or paper and light plastic 'disposable bags';
- In 1.0 or 1.5 metric ton heavy woven plastic reusable 'bulk bags';
- Loose in skips, tanks and hull on bulk ships and trucks (similar to bulk grain).

The operation in Majuro will eventually utilize all of these packaging types. Currently all feed for the pilot project is transported in disposable bags. These bags are able to be incinerated after use. This type of packaging will be used as little as possible as the farm expands and in the longer-term will be primarily used for the smaller sized feeds that are purchased in relatively small quantities. Assuming that up to 5,000 metric tons per year of fish feed is packed in the disposable bags the total number of waste bags will be 250. This is a small amount of waste that can easily be incinerated in Majuro.

As the operation expands the use of the bulk bags will be introduced. These bags will be returned to the feed manufacturers in other countries for reuse and will not be disposed of in Majuro. It is expected that this packaging type will be used for the majority of feed utilized in Majuro.

Loose feed transport is not associated with any consumable waste production.

The foam boxes used in the transport of live fish fingerlings are easily incinerated. There is also the possibly of reuse for the export of other goods from Majuro such as live aquarium fish, corals and clams by other businesses. The plastic bags used in the foam boxes are reused and will not be disposed of in Majuro. As the operation expands GFB intends to transport the majority of the live fish to and from the island by special ships. These ships remove the need for packaging. As such the use of air freight transport and the associated foam box waste will in time be eliminated.

The amount of consumable goods waste produced by the fish farming operation will be minimal and is considered of **negligible** magnitude at the **atoll** level. All of the consumable goods are able to be incinerated and will not contribute to landfill problems in Majuro. As such the consumable goods waste impact is best considered as short-term and reversible. The overall significance of the impact is assessed as **minor**.

Assessment of Impact – Summary

Positive	Negative

		Magnitude of impact			
		Negligible	**Low**	**Medium**	**High**
Level of importance of receptors	**Wetos**	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Waste from Decommissioned Farm Materials

The materials that comprise the fish farms have limited life spans. At the end of their serviceable lives these materials will need to be disposed. The materials are described in Table 5.10 below. The disposal of moorings has been previously discussed in a separate section.

Table 5.10: Fish Farm Materials and Decommissioning

Material	Estimated Serviceable Life	Disposal Method
Seacages	20 – 30 years	Either sold on island for reuse or taken off island for recycling or disposal.
Cage Nets	2-5 years	Either sold on island for reuse, taken off island for disposal or incinerated on island. Steel nets may be scuttled offshore on individual agreement with appropriate RMI Authorities.
Buoys	20-30 years	Either sold on island for reuse or taken off island for recycling or disposal.
Ropes and strapping	5 years	Either sold on island for reuse, taken off island for disposal or incinerated on island.
Barges and Ships	30-50 years	Taken off island for recycling or disposal or cleaned and scuttled offshore on individual agreement with appropriate RMI Authorities.
Work Boats	20-30 years	Either sold on island for reuse or taken off island for recycling or disposal.
Miscellaneous mechanical equipment (fish graders, fish pumps, augers, generators etc)	10-20 years	Taken off island for recycling or disposal or cleaned and scuttled offshore on individual agreement with appropriate RMI Authorities.
Mooring blocks, anchors and chains	10-20 years	Left in Situ at the bottom of central Majuro lagoon.

All decommissioned materials that are not able to reused on island or incinerated will be taken off island. As such the magnitude of the impact of the decommissioned farm materials is considered as **negligible** at the **atoll** level. As materials will be incinerated or taken off island the impacts are best considered short-term and reversible. The overall significance of the impact is assessed as **minor**.

Assessment of Impact – Summary

Positive	Negative

		Magnitude of impact			
		Negligible	Low	Medium	High
Level of importance of receptors	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Waste from Fish Processing

It is estimated at this stage that 80%-90% of the production of the fish farm production when at full capacity will be species that have potential for further processing in Majuro. Processing results in fish waste varying from about 15% of whole body weight (for gilled and gutted) up to about 40% of whole body weight (for fillet production). Depending on the product mix produced at the time (this will depend on market demands) between 6,000 metric tons and 18,000 metric tons of fresh fish waste may be produced in Majuro per year.

GFB intends to conduct all fish processing through existing fish processing operations in Majuro in the foreseeable future and therefore will depend on the existing mitigation procedures of these operations for the fish processing impacts. Provided that the fish waste is disposed of appropriately (for example at sufficient distance offshore) there is unlikely to be a significant impact associated with the additional processing volumes. If at any time in the future GFB seeks to operate its own processing in the RMI it will engage the appropriate authorities to determine the appropriate commissioning and operating procedures and regulations.

Assessment of Impact – N/A

1.1.1.17 *Mitigation Measures*

Production of Waster Materials from Construction and Mooring of Seacages

Impacts due to waste from the construction and mooring of seacages is assessed as **minor.** Key to mitigating this impact will be the use of prefabricated seacages and equipment where possible.

Mooring Blocks and Anchors

The impact of mooring blocks and anchors being left in situ at the fish farming sites after their useful lives is assessed as **negligible.** No mitigating measures are proposed for this impact.

Consumable Goods Waste

The impact of consumable goods waste from the operation of the fish farm is assessed as **minor.** GFB will utilize bulk feed packaging (reusable) where possible to minimize consumable goods waste.

Waste from Decommissioned Farm Materials

The impact of waste from decommissioned farm materials is assessed as **minor.** In order to minimize waste from decommissioned farm materials GFB will either sell decommissioned materials on island where they are reusable, recycle, incinerate or take the materials off island.

5.7 Air, Climate, Noise and Vibration

Table 5.11: Summary of Impacts

Impact	Activity and Description	Assessment
Costs		
Increased Noise from Construction on Land	Noise from the assembly and construction of fish farming equipment in Majuro may impact on surrounding areas.	Assembly activities on land will take place in areas with existing industrial activity and will be similar in impact to residential construction. This impact is considered to be of **negligible** significance.
Increased Noise from Construction on Water	Noise from the assembly, construction and mooring of fish farming equipment on the fish farm sites may impact on surrounding areas.	The fish farm sites are at a minimum of 2.5 to 3.0 kilometers from any residences. The level of noise at the fish farm sites will be similar to a residential construction project. Activity will not be conducted after 10pm. Under some conditions noise may be 'blown' towards residences. The impact is considered to be of **minor** significance.
Increased Boat Traffic (construction)	Increased boat traffic in Majuro associated with the construction will involve a level of increased noise disturbance.	The operation will aim to minimize boat traffic with barges moored on site as work stations in the longer term reducing travel. Against the level of background boat traffic the impact is considered to be of **minor** significance.
Increased Boat Traffic (operation)	Increased boat traffic in Majuro associated with the construction will involve a level of increased noise disturbance.	The operation will aim to minimize boat traffic with barges moored on site as work stations in the longer term reducing travel. Against the level of background boat traffic the impact is considered to be of **minor** significance.

5.7.1 Assessment and Mitigation of Effects

1.1.1.18 Construction Impacts

Increased Noise from Construction on Land

Some activities associated with the establishment of the fish farm, in particular in the earlier stages of the operation before suitable working barges are present on site, will require assembly and construction of materials on land in Majuro.

These activities will include the assembly of seacages, splicing of ropes, pre-servicing of machinery and pouring of concrete mooring blocks. Some additional operation of machinery such as trucks and forklifts will also be associated with this activity.

The level of noise and disturbance associated with this construction activity will be similar to that associated with a residential building site. Construction activities will be conducted in existing industrialized areas within normal working hours (6am to 10pm).

In terms of the type of construction activities and their locations the magnitude of the impacts is considered to be **negligible** at the **weto** level. Impacts are short-term and reversible. The significance of the impact is assessed as **negligible.**

Assessment of Impact – Summary

Positive	Negative

		Magnitude of impact			
		Negligible	Low	Medium	High
Level of importance of receptors	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Increased Noise from Construction on Water

As the operation expends in size working barges will be moored at the fish farm sites which will allow many of the fish farm construction activities to take place directly on site. This will transfer the impacts discussed in the section above to the fish farm sites and result in increased boat activity on the site.

The fish farm sites are located with a minimum 2.5km to 3.0km to any land areas. At these distances noise impacts will be minimal. A 100 decibel noise would reduce to 50 decibels over a distance of 320 meters. The level of noise associated with the fish farm construction activities will be at most similar to a light industrial area (about 70 decibels). At 2.5km the level of noise will be below that generally accepted as suitable for a rural residential area at night (approximately 40 decibels) and is unlikely to be discernable under most conditions.

The magnitude of the impact of increased noise from construction on water is considered to be low (possibly detectable impacts but minimal changes to the established structure and function) at the weto level (only the nearest wetos have any potential for impact). The impact is short-term and reversible however some level will take place throughout the life of the project. The significance of the impact is assessed as being **minor**.

Assessment of Impact – Summary

Positive	Negative

Level of Importance of receptors		Magnitude of impact			
		Negligible	**Low**	**Medium**	**High**
	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

Increased Boat Traffic

The establishment and construction of the fish farm will result in increased boat traffic between East Majuro and the fish farm sites. Associated with this increased boat traffic will be a level of noise. However the noise levels are relatively low and unlikely to affect any residences or other uses in Majuro unless boats are traveling at high speeds within several hundred meters of the shore. The impact also needs to be considered in the context of the amount of boat traffic already present on Majuro lagoon.

In the context of the background level of boat traffic it is considered the increased boat traffic will have a **negligible** magnitude of impact on noise levels at the **atoll** level. The impact is short-term and reversible although some level will continue through the life of the project. The significance of the impact is assessed as **minor.**

Assessment of Impact – Summary

Positive	Negative

		Magnitude of impact			
		Negligible	Low	Medium	High
Level of importance of receptors	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

1.1.1.19 Operational Impacts

Increased Boat Traffic

The operation of the fish farm will also result in increased boat traffic between East Majuro and the fish farm sites. Again the noise levels are relatively low and unlikely to affect any residences or other uses in Majuro unless boats are traveling at high speeds within several hundred meters of the shore. The impact also needs to be considered in the context of the amount of boat traffic already present on Majuro lagoon.

In the context of the background level of boat traffic it is considered the increased boat traffic will have a **negligible** magnitude of impact on noise levels at the **atoll** level. The impact is reversible however needs to be considered for the life of the project. The significance of the impact is assessed as **minor.**

Assessment of Impact – Summary

Positive	Negative

		Magnitude of impact			
		Negligible	**Low**	**Medium**	**High**
Level of importance of receptors	**Wetos**	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

1.1.1.20 *Mitigation Measures*

Increased Noise from Construction on Land

The impact of noise from assembly operations on land due to the establishment of the fish farm is assessed as **negligible.** The key mitigating measure will be to use existing industrial localities for land-based construction.

Increased Noise from Construction on Water

The impact of noise from farm construction activities on the water is assessed as **minor.** The proposed fish farm sites are situated at a significant distance from residences and other businesses to minimize the potential for conflict. It is also proposed that farm construction activities on the water are restricted to between sunrise and 10pm.

Increased Boat Traffic (Construction)

The impact of increased boat traffic in Majuro due to construction activities associated with the fish farm is assessed as **minor.** In order to minimize the amount of boat traffic GFB will utilize barges / work platforms on site for the majority of assembly once the farm is of a sufficient scale.

Increased Boat Traffic (Operation)

The impact of increased boat traffic in Majuro due to operating activities associated with the fish farm is assessed as minor. In order to minimize the amount of boat traffic GFB will utilize barges / work platforms on site as a base for operations once the farm is of a sufficient scale.

5.8 Landscape and Visual Amenity

Table 5.12: Summary of Impacts

Impact	Activity and Description	Assessment
Costs		
Visual Impact at Component Assemblage Sites	Assembly of fish farm equipment may alter the visual impact of the assembly sites.	Fish farm equipment will be assembled in areas with existing industrial values. The level of visual impact is considered to be less than at a residential construction site. The impact is considered to be of negligible significance.
Visual Impact of Fish Farm and Supply Vessels	Fish farm cages, boats, barges and buoys are visible at a distance from the sites.	The fish farm will be visible from some residential areas such as the Woja area. At a minimum distance of 2.5 to 3.0 kilometers the residences are at a distance (greater than 500 to 700 meters) where visual impact would generally be considered to be acceptable. The impact is considered to be of minor / moderate significance.

5.8.1 Assessment and Mitigation of Effects

1.1.1.21 Construction Impacts

Visual Impact at Component Assemblage Sites

The assembly of various fish farm equipment at sites on Majuro will alter the appearance of these sites. The key to mitigating this impact is to ensure assembly is conducted in areas of existing light industrial activity. In the context of this appropriate siting the visual impact is considered to be minimal.

With appropriate siting the visual impact of component assemblage is considered to be of negligible magnitude at the weto level. The impact is short-term and reversible. Overall the impact is assessed as negligible.

Assessment of Impact – Summary

Positive	Negative

	Magnitude of impact			
Level of importance of receptors	Negligible	Low	Medium	High
Wetos	Negligible	Minor	Minor/Moderate	Major
Atoll	Minor	Minor/Moderate	Moderate/Major	Major
Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

1.1.1.22 *Operational Impacts*

Visual Impact of Fish Farm and Supply Vessels

The established fish farms will have a visual impact though occupying areas that are currently clear sea. There are no buffers to the line of site to the fish farm sites from most parts of Majuro.

The fish cages are low profile (about 1.0 meters above sea level at a maximum) and semi-transparent. In all, the aquaculture sites will occupy less than 2% of the lagoon surface area. Within the aquaculture sites actual fish farm infrastructure will occupy less than 3% of the water area within the designated aquaculture farming space (the remaining 97% being clear water). Similar fish farms are located in relatively high visual amenity areas in many other parts of the world including Europe, Australia and North America and are generally not considered to have a high impact.

Examples of the visual impact of similar fish farms in other parts of the world are displayed below.

Figure 5.8.1: Example of Visual Impact - Salmon Farm in the Shetland Islands

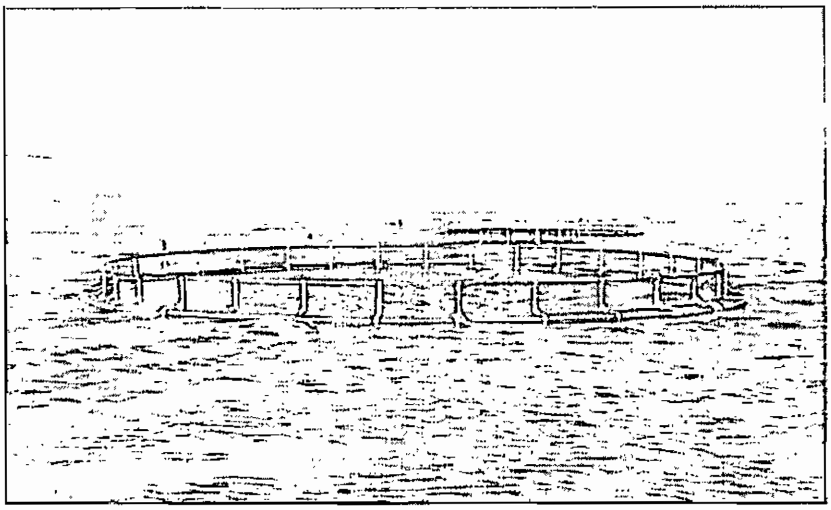


Figure 5.8.2: Example of Visual Impact – Salmon Farm in South Africa

The operation of the fish farms will result in boats, ships and barges moored around the seacages which will present a greater visual impact than the fish cages themselves. Many boats and ships presently moor within Majuro Lagoon however this is primarily in the eastern portion.

Based on the visual impact of similar fish farms in other parts of the world it is expected that the visual impact of the seacages will be minimal to non-existent from any land area in Majuro. Similar fish farms in other parts of the world are generally considered to have an acceptable visual impact at distances greater than 500 to 700 meters from the site at elevations of less than 15 meters. A proximate 1kilometer zone surrounding the fish farm sites is displayed in Figure 5.8.3.

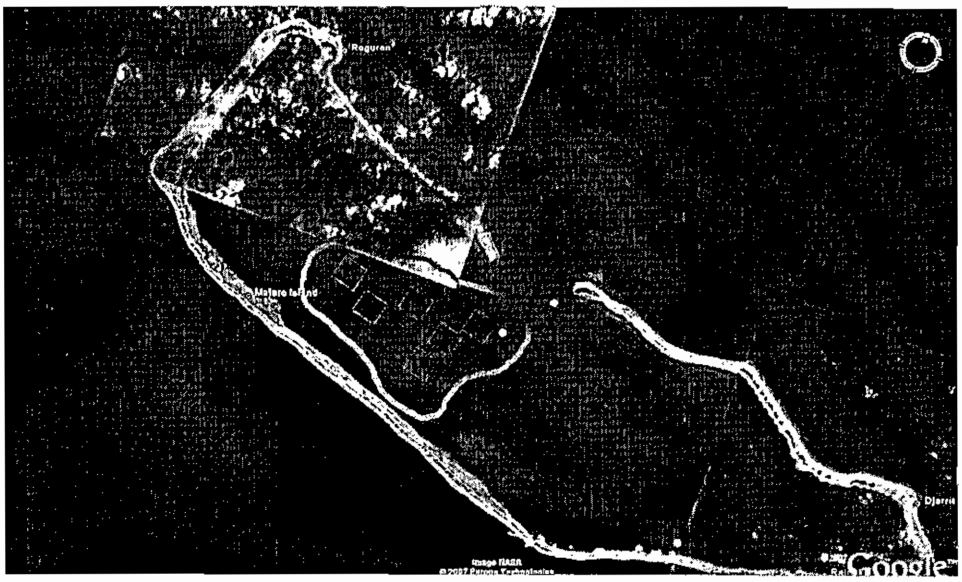


Figure 5.8.3: Zone of Most Significant Visual Impact from the Proposed Fish Farm Sites

The barges and ships will be more visible, particularly at night, however need to be considered in the context of other ships visible on Majuro Lagoon.

The overall visual impact is assessed of **medium** magnitude at the **wetos** level (will only be visible from the Woja area) with detectable impacts characterized by significant changes in structure, composition and function. Recovery from impacts is rapidly achievable on decommissioning of the farm. The resulting significance of the impact is assessed as **minor / moderate.**

Assessment of Impact – Summary

Positive	Negative

		Magnitude of impact			
		Negligible	Low	Medium	High
Level of importance of receptors	Wetos	Negligible	Minor	Minor/Moderate	Major
	Atoll	Minor	Minor/Moderate	Moderate/Major	Major
	Republic of the Marshall Islands	Minor	Moderate	Moderate/Major	Major
	Worldwide and Pacific Region	Minor	Moderate	Major	Major

Nature of Impact	
Short-term	Reversible
Medium-term	Irreversible
Long-term	

1.1.1.23 Mitigation Measures

Visual Impact at Component Assemblage Sites

The impact on visual amenity of fish farm component assemblage sites is assessed as negligible. It is proposed that sites within areas with existing industrial values are utilized in order to mitigate this impact.

Visual Impact of Fish Farm and Supply Vessels

The visual impact of the fish farm and its supply vessels is assessed as minor / moderate. The fish farm sites have been selected in part to maximize the distance to residential areas. GFB will also limit lighting on the fish farm sites to the minimum required for safety reasons from 10pm to sunrise.

5.9 Cultural Heritage, Archaeology and Material Assets

N/A

5.10 Traffic and Transport

N/A

5.11 Cumulative Impacts

The proposed development is in a relatively remote part of Majuro lagoon and for most impacts there is no potential for cumulative impacts in combination with other sources of impact.

Evidence of anthropogenic water quality impacts have been noted for parts of Majuro lagoon, particularly in the relatively poorly flushed eastern section, however there is little data to quantify the level of impact. The proposed fish farm will not involve chemical pollution and will not add to water quality impacts associated with chemical pollution (eg. heavy metals, pesticides, solvents).

Nutrient excretion from the fish farm has the potential to have a cumulative effect with anthropogenic nutrient enhancement of the atoll. However the evidence suggests that the cumulative effect will be negligible. The huge water volumes in Majuro lagoon and the relatively high flush rates ensures the anthropogenic nutrient impacts are confined to areas close to discharge points and areas of poor flushing. Nutrient impacts from eastern Majuro and agricultural runoff from the lagoon rim will be diluted and assimilated to close to background levels by the time they reach the fish farm sites.

5.12 Environmental Enhancements

The establishment of the project will be associated with a number of environmental enhancements. These are:

- **Increased water quality monitoring:** Water quality monitoring conducted by GFB will be the first long term monitoring of Majuro's water quality conducted. This will improve the knowledge of the baseline for future developments and environmental studies;

- **Water quality advocate:** GFB has a strong commercial interest in maintaining high water quality in Majuro lagoon, particularly in regards to chemical pollution. The existence of the farm will provide an extra level of vigilance for environmental protection in Majuro;

- **Compensatory habitat (fish farm structures):** The fish farm structures will aggregate fish in the otherwise low structure area and develop a significant population of fish in an area of otherwise little value as a fish habitat; and,

- **Fish reserves:** The fish farm sites will be access restricted and will aggregate significant numbers of wild fish. These fish will be protected with the site providing a sanctuary to protect breeding stocks of fish to ensure restocking of other areas. While doing so the site will not significantly reduce the tradition fishing areas of Majuro.

6 Conclusions and Recommendations

6.1 Summary of Environmental Impacts

All associated potential environmental impacts of the proposed fish farm are summarized in section 7.1. In summary the key environmental impact points are:

- The development will minimize land-based impacts with the majority of activity occurring in the relatively remote central Majuro Lagoon;
- Access to the proposed sites will be restricted however the relatively remote and low value areas proposed reduces the impact of these measures;
- The project will result in a major increase in employment and skills in Majuro;
- The fish farm sites are likely to see changes to some ecological communities in the near field (within 1,000 meters of the seacages) associated with natural responses to assimilating fish farm wastes;
- Numerous studies of similar fish farms and water quality modeling indicates that the intermediate field impacts (beyond 1,000 meters of the seacages) will be at the limit of detection and well below the level where impacts on the atolls coral reefs are possible;
- Through the application of appropriate biosecurity measures the risk of unwanted introductions will be reduced to no greater than that associated with normal shipping to Majuro.

6.2 Requirement for Environmental Permits

For the establishment of the fish farming project the following permits are sought:

Majuro Local Government:

Permit for the establishment of fish farm infrastructure within the proposed fish farm sites.

Traditional Owner

Written support from the Majuro Iroji for the conduct of the proposed aquaculture activities in Majuro Lagoon.

MIMRA

Permit for exclusive use by GFB of the 6 proposed fish farm sites for fish farming activities and operations.

EPA

Approval of the Environmental Impact Assessment for the aquaculture of 50,000 tonnes per annum of fish in Majuro;

Approval of the Environmental Management Plan for aquaculture of 50,000 tonnes per annum of fish in Majuro; and,

Permit to establish the fish farming infrastructure (cages and mooring) within the outlined cage sites.

7 List of Prepares

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7.1 Summary Table Environmental Impacts

Receptor / Environmental Resource	Description of Impact	Impact	Duration of Impact	Reversibility of Effect	Significance of Impact	Mitigation Measures	Residual Significance
Human Beings and Land Use	**Construction impacts**						
	Increased boat traffic	Adverse	Short-term	Reversible	Minor/Moderate	GFB RMI aims to minimize the amount of boat traffic to and from the fish farm sites by: Mooring large service barges on site to store feed, supplies and some equipment; Ferrying farm workers to site on several large boats; Providing accommodation on boats on site; and, Working with RMI authorities to develop procedures for import / customs / quarantine inspections at sea to avoid double transfer of goods and unnecessary use of the ports in Majuro.	Minor
	Employment generation	Beneficial	Short-term	Reversible	Moderate/Major	Nil, positive impact	Moderate/Major
	Increased skills of Marshallese	Beneficial	Long-term	Irreversible	Major	Nil, positive impact	Major
	Operational impacts						
	Restricted access	Adverse	Long-term	Reversible	Minor/Moderate	Position fish farm sites in low use areas.	Minor
	Restriction of recreational fishing	Adverse	Long-term	Reversible	Minor	Position fish farm sites in areas of low value to recreational fishing.	Minor
	Impact on other businesses	Adverse	Long-term	Reversible	Minor	Position fish farm sites distant from other businesses	Minor
	Restriction of boat traffic	Adverse	Long-term	Reversible	Minor	Position fish farm sites in areas of low boat traffic; Allow passage between fish farm sites; and, Ensure sites are clearly marked for marine navigation day and night.	Minor
	Increased skills of Marshallese	Beneficial	Long-term	Irreversible	Major	Nil, positive impact	Major
	Employment generation	Beneficial	Long-term	Reversible	Moderate/Major	Nil, positive impact	Moderate/Major
Habitats and Species	**Construction impacts**						
	Placement of mooring blocks	Adverse	Long-term	Reversible	Negligible	Use of permanent moorings for boats in order to minimize the need for dropping anchors in various parts of the farm; and; and, Sites where moorings are to be placed will be inspected to ensure any bommies or potential higher value habitat is avoided.	Negligible
	Operational impacts						
	Aggregation of wild fish assemblages	Adverse and Beneficial	Long-term	Reversible	Minor/Moderate	Considered partly positive impact in mitigating fish waste.	Minor/Moderate
	Changes to	Adverse and	Short-term	Reversible	Minor/Moderate	Considered partly positive impact in mitigating fish	Minor

	macrobenthic assemblages	Beneficial				waste. The location of the fish farm sites in relatively deep water will reduce the potential for this impact. Measures to mitigate impacts of changes to macrobenthic assemblages are: Moving of cages around the lease area to provide fallowing·; Use of pellets for food to minimize wastes; and, Monitoring of feeding to minimize waste.	
	Boat strike when traveling to site	Adverse	Long-term	Reversible	Minor	Nil	Minor
	Disease and pathogen transfer to the wild	Adverse	Long-term	Irreversible	Minor/Moderate	Measures to mitigate the risk of disease and pathogen transfer to the wild are: Remove any dead fish from cages ASAP; Use appropriate existing disease management protocols (stress management, sampling for disease where appropriate); and, Do not overstock cages.	Minor
	Entanglement of megafauna	Adverse	Short-term	Reversible	Minor	Measures to mitigate this risk are: Separate predator nets not to be used; Removal of any dead fish from cages ASAP to minimize attraction to cages; Use of rigid netting material for cages; and, Ensure all ropes/cables etc and cage material is taut.	Negligible
	Escaped stock	Adverse	Short-term	Reversible	Minor/Moderate	Measures to mitigate this risk are: Regular checking of cage material to ensure integrity, Ensure cage material and structures are engineered to withstand extreme weather events; Ensure that species are endemic; and, Ensure good site security.	Minor
	Food web changes	Adverse	Long-term	Reversible	Minor/Moderate	Food web changes in the near field are in positive in helping to mitigate fish wastes. Measures to mitigate this impact are: Moving of cages around the lease area to provide fallowing·; Use pellets for food to minimize wastes; Use a feeding regime that minimizes waste; and, Remove any dead fish from cages ASAP.	Minor/Moderate
	Seabird interactions	Adverse	Short-term	Reversible	Minor	Taught bird nets will be used over the cages and netting type reviewed in tangling of seabirds proves to be a problem.	Negligible
	Sediment changes	Adverse	Short-term	Reversible	Minor	Measures to mitigate this impact are: Ensure cages are sited in an area with a high flushing rate; Ensure cages are in relatively deep water; Moving of cages around the lease area to provide fallowing if sediment deteriorates; Use pellets for food to minimize wastes; Use a feeding regime that minimizes waste; and, Remove any dead fish from cages ASAP.	Minor
	Water quality (near field)	Adverse	Long-term	Reversible	Minor/Moderate	Measures to mitigate this impact are: Ensure cages are sited in an area with a high flushing rate; Use pellets for food to minimize wastes; Use a feeding regime that	Minor/Moderate

						minimizes waste; Remove any dead fish from cages ASAP; and, Monitor water quality parameters (Nitrogen, Phosphorus and Chlorophyll a).	
	Water quality (intermediate field)	Adverse	Long-term	Reversible	Minor/Moderate	Measures to mitigate this impact are: Ensure cages are sited in an area with a high flushing rate; Use pellets for food to minimize wastes; Use a feeding regime that minimizes waste; Remove any dead fish from cages ASAP; and, Monitor water quality parameters (Nitrogen, Phosphorus and Chlorophyll a).	Minor/Moderate
	Translocation of species	Adverse	Long-term	Irreversible	Minor	Measures to mitigate this impact are: Ensure cultured species are endemic; Exchange ballast water at least 30 miles from Majuro; Ensure all fish imported are from controlled hatcheries; and, Prophylactically treat fish tanks during shipping to the RMI to kill any potential invertebrates in the tanks.	Minor
Geology and Coastal Processes	Construction Impacts						
	N/A						
	Operation Impacts						
	N/A						
Water	Construction impacts						
	Disturbance of sediments	Adverse	Short-term	Reversible	Negligible	Use fixed mooring buoys for boat anchorage; and, Use mooring blocks and anchors designed to 'dig and hold' rather than drag.	Negligible
	Operational impacts						
	Increase in nutrient levels	Adverse	Long-term	Reversible	Minor/Moderate	Feed formulated pellets only; Avoid overfeeding; Locate fish farm sites in high flush areas; Cap fish production to levels within assimilation capacity of the environment; and, Monitor water quality.	Minor/Moderate
	Introduction of chemicals	Adverse	Short-term	Reversible	Minor	Maintain equipment in good order to minimize the chance of fuel or oil leaks.	Minor
Waste	Construction Impacts						
	Production of waste materials from construction and mooring of seacages	Adverse	Long-term	Irreversible	Minor	Utilize prefabricated seacages and equipment where possible.	Minor
	Mooring blocks and anchors	Adverse	Long-term	Irreversible	Negligible	Nil.	Negligible
	Operational impacts						
	Consumable goods waste	Adverse	Short-term	Reversible	Minor	Utilize bulk feed containers (Reusable) where possible.	Minor
	Waste from decommissioned farm materials	Adverse	Short-term	Reversible	Minor	Either sell decommissioned materials on island where they are reusable, recycle, incinerate or take the materials off island.	Minor
	Construction impacts						

Air, Climate, Noise and Air, Climate, Noise and Vibration	**Construction impacts**						
	Increased noise from construction on water	Adverse	Long-term	Reversible	Minor	Maximize distance of fish farm sites from residential areas; and, Conduct farm construction activities between sunrise and 10pm.	Negligible
	Increased boat traffic	Adverse	Short-term	Reversible	Minor	Utilize barges / work platforms on site to minimize boat movements to site.	Negligible
	Operational impacts						
	Increased boat traffic	Adverse	Long-term	Reversible	Minor	Utilize barges / work platforms on site to minimize boat movements to site.	Negligible
Landscape and Visual Amenity	**Construction impacts**						
	Visual impact at component assemblage sites	Adverse	Short-term	Reversible	Negligible	Utilize existing industrial localities for land-based construction.	Negligible
	Operational impacts						
	Visual impact of farm and service vessels	Adverse	Long-term	Reversible	Minor/Moderate	Maximize distance of fish farm sites from residential and tourism areas; and, Minimize lighting from 10pm to sunrise to that required for safety and navigation.	Minor

8 Environmental Management Plan

8.1 Introduction

This Environmental Management Plan (EMP) summarizes the actions required to implement the proposed project in accordance with the Environmental Impact Assessment (EIA) report that has been prepared under EIA Regulations 1994.

It sets out generic and specific objectives and targets defining the way in which the Environmental Protection Authority (EPA) wishes the EIA and its findings to be addressed during the implementation phase of the project (e.g. detailed design, construction and post-construction operation phases). It also details roles and responsibilities of those involved in the proposed project, and refers to all temporary and permanent works and should include measures for decommissioning if the project is not permanent.

The EMP is a live document and will be updated as and when necessary. For example, if the construction techniques are altered then there may be a need to implement alternative mitigation measures. However once the EMP is signed off by the EPA and proponent, each phase of the project can be commenced.

In some instances, the EPA may waive the requirement for a developer to submit an EIA report if the project is not deemed as significant as major projects, yet the project may still require an EMP to commit the project to mitigation measures to prevent impact on the environment.

Contractual status:

In every project, the EMP forms part of contract or work documentation and is incorporated within the specification and/or as Works Information. The EPA will have agreed that the EMP is satisfactorily integrated and will advise the EIA consultant or proponent on the number of copies to be provided.

Summary of Environmental Management Plan Procedures:

The EMP details how the EIA process will continue through to the completion of the proposal and how the protection, conservation, mitigation and enhancement measures for this proposal will be delivered by the contractor or proponent on behalf of the EPA. It forms part of the published EIA objectives, and as such forms the EMP's commitment to deliver environmental outputs in the form specified.

New Environmentally Significant Changes:

Any potential change in design, work processes or implementation must be communicated to the EPA Environmental Advisor immediately who will assess significance and decide whether consultation and / or an EIA or EMP Addendum is required.

Communicating the EAP:

Prior to the commencement of the construction works, the EPA Coastal Management Unit, together with the Consultant and Proponent will explain the EMP to the implementation team. Monitoring and program arrangements will also be advised.

Environmental Incident Reporting System:

An Environmental Incident shall be defined as an occurrence of a failure of an environmental constraint target or the occurrence of an environmental impact that was not identified in the EIA/EMP. Such incidents may arise from impacts unforeseen in the development of the scheme, or deviations from the planned method of working and contractual obligations in respect of environmental matters. Irrespective of cause, failures must be reported by the Site supervisor, Contractor to the Project

Manager and EPA. The Project Manager will consult with the EPA Environmental Advisor and the Project Team will agree an acceptable solution.

Any pollution incidents or releases of potentially hazardous substances must be reported immediately by the Site Supervisor to the EPA.

Role of the Environmental Impact Assessment Consultant or Site Supervisor:

The Developer or Proponent will appoint a suitably qualified site supervisor to ensure continued compliance with the EMP. The EPA may advise on roles, competencies and staff to carry out environmental responsibilities according the Work Instruction. The EPA will act through the Project Manager with respect to the issuing of instruction and the giving of advice to the Contractor, so that the correct contractual procedures are complied with and all communication is clearly and effectively managed.

An EPA Task Force will be appointed to visit the site and monitor compliance with the EMP approximately once a month, or as and when necessary. The site supervisor will attend site progress meetings and submit progress reports on work activities as when deemed necessary by the EPA, including any persistent non-compliance. Non compliance with the EMP may be subject to a violation, financial penalty and or revoke of the EPA permit for the development if necessary.

8.2 Sign Off for the EMP

Please fill in the table below stating that you have read and understood the content of the EMP and will adhere to it.

Name	Position/project responsibility	Organization	Signature	Date
Carey Ramm	Director	GFB RMI Inc.		
Provan Crump	Farm Manager,	GFB RMI Inc.		
John Bugnitak	Director	RMI EPA		

8.3 Environmental Management Plan

The EMP for this scheme has been produced as a separate document and the main table should be included in this EIA for reference if applicable. It sets out how the mitigation measures, identified during the EIA, will be implemented. It is a "live" document which will be updated throughout the project as and when necessary allowing unforeseen impacts to be identified and mitigated. The EMP also has the capability to adapt to changes in the extent and design of the scheme. As the project progresses individuals rather than organizations will be named under the responsibility column.

8.3.1 EMP Tables

The EMP table consists of three major compliance phases:

- Before Construction, whereby no construction works are to be allowed until the 'Before Construction' section of the EMP has been audited for compliance and signed off.

- During Construction, whereby construction works will be audited for compliance during the construction phase of the project and signed off.

- Post Construction (Operation), whereby once the project has been built, the operation phase of the project will be audited for compliance and signed off.

- Post Operation (Decommissioning), whereby fish farm infrastructure is decommissioned, will be audited for compliance and signed off.

For each phase of the project, environmental objectives and actions will be stated under separate themes as identified by the EIA:

These can be specific to the project but may also include (if necessary):

- Human Beings and Land Use including residential areas, landowners, tourism, commercial operations and social economics

- Habitats and Species, including marine and terrestrial habitats and species and sensitive species

- Water Quality, including groundwater resources and marine water quality

- Waste, including solid and hazardous waste

- Coastal Process and use of Natural Resources, i.e. dredged sand and rock

- Air Quality

- Noise and vibration

- Landscape and visual amenity

- Archaeology and Cultural Heritage

- Traffic and Transport.

The measures provided in this draft EMP will be used to measure environmental compliance. The EPA encourages proponents and the EIA consultant to be proactive and forward-thinking in addressing impacts by creating as a range of effective mitigation measures to prevent impact. Proponents with comprehensive mitigation measures and commitments to environmental enhancements will be acknowledged during the review and approval processing stage by the EPA.

TABLE 1: GENERIC ISSUES BEFORE CONSTRUCTION

Ref. No	Objective	Action	Target	Responsibility	Reference to further information	Monitoring and Observation	Further Action Required (Y/N)	Sign-Off of Completion
HUMAN BEINGS								
BC1	Ensure farm involves minimal conflicts with other uses	Fish farm sites are located in a relatively remote part of Majuro lagoon with little value for alternative uses. Cage sites will be clearly marked by buoys and lights in consultation with the RMI Ports Authority. Location of fish farm sites will be advertised as they are developed for use.	Fish farm sites that are clearly defined from surrounding waters to the satisfaction of the RMI Ports Authority.	GFB, RMI Ports Authority	See location of proposed fish farm sites	EPA is welcome to inspect installations respect to the outlined target	Y	
BC2	Stakeholders informed and supportive of project	GFB to ensure stakeholders are informed regarding the project.	Relevant stakeholders (MIMRA, EPA, Local Government and Iroij of Majuro) supportive of proposed sites.	GFB	N/A	N/A	Y	
HABITATS AND SPECIES								
BC3	Locate project in suitable area away from sensitive coral reef areas	The proposed fish farm sites (other than the temporary site off Lobekerae Island) are a minimum of 2.5 kilometers from any significant coral areas. This provides a large buffer area for near-field assimilation processes.	The site of the pilot fish farm meets the criteria for an environmentally sound fish farm location that being: - Well flushed with new water; - Relatively deep; - Positioned over a relatively low value ecosystem (coral sand flat with relatively low ecological value).	GFB	A survey of the proposed sites to be developed first are included in this EIA. Surveys of the other sites will be conducted and submitted to the RMI EPA prior to the establishment of any infrastructure on the sites.	RMI EPA staff are welcome to inspect and dive the sites at any time. GFB asks a that a courtesy minimum of 2 days notification is given to GFB to ensure a representative of GFB is available at the time of inspection.	Y GFB will dive the fish farm sites at least every quarter to inspect for any need to fallow sites. The reference site in Calalin Pass described in the EIA will be dived and	

Ref. No	Objective	Action	Target	Responsibility	Reference to further information	Monitoring and Observation	Further Action Required (Y/N)	Sign-Off of Completion
							photographed every six months and a report with pictures submitted to the RMI EPA.	
BC3	Ensure RMI biosecurity is preserved	Ensure probability of disease transfer is minimized through appropriate inspection and quarantine procedures. Procedures for air-based and sea-based import are in Appendix A: . The fish are produced in high-health facilities in Australia. Australia has only two fish diseases of international concern – one being a cold water disease not relevant to the species under question and the other being a fresh and brackish water disease only.	Procedures for inspection and quarantine that are appropriate for both the level of risk and normal international fish import protocols	GFB MIMRA EPA		MIMRA Scientists to conduct quarantine and health inspections. EPA to be notified 1 week in advance of any fish imports. EPA to be able to inspect fish with prior arrangement with the MIMRA scientist in charge.	N	
WATER								
BC4	Obtain Baseline Water Quality Measures	Baseline water sampling of the proposed reference sites outlined in Appendix C: to be begun monthly on approval of the EIA. Fish farm sites will be sampled only once fish have been stocked	N/A – baseline data collection only	GFB to collect samples and arrange testing. Samples to be frozen and stored at	Further monthly water samples as described in Appendix C: to be collected throughout the	N/A	Y	

Ref. No	Objective	Action	Target	Responsibility	Reference to further information	Monitoring and Observation	Further Action Required (Y/N)	Sign-Off of Completion
		at the sites.		MIMRA.EPA are permitted to inspect sample collections.	project and reported to the RMI EPA twice a year.			
WASTE								
COASTAL PROCESSES								
AIR QUALITY								
NOISE AND VIBRATION								
LANDSCAPE AND VISUAL AMENITY								
COASTAL PROCESSES								
MARINE NAVIGATION								
BC5	Ensure no hazard to Marine Navigation	See BC1 above	See BC1 above	See BC1 above		See BC1 above	See BC1 above	
TRAFFIC AND TRANSPORT								

TABLE 2: GENERIC ISSUES DURING CONSTRUCTION

Ref. No	Objective	Action	Target	Responsibility	Reference to further information	Monitoring and Observation	Further Action Required (Y/N)	Sign-Off of Completion
HUMAN BEINGS								
DC1	Ensure minimal impact of construction	Initially cages and moorings to be constructed on an existing construction site at Long Island, Majuro, and transported to site. In the longer-term barges to moored on site to maximize the amount of construction activity that can be conducted on site.	No additional impacts	GFB		N/A	N	
DC2	Minimize increases in boat traffic	GFB RMI aims to minimize the amount of boat traffic to and from the fish farm sites by mooring large service barges on site to store feed, supplies and some equipment, ferrying farm workers to site on several large boat, providing accommodation on boats on site and working with RMI authorities to develop procedures for import / customs / quarantine inspections at sea to avoid double transfer of goods and unnecessary use of the ports in Majuro.	Minimal use of land for fish farm related activities and storage.	GFB		N/A	N	
HABITATS AND SPECIES								
DC3	Ensure water flow and dilution is maximized	The fish farm sites have been selected as providing the most rapid flushing of wastes out of the atoll. Cages will be located separately and spaced around the sites to maximize water flow.	N/A	GFB	Fish farm layout in EIA	N/A	N	
DC4	Minimize impacts of placement of mooring blocks and	Use permanent moorings for boats in order to minimize the need for dropping anchors in various parts	No physical impact on hard habitats (Eg. Bommies)	GFB	N/A	EPA welcome to inspect farm moorings	N	

Ref. No	Objective	Action	Target	Responsibility	Reference to further information	Monitoring and Observation	Further Action Required (Y/N)	Sign-Off of Completion
	anchors.	of the farm. Inspect areas where moorings are to be placed will be inspected to ensure any bommies or potential higher value habitat is avoided.				with arrangement with GFB.		
WATER								
DC5	Minimize disturbance of sediments	Use fixed mooring buoys for boat anchorage. Use mooring blocks and anchors designed to 'dig and hold' rather than drag.	No disturbance of sediments others than associated with initial placement of moorings.	GFB		N/A	N	
WASTE								
DC6	Minimize waste materials from construction and mooring of seacages	Utilize prefabricated seacages and equipment where possible. Minimal offcuts and waste will be disposed of locally with a negligible impact on the Majuro dump.	Negligible waste production	GFB		N/A	N	
COASTAL PROCESSES								
AIR QUALITY								
NOISE AND VIBRATION								
DC7	Minimize noise impacts from construction on land	Utilize existing industrial localities for land-based construction.	Noise impact no greater than a residential building site.	GFB		N/A	N	
DC8	Minimize noise impacts from	Maximize distance of fish farm	Noise impact no greater than a residential building	GFB		N/A	N	

Ref. No	Objective	Action	Target	Responsibility	Reference to further information	Monitoring and Observation	Further Action Required (Y/N)	Sign-Off of Completion
	construction on water	sites from residential areas. Conduct farm construction activities between sunrise and 10pm.	site at the source. Noise not noticeable against background in residential areas.					
DC9	Minimize increases in boat traffic in Majuro.	GFB RMI aims to minimize the amount of boat traffic to and from the fish farm sites by mooring large service barges on site to store feed, supplies and some equipment, ferrying farm workers to site on several large boat, providing accommodation on boats on site and working with RMI authorities to develop procedures for import / customs / quarantine inspections at sea to avoid double transfer of goods and unnecessary use of the ports in Majuro.	Minimal use of land for fish farm related activities and storage.	GFB		N/A	N	
LANDSCAPE AND VISUAL AMENITY								
DC10	Visual impact at component assemblage sites	Utilize existing industrial localities for land-based construction.	Visual impact less than a residential construction site.	GFB		N/A	N	
COASTAL PROCESSES								
MARINE NAVIGATION								
TRAFFIC AND TRANSPORT								

TABLE 3: GENERIC ISSUES POST CONSTRUCTION (OPERATION)

Ref. No	Objective	Action	Target	Responsibility	Reference to further information	Monitoring and Observation	Further Action Required (Y/N)	Sign-Off of Completion
HUMAN BEINGS								
PC1	Minimize disturbance on nearest residences	Minimize activities and lighting on sites between 10pm and dawn.	No significant impact on residents	GFB		N/A	N	
PC2	Ensure security of site	Enforce no-go fish farm site areas. Provide 24hr staffing of sites.	No unnoticed visits to the fish farm	GFB	Security plan in EIA.	N/A	N	
PC3	Maintain restricted access	Position fish farm sites in low use areas. Clearly mark fish farm sites in consultation with RMI Ports Authority. Enforce no-go fish farm site areas. Advertise fish farm sites as utilized for production.	No public visits to the fish farm	GFB	Security plan in EIA.	N/A	N	
PC4	Minimal inconvenience from restriction of boat traffic	Position fish farm sites in areas of low boat traffic. Allow passage between fish farm sites. Ensure sites are clearly marked for marine navigation day and night. Advertise restricted areas prior to marking and utilization.	No major route changes needed for existing boat traffic.	GFB, RMI Ports Authority.		N/A	N	
HABITATS AND SPECIES								
PC5	Minimize and monitor water quality	Water samples shall be collected monthly as per plan in the EIA and analysed at six monthly intervals. A report on the results shall be provided to the EPA. The EPA shall also be informed of any observations during day-to-day operation of the pilot that suggests an impact on water quality.	Regular water quality tests	GFB EPA is welcome to attend water sample collection		Monthly samples. Six monthly analysis and reporting	Y	
PC6	Monitor impact on	A reference site at Calalin Pass	Twice yearly dive	GFB		Twice yearly	Y	Y

Ref. No	Objective	Action	Target	Responsibility	Reference to further information	Monitoring and Observation	Further Action Required (Y/N)	Sign-Off of Completion
	surrounding ecosystems	shall be dived every six months and a report with photographs submitted to EPA as to any visible impacts.	inspection of site and nearest reef	EPA is welcome to attend site inspections (at own cost for diving)		inspection and reporting		
PC7	Minimize chemical spills	Hazardous chemicals not to be used by GFB. Equipment to be kept in good working order to minimize chance of fuel or oil leaks.	No hazardous discharges	GFB		Any suspected fuel or oil leaks to be reported to the EPA either in the six monthly report (if suspected less than 1 liter) or within 2 working days (if greater than 1 liter)	Y	N
PC8	Minimize fish escape	The fish shall be contained in predator proof nets at all times. The escape of fish presents a major economic loss to GFB Fisheries however will have no impact on the environment as the species to be farmed are naturally occurring	No fish escapes	GFB		GFB will inform EPA of any suspected fish escapes	Y	N
PC9	Minimal changes to macrobenthic assemblages	Move cages around the lease area to provide fallowing. Formulated pellets will be used exclusively for food to minimize wastes and feeding will be carefully monitored.	Level of benthic change that returns to pre-impact levels within 1 year of fallowing.	GFB		GFB will collect a series of representative photos of the benthos prior to stocking an array of cages at a site. This will be used compare to a series of	Y	N

Ref. No	Objective	Action	Target	Responsibility	Reference to further information	Monitoring and Observation	Further Action Required (Y/N)	Sign-Off of Completion
						photos taken just prior to site fallowing and on return of the site to production.		
PC10	No additional disease and pathogen pressure on wild stocks	Remove any dead fish from cages ASAP. Use appropriate existing disease management protocols (stress management, sampling for disease where appropriate). Cages not to be overstocked.	No additional disease and pathogen pressure on wild stocks	GFB		Any potentially infectious disease outbreaks to be noted in six monthly report to the EPA.	N	
PC11	No entanglement of megafauna	Separate predator nets not to be used. Removal of any dead fish from cages ASAP to minimize attraction to cages. Use of rigid netting material for cages. Ensure all ropes/cables etc and cage material is taut.	No incidence of megafauna entanglements	GFB		Any interactions with megafauna to be noted in six monthly report to the EPA.	N	
PC12	Minimal escaped stock	Regular checking of cage material to ensure integrity. Ensure cage material and structures are engineered to withstand extreme weather events. Ensure that species are endemic. Ensure good site security.	No escapees	GFB	See endemicy data in the EIA	Report on suspected escapees in six monthly report to the EPA.	N	
PC13	Food web changes	Moving of cages around the lease area to provide fallowing as required. Use pellets for food to minimize wastes. Monitor feeding carefully to minimizes waste. Remove any dead fish from cages ASAP.	Food web changes only measurable in the near field.	GFB		Water quality and Calalin Channel reef monitoring.	Y	
PC14	Seabird interactions	Taught bird nets will be used over the cages and netting type reviewed in tangling of seabirds proves to be a problem.	No deleterious seabird interactions.	GFB		Any deleterious seabird interactions to be noted in 6	Y	

Ref. No	Objective	Action	Target	Responsibility	Reference to further information	Monitoring and Observation	Further Action Required (Y/N)	Sign-Off of Completion
						monthly report		
PC15	Sediment changes	Ensure cages are sited in an area with a high flushing rate. Ensure cages are in relatively deep water;· Move cages around the lease area to provide fallowing if sediment deteriorates. Use pellets for food to minimize wastes. Use a feeding regime that minimizes waste. Remove any dead fish from cages ASAP.	Sediment quality that is capable of returning to pre-impact condition within 1 year of fallowing.	GFB		GFB will collect a series of representative photos of the benthos prior to stocking an array of cages at a site. This will be used compare to a series of photos taken just prior to site fallowing and on return of the site to production.	Y	
PC16	Water quality (near field)	Ensure cages are sited in an area with a high flushing rate. Use pellets for food to minimize wastes. Use a feeding regime that minimizes waste. Remove any dead fish from cages ASAP. Monitor water quality parameters (Nitrogen, Phosphorus and Chlorophyll a).	As per water quality targets in the EIA	GFB	EIA Appendix C:	Water quality monitoring results to be included in the six monthly report	Y	
PC17	Water quality (intermediate field)	Ensure cages are sited in an area with a high flushing rate. Use pellets for food to minimize wastes. Use a feeding regime that minimizes waste. Remove any dead fish from cages ASAP. Monitor water quality parameters (Nitrogen, Phosphorus and Chlorophyll a).	As per water quality targets in the EIA	GFB	EIA Appendix C:	Water quality monitoring results to be included in the six monthly report	Y	
PC18	Translocation of species	Ensure cultured species are endemic. Exchange ballast water	No new species translocated to Majuro.	GFB, MIMRA	EIA Appendix C:	MIMRA to monitor	N	

Ref. No	Objective	Action	Target	Responsibility	Reference to further Information	Monitoring and Observation	Further Action Required (Y/N)	Sign-Off of Completion
		at least 30 miles from Majuro. Ensure all fish imported are from controlled hatcheries. Prophylactically treat fish tanks during shipping to the RMI to kill any potential invertebrates or fish larvae in the tanks.				imports.		
WATER								
PC19	Increase in nutrient levels	Feed formulated pellets only.. Avoid overfeeding. Locate fish farm sites in high flush areas. Cap fish production to levels within assimilation capacity of the environment. Monitor water quality.	As per water quality targets in the EIA	GFB	EIA Appendix C:	Water quality monitoring results to be included in the six monthly report	Y	
PC20	Minimize chemical spills	Hazardous chemicals not to be used by GFB. Equipment to be kept in good working order to minimize chance of fuel or oil leaks.	No hazardous discharges	GFB		Any suspected fuel or oil leaks to be reported to the EPA either in the six monthly report (if suspected less than 1 liter) or within 2 working days (if greater than 1 liter)	Y	N
WASTE								
PC21	Consumable goods waste	Utilize bulk feed containers (Reusable) where possible.	Only easily incinerated consumable waste disposed on island.	GFB		N/A	N	
COASTAL PROCESSES:								

Ref. No	Objective	Action	Target	Responsibility	Reference to further information	Monitoring and Observation	Further Action Required (Y/N)	Sign-Off of Completion
AIR QUALITY								
NOISE AND VIBRATION								
PC22	Increased boat traffic	Utilize barges / work platforms on site to minimize boat movements to site.	Bulk boat movements 80% of boating associated with operation.	GFB		N/A	N	
LANDSCAPE AND VISUAL AMENITY								
PC23	Visual impact of farm and service vessels	Maximize distance of fish farm sites from residential and tourism areas. Minimize lighting from 10pm to sunrise to that required for safety and navigation.	No complaints from residences on visual amenity.	GFB		N/A	N	
COASTAL PROCESSES								
MARINE NAVIGATION								
TRAFFIC AND TRANSPORT								

TABLE 3: GENERIC ISSUES FOR FARM DECOMMISIONING

Ref. No	Objective	Action	Target	Responsibility	Reference to further information	Monitoring and Observation	Further Action Required (Y/N)	Sign-Off of Completion
HUMAN BEINGS								
HABITATS AND SPECIES								
WATER								
WASTE								
FD1	Minimize impact of decommissioned farm materials on solid waste facilities on Majuro	Decommissioned materials from the fish farming project will either be reused, recycled, incinerated or take the materials off island.	Minimal pressure on solid waste facilities in Majuro from decommissioned farm materials.	GFB	EIA	N/A	N	N
COASTAL PROCESSES								
AIR QUALITY								

Ref. No	Objective	Action	Target	Responsibility	Reference to further information	Monitoring and Observation	Further Action Required (Y/N)	Sign-Off of Completion
NOISE AND VIBRATION								
LANDSCAPE AND VISUAL AMENITY								
COASTAL PROCESSES								
MARINE NAVIGATION								
TRAFFIC AND TRANSPORT								

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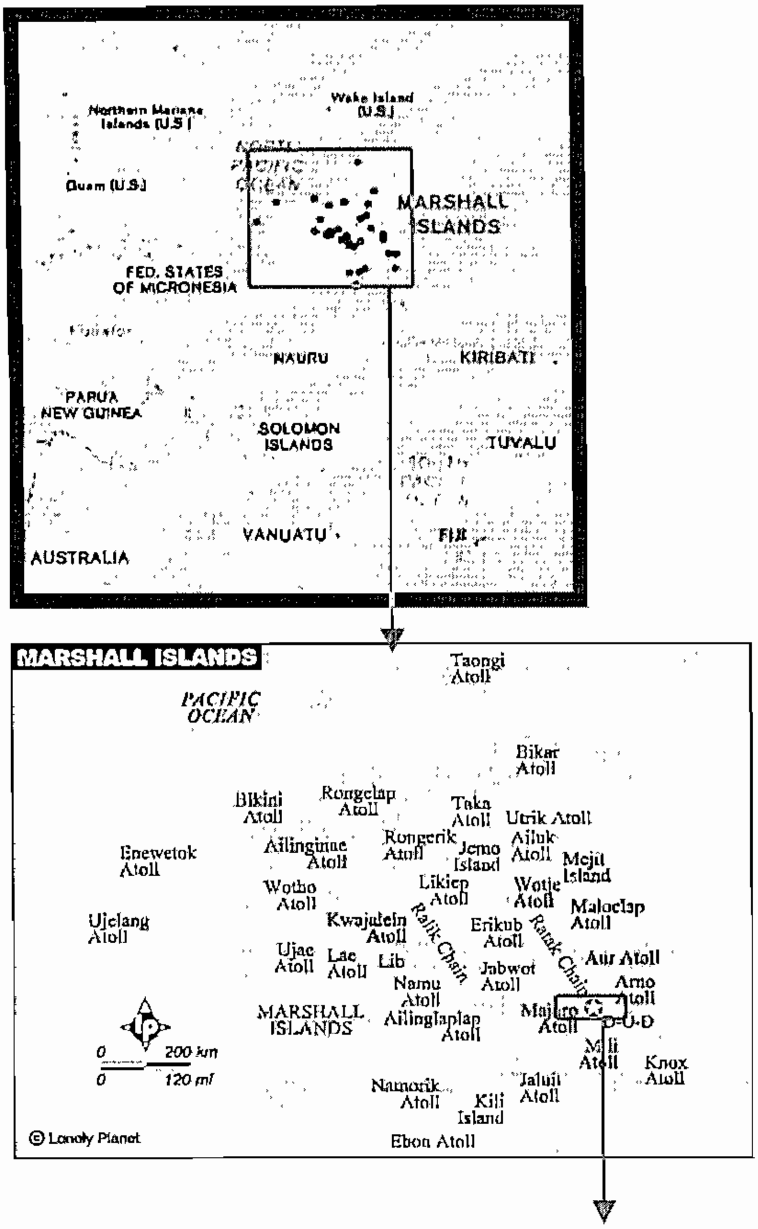
10 Appendices

Appendix A: ***FIGURES REFERRED TO IN THE REPORT***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PAPUA NEW GUINEA
SOLOMON ISLANDS
TUVALU
VANUATU
FIJI
AUSTRALIA
MARSHALL ISLANDS
PACIFIC OCEAN
Taongi Atoll
Bikar Atoll
Bikini Atoll
Rongelap Atoll
Taka Atoll
Utrik Atoll
Enewetok Atoll
Ailinginae Atoll
Rongerik Atoll
Jemo Island
Ailuk Atoll
Mejit Island
Wotho Atoll
Likiep Atoll
Wotje Atoll
Ujelang Atoll
Kwajalein Atoll
Ralik Chain
Erikub Atoll
Ratak Chain
Maloelap Atoll
Ujae Atoll
Lae Atoll
Lib
Jabwot Atoll
Aur Atoll
Namu Atoll
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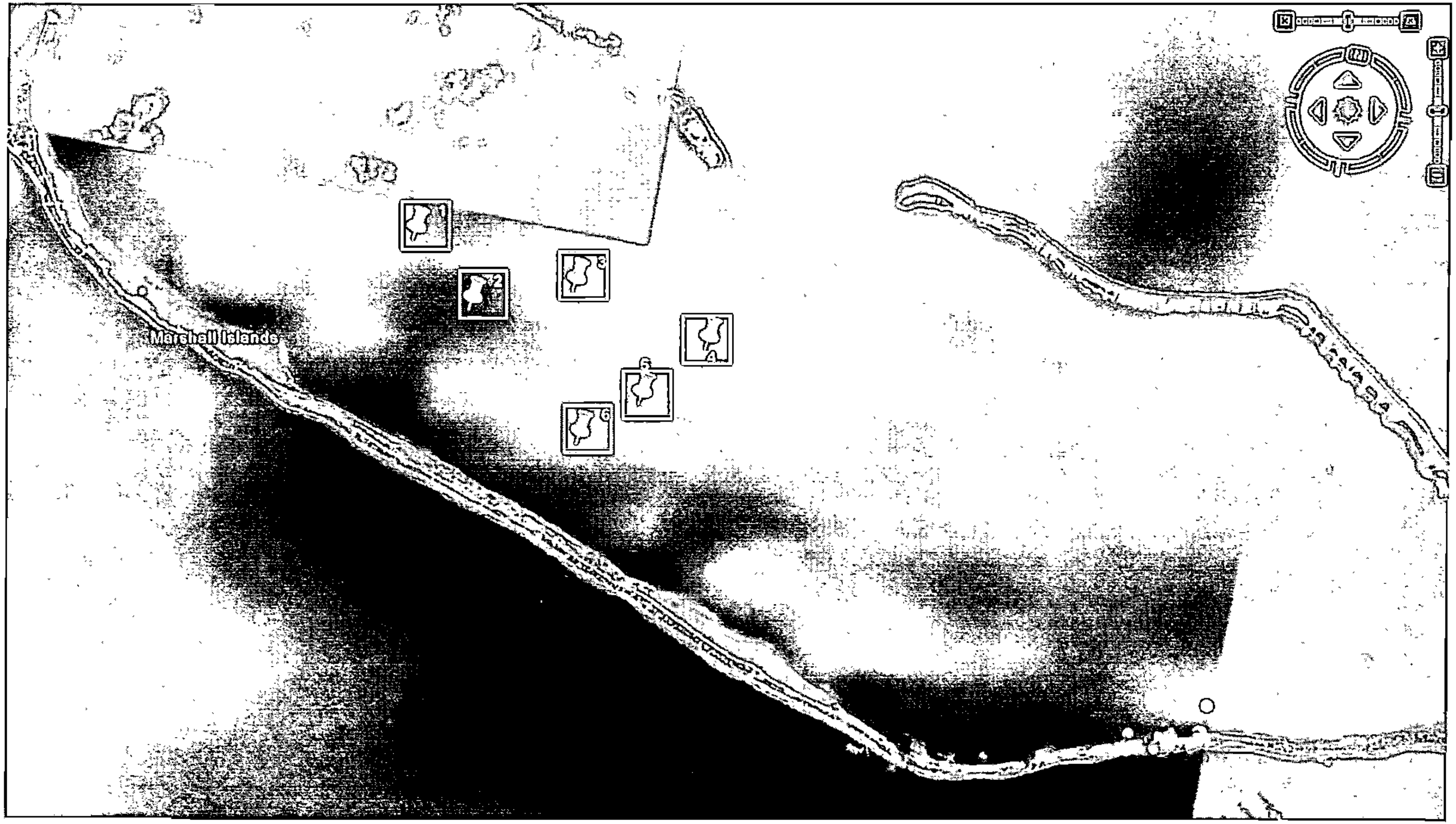


Figure 8.3.1: Location of the Proposed Fish Farm Sites (Source: Google Earth)

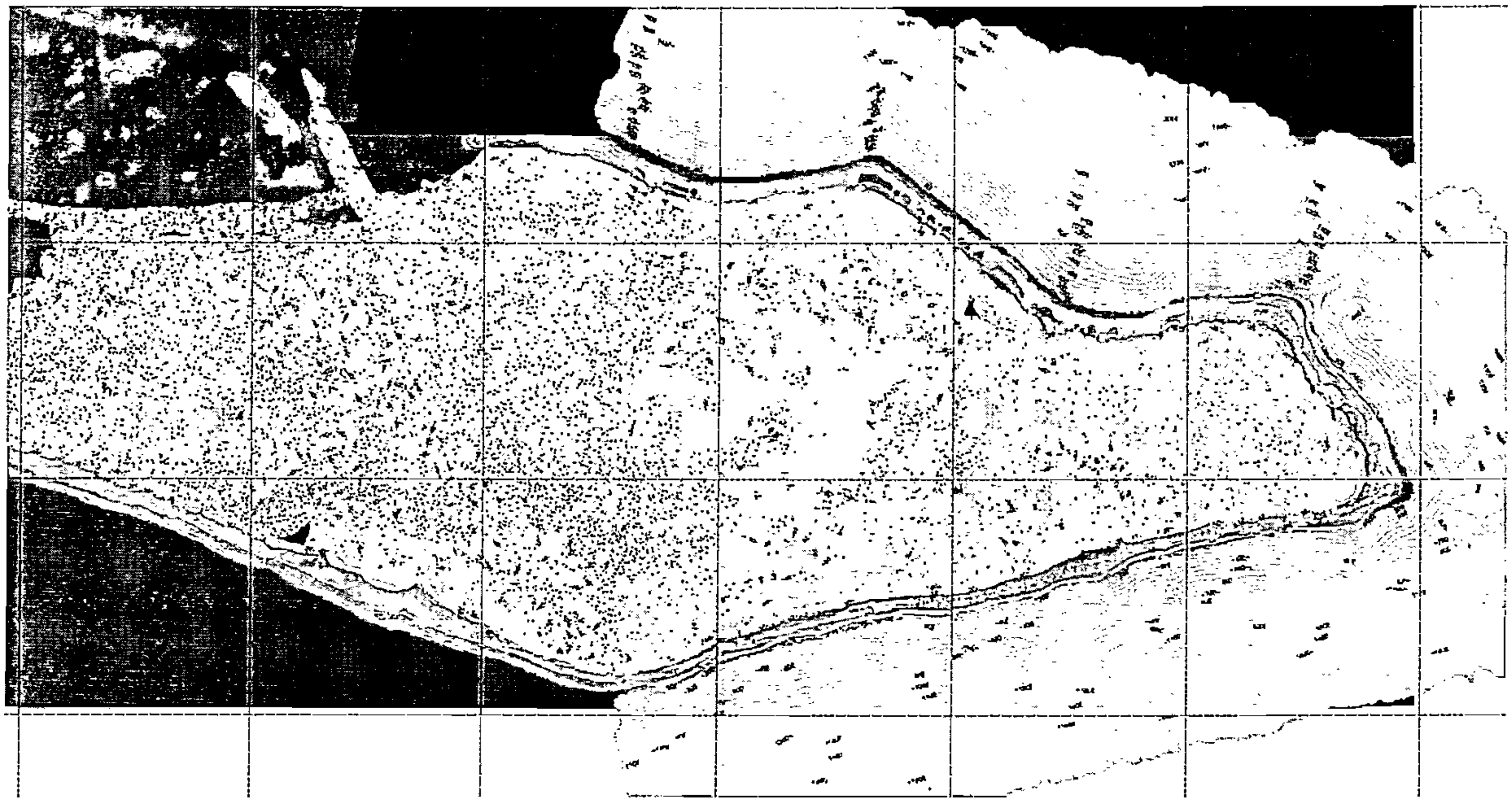


Figure 8.3.2: Bathymetric profile of Majuro atoll (Source: SOPAC)

TENCATE
Aquagrid

Fast Facts
News Bulletin
Bulletin A2007-01

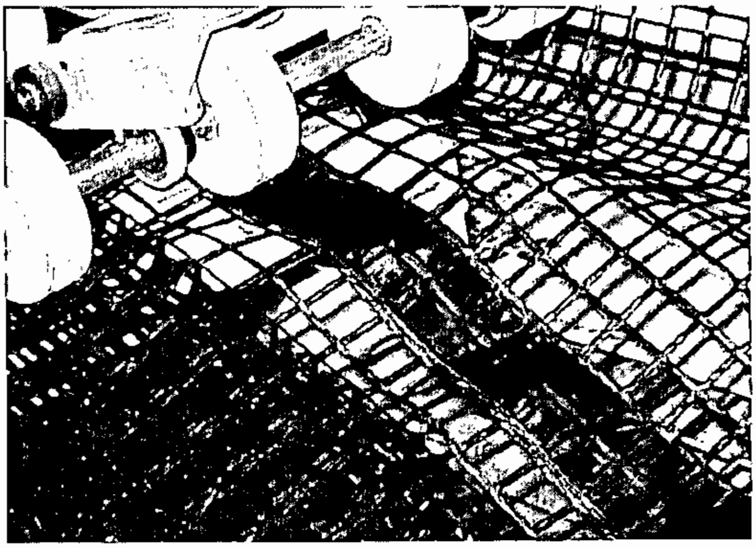
Hot Air Welding Update: Capabilities For Aquagrid™ Net Assembly Expand To New Continents

Facilities now in production in Canada, Indonesia, and South America, with other operations planned for other areas, speeding availability of Aquagrid™ cages.

Fish farms all over the world are using Aquagrid™ nets because of their durability, easy cleaning, and strength. Now it's becoming even easier to take advantage of these benefits.

New high speed, hot air welding equipment for seaming Aquagrid™ net panels is being installed in additional locations around the world. The hot air welding technique provides exceptionally strong seams for Aquagrid™ nets. And more availability of welding equipment provides net lofts with ready access to assembled Aquagrid™ panels—which in turn makes it easier for fish farms to get completed Aquagrid™ cages.

TenCate develops and produces materials that function to increase performance, reduce cost and deliver measurable results by working with our customers to provide advanced solutions. TenCate Aquagrid, the manufacturer of Aquagrid™ semi-rigid netting, has worked with organizations in different parts of the world to install hot air welding equipment for assembling Aquagrid™ net sections.



High speed, hot air welding being done on an Aquagrid™ net. This technique for seaming is fast, efficient, permanent, and remarkably strong. Welding equipment is now available in more locations.

"We have people coming to us all the time asking TenCate Aquagrid to build cages to their specifications," said Mark Gunzenhauser, Vice President of Industrial Fabrics. "But we're in the net material business, not the cage business. So we began working closely with high-quality net lofts to help them get the equipment and training to provide finished Aquagrid™ cages. Part of this effort is the installation of the hot air welding equipment."

The unique hot air welding technique for Aquagrid™ nets melts the PVC coating of the net and bonds it to a woven, PVC coated webbing that forms the seam between panels. The bonded seam is nearly as strong as the net itself—and significantly stronger than the sewn seams used for traditional nylon nets.

The welded seam is accomplished by overlapping two squares of Aquagrid™ net, then applying the seam material. The net is heated with hot air, and the seam material and net pressed together. As it cools, the bond formed is strong and permanent.

The welded seam has other benefits: because it is relatively flat and smooth, there is less likelihood of irritation or injury if fish brush against it, and the low-profile also is easier to clean with a rotary wash.

Since last year, TenCate Aquagrid has partnered with net lofts on different continents to install hot air welding equipment and make finished cages available.

Companies who have the hot air welding equipment installed now include:

- Novatech (Chile)
- Aquaculture Engineering Group (Canada)
- PT Fega Marikultura (Indonesia)

(More)

Protective & Outdoor Fabrics
Aerospace Composites
Armour Composites
Geosynthetics
Industrial Fabrics
Synthetic Grass

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materials that make a difference

In addition, hot air welding equipment is currently under consideration for installation in Australia and in Europe.

"As net assembly functions continue to consolidate and fish farm operators expand the practice of ordering completed net assemblies, the ability to provide hot air welded Aquagrid™ panels—or completed cages—in regions around the world will become more important," Gunzenhauser said. "We're now in a position where any aquaculture facility that wants Aquagrid™ nets can get access to them."

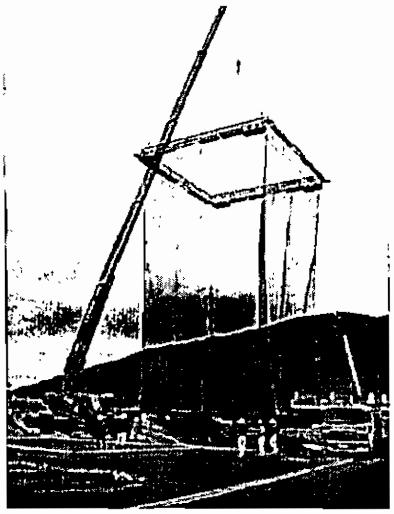
Aquagrid™ nets are now being used in Australia, Belize, Chile, Greece, Finland, Israel, Japan, Norway, Scotland, Spain, Tasmania, Canada, Nicaragua, Taiwan, and the United States. Noomas Sertifisering, an accreditation company authorized by the Norwegian government, has issued the NS 9415 certificate to TenCate, manufacturer of Aquagrid™ nets, which allows the nets to be used in all square and circular cage classes of aquaculture operations in Norway.

Aquagrid™ nets have demonstrated in testing strength that is 100% greater than traditional nylon nets. Because of their PVC coating, no anti-foulant is needed. The coating also prevents biofouling organisms from attaching themselves to the net fiber, so cleaning is much easier. In fact, in many parts of the world, Aquagrid™ nets are cleaned in the water. The extra strength of Aquagrid™ nets is also a deterrent to many predators, and for many installations a second predator net is not required.

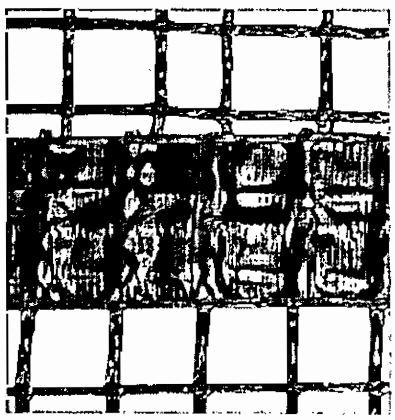
Aquagrid™ nets are appropriate for a variety of species, including salmon, trout, sea bass, sea bream, carp, catfish, cobia, cod, striped bass, tilapia, halibut, flounder, tuna, and barramundi.

A cost calculator that lets operators look at their own savings from using Aquagrid™ nets is available at the product's website, www.aquagrid.com. There is also more technical information about product sizes, strength testing, and other issues.

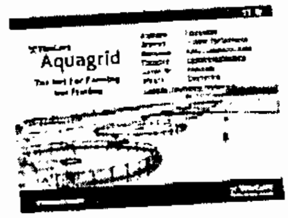
Because specifications for Aquagrid™ nets can be different than traditional nylon nets, there are some unique cost-saving approaches that can be used. To learn more, contact Don Bishop, Aquaculture Specialist, at don@aquagrid.com.



A completed cage, ready for installation. With hot air welding equipment being installed around the world, Aquagrid ™ cages are now readily available to virtually every aquaculture facility.



The hot air welded seam in an Aquagrid ™ net. Testing shows the bond is permanent and nearly as strong as the net itself. Aquagrid™ nets have been shown to be up to 100% stronger than traditional nylon nets.



Aquagrid™ Nets CD Available

Want to know more about how Aquagrid™ nets can reduce costs, cut escapes, and improve productivity?

A new CD from TenCate Aquagrid covers all aspects of the product, and explains its advantages over traditional nylon netting. The semi-rigid Aquagrid™ net is the first net designed specially for fish farming, not just fishing, and it offers benefits in durability, cleaning, predation control, and even fish health.

"This presentation covers not just what we knew about Aquagrid™ nets when we first introduced them, but also what we have learned in the field over the last three years," said Mark Gunzenhauser, Vice President of Industrial Fabrics. "As more operators use Aquagrid™ nets, they discover advantages we had not thought of yet."

The presentation also covers another product, Geotube® dewatering technology has applications for fish processing, cage bottom cleanup, and even net washing.

For a copy of the presentation, contact TenCate Aquagrid at www.aquagrid.com or by calling 706-693-2226, ext. 1785.

Contact:
Don Bishop
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Cell: 613.639.3474
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Phone: 706.693.2226, ext. 1785
Fax: 706.693.4400

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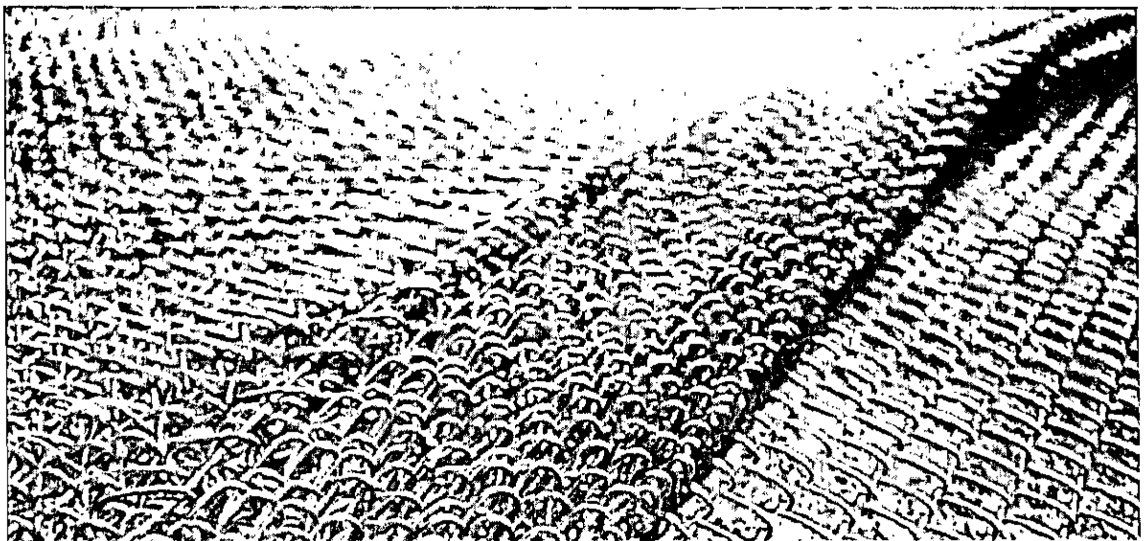
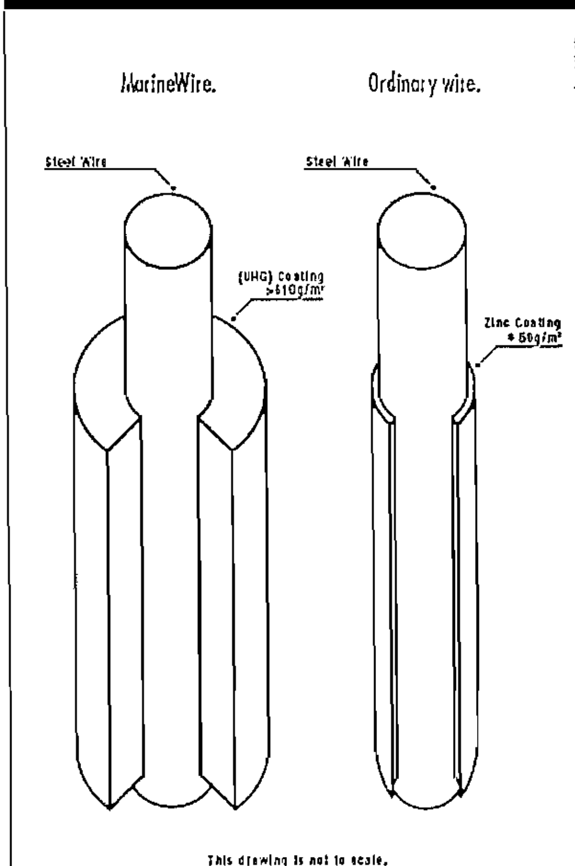
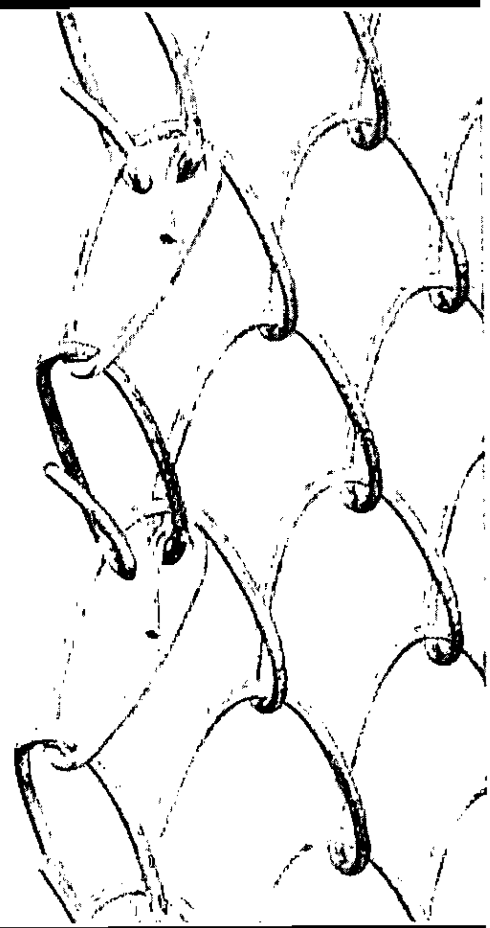
Figure 8.3.3: Details of Aquagrid Fish Cage Netting



MarineMesh chain link weave provides flexibility.



MarineWire has a coating weight 12 times that of ordinary wire.



The double knot of MarineKnuckle gives it greater strength and flexibility.

WHAT'S BEHIND OUR NEW DEFENCE SYSTEM.

A defensive barrier of steel mesh called MarineMesh™ forms the basis of our new anti-predatory fish farming system.

The key to its impenetrability lies in the quality of the steel wire used. It's made from ultra heavily galvanised wire called MarineWire.™

This wire ensures greater protection from the number one enemy of steel – i.e. corrosion – by providing multiple layers of protection.

It incorporates a tough alloy layer and a zinc coating that has twelve times the coating weight of ordinary galvanised wire.

For added strength, it has been finished with a double knot called MarineKnuckle.™ Tests* have shown that this finish provides more than three times the edge strength of ordinary chain mesh.

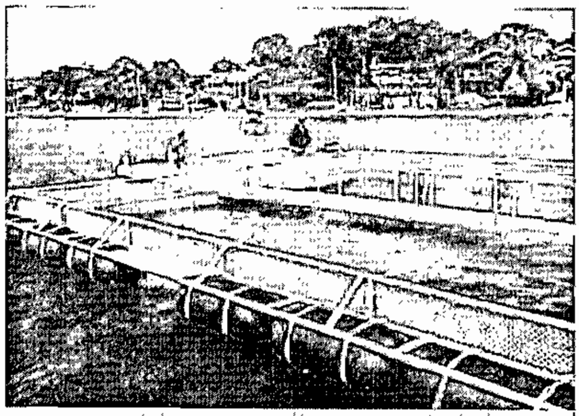
Together with the chain link weave, the MarineKnuckle finish also enables the MarineMesh net to flex easily in marine environments.

All of which helps to ensure that with MarineMesh fish nets you can provide a secure environment for growing fish.

MarineMesh™

*OneSteel trials conducted in June 2000.

Figure 8.3.4: Details of Marine Mesh Fish Cage Netting



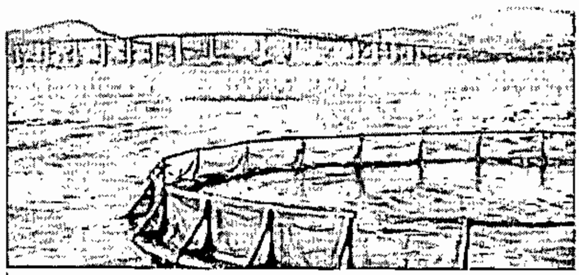
Botany Bay, NSW.

MarineMesh 10m x 10m x 5m net,
attached to a steel
square pen for farming Snapper.
Main predator: sharks.

Cardwell, North Queensland.

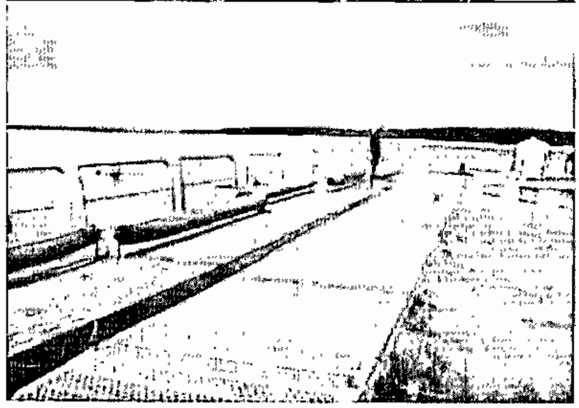
MarineMesh 15m x 10m x 3m net
attached to a rectangular pen
for farming Barramundi.
Main predators: sharks and crocodiles.

TESTED IN A VARIETY OF ENVIRONMENTS.



Bruny Island, Tasmania.

MarineMesh net attached to a 60m
circumference plastic pen for farming
Atlantic Salmon. Launched in Hobart.
Main predator: seals.



Bathurst Island, Northern Territory.

MarineMesh 24m x 24m x 4.2m net
attached to a square pen
for farming Barramundi.
Main predators: sharks and crocodiles.

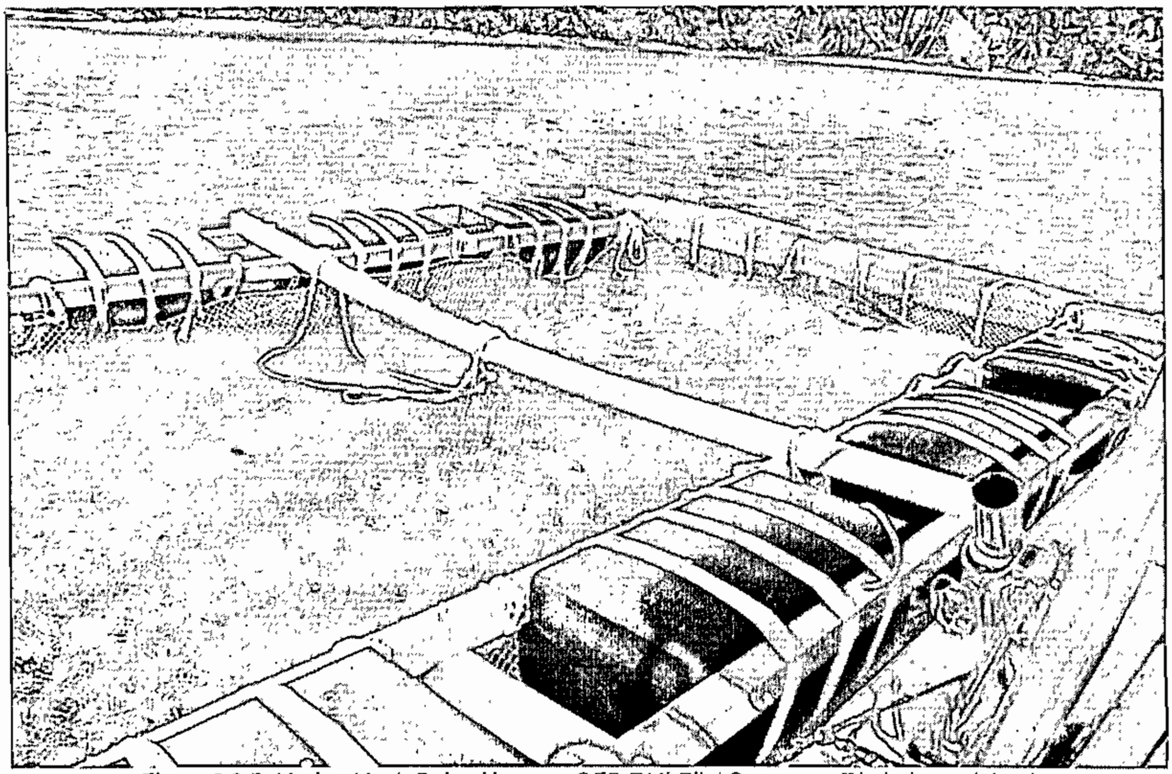


Figure 8.3.5: Marine Mesh Being Hung on GFB RMI Pilot Seacage off Lobekerae Island

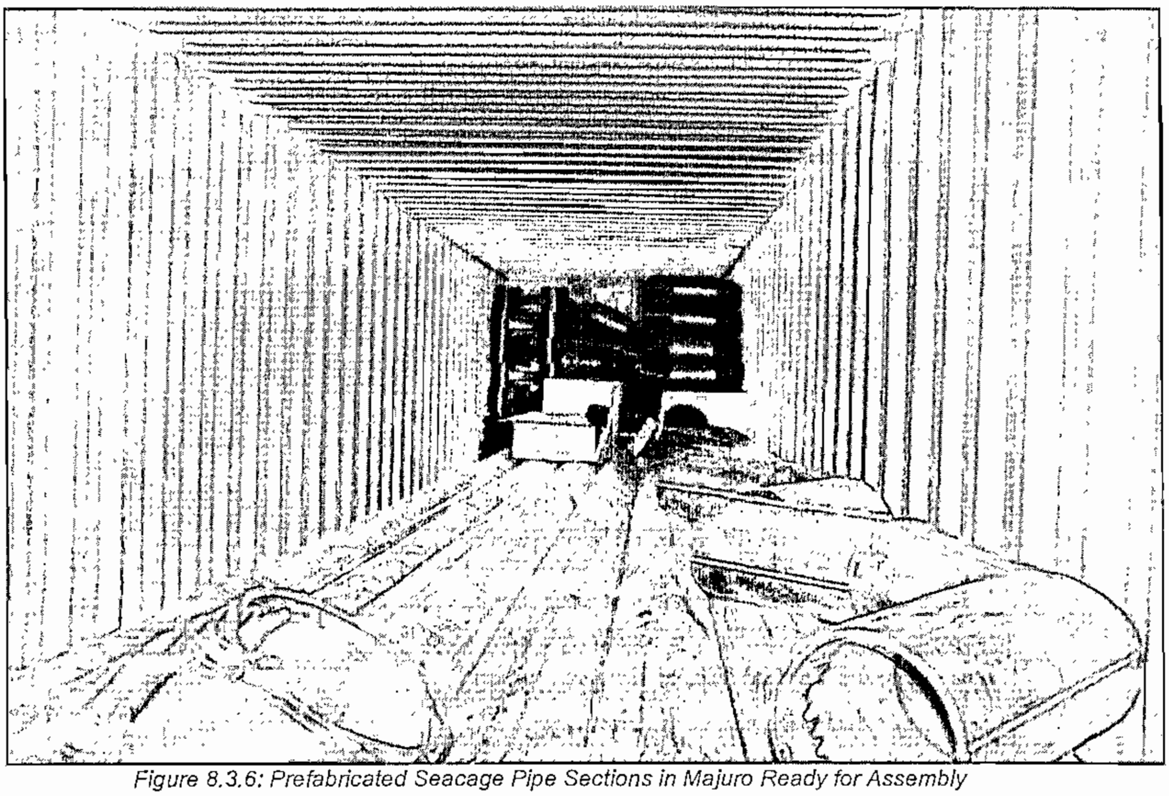


Figure 8.3.6: Prefabricated Seacage Pipe Sections in Majuro Ready for Assembly

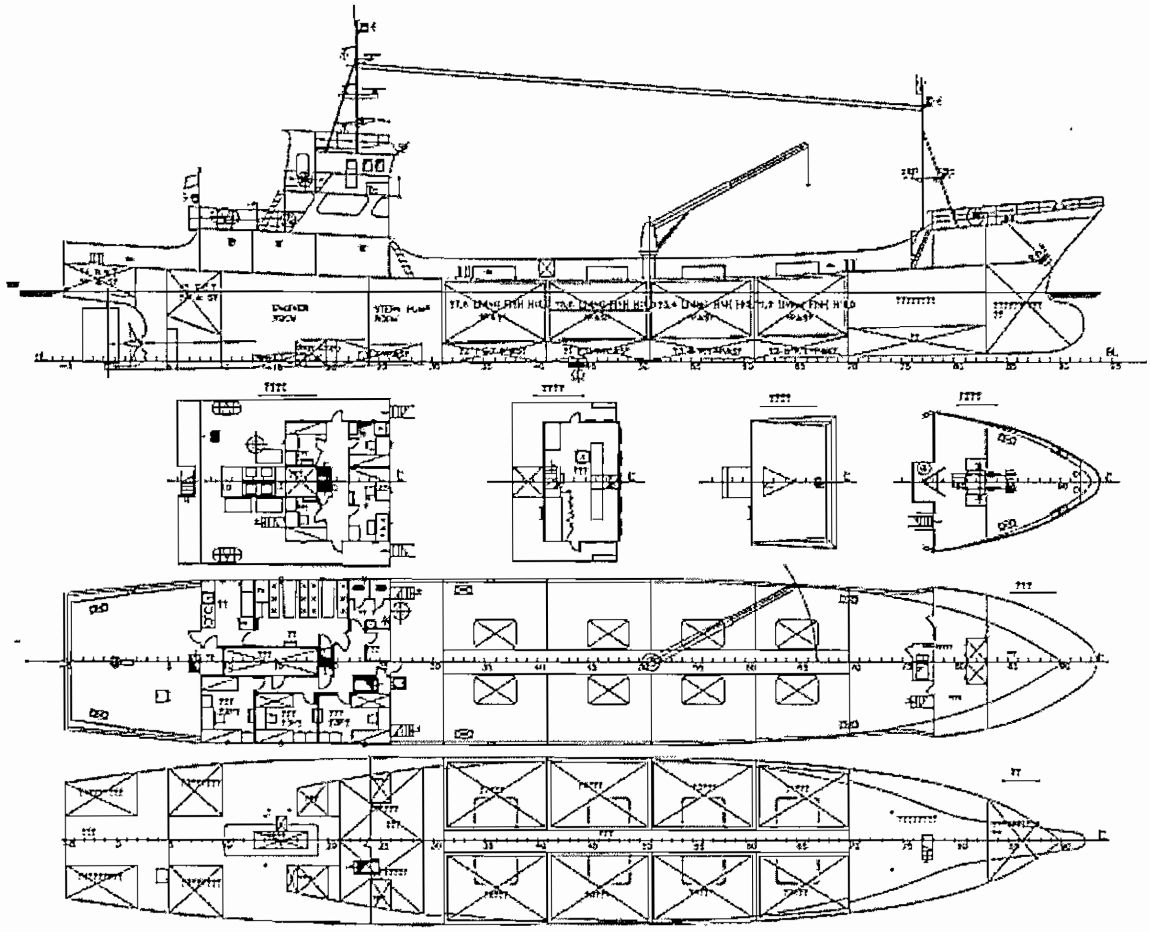


Figure 8.3.7: Live Fish Carrier Ship Design Commissioned by GFB RMI

Figure 8.3.8: The 'Good Fortune III' Prior to Being Retrofitted by GFB for Live Fish Shipping

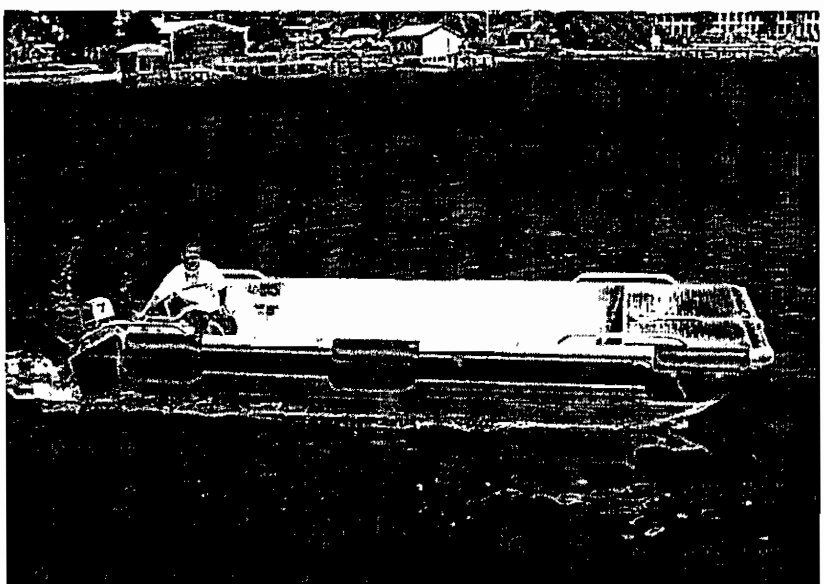


Figure 8.3.9: Small Fish Farm Work Boat

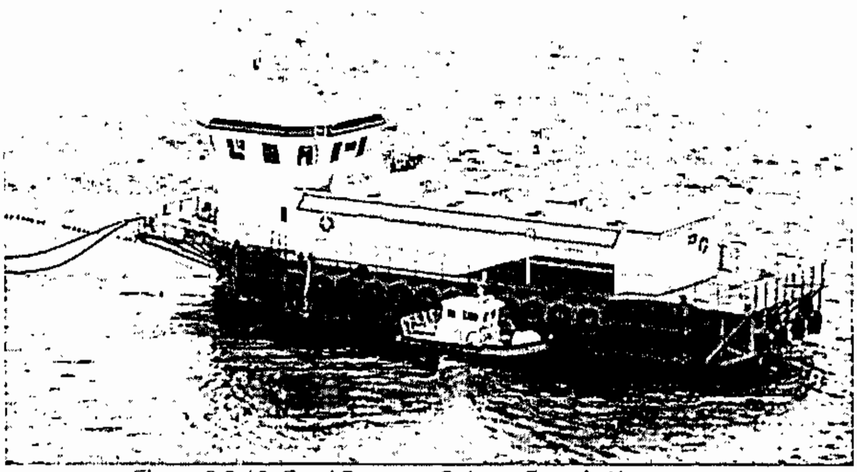


Figure 8.3.10: Feed Barge on Salmon Farm in Norway

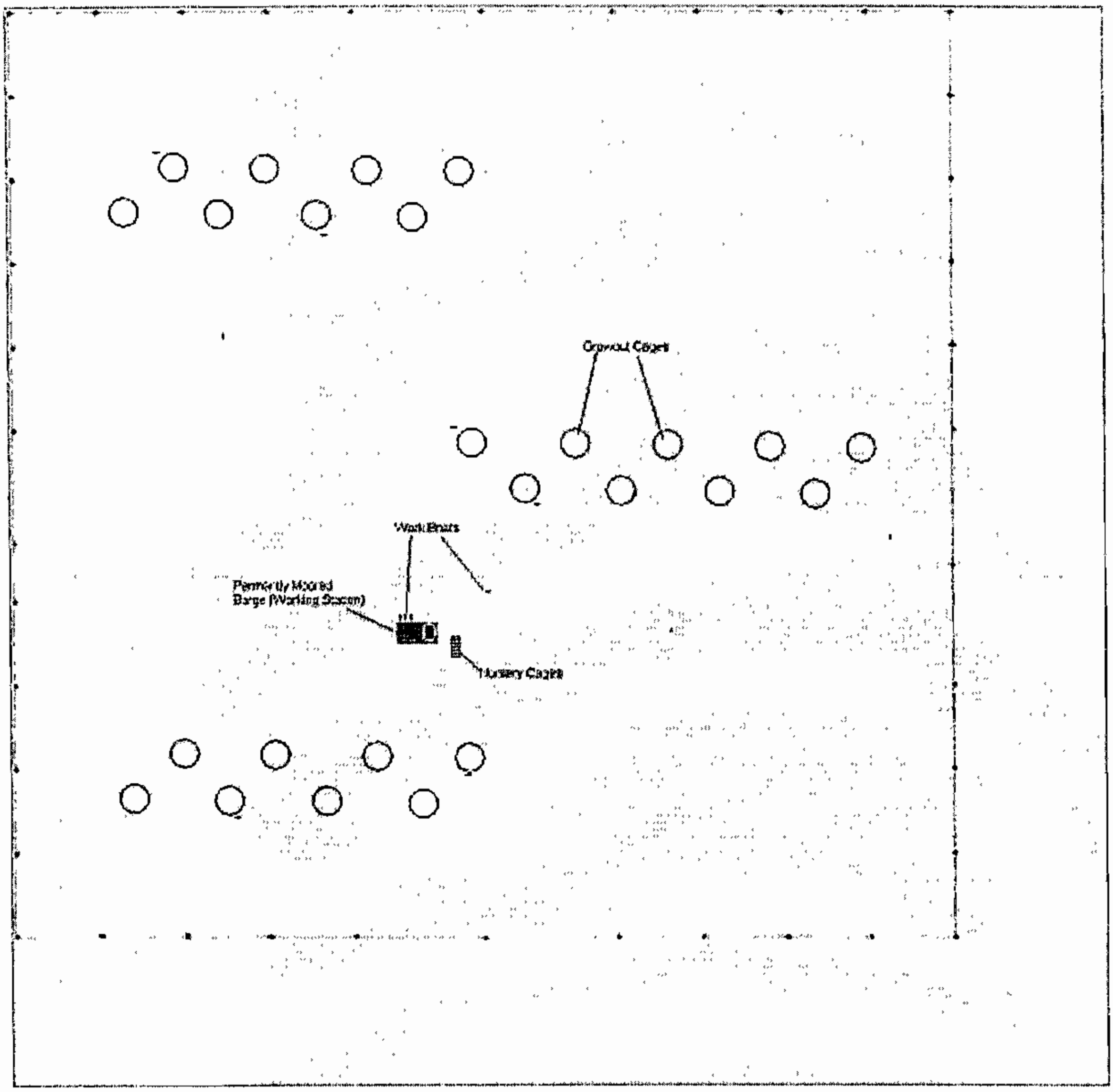


Figure 8.3.11: Diagram of Scale of the Infrastructure Proposed per 125 hectare Fish Farming Site

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Grouper Fish Feeds

COMPOSITION (%)

FEED TYPE	Moisture	C. Protein	C. Fat	C. Ash	C. Fiber	Total Phosphate
Grouper No.1	10	48	8	16	2.0	3
Grouper No. 2-3	10	47	10	16	3.0	3
Grouper 4-5	10	46	12	16	3.0	3
Grouper 6-9	10	45	14	16	3.0	3

INGREDIENTS

Fine quality fish meal、Fish oil、Wheat flour、Soybean meal、Lecithin、Yeast、Attractants、Vitamins and Minerals。

RECOMMENDED FEEDING GUIDE

Item / Code	Feed Type	Feed Size	Fish Size		Feeding Rate	Feeding Time
		(mm)	Body Length (cm)	Body weight (g)	(%)	(Times/day)
Grouper No.1	EP	ϕ2.5 L2.5	6-9	5-15	6-8	4-5
Grouper No.2	EP	ϕ4.0 L3.0	9-12	15-30	5-6	3-4
Grouper No.3	EP	ϕ6.0 L3.5	12-15	30-120	4-5	2-3
Grouper No.4	EP	ϕ8.0 L4.0	15-21	120-200	3-4	2-3
Grouper No.5	EP	ϕ10.0 L5.0	21-24	200-300	2.5-3	1.5-2
Grouper No.6	EP	ϕ12.5 L5.0	24-27	300-450	1.5-2.5	1-2
Grouper No.7	EP	ϕ16.0 L6.0	27-36	450-900	1.0-1.5	1
Grouper No.8	EP	ϕ20.0 L8.0	36-42	900-1500	1.0-1.2	1
Grouper No.9	EP	ϕ27.0 L10.0	42 ↑	1500 ↑	0.5-1.0	1

The data given above is just for reference. Please adjusted according to climate conditions, water temperature, water quality, appetite, fish body weight and size.

Figure 8.3.12: Data Sheet for Grouper Feed

統一企業公司
UNI-PRESIDENT ENTERPRISES CORP.

Cobia Feed (Sinking Type)

COMPOSITION (%)

FEED TYPE	Moisture	C. Protein	C. Fat	C. Ash	C. Fiber	Total Phosphate	HCL-insoluble
Cobia No. 1-2	11	48	10	13	2.0	3	2.0
Cobia No. 3-4	11	46	12	13	2.0	3	2.0
Cobia No. 5-7	11	45	16	13	2.0	3	2.0

INGREDIENTS

Fine quality fish meal、Fish oil、Wheat flour、Soybean meal、Lecithin、Yeast、Attractants、Vitamins and Minerals。

RECOMMENDED FEEDING GUIDE

Item / Code	Feed Type	Feed Size	Fish Size		Feeding Rate	Feeding Time
		(mm)	Body Length (cm)	Body weight (g)	(%)	(Times/day)
Cobia 1	EP	φ2.0 ±0.2	15-20	30-100	6.0-8.0	2-3
Cobia 2	EP	φ2.5 ±0.2	20-25	100-300	5.0-6.0	1-2
Cobia 3	EP	φ3.5 ±0.3	25-35	300-600	4.5-5.0	1-2
Cobia 4	EP	φ4.5 ±0.3	35-45	600-1200	4.0-4.5	1-2
Cobia 5	EP	φ6.0 ±0.3	45-55	1200-2500	2.5-4.0	1
Cobia 6	EP	φ8.0 ±0.3	55-65	2500-4000	1.5-2.5	1
Cobia 7	EP	φ10.0 ±0.3	65↑	4000↑	1.0-1.5	1

Remark

1. *For 4 kgs above fish please feed with Cobia No. 7*
2. *The data given above is just for reference. Please adjusted according to climate conditions, water temperature, water quality, appetite, fish body weight and size.*

Figure 8.3.13: Data Sheet for Cobia Feed

Appendix B: ***BIOSECURITY PROTOCOLS FOR IMPORT OF FISH TO THE RMI***

Sea Transport

The majority, and in the future perhaps all, of the fish imported to the RMI from Australia will be transported by ship. The ship provides a less stressful, logistically easier and more cost-efficient method of transfer. The live fish ships will also be necessary for transport of live grouper from the farm to markets in Asia.

Sea transport involves some additional risk of inadvertent translocation of species in the fish holds. With the procedures outlined below the risk of inadvertent translocation of species in the fish holds is reduced to be less than that associated with normal shipping, where species may be translocated through the ballast tanks (even with ballast exchange prior to port – fall) and on the ships hull. While the fish originate from Australia, which is relatively bio-secure, and a bio-secure hatchery, additional precautionary procedures to minimize any risk of unintended organisms establishing in the fish transport holds on the ship are included.

Table 10.1: Sea Vessel Based Fish Import Biosecurity Procedures

Hatchery (Australia)	Shipping	Arrival in Majuro
1. Fish will be observed throughout the hatchery rearing stage of rearing for any signs of disease, as per normal hatchery protocols and any events noted on the batch records form. 2. Batch record forms shall be sent to MIMRA in electronic form when the fish are shipped from Australia.	1. Fish bulk transporters for carriage to vessel to be sterilized and filled with sterile hatchery water. 2. Live fish holds on the vessel are to be filled with water from an area not closer than 20 nautical miles (nm) from the Australian coast. If for any reason this is not possible holds are to be filled with available seawater and sterilized with Cl- at 10ppm for a period of at least 1hour (holds should then be neutralized with a solution of Sodium thiosulphate). 3. Water exchange in the fish holds not to be initiated until reaching an area at least 20nm from the coastline. 4. Water exchange in live fish holds take place continuously from 20nm from Australian coastline to 20nm from Majuro unless vessel reaches within 20nm of another land mass on route (on which water exchange will be temporarily halted). 5. Fish to spend a minimum seven (7) days in waters 20nm from Australia and 20nm from Majuro. 6. Live fish holds to be treated with 0.5ppm $CuSO_4$ 100nm from Majuro as additional precaution for any incidental invertebrates possibly picked up during transit.	1. On approach to Majuro Exchange to the fish holds will cease no less than 20nm from the atoll. Authorities will be notified in advance of arrival in preparation for inspection of fish. 2. Fish will remain in vessel and no water will be exchanged until the relevant authorities carry out applicable inspections. Authorities will have minimum 1-week preliminary notice prior to inspection date and minimum 24hrs advanced notice prior to inspection. If authorities do not undertake inspection on the nominated day, fish will be assessed by authorized GFB staff and observations recorded. Upon satisfactory inspection by GFB staff that fish are disease free, they will be stocked into cages. 3. If fish displays undiagnosable symptoms of concern, samples to be flown to Hawaii for fish pathologist testing. 4. If fish are deemed unsatisfactory by the RMI authorities one of the following actions is to be taken at the discretion of GFB a) held on the ship with no water exchange except for at locations greater than 20nm from Majuro until cleared; b) transferred to approved quarantine facilities until cleared; c) ship to leave the RMI with the fish; or d) fish euthanased and disposed of in land fill. 5. All standard importation documentation, permits and fees will be finalized prior to any fish being stocked into cages.

Air Transport

Fish previously imported into the RMI by GFB have been done so by air, either on Our Airlines or Continental and Air Pacific Cargo. These fish are transferred directly to MIMRA's quarantine facility at Woja for a period of two weeks.

GFB intends to import the majority of fish in the future via sea going vessel. Small numbers may continue to be transported by air. In line with the Sea Vessel Based Fish Import Biosecurity Procedures GFB proposes to improve the fish production chain reporting with imports and reduce the time in quarantine from two (2) weeks to one (1) week in line with marine fish quarantine times in Australia (1 week), which has some of the strictest biosecurity regulations in the world. The USA, Canada, Europe and the UK do not typically quarantine fish imports unless they are considered to be from a high risk source (eg. Salmonids from areas of outbreak of diseases of concern).

Table 10.2: Air Based Fish Import Biosecurity Proceedures

Hatchery (Australia)	Shipping	Arrival in Majuro
1. Fish will be observed throughout the hatchery rearing stage of rearing for any signs of disease, as per normal hatchery protocols and any events noted on the batch records form. 2. Batch record forms shall be sent to MIMRA in electronic form when the fish are shipped from Australia.	1. Fish bulk transporters for carriage to packing facilities to be sterilized and filled with sterile hatchery water. 2. Fish to be packed in airline approved packaging in sterile water.	1. On arrival in Majuro MIMRA to inspect several random boxes of fish for health. 2. Fish to be immediately transported to quarantine facility and stocked in tanks. Due to the level of stress during air transport some deaths during transport and for several days following is not uncommon particularly if flights are delayed. 3. If fish displays undiagnosable symptoms of concern during quarantine, samples to be flown to Hawaii for fish pathologist testing. 4. Fish to be inspected at the quarantine facility 7 days after arrival and either a) approved for stocking to seacages; b) held for further time to clarify health; c) if deemed unsatisfactory ordered to be sent out of the RMI by air or sea vessel or euthanased and disposed of in land fill. 5. All standard importation documentation, permits and fees will be finalized prior to any fish being stocked into cages.

Appendix C: ***WATER QUALITY AND ECOLOGICAL MONITORING PROGRAM***

Water Quality

Water quality monitoring associated with the development of the fish farm will ensure that the actual impacts of the fish farm remain within the levels modeled for the EIA. There will also be a further benefit to the RMI of establishing a baseline of water quality around Majuro to inform future developments and environmental standards.

The potential water quality impacts of the fish farm are relatively easy to measure based on the two major nutrients (nitrogen and phosphorous) and chlorophyll a (which is a proxy for microalgal abundance, a good indicator of general eutrophication). The Great Barrier Reef Marine Park Authority favors Chlorophyll a is an indicator of eutrophication of coral reef waters as explained in the text box below. In the GBR lagoon chlorophyll a concentrations typically range from 0.3 to 1.0 ug/ liter.

Value of Chlorophyll a as a water quality indicator in coral reef waters

Phytoplankton must obtain a range of essential nutrients, minerals and vitamins from their environment to sustain continued growth and division. The nutrients, nitrogen and phosphorus, are present at low environmental concentrations and are widely considered to be limiting to the growth of phytoplankton. Nitrogen is essential for the synthesis of amino acids and their anabolic products. Phosphorus is essential for the synthesis of nucleic acids and structural compounds such as phospholipids, and in cyclicphosphorylation.

Measurement of chlorophyll a (universally present in marine algae) is one the most frequently employed techniques for assessing phytoplankton standing stock. As phytoplankton stocks respond quickly to changes in nutrient availability, measurement of chlorophyll a concentration was chosen as a proxy indicator of nutrient status. The advantages of monitoring chlorophyll a concentrations as compared with nutrient concentrations include:

- Integration over time: phytoplankton assimilate available nutrients over their life-time, whereas water column inorganic nutrient concentrations are notoriously variable over much shorter time scales;
- Bioavailable nutrients: phytoplankton take up only those forms of nutrients which are bio-available. These include organic nitrogen and phosphorus compounds which comprise a major proportion of total nutrient stocks, and are analytically difficult to measure;
- Sensitive: phytoplankton respond rapidly to pulsed nutrient inputs that might otherwise go undetected by regular nutrient sampling;
- Ease of collection: chlorophyll a samples require minimal processing and storage in the field and are not easily contaminated; and
- Cost: chlorophyll a is cheap in comparison to the analysis of a full suite of dissolved nutrients.

GFB proposes to sample a number of reference and indicator sites monthly for total nitrogen, total phosphorus and chlorophyll a. Water quality will be tested at accredited laboratories.

Table 10.3: Water Quality Sampling Locations.

Site	Location	Purpose
(1) East Lagoon	7° 05' 13.58"N 171° 22'13.13"E	Provide a comparison sample from the relatively polluted east lagoon
(2) Ocean	7° 04' 46.62"N 171° 21'31.14"E	Provide a background sample of the open ocean
(3) Calalin Channel	7° 09' 27.7"N 171° 09' 13.2"E	Provide a measure of the water quality at the coral areas most proximate to the fish farms
Samples Taken Whilst in Production only		
(4) Lobekerae Island	50 meters to the east of eastern most cage off Lobekerae Island	Measure the near field impact on water quality
(5) Fish farm site 1.	Center of north boundary of fish farm site 1.	Measure the near field impact on water quality
(6) Fish farm site 2.	Center of north boundary of fish farm site 2.	Measure the near field impact on water quality

(7) Fish farm site 3.	Center of north boundary of fish farm site 3.	Measure the near field impact on water quality
(8) Fish farm site 4.	Center of north boundary of fish farm site 4.	Measure the near field impact on water quality
(9) Fish farm site 5.	Center of north boundary of fish farm site 5.	Measure the near field impact on water quality
(10) Fish farm site 6.	Center of north boundary of fish farm site 6.	Measure the near field impact on water quality

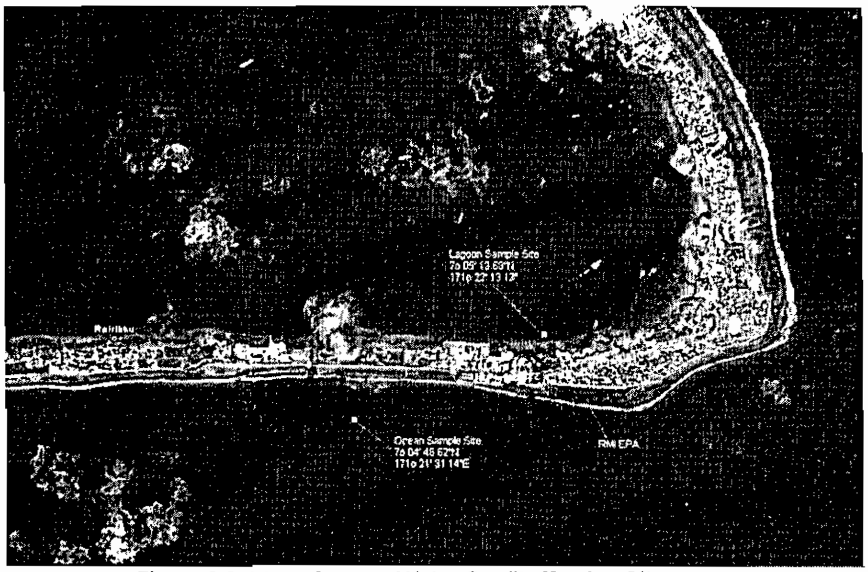


Figure 8.3.14: Reference Water Quality Testing Sites

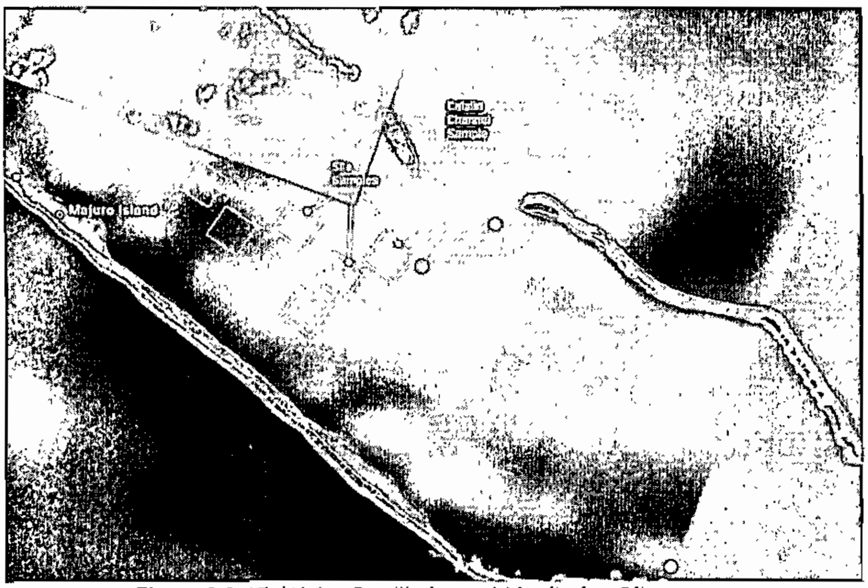


Figure 8.3.15: Water Quality Impact Monitoring Sites

With regards to water quality standards it needs to be noted that samples from Lobekerae Island prior to fish being stocked varied by almost 20% between two sites within 300 meters of each other. It is GFB's target that water quality impacts remain within 10% of background levels however the level of noise with background nutrient levels near to the limits of detection needs to be considered. The modeled level of nutrient impact against the background levels (average) and observed variability (at Lobekerae Island are displayed in Figure 8.3.16.

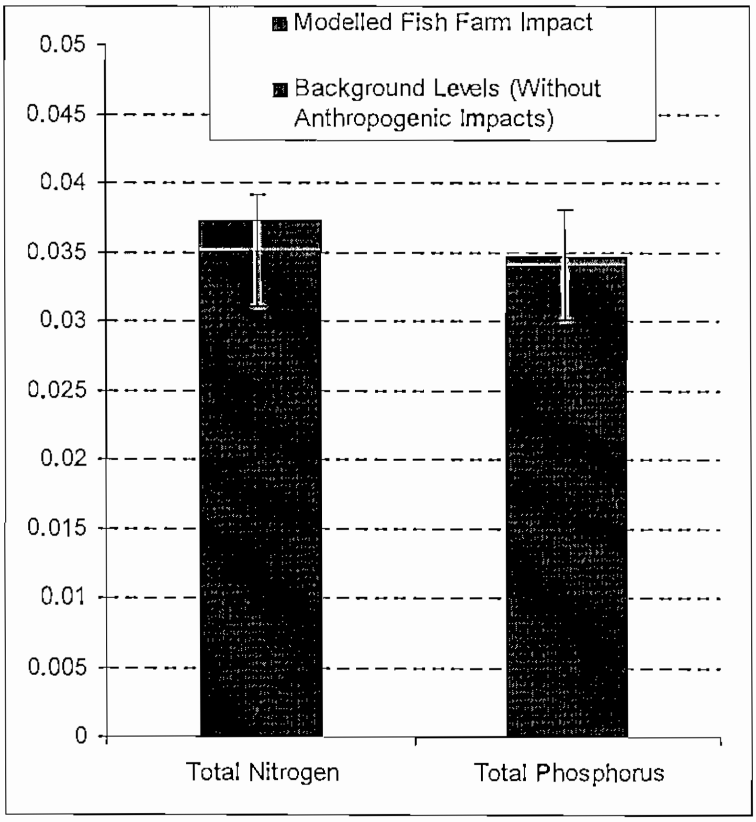


Figure 8.3.16: Level of Impact of Fish Farm on Water Quality in mg/ liter (Error bars represent natural variability in water quality between samples)

Given the natural variability in water samples the variation from target will need to be considered over time. The proposed targets for water quality impacts are presented below.

Table 10.4: Water Quality Targets

Site	Target Total Nitrogen	Target Total Phosphorus	Target Chorophyll a
(1) East Lagoon	Reference Sample – no target	Reference Sample – no target	Reference Sample – no target
(2) Ocean	Reference Sample – no target	Reference Sample – no target	Reference Sample – no target
(3) Calalin Channel	Within 110% of levels in Sample (2)	Within 110% of levels in Sample (2)	Within 110% of levels in Sample (2)
Samples Taken Whilst in Production only			
(4) Lobekerae Island	Within 0.004 mg/l of Sample (2) with reference to sample (1)	Within 0.001 mg/l of Sample (2) with respect to Sample (1)	Within 120% of Sample (2) with respect to Sample (1)
(5) Fish farm site 1.	Within 0.004 mg/l of Sample (2) with reference to sample (1)	Within 0.001 mg/l of Sample (2) with respect to Sample (1)	Within 120% of Sample (2) with respect to Sample (1)
(6) Fish farm site 2.	Within 0.004 mg/l of Sample (2) with reference to sample (1)	Within 0.001 mg/l of Sample (2) with respect to Sample (1)	Within 120% of Sample (2) with respect to Sample (1)
(7) Fish farm site 3.	Within 0.004 mg/l of Sample (2) with reference to sample (1)	Within 0.001 mg/l of Sample (2) with respect to Sample (1)	Within 120% of Sample (2) with respect to Sample (1)
(8) Fish farm site 4.	Within 0.004 mg/l of Sample (2) with reference to sample (1)	Within 0.001 mg/l of Sample (2) with respect to Sample (1)	Within 120% of Sample (2) with respect to Sample (1)
(9) Fish farm site 5.	Within 0.004 mg/l of Sample (2) with reference to sample (1)	Within 0.001 mg/l of Sample (2) with respect to Sample (1)	Within 120% of Sample (2) with respect to Sample (1)
(10) Fish farm site 6.	Within 0.004 mg/l of Sample (2) with reference to sample (1)	Within 0.001 mg/l of Sample (2) with respect to Sample (1)	Within 120% of Sample (2) with respect to Sample (1)

Dive Surveys

GFB proposes that a six monthly dive transect (100m) be undertaken at the Calalin Pass water sample site. A series of photos are to be taken along the same transect on each date to provide a visual history of the site. This site is proposed as the most appropriate to survey to ensure that the fish farming is creating no impact on the coral reefs.

The location of the transect site is displayed below.

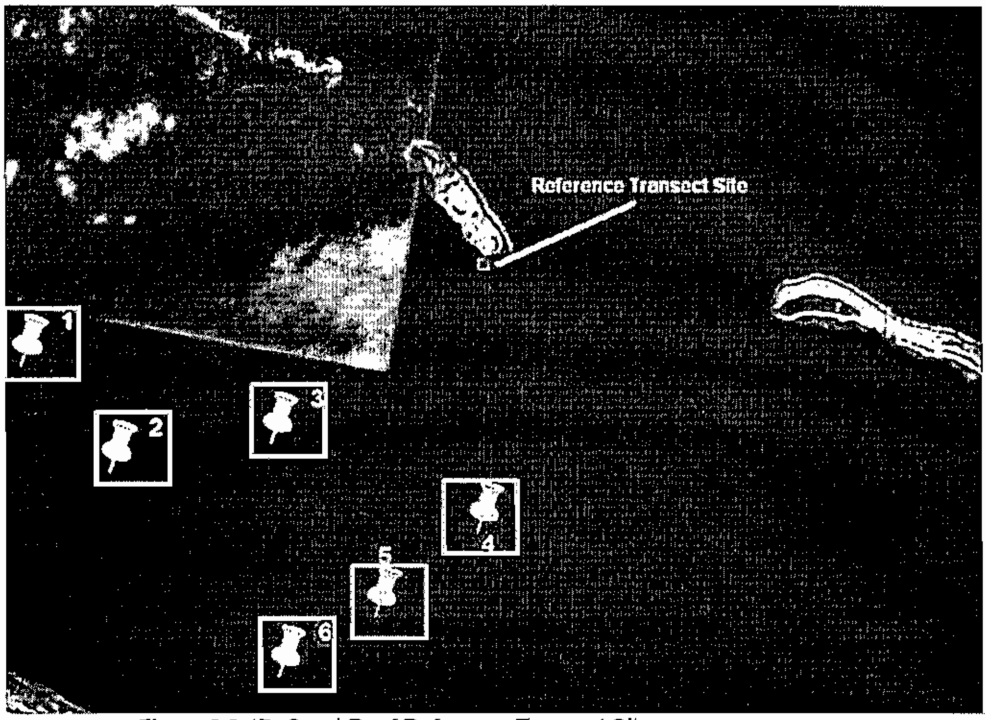


Figure 8.3.17: Coral Reef Reference Transect Site

A transect of the Calalin site has been dived with pictures along the transect presented below.

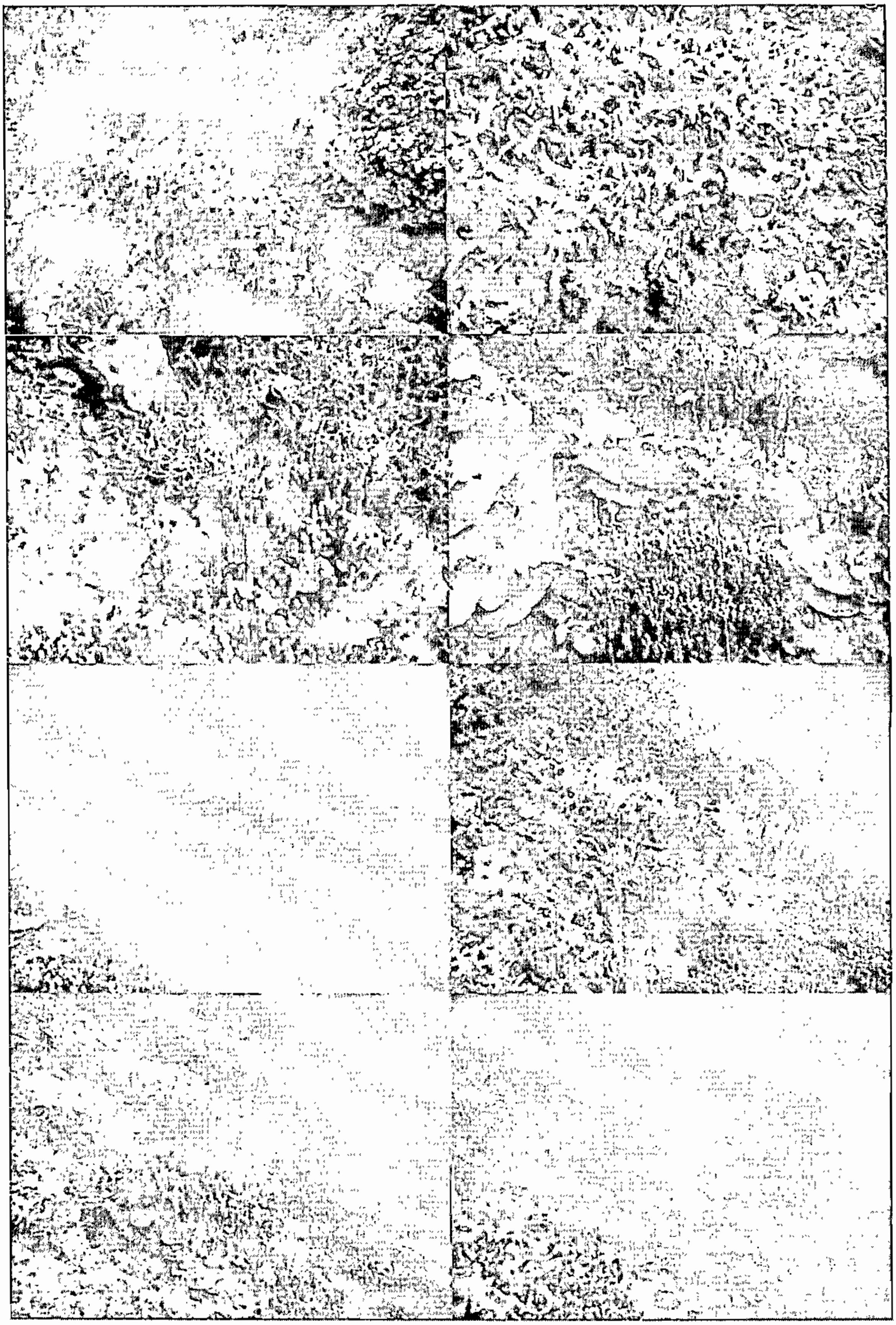


Figure 8.3.18: Baseline Transect of Calalin Pass Reference Site. The photographic transect (see red line in the pictures) will be repeated at six monthly intervals for the life of the project.

GFB has dived several of th proposed fish farm sites in central Majuro Lagoon and confirmed the relatively low ecological value of the sites. Photos from these dives are presented below and demonstrate relatively uniform decomposed coral flats at 30 to 40 meters of depth. All sites will be dived and a report on their status submitted to the RMI EPA prior to the establishment of any fish farm infrastructure. To site 4 has been dived. A 'pinnacle' in the south-west corner was observed but no coral or hard structures. The site consisted of relatively uniform decomposed coral sediment.

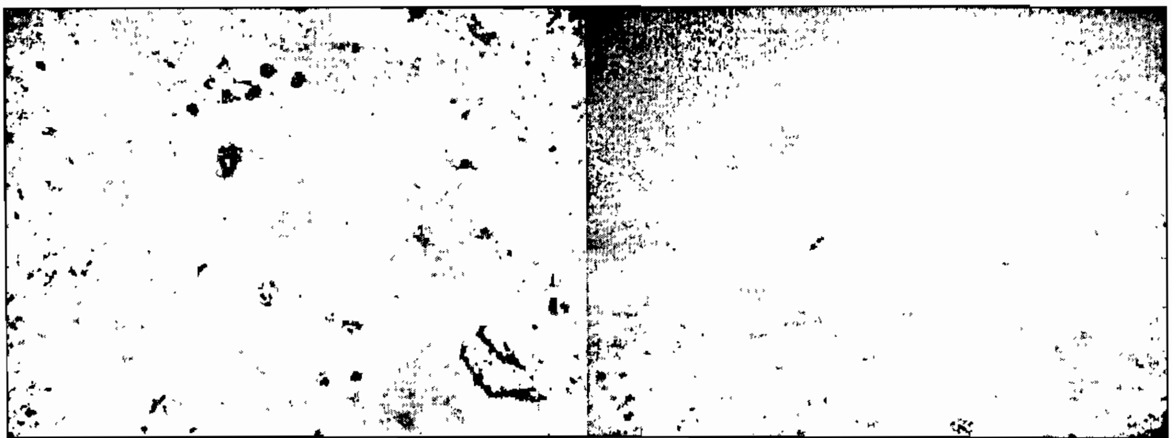
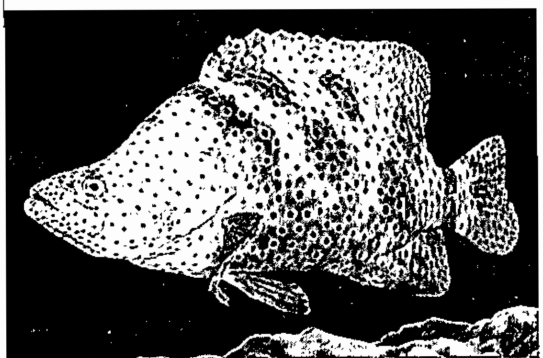


Figure 8.3.19: Benthic Situation at Proposed Fish Farm Site 4 (07° 06' 060" N, 171° 09' 090"E)

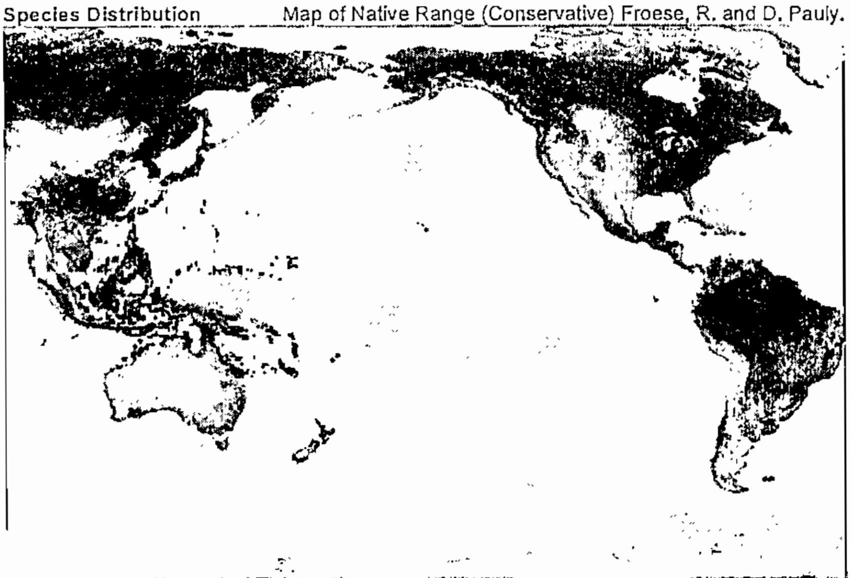
Appendix D: SUPPLEMENTARY ECOLOGICAL INFORMATION

Species to be Farmed Data Sheets and Risk Assessments

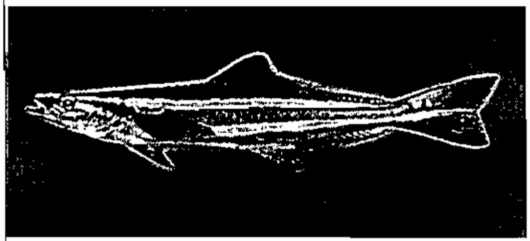


LATIN NAME: *Cromileptes altivelis*
MARSHALLESE NAME:
ENGLISH NAME: Humpback grouper

Species Distribution — Map of Native Range (Conservative) Froese, R. and D. Pauly. Editors. 2007.FishBase

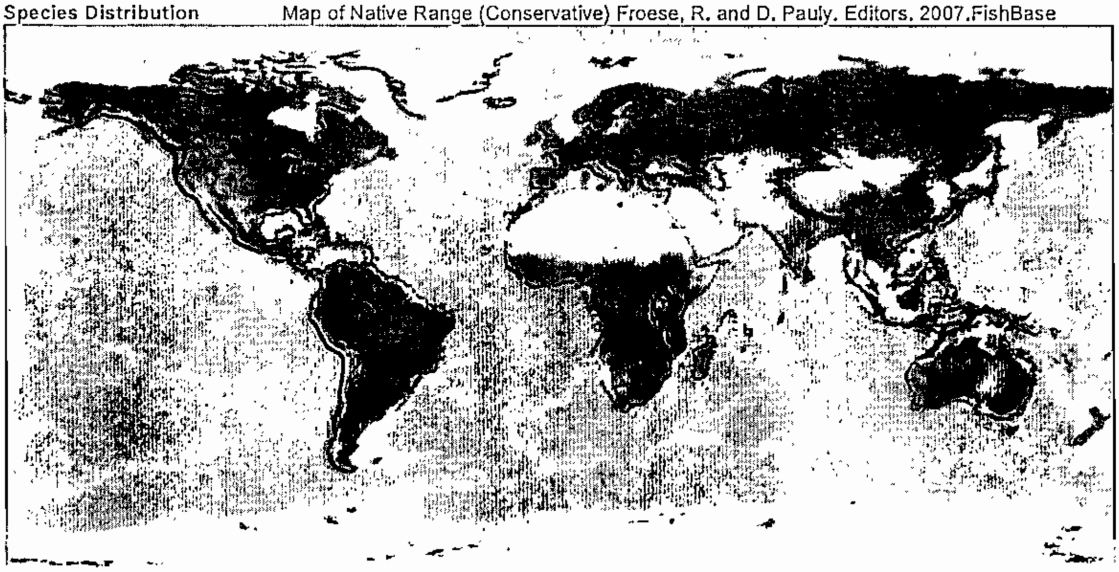


Recorded in RMI?	Yes
Scientific Records from Central Pacific:	Bikini Atoll, Enewetak Atoll, Kiribati, Tokelau, Johnston Atoll, Pitcain Island, Micronesia (see reference list)
Other Records in RMI:	Local Fishman, MIMRA
Biology:	Reef-associated; marine; depth range 2 – 40 m. Generally inhabits lagoon and seaward reefs and are typically found in dead or silty areas. Also found around coral reefs and in tide pools. Growth is very slow. Feed on small fishes and crustaceans. Juveniles are commonly caught for the aquarium trade while adults are utilized as a food fish.
Resilience:	Low, minimum population doubling time 4.5 - 14 years.
Risk Assessment:	Appears rare in the RMI, possibly due to lack of preferred juvenile habitat (mangrove areas). Fisherman reports from Majuro are ocean side only. Slow growing, not regarded as a vigorous species in culture or the wild. Any escapes will adopt a similar ecological niche in reef areas to other groupers which are heavily fished in Majuro. Escapes not considered a risk of unnatural ecological stress on other species in the RMI.

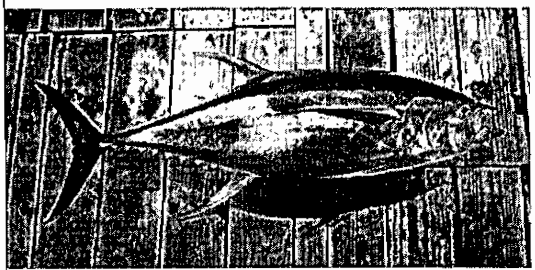


LATIN NAME: *Rachycentron canadum*
MARSHALLESE NAME:
ENGLISH NAME: Cobia

Species Distribution Map of Native Range (Conservative) Froese, R. and D. Pauly. Editors. 2007.FishBase

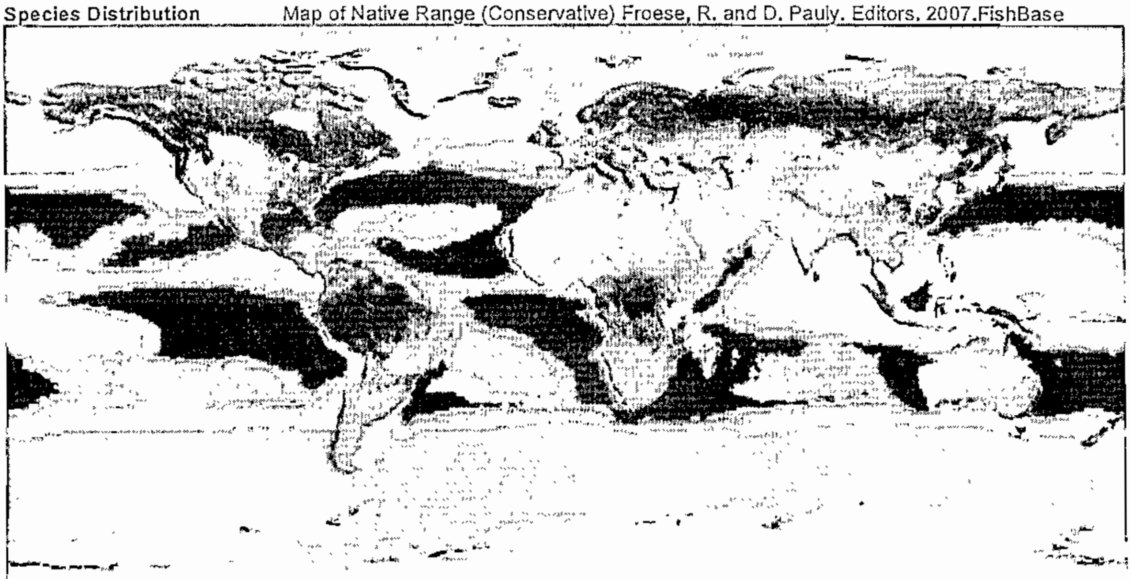


Recorded in RMI?	Yes
Scientific Records from Central Pacific:	Pohnpie, Fiji, Chile, Marshall Islands (see reference list)
Other Records in RMI:	Fisherman (see attached declarations)
Biology:	Reef-associated; oceanodromous; brackish; marine; depth range 0 – 1200 m. Occurs in a variety of habitats, over mud, sand and gravel bottoms; over coral reefs, off rocky shores and in mangrove sloughs; inshore around pilings and buoys, and offshore around drifting and stationary objects; occasionally in estuaries. Forms small groups and may pursue small pelagic inshore. Feeds on crabs, fishes, and squids. Caught in small quantities due to its solitary behavior. Good food fish; marketed fresh, smoked, and frozen.
Resilience:	Medium, minimum population doubling time 1.4 - 4.4 years.
Risk Assessment:	RMI reports are from deep water on ocean side only, preferred pelagic habit likely faces strong competition and predation from true pelagic species in the RMI (eg. tuna, mahimahi, billfish). Captive stock displays strong domesticity, any escapes likely to remain around farm. Other escapes likely to export from atoll, disperse and fill an ecological niche approximating mahimahi. Escapes not considered a risk of unnatural ecological stress on other species in the RMI.



LATIN NAME: *Thunnus albacares*
MARSHALLESE NAME:
ENGLISH NAME: Yellowfin Tuna

Species Distribution Map of Native Range (Conservative) Froese, R. and D. Pauly. Editors. 2007.FishBase



Recorded in RMI? Yes

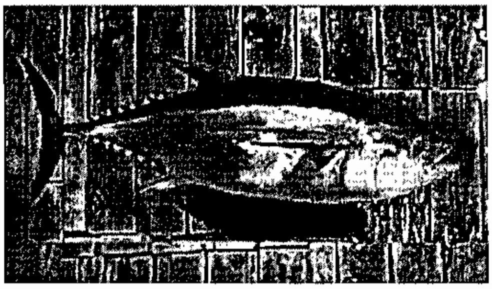
Scientific Records from Central Pacific: Marshall Islands (see attached reference list)

Other Records in RMI: Fish of Marshall Islands Poster

Biology: Pelagic; oceanodromous; brackish; marine; depth range 1 – 250 m. An oceanic species occurring above and below the thermoclines. Pelagic in open water , but rarely seen near reefs. They school primarily by size, either in monospecific or multi-species groups. Larger fish frequently school with porpoises, also associated with floating debris and other objects. Feed on fishes, crustaceans and squids. It is sensitive to low concentrations of oxygen and therefore is not usually caught below 250 m in the tropics. Marketed mainly frozen and canned, but also fresh and smoked. Highly valued for sashimi.

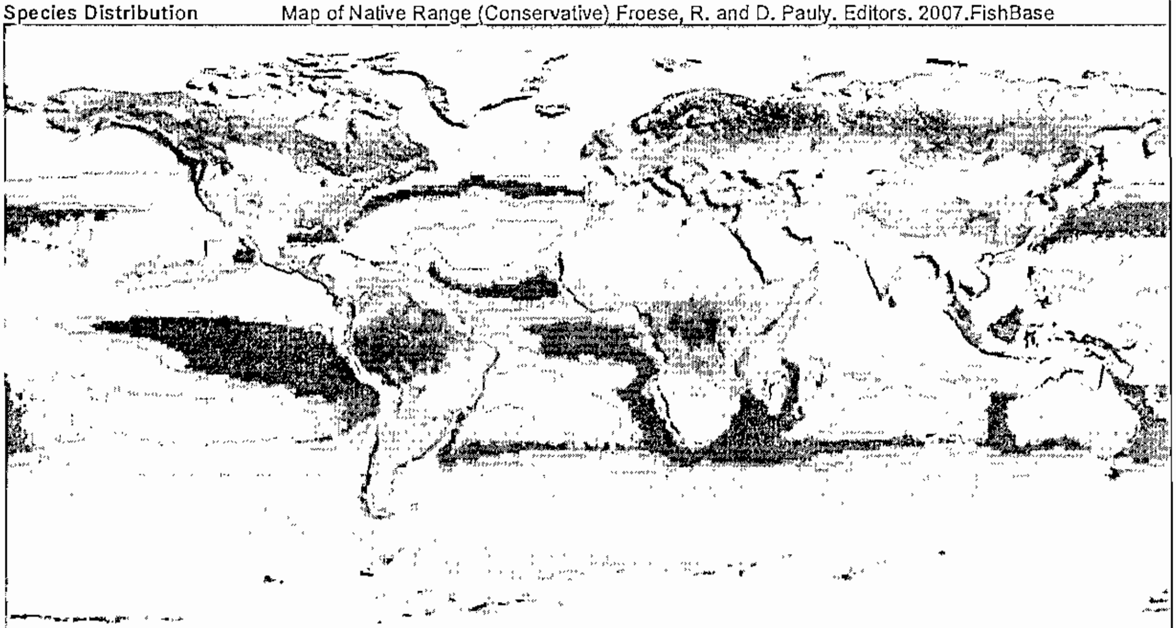
Resilience: Medium, minimum population doubling time 1.4 - 4.4 years.

Risk Assessment: RMI reports are from ocean side only, preferred pelagic habit likely faces strong competition and predation from other pelagic species in the RMI (eg. Other tuna, mahimahi, billfish). Escapes likely to export from atoll and rapidly disperse – highly migratory species. Any escapes not considered a risk of unnatural ecological stress on other species in the RMI.

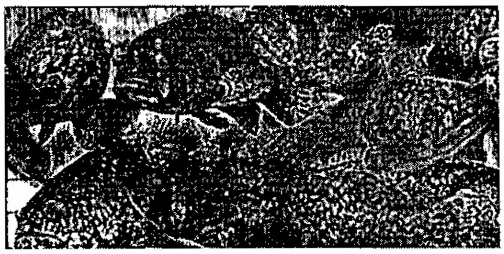


LATIN NAME: *Thunnus obesus*
MARSHALLESE NAME: Bwebwe
ENGLISH NAME: Bigeye Tuna

Species Distribution Map of Native Range (Conservative) Froese, R. and D. Pauly. Editors. 2007.FishBase

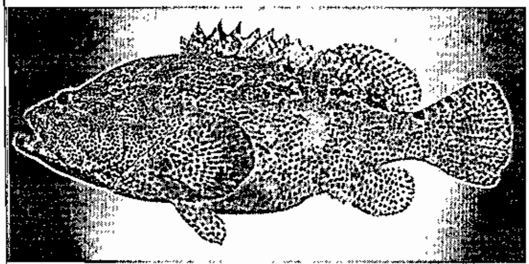


Recorded in RMI?	Yes
Scientific Records from Central Pacific:	Marshall Islands (see reference list)
Other Records in RMI:	Fisherman, MIMRA
Biology:	Pelagic; oceanodromous; marine; depth range 0 – 250 m. Occur in areas where water temperatures range from 13°-29°C, but the optimum is between 17° and 22°C. Variation in occurrence is closely related to seasonal and climatic changes in surface temperature and thermocline. Juveniles and small adults school at the surface in mono-species groups or mixed with other tunas, may be associated with floating objects. Adults stay in deeper waters. Feed on a wide variety of fishes, cephalopods and crustaceans during the day and at night. Meat is highly prized and processed into sashimi in Japan. Marketed mainly canned or frozen, but also sold fresh
Resilience:	Medium, minimum population doubling time 1.4 - 4.4 years.
Risk Assessment:	RMI reports are from ocean side only, preferred pelagic habit likely faces strong competition and predation from other pelagic species in the RMI (eg. Other tuna, mahimahi, billfish). Slow growing species. Escapes likely to export from atoll and rapidly disperse – highly migratory species. Any escapes not considered a risk of unnatural ecological stress on other species in the RMI.



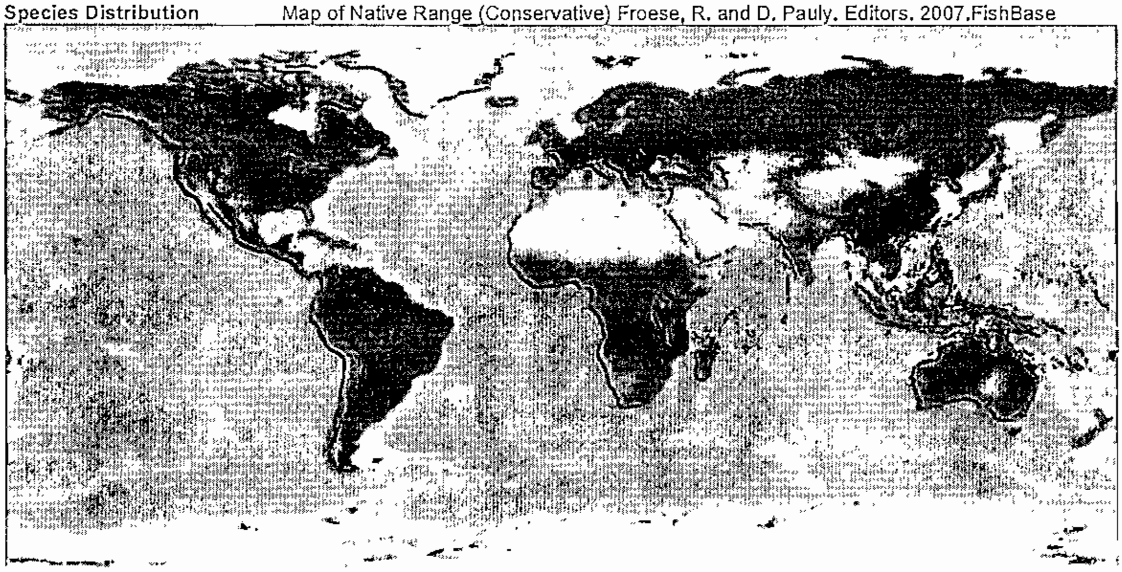
LATIN NAME:	*Epinephelus lanceolatus*
MARSHALLESE NAME:	Jawe
ENGLISH NAME:	Giant Grouper

Species Distribution	Indo-Pacific: Red Sea to Algoa Bay, South Africa and eastward to the Hawaiian and Pitcairn islands, north to southern Japan, south to Australia. Absence in the Persian Gulf is considered puzzling.
Recorded in RMI?	Yes
Scientific Records from Central Pacific:	Marshall Islands (see attached reference list)
Other Records in RMI:	Fisherman
Biology:	Reef-associated; brackish; marine; depth range ? – 100 m. The largest bony fish found in coral reefs. Common in shallow waters. Found in caves or wrecks; also in estuaries. Individuals more than a meter long have been caught from shore and in harbors. Juveniles secretive in reefs and rarely seen. Feeds on spiny lobsters, fishes, including small sharks and batoids, and juvenile sea turtles and crustaceans. In South African estuaries, the main prey item is the mud crab, *Scylla serrata*. Unconfirmed reports of fatal attacks on humans. Nearly wiped out in heavily fished areas
Resilience:	Very low, minimum population doubling time more than 14 years
Risk Assessment:	Appears rare in the RMI. Relatively fast-growing and vigorous species. Escapees, when small, will adopt a similar ecological niche in reef areas to other groupers which are heavily fished in Majuro. Large numbers of escapees growing to very large size may have some potential to exert altered ecological pressure relative to natural balance. Escapes not considered a risk of unnatural ecological stress in moderate numbers however large numbers of escapees recruiting to very large sizes should be monitored.

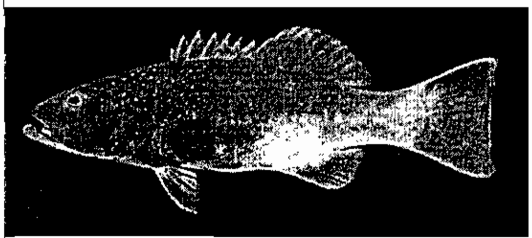


LATIN NAME: *Epinephelus fuscoguttatus*
MARSHALLESE NAME: Kiro
ENGLISH NAME: Tiger Grouper

Species Distribution Map of Native Range (Conservative) Froese, R. and D. Pauly. Editors. 2007.FishBase



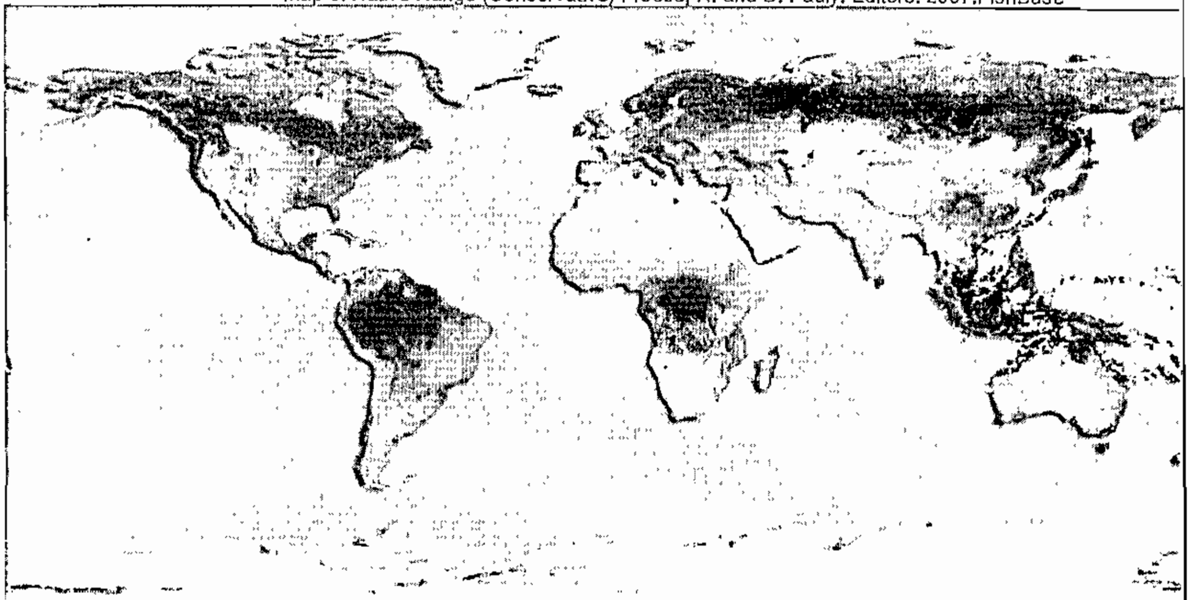
Recorded in RMI?	Yes
Scientific Records from Central Pacific:	Marshall Islands (see attached reference list)
Other Records in RMI:	Fish of Marshall Islands Poster
Biology:	Reef-associated; marine; depth range 1 -- 60 m. Occurs in lagoon pinnacles, channels, and outer reef slopes, in coral-rich areas and with clear waters. Juveniles in seagrass beds. Feeds on fishes, crabs, and cephalopods. May be ciguatoxic in some areas. Mainly active at dusk.
Resilience:	Medium, minimum population doubling time 1.4 - 4.4 years.
Risk Assessment:	Common in the RMI from both lagoon and ocean side. Relatively fast growing. Any escapes will adopt a similar ecological niche in reef areas to other groupers which are heavily fished in Majuro. Although it grows to a relatively large size as it is common in Majuro escapes not considered a risk of unnatural ecological stress on other species in the RMI.



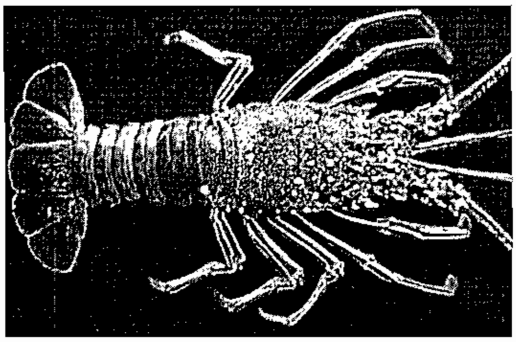
LATIN NAME: *Plectropomus leopardus*
MARSHALLESE NAME: Ikuit
ENGLISH NAME: Leopard coralgrouper

Species Distribution

Map of Native Range (Conservative) Froese, R. and D. Pauly. Editors. 2007.FishBase

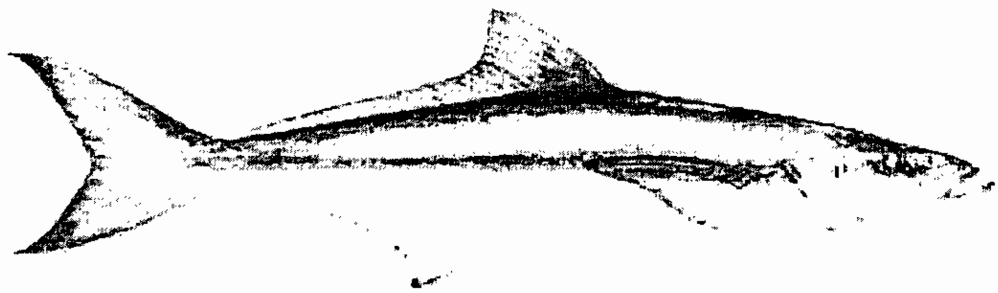


Recorded in RMI?	Yes
Scientific Records from Central Pacific:	Marshall Islands (see attached reference list)
Other Records in RMI:	Fisherman
Biology:	Reef-associated; oceanodromous; marine; depth range 3 – 100 m. Inhabit coral-rich areas of lagoon reefs and mid-shelf reefs. Inactive at night, hiding under ledges. Juveniles have a demersal existence in shallow water in reef habitats, especially around coral rubble. Adults feed mainly on fish. Juveniles feed on small fish and invertebrates such as crustaceans and squid. Form several spawning aggregations on a reef occurring around the new moon. On the Great Barrier Reef, its maximum lifespan is 14 years.
Resilience:	Medium, minimum population doubling time 1.4 - 4.4 years.
Risk Assessment:	Not rare in the RMI although not as common as *Plectropomus laevis* or *Plectropomus areolatus*. From both lagoon and ocean side. Relatively fast growing. Any escapes will adopt a similar ecological niche in reef areas to other groupers which are heavily fished in Majuro. Not considered a risk of unnatural ecological stress on other species in the RMI.



LATIN NAME:	*Panulirus Penicillatus*
MARSHALLESE NAME:	
ENGLISH NAME:	Tropical lobster
Species Distribution	Indo-West Pacific and Eastern Pacific regions: Red Sea, E. and S.E. Africa to Japan, Hawaii, Samoa and the Tuamotu Archipelago and further east to the islands off the west coast of America (Clipperton Island, Revillagigedo Archipelago, Cocos Island, Galapagos Archipelago) and in some localities near the continental coast of Mexico (Sinaloa, Nayarit and Guerrero).
Recorded in RMI?	Yes
Scientific Records from Central Pacific:	Marshall Islands (see reference list)
Other Records in RMI:	Fisherman
Biology:	Reef-associated; oceanodromous; marine; depth range 3 – 100 m. Inhabit coral-rich areas of lagoon reefs and mid-shelf reefs. Inactive at night, hiding under ledges. Juveniles have a demersal existence in shallow water in reef habitats, especially around coral rubble. Adults feed mainly on fish. Juveniles feed on small fish and invertebrates such as crustaceans and squid. Form several spawning aggregations on a reef occurring around the new moon. On the Great Barrier Reef, its maximum lifespan is 14 years.
Resilience:	Medium, minimum population doubling time 1.4 - 4.4 years.
Risk Assessment:	Not rare in the RMI although quite heavily fished. From both lagoon and ocean side. Relatively fast growing. Any escapes likely to face severe natural predatory pressure due to lack of cover in vicinity of culture sites. Not considered a risk of unnatural ecological stress on other species in the RMI.

Appendix E: **C.V'S, LETTERS AND DECLARATIONS**



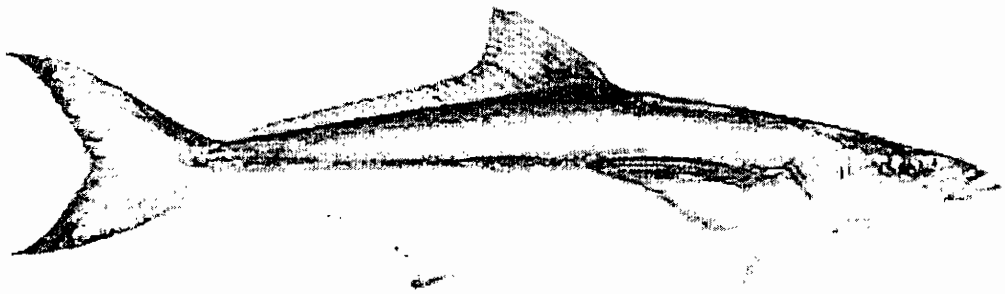
I declare that I, Leigh Tobin have witnessed the above fish (cobia) been caught with in Marshall Islands waters.

Details of capture: off The walls at Rouglap & Anno, Trolling & Diving. up to 40LB-50LB. Deep when Diving we were at 150', while Trolling we were on the wall were useing Deep Diven.

Name: Leigh Tobin
Address: Majuro. MI
Phone Number: Comercial fisherman & Charter Boat operator in Majuro

Signature: ______________________

Figure 8.3.20: Letter of Capture of Cobia in the Marshall Islands (Mr Leigh Tobin)



I declare that I, Ronald V. Alfred have witnessed the above fish (cobia) been caught with in Marshall Islands waters.

Details of capture: Deep water line fishing at night at the depth of 50 fathoms and deeper. This particular fish is available in Namdrik waters.

Name: RONALD V. ALFRED
Address: P.O. Box 1441
Phone Number: 528-2618 (work)

Signature: Ronald V. Alfred

Figure 8.3.21: Letter of Capture of Cobia in the Marshall Islands (Mr Ronald Virgil Alfred)

Figure 8.3.22: C.V. - Dr Daryl McPhee

WorleyParsons
resources & energy

Dr Daryl McPhee

Principal Environmental Scientist

Resume

1. SUMMARY

Fields of special competence:

- Fisheries ecology and management
- Impact assessment studies
- Experimental design and analysis
- Application of sustainable development principles, in particular the precautionary principle in the coastal zone
- Fisheries and aquaculture planning and policy

2. EXPERIENCE

2007 - present Principal Environmental Scientist - WorleyParsons

- Provide expert technical advice for coastal and marine projects.
- Screening and scoping of Environmental Impact Statements for the minerals, energy and coastal infrastructure sectors.

2003 - 2007 Lecturer – Environmental Management Centre, University of Queensland.

- Coordinate and teach undergraduate courses in Environmental Impact Assessment and Sustainable Development at both undergraduate and postgraduate levels.
- Supervise PhD students.
- Undertake high quality multi-disciplinary research in the fields of aquaculture, fisheries, and environmental planning and management.

Undertake environmental consulting projects.

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Dr Daryl McPhee

Principal Environmental Scientist

Resume

2002 — Senior Environmental Planner - Planning NSW

- Prepare EIS Guidelines.
- Provide environmental assessments of all designated fishing activities under the NSW EP&A Act.
- Provide advice on whether projects were consistent with the statutory requirements for ecological sustainable development as outlined in the NSW *Environmental Planning and Assessment Act 1979*.
- Develop and implement strategic approaches to environmental assessment.
- Provide input and expertise into regional and sector planning for aquaculture development.
- Liaise with other NSW Government agencies on relevant whole of government issues.
- Review and provide expert advice on development applications for state significant projects including conditions of consent and assess the adequacy of Eight-Part tests and Species Impact Statements.

2001 - 2002 — Aquatic Ecologist - WBM Oceanics Australia

- Prepare project tender documents.
- Undertake relevant field work in remote locations.
- Prepare EIS' and undertake other consultancy briefs.
- Provide expert advice for relevant court cases.

2000 – 2001 — Postdoctoral Research Associate- Department of Zoology and Entomology, University of Queensland

- Design and undertake research on human impacts in the coastal zone.
- Taxonomy of fish and macrobenthic invertebrates.
- Teach marine ecology (including field work).

1998 – 2000 — Postdoctoral Research Associate - Department of Zoology and Entomology, University of Queensland (50% fractional appointment)

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Dr Daryl McPhee

Principal Environmental Scientist

Resume

1998 - 2000 Scientific Advisor - Queensland Commercial Fishermen's Organisation (50% fractional appointment)

- Prepare relevant policies.
- Prepare media releases, newsletters and magazine articles.
- Provide high level scientific input and liaise with external government agencies.
- Communicate complex management and policy issues to commercial fishers.
- Develop structural adjustment frameworks.
- Undertake dispute resolution on contentious issues.
- Provide input government planning and management processes.

1997 – 1998 Senior Project Officer - Queensland Commercial Fishermen's Organisation

1997 Project Officer - Queensland Commercial Fishermen's Organisation

1993 – 2000 Tutor, Department of Zoology, University of Queensland

3. EDUCATION & PROFESSIONAL AFFILIATIONS

- Bachelor of Science, University of Qld (1990-1992)
- 1st Class Honours, Dept of Zoology, University of Queensland (1993)
- Doctor of Philosophy, Dept of Zoology, University of Queensland (1994-1998)

4. REFEREED PUBLICATIONS

McPhee, D.P. and Hale, P.T. (1995) Sustainable use of inshore fisheries. In: *Conservation Through Sustainable Use of Wildlife*. (Eds: G.C. Grigg, P.T. Hale, and D. Lunney). University of Queensland Press. pp 321-330.

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Principal Environmental Scientist

Resume

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Dr Daryl McPhee

Principal Environmental Scientist

Resume

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McPhee, D.P. (in press) *Fisheries Management in Australia* Federation Press. 224 pp.

5. CONFERENCE PRESENTATIONS

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McPhee, D.P., Tucker, A.D. and Robins, J.B. (1996) Comparing the introduction of trawl excluder and bycatch reduction devices in Australia and the USA. *Second World Fisheries Congress.* (Brisbane) (poster presentation).

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Dr Daryl McPhee

Principal Environmental Scientist

Resume

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McPhee, D.P. (2005) The South-east Queensland Plan: Environmental Implications and Opportunities. *Australian Property Institute Annual Conference* (invited oral presentation)

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6. CONSULTING REPORTS

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Principal Environmental Scientist

Resume

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Figure 8.3.23: C.V. - Ben Lawes

CURRICULUM VITAE

Name:	Benjamin John Lawes
Address:	233 Flinders St East Townsville, Queensland, Australia, 4810
Telephone:	(+61) 7 47715550
Email:	lawesb@gfbfisheries.com.com

EDUCATION

1995 – 1997	Bachelor of Aquatic Science Major: Aquatic Chemistry & Aquatic Biology. Deakin University Warrnambool Campus
1998	Graduate Diploma Aquaculture Deakin University Warrnambool Campus

EMPLOYMENT HISTORY

May 2007 - Ongoing	GFB Fisheries Ltd. Project Manager
January 2004 -- May 2007	GFB Fisheries Ltd. Hatchery Manager
May 2002- December 2004	Hamilton Prawn Farm. Hatchery Manager.
July 2001 – April 2002	Great barrier Reef Shrimp Hatchery. Hatchery Manager.
December 2000- July 2001	Great barrier Reef Shrimp Hatchery Assistant Manager.
February 2000- November 2000	Harvest Home Barramundi. Senior Technician.
July 1999 – February 2000	Queensland Aquaculture. Technician
February 1999 – June 1999	Jerilderie Silver Perch & Murray Cod. Technician

Figure 8.3.24: C.V. – Provan Crump

CURRICULUM VITAE

Name:	Provan Kelvin Crump
Address:	C/O MIMRA Po Box 860, Majuro, MI, 96960
Telephone:	(692) 455 7728
Email:	provan@mimra.com

EDUCATION

1994 – 1997	Diploma in Aquaculture University of Tasmania Launceston Campus
2001	Coxswains Certificate 2 Gold Coast Institute of TAFE
2003	Chemical Spills Handling. Northern Fisheries Center, DPI.

EMPLOYMENT HISTORY

October 2007 - Ongoing	GFB RMI Inc. Farm Manager
April 2005 – October 2007	Woja Pearl Oyster Hatchery MIMRA Aquaculture Specialist
Sept 2004- April 2005	Southern Fisheries Centre, DPI. Senior Fisheries Technician.
March 2002 – Sept 2004	Northern Fisheries Center, DPI. Fisheries Technician (Full Time)
July 2001- Feb 2002	Center for Marine Studies (Uni of Qld) Assistant
June 2001	Ocean Oddities Seahorse Farm Assistant
Sept 2000 – April 2001	Pisces Snapper Hatchery Hatchery Technician
Dec 1999 – June 2000	Rocky Point Prawn Farm Farm Technician Duties:
July 1999 – Dec 1999	Rocky Point Prawn Hatchery Hatchery Technician
June 1998 – Nov 1998	Blue Seas Pearling Co. Farm Technician

Figure 8.3.25: Comments from RMI Ports Authority RE: Proposed Fish Farm Sites.

Comments from RMIPA re GFB Fish Project 012808

From:	"Captain Joe Tiobech" <rmipa.seaport@ntamar.net>
To:	finlayrao@yahoo.co.uk
CC:	"RMI Ports Authority" <rmiports@ntamar.net>
Subject:	comments(aquaculture)
Date:	Mon, 28 Jan 2008 13:14:11 +1200

Having reviewed the proposed locations they are well outside of the existing shipping lanes and approaches to all our facilities including the main entrance at callalin.

We ask however that we be consulted with the proposed lighting of the cages to ensure that characteristics of such lights will not be confused with the existing navigational aids used by vessels during night transit to and from port of Majuro.

Thank you

Joe Tiobech