



Cook Islands

Aquaculture Development Plan

2012-2016



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2012–2016

Produced by the Ministry of Marine Resources
with the assistance of the Secretariat of the Pacific Community



Secretariat of the Pacific Community
Noumea, New Caledonia, 2012

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Original text: English

Secretariat of the Pacific Community Cataloguing-in-publication data

Cook Islands Aquaculture Development Plan: 2012–2016 / produced
by the Ministry of Marine Resources, with the assistance of the Secretariat
of the Pacific Community

1. Aquaculture — Economic aspects — Oceania.
2. Marine ecosystem management — Oceania.
3. Aquaculture — Management — Oceania.

I. Title II. Cook Islands. Ministry of Marine Resources
III. Secretariat of the Pacific Community

639.20995

AACR2

ISBN: 978-982-00-0590-7

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Layout and cover design: Muriel Borderie - SPC Publications Section
Printed by Copy Direct, New Zealand

Secretariat of the Pacific Community headquarters
Noumea, New Caledonia, 2012

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Foreword

I am very pleased to introduce you to this first Cook Islands Aquaculture Development Plan. Drafted in close consultation with aquaculture stakeholders, it is intended to serve as a comprehensive guide to the aquaculture sector in Cook Islands. This Plan captures the aspirations of Cook Islanders for sustainable aquaculture development. It was prepared by Ministry of Marine Resources (MMR) staff, with the valuable assistance and support of the Secretariat of the Pacific Community (SPC).

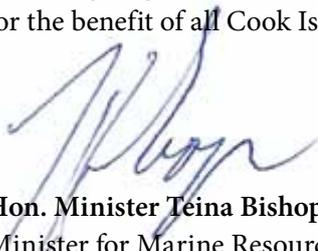
The Cook Islands Aquaculture Development Plan encapsulates MMR's contribution toward implementing the National Sustainable Development Plan 2011–2015 (NSDP), and the successive Corporate Plans of my Ministry, for the stated goals and objectives relevant to economic development in aquaculture.

Aquaculture is already making a significant contribution to the Cook Islands economy, mainly in pearls. This Plan indicates the best path forward to increase and diversify sustainable benefits from aquaculture development. It provides guidance to aquaculture investors, by indicating which aquaculture commodities in Cook Islands show the most development potential and carry the least risks. Strategies are outlined to forge partnerships between the public and private sectors, form links with experts in other development sectors such as agriculture, and join forces to gain critical mass for specific aquaculture developments.

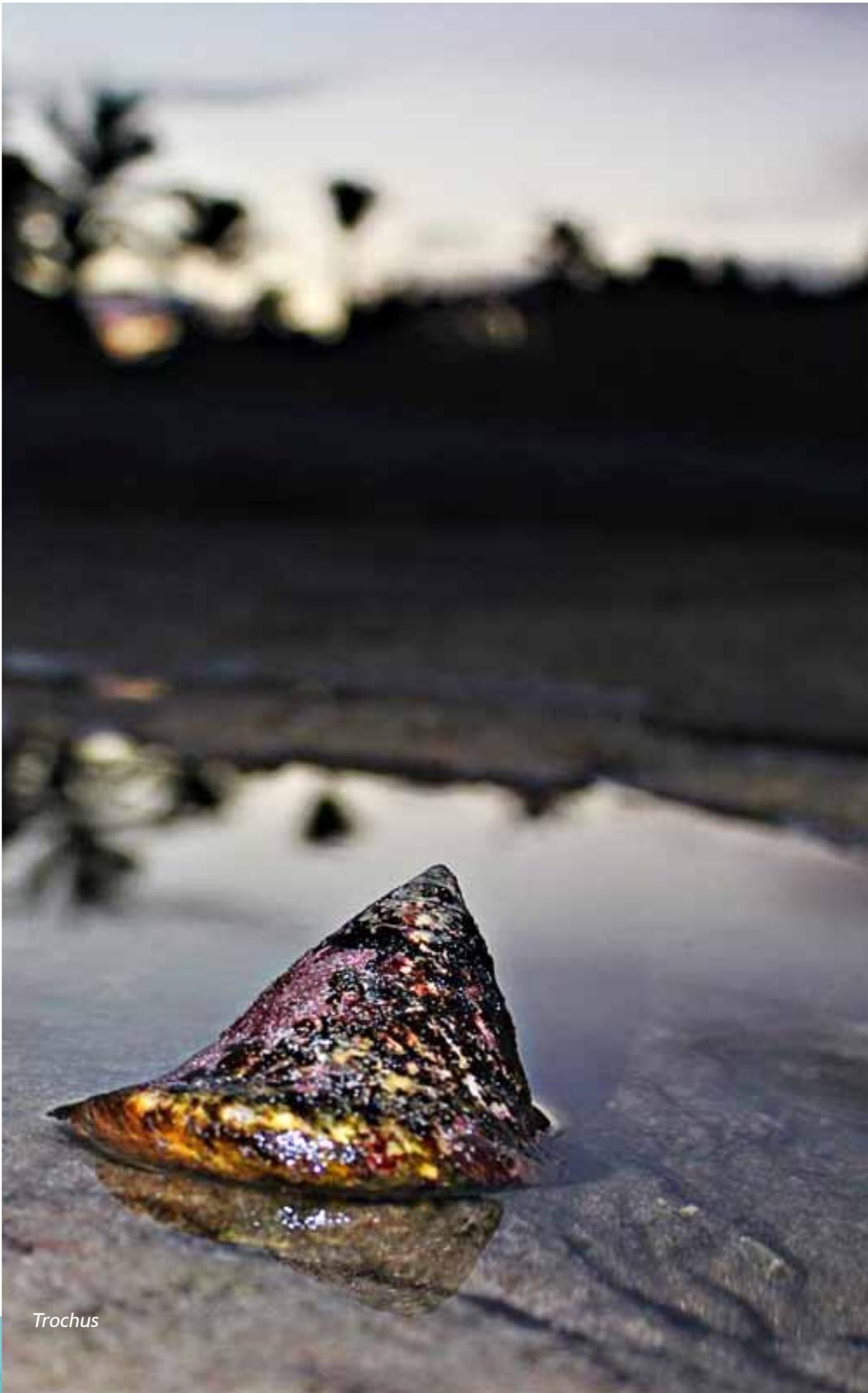
Well-managed fisheries will always be the best source of seafood for Cook Islanders. Certain factors including increasing visitor numbers, the projected effects of climate change on coral reefs, and the rising cost of fuel, are encouraging the development of new sources of fish much closer to home, such as those caught by nearshore fish aggregating devices, and aquaculture. Because much of the specialty seafood served in our hospitality industries is imported, there is scope to capture a larger percentage of the tourist dollar through local production from Cook Island aquaculture.

Increased awareness of non-communicable diseases (NCDs) such as diabetes and heart disease is strengthening the arguments to increase seafood availability and make it more affordable to our citizens. The World Health Organization recommends an annual per capita seafood consumption of 35 kg for healthy living. The Cook Islands national average already exceeds this target, but the figure for the population of Rarotonga is presently only 25 kg.

I look forward to seeing tangible results flow from implementation of the Cook Islands Aquaculture Development Plan over the next five years. I commit my Ministry toward achieving its goals, and I encourage you all to work in support of these worthy activities for the benefit of all Cook Islanders.



Hon. Minister Teina Bishop
Minister for Marine Resources



Part 1: Current status of aquaculture in Cook Islands

Aquaculture is a relatively recent activity in Cook Islands, dating only from the early 1970s. By the mid-1980s, however, Cook Islands had emerged as one of the region's major players (in terms of value) based on the success of the blacklip pearl farming industry.

Early 1970s projects included a 1971 proposal by the Oceanic Institute of Hawaii for a Total Atoll Production System (TAPS) such as the culture of mullet, oyster, prawn and *ature* (scad), which was not successful. A turtle farm initiated by SPC in 1974 in Aitutaki, successfully hatched green turtle eggs. Because the young turtles proved difficult to keep healthy and feed adequately, the project was terminated.

As part of an SPC Pacific Island regional initiative, Mozambique tilapia *Oreochromis mossambicus* was intentionally introduced in 1955 to the main island of Rarotonga, not for aquaculture but as a biological control mechanism for mosquito larvae. Tilapia has since been spread to islands in both the Northern and Southern Groups for stocking into natural waterbodies, from which it is used as food for household consumption as well as a source of pig food. In a couple of places (such as Pukapuka Island) this *mossambicus* species of tilapia is also regarded as a pest.

Globally the preferred variety for aquaculture is the Nile tilapia *Oreochromis niloticus*, which was introduced to Rarotonga for aquaculture trials during 2007. The tilapia grow-out and marketing trials were successful, and Nile tilapia continues to have potential as a food fish in Rarotonga.

Hatchery production of giant clams has been ongoing since the early 1990s. Five species of giant clams can be successfully hatchery-reared in Cook Islands. These are *Tridacna maxima* and *T. squamosa* which are both indigenous, *T. gigas* (largest and fastest growing), *H. hippopus* (a hardy intertidal species) both introduced from Australia, and *T. derasa* which was spawned from broodstock introduced as juveniles from Palau.

High predation rates of clams by *Cematium* snails, and labour intensive culture systems that involve a lot of scrubbing and cleaning, mean that commercial clam farming is not always as easy as it first appears. Reef re-stocking with loose clams has not been successful, as a result of poor survival after release. Stock enhancement of selected visitor snorkelling spots, subsidised by Government, has been successful.

Culture of clams in cages to harvest at small size for the marine aquarium market commenced from 2003 and is the most successful form of clam aquaculture in Cook Islands. Because cage-cleaning is a time-consuming burden, currently there are just two private sector farmers, who get between \$3 and \$6 per clam. Their clams are marketed by a middleman in Rarotonga who is also a marine ornamental fish exporter. Their vivid colours mean that Cook Islands ornamental clams are well-received by overseas buyers, who could take 2000 pieces per month if the clams were available.

In the Northern Group islands, pearl farming has had some success. In 1905 silver-lipped pearl oysters *Pinctada maxima* were introduced into Suvarrow Atoll for pearl culture but soon afterwards a cyclone hit and the venture was discontinued. Historically the blacklip oysters *Pinctada margaritifera* were harvested for their mother of pearl shell. Then in 1986 the first blacklip pearl farms were established in Manihiki, followed in the early 1990s by pearl farms and a hatchery on the island of Penrhyn. In the late 1990s the island of Rakahanga established a community farm.

Blacklip pearl culture grew to become the largest aquaculture industry in Cook Islands. At its peak in 2000 there were 81 farms with 2 million shells in the water, providing a pearl yield worth \$18 million dollars annually, accounting for more than 90% of national exports and 20% of gross domestic product. In terms of local production, 95% of pearls were from Manihiki and the rest from Penrhyn and Rakahanga. Cook Islands along with the other Pacific islands produced 10% of the world's black pearls, while the remainder originated from French Polynesia.

In recent times problems have emerged to take some of the lustre from the industry, for example, a progressively declining average world price for black pearls because of over-production by all players of lesser quality pearls. Closer to home, outbreaks of pearl oyster disease caused high shell mortality among farms in Manihiki, a problem related to farm management combined with climate change. Careful planning, coordinated effort and rigorous adoption of best practices by stakeholders through all phases of farming and marketing will be crucial for a strong, long-lasting pearl industry in Cook Islands.

Freshwater prawn *Macrobrachium rosenbergii* was introduced to Rarotonga from Tahiti in 1992 for a commercial-scale trial, based on imported seed and feed. The trial indicated that good growth rates could be achieved, but the cost of seed, feed and labour rendered the project uneconomic despite a very encouraging selling price in the range of \$40–\$50 per kg. Seasonal drying-up of freshwater sources is a further constraint. Some very small-scale capture-based culture of the indigenous prawn *Macrobrachium lar* continues at Rarotonga, though constrained by the supply of juveniles for pond stocking.

The carrageenan-bearing seaweed *Kappaphycus alvarezii* was introduced to Aitutaki for trials in 1986, and to Rakahanga in 2001. The first trial was destroyed by a cyclone. The second showed good growth rates but high levels of herbivory by fish such as siganids. Low international prices for dried seaweed, and the high cost of inter-island transport, are persistent disincentives for seaweed farming in Cook Islands.

Trochus were introduced to Cook Islands in 1957. The average annual harvest during the past 10 years has been 16 tonnes. Trials of hatchery-reared trochus for restocking were conducted but the cost of rearing juveniles through the nursery phase was high. Better fishery management of existing wild stock, and translocation of adult broodstock to restore depleted areas, are the preferred options to maintain the industry.

Milkfish can at times be easily captured in Northern Cook Islands, and transferred for culture in natural pools in places like Manihiki. Fingerlings were introduced from Hawaii in the 1980s for trials in Mitiaro and other Southern Cook islands. Natural spawning occurs more commonly in Northern Group where waters are warmer, but unfortunately the greatest demand for milkfish as food comes mainly from Southern Group. A trial shipment of fingerlings by sea was not successful, but there is scope for improvement. Air shipments of fingerlings from Manihiki to Rarotonga in 2006 and 2007 for experimental grow-out trials, were technically successful, but the cost of air freight was too high. Polyculture of milkfish with Pacific oysters was also tried, though the oysters did not thrive.

Summary of production and value for the main commercialised aquaculture commodities (Value × 000)

	Pearls	Giant clams	Trochus	Tilapia	Aquarium fish	Land crab	Giant Malaysian freshwater prawn	Milkfish	Mantis shrimp	Sea grapes	Eels
2005	1646				111						
2006	2044				141						
2007	2129				62			0.5			
2008	2053				205						
2009	1197			2.5	211						
2010 (Mar-Sept)	1384	180									

Pearls – Data obtained from Government Bureau of Statistics;

Giant Clams – data both from Government Bureau of Statistics and from Cook Islands Aquarium Ltd;

Trochus – The most recent trochus harvest was in 2011 and had a value of \$83,200;

Tilapia – harvest in 2008/2009 approximately 2 tonnes sold at the Avatiu Market from Titikaveka Growers Association, estimated price \$2500 (4 fish to 1 kg);

Land crab – domestic harvest;

Giant Malaysian freshwater prawn – introduced in 1994, a few hundred less than a tonne harvested at \$40/kg, but less than 100 kg were actually sold, \$4000;

Milkfish – Only a few were actually sold, which was not enough: estimated to have earned about \$500;

Mantis Shrimp – research indicates hundreds of juveniles;

Sea Grapes – domestic harvest;

Eels – domestic market.

Cook Islands Aquarium Ltd Catch			
Aquarium Fish for Ornamental Market			
Species	2009	2010	2011
<i>Acanthurus achilles</i>	94		
<i>Anthias ventralis</i>	5141	1617	
<i>Centropyge flavissimus</i>	50	1	
<i>Centropyge loriculus</i>	91	9	
<i>Chrysiptera galba</i>	453	7	
<i>Cirrhilabrus scottorum</i>	1109	198	
<i>Labroides rubrolabiatus</i>	81	1	
<i>Nemateleotris helfrichi</i>	78	14	
<i>Pseudanthias lori</i>	36		
<i>Pseudanthias pascalus</i>	193		
<i>Pseudanthias privatera</i>	47		
	7373	1847	
Clams for Ornamental Market			
<i>Tridacna derasa</i>		2566	507
<i>Tridacna maxima</i>		5379	4435
Total clams		7945	4942

Notes: In 2009, there were two fish collectors, one of whom could not work for 3 months.

No clams were available for 2009 due to spawning and growing-out to size.

In 2010, there were no fish collectors for 9 months.

In 2011, to 6 June, there were no fish collectors.

Fish sales are limited by airline connections, air freight, the skill of collectors and their availability, weather conditions, and market prices.

Clam sales are limited by shortage of inventory.

Part 2: Legislative and policy framework for Cook Islands aquaculture

Ministry of Marine Resources (MMR)

MMR is the lead agency for aquaculture in Cook Islands. The Ministry has regulatory, research and development, advisory and facilitation roles. MMR activities and functions that can underpin Cook Islands aquaculture include:

- ▶▶ links to regional expertise;
- ▶▶ training and consultancies;
- ▶▶ assistance with government permits;
- ▶▶ assist with project proposals;
- ▶▶ directly fund small projects;
- ▶▶ joint R&D programmes with private sector or grower associations (public private partnerships);
- ▶▶ operation of three Marine Research Stations (Aitutaki, Manihiki and Penrhyn);
- ▶▶ institutional memory for lessons learned and best practices.

Marine Resources Act 2005

MMR administers the Marine Resources Act 2005, and exercises its powers in aquaculture, including:

Part II, Section 7, Designation of Aquaculture Management Areas

- (1) The Queen's Representative may by Order in Executive Council designate an aquaculture management area.
- (2) The Secretary, or where appropriate, a local authority, shall prepare an aquaculture management plan for such aquaculture management area.
- (3) Each aquaculture management plan shall:
 - (a) identify the area to which the plan shall apply;
 - (b) describe the status of aquaculture activities in the area;
 - (c) specify management measures to be applied to ensure sustainable aquaculture;
 - (d) specify the process for allocating and authorising participation in the area; and
 - (e) address any other matter necessary for sustainable aquaculture.
- (4) The Secretary shall approve any aquaculture management plan prepared by a local authority in accordance with Subsection (2), and may not do so if it is inconsistent with the objectives, functions or authority in Section 3 or the principles and measures in Section 4 of this Act.

The Marine Resources Act 2005 is to be reviewed for possible amendment, commencing in 2012.

Cook Islands Economic Summit 2011: Fisheries and aquaculture

During the April 2011 Economic Summit, wide public consultation generated around one hundred recommendations to prioritise directions for economic growth and shape government spending during the next 4 years. Recommendations arising from the Summit for aquaculture are highlighted in Table 1.

Table 1: Aquaculture recommendations from the Cook Islands Economic Summit 2011

Broad Strategic Priority	Energise and grow the economy by supporting our key economic drivers and advancing innovation in potential areas of growth
Policy Initiative	1.6 Support and rejuvenate levels of pearl production in Manihiki lagoon
Broad Strategic Priority	Energise and grow the economy by supporting our key economic drivers and advancing innovation in potential areas of growth
Policy Initiative	1.7. Strengthen marine eco-tourism links in all islands
Broad Strategic Priority	Energise and grow the economy by supporting our key economic drivers and advancing innovation in potential areas of growth
Policy Initiative	1.9 - Support small-scale fisheries and aquaculture initiatives to conserve our resources and culture, promote healthy nutrition and substitute imports

National Development Strategic Plan 2011–2015

The Cook Islands National Vision 1997 is ‘To enjoy the highest quality of life consistent with the aspirations of our people, and in harmony with our culture and environment.’

The National Development Strategic Plan (NSDP) is the roadmap to achieving the national vision set by the country’s leaders. The NSDP Te Kaveinga Nui 2007–2010 is currently being updated and a draft NSDP 2011–2015 is now in circulation. The final version will also incorporate the priorities set by the Economic Summit held in 2011. It will set the scene for the economic development in Cook Islands for the next 4 years. The Marine & Freshwater Sector of this draft Plan contains broad objectives for aquatic resources development, which are outlined below. Any aquaculture sector plan should have regard for these objectives and, where applicable, play its part to help fulfil them:

- (1) **Offshore Fisheries Development:** expanded income earning opportunities from sustainably managed offshore fisheries through capacity building, and infrastructure and market development;
- (2) **Pearl Industry Rejuvenation:** profitable and sustainable pearl industry through improved productivity and environmental management;
- (3) **Inshore Fisheries and Aquaculture Development:** improving income generating opportunities for the private sector particularly in the Outer Islands, through increased provision of technical and scientific assistance;
- (4) **Food security and subsistence fisheries:** ensuring sustainable fishing and conservation practices resulting in long-term food security and traditional subsistence practices;
- (5) **Marine conservation, biodiversity and eco-tourism:** support the protection and conservation of our natural marine biodiversity, its affiliated customary practices and knowledge and potential commercialisation such as marine eco-tourism;
- (6) **Management of non-living marine resources:** support the wise exploitation of our non-living marine resources.



Giant clams

Indicators for implementing actions to achieve the aquaculture objectives of the NDSP are shown in Table 2.

Table 2: Indicators specified in the National Sustainable Development Plan 2011–2015 (NSDP) for implementation of actions to achieve aquaculture development objectives

	IMMEDIATE (2011)	MEDIUM (2015)	LONG TERM (2020)
Pearl Industry Rejuvenation	<ul style="list-style-type: none"> Lagoon and farm management plan is strengthened 600,000 pearl shell on Manihiki Value of pearl production \$2.7 million 	<ul style="list-style-type: none"> Pearl disease monitoring in place 1.2 million farmed shell on Manihiki Value of pearl production \$6 million dollars per annum 	<ul style="list-style-type: none"> 500,000 farmed shell on Rakahanga and Penrhyn Triploidy and genetic selection to increase pearl price per piece by 30%
Inshore Fisheries and Aquaculture Development	<ul style="list-style-type: none"> 50 mt/yr tuna from coastal/FAD on Rarotonga – artisanal Seafood \$4 million/yr household expenditure (2004) Decrease the amount of canned fish imports (\$720,000 per year) 	<ul style="list-style-type: none"> 50 mt/yr of reef-fish exports 60 mt/yr snapper exports Aquaculture of crustaceans such as freshwater prawn initiated Farming of tilapia and milkfish Consumption of tuna increases 30% 100 mt/yr tuna coastal/FAD Export of trochus 30 mt/ biannual 	<ul style="list-style-type: none"> Market–supply chains from Northern and southern group islands to Rarotonga Licensed and accredited fresh seafood (finfish, invertebrates) outer island fishers Aquaculture of prawns and increased local supply of finfish to substitute for >80% of imports
Food security and subsistence fisheries	<ul style="list-style-type: none"> Fish consumption on Rarotonga is 25 kg/yr/capita (compared with national average of 35, or outer islands = 51) WHO level is 35 kg 250 mt/yr caught = 250mt/yr brought 	<ul style="list-style-type: none"> Rarotonga fish consumption >35 kg/yr/capita 650 mt fish per year to meet WHO nutritional requirements 	<ul style="list-style-type: none"> Access to subsistence fishing opportunities remains the same Price of fresh Tuna is affordable to Cook Islanders
Marine conservation, biodiversity and eco-tourism	<ul style="list-style-type: none"> Coral and clam garden sites established Legislative support for Ra’ui 	<ul style="list-style-type: none"> Aituaki & Manuae are premier location bonefish Lagoon water quality maintained at WHO health standards High compliance with Ra’ui Low impact marine lagoon and reef eco-tours 	<ul style="list-style-type: none"> Marine pharmaceuticals 100% of spawning aggregations protected Restoration of wetlands, key habitats Protection of marine endemics Control of invasive marine species



Pearl Plan 2008–2013

The 2008–2013 Pearl Industry Reform programme coordinated by MMR aims to contribute to the revival and long term viability of the Cook Islands Pearl Industry, by implementing key marketing, production and capacity building initiatives.

Problems in the industry in recent years have resulted in declining living standards and available services in the Northern Group, and there has been significant de-population as a result. Yet pearl remains a commodity ideally suited to the circumstances of the Northern Group. It is a high-value, non-perishable commodity, cultured in a manner compatible with traditional lifestyles, for which there is a good track record of local experience, investment and ownership. Reinvestment and redevelopment of pearl farming is recognised as creating further opportunities for enterprise and employment, and is expected to mitigate emigration.

The 3-year Cook Islands Pearl Industry Support Programme is funded by government, industry and New Zealand Aid Programme to develop sustainable pearl farm production capacity and resources, to implement strategic marketing and sales promoting initiatives, and to develop key stakeholder capacity towards managing an integrated pearl industry.

The Pearl Plan 2008–2013 and the Pearl Industry Support Programme will work toward:

- increased numbers of seeded shell;
- increased quality and quantity of Cook Islands produced pearls;
- improved quality of Cook Islands produced pearls;
- increased revenue and profit from Cook Islands produced pearl sales;
- integrated industry management.

National Environment Services

CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) is an international treaty established in 1973 to ensure that the international trade in endangered wild animals and plants does not threaten their survival.

Cook Islands is not a party to the CITES Convention but there are still obligations to be met if the export of CITES listed materials is to one of the 175 countries that are a party, including major markets such as the United States and Europe. National Environment Services (NES) is the issuing agency for CITES permits. These are only issued for species listed in Appendix II and III (for example, live giant clams) of the CITES convention, but permits are sometimes issued for species listed in Appendix I for scientific purposes, for example, whale skin.

Farmed (and aquaculture) specimens are exempt from the CITES listing. When issuing export permits for the live ornamental clams, the exporter would need to provide a letter of confirmation that the clams are artificially bred in Cook Islands (presently at the Ministry of Marine Resources hatchery). These clams should be propagated from hatchery reared broodstock.

Ministry of Agriculture

The *Cook Islands Biosecurity Act 2008* consolidates existing laws on animal and plant imports and internal controls, uses up-to-date legislative style and techniques, and is transparent and accountable. These changes are a response to global developments; Pacific Islands Forum countries have agreed that animal and plant quarantine laws of the region should be modernised and harmonised in order to meet their international obligations in respect of trade products.

Part 4 of the Bill addresses the biosecurity entry, import specifications, access arrangements and the import permit, which will apply to live animal or plant imports such as any undertaken for aquaculture. Part 5 of the Bill stipulates the procedures for biosecurity which relate to exports. These provisions are all compulsory and the arrangements specified must be followed.

For introduction of aquatic species under this Act, applications are referred to MMR for their recommendation and advice.

Part 3: Vision and goals for Cook Islands aquaculture

Mindful of the development aspirations of Cook Islanders which emerged as recommendations from the Economic Summit 2011, and the over-arching framework provided by the draft Cook Islands National Development Plan, aquaculture stakeholders have deliberated on, and unanimously agreed to, the following statement as the Vision and Goals for aquaculture in Cook Islands.

Vision:

A vibrant and sustainable aquaculture sector, which can enhance the livelihoods and well-being of Cook Islands people.

Goals:

Promote aquaculture best practices to responsibly and sustainably:

- enhance populations of selected aquatic resources;
- maintain food security;
- diversify income-generating opportunities particularly in the Outer Islands; and
- supplement capture fisheries in Cook Islands.



Part 4: Aquaculture commodity development strategies

Prioritisation of commodities

During a public workshop hosted by the Ministry of Marine Resources and facilitated by SPC, various aquaculture stakeholders (see Part 6) reached a consensus on the main priorities and formulated strategies for Cook Islands aquaculture development.

Workshop participants drew up a list of aquaculture commodities which they viewed as having potential in Cook Islands. Each commodity was assigned a preliminary ranking A, B or C. A = much potential, B = some potential and C = no potential within a Cook Islands context.

Pearl	A	Limpet <i>mapi'i</i>	B
Milkfish	A	Trochus	B
Nile tilapia	A	Malaysian prawn	A
Local prawn <i>ura vai</i>	A	Giant clams	A
Green snail	C	Sea grapes (<i>rimu</i>)	A
Trochus	B	Sea cucumber	B
Turban snail <i>ariri</i>	B	Mantis shrimp <i>varo</i>	A
Mud crab	B	Sea urchin	B
Rabbitfish	A	Reef fish	B
FW eel <i>tuna</i>	A	Pacific oysters	C
Coral/live rock	A	MO fish + PCC	B
Land crabs	A	Kappaphycus	C
Marine shrimp	B		

Participants next discussed the attributes of the A List and B List commodities and, on the basis of their perceived advantages and disadvantages, assigned to each a ranking between 1 and 10 in terms of:

FEASIBILITY - *What is the feasibility of successfully developing the commodity?*

- » How easily can the technology to farm the commodity be accessed?
- » How appropriate is the technology for Cook Islands?
- » How well can the commodity be grown or marketed?

IMPACT - *What is the potential of the commodity to make a positive impact?*

- » How widespread would the benefits be?
- » How will the commodity affect local culture, society, or the environment?

The rankings that emerged for Cook Islands aquaculture commodities, expressed in terms of their feasibility and impact, are shown in Table 3.

Ten commodities were given high rankings, after consideration within a Cook Islands context. Four can be regarded as top priorities, because they already have an established track record of suitability or success in Cook Islands: pearl, giant clam, trochus, and tilapia.

Another six commodities look very promising, but because experience with these is still limited they need to be further researched for potential through literature and desk top studies and, if deemed potentially viable, tested in pilot commercial scale trials: land crab, Malaysian freshwater prawn, mantis shrimp, sea grapes, eel, and milkfish.

Aquaculture stakeholders formulated a strategy for each commodity, comprising specific actions and timeframes to address their respective challenges and constraints. These strategies are set out in the pages following Table 3.

Table 3: Outcomes of aquaculture commodity prioritisation in Cook Islands

High	Turban snail Sea urchin	Sea cucumber Rabbitfish Reef fish	Pearls Clams Trochus Tilapia Land crab Malaysian prawn Mantis shrimp Sea grapes Eel Milkfish
		Marine shrimp Mud crab	
IMPACT Medium			
Low	MO Fish		Local <i>Macrobrachium lar</i> prawn (<i>ura vai</i>)
	Low	Medium FEASIBILITY	High



Pearl seeding technician



Pearl

The methods used for aquaculture of blacklip pearl *Pinctada margaritifera* are relatively simple. Shell can be sourced either by catching spat from the wild on collectors, or they can be reared in a hatchery. No feeding is required, though hatchery-reared juveniles do better if supplied with specially grown algae. Environmental impacts are low if correct farm husbandry is observed. The techniques for pearl implanting require a very high level of skill and experience which is costly to obtain if sourced from overseas. Pearls are a high value product that are easily transported and stored.

Pearls have well-established national and international markets, and a range of product forms that include shell, half and round pearls, carved shell jewellery and the oyster meat.

Feasibility: 7

Impact: 8

Advantages:

- an established industry in Cook Islands;
- effective management protocols are already in place.

Disadvantages:

- strong competition for markets (with French Polynesia, Fiji and possibly Australia);
- reliance on expensive foreign technicians.

Strategy:

Immediately:	Within 2 years:	Within 5 years:
Focus upon quality, not quantity. Discard poor-grade pearls, and legislate for controls to limit them entering the market	Farmers to formulate business plans using advice based upon pearl farming best practice	Cook Islands pearls established as a premium product with glamour image, and a high price per piece paid to producers
Investigate past farm failures to obtain lessons learned, and monitor on-going farms to avoid repetition of such failures	Innovative international marketing strategy to win recognition for Cook Islands pearls as a premium product	
Conduct shell stock-take of all pearl farms	Ensure sufficient spat availability through improved hatchery techniques	
Provide on-going scientific and technical support to farmers on site	Improve farmer access to necessary farming equipment and resources	
Establish guidelines and management protocols for the stock density of shells on pearl farms	Improve availability and reliability of appropriately-skilled farm labour	
Map all farms to accurately establish farm boundaries, and if necessary re-adjust to avoid over-crowding	Investigate possible markets for pearl meat	
Establish on-going water quality monitoring as a basis for farm management		



Giant clams



Giant clams

Methods for all phases of aquaculture of *Tridacna gigas*, *T. derasa*, *T. squamosa*, *T. maxima*, and *Hippopus hippopus* have been developed and are readily accessible. Techniques for rearing larvae are relatively simple. The very high number of eggs available from each spawning compensates for the low survival rate. Facilities for spawning and larval rearing are relatively simple and inexpensive. Commercial size for the aquarium trade can be reached in approximately 2 years, but takes much longer for the meat market. Environmental impacts are low at all stages of production. Live ornamental giant clams can be sold for very high retail prices in the USA, Europe and Japan, where tropical aquaria are popular.

Feasibility: 9

Impact: 9

Advantages:

- Easy to breed and rear
- Seed available
- Does not require feeding
- Market is available locally
- Relatively cheap to set up farms

Disadvantages:

- Grows slowly
- High-maintenance to keep clean from algae and during snail season
- Limited market for MO trade

Strategy:

Immediately:	Within 2 years:	Within 5 years:
Build many more cages for nursery production	Encourage labour for cage cleaning during grow-out	Investigate options for alternative and renewable energy sources to reduce costs of clam production
MMR to produce more spat for nurseries	Training and capacity building for nursery and grow-out management	
Establish private public partnership under a clear MOU for spat production, nursery management, grow-out and harvesting by MMR in partnership with communities and private sector	Review marketing arrangements and explore innovative marketing strategies	



Trochus



Trochus

Hatchery technology for mass seed production of *Trochus niloticus* is easy and standardised. Large-scale production of small juveniles (1–2 mm) is considered economic under Pacific conditions. The larval cycle is simple and larvae do not require feeding during the planktonic larval phase. Juveniles and adults are easily transported for stocking. Juveniles for stock enhancement and culture are not available from the wild, but can be produced in the hatchery. Because growth is slow, to reduce costs after the nursery phase, the reared shells need to be out-planted onto reefs. Translocation of adult broodstock to reefs is a viable way of establishing or restoring natural populations, as an alternative to release of hatchery-raised juveniles.

The market for the shell product is well developed, and the meat is also sought after as food. Value can be added by making trochus into button blanks or shell jewellery.

Feasibility: 9

Impact: 7

Advantages:

- low-tech – easy to spawn and rear;
- both meat and shell have value;
- market is available locally;
- technology has already been tried in Cook Islands.

Disadvantages:

- economic viability of hatchery production for re-stocking is not proven;
- slow-growing, need out-planting to reef.

Strategy:

Immediately:	Within 2 years:	Within 5 years:
Survey of Southern Cook Islands to assess stock status	Survey of Northern Cook Islands to assess stock status	Through either re-stocking, or improved harvest management, or both (as appropriate) achieve a 25% increase in trochus landings
Review other countries' success with fishery re-stocking using hatchery-reared juveniles	Review Cook Islands trochus stock status to determine whether re-stocking of selected areas using hatchery-reared juveniles will be beneficial or not	
Consider public private partnerships to manage re-stocking and grow-out	Capacity-building in hatchery, nursery, and post-release monitoring techniques for trochus re-stocking	
Conduct economic survey to compare potential returns from marketing (i) trochus meat and (ii) trochus shell	Investigate alternative and innovative strategies for trochus product development, promotion and marketing	
Socio-economic survey of current use and harvesting practices in the trochus resource, to identify ways to maximise returns to the community and minimise waste		
Fishery stakeholders to collaborate on improving arrangements for management of trochus harvest, fishery closures, and rights to harvest; government to promulgate new arrangements for trochus harvest, based upon stakeholder consultations		



Tilapia



Tilapia

Tilapia are not indigenous to Cook Islands, but *O. mossambicus* is long-established. The Nile tilapia *O. niloticus* has also recently been introduced to inland ponds in Rarotonga for aquaculture. These freshwater fish are hardy, easy to breed, flexible in food requirements and have high survival in grow-out ponds or cages. *O. niloticus* is the preferred variety for aquaculture. Growth is fast and fish can be marketed after about 6 months.

They are less favoured than reef fish by consumers, but tilapia do have a ready market because of reef-fish scarcity and because of population segments in Cook Islands who are long accustomed to eating them.

Feasibility: 8

Impact: 8

Advantages:

- versatile – can be intensive (tanks) or semi-intensive (ponds) or extensive (lake stocking);
- some infrastructure already exists;
- Nile tilapia already present in Cook Islands;
- has a moderate (and increasing) market potential.

Disadvantages:

- water and feed requirements need investigation;
- difficulty of sludge removal from intensive tanks;
- technical capacity for hatchery/nursery needs to be acquired.

Value-adding to increase market appeal is required

Strategy:

Immediately:	Within 2 years:	Within 5 years:
Capacity building on farming best-practice, and to adopt more efficient techniques such as mono-sex culture	Develop strategies for appropriate disposal of pond effluent, including riparian-strip treatment, or water recycling, or partnership with agro-industries	Increase in fish availability and employment opportunities through viable tilapia aquaculture enterprises
Review sources for local feed ingredients and possible feed formulations, procure feed-making equipment	Conduct market feasibility study to estimate the size and source of current market demand for tilapia	
Consider public private partnership, e.g. a demonstration farm to show economic viability, establish optimum farming intensity, and to provide capacity-building opportunities	Investigate ways to win new market segments for tilapia, and increase market size through product diversification, value-adding, and trial of alternative production systems such as aquaponics	
Develop site selection criteria for farm construction to ensure farm viability and to minimise any environmental impacts	Investigate ways to improve tilapia production in those lakes where tilapia are already established, e.g. through cage culture, and culling to reduce over-stocking	



Land crab



Land crab (butcher land crab – *Cardisoma carnifex*)

The butcher land crab is indigenous to Cook Islands and can be found in large numbers and sizes in some places such as Aitutaki. They are a popular delicacy, which can be improved in flavour and fatness by capture and a period of culture using certain food types. No hatchery systems are required, provided that adult populations are protected by management measures that allow them to breed freely.

Feasibility: 9

Impact: 7

Advantages:

- easy to capture and farm;
- high in demand (good local market);
- can fatten on coconut and pawpaw to improve quality.

Disadvantages:

- no surveys done on stock numbers;
- possibility of 'over-fishing'.

Strategy:

Immediately:	Within 2 years:	Within 5 years:
Market research to estimate size of market, the target market-segments (whole live product for locals, or crab meat for visitors?) draft business plans and to compile lessons learned from past efforts	Certification scheme to provide customer assurance that crabs sold are <i>farmed</i> crabs of superior quality and flavour	
Stock assessment and scientific research in selected key harvest areas, to establish sustainable limits of crab harvest for fattening	Harvest management controls promulgated, based upon outcomes of scientific research and stakeholder consultations	
	Research on best practice (e.g. feed choices) for fattening of crabs	



Freshwater prawn *Macrobrachium rosenbergii*



Giant Malaysian freshwater prawn

The freshwater prawn *Macrobrachium rosenbergii* is one of the more straightforward of the high-value edible crustaceans to rear through hatchery phases for grow-out in ponds. Though not as valuable or as well-researched as marine shrimp, a sizeable body of knowledge exists about techniques to breed and rear them. Their food requirements in grow-out are not as stringent as for marine shrimp, but they do take longer to pass through the larval life cycle which adds cost to the rearing process.

A ready market exists in Cook Islands and throughout the Pacific for Malaysian freshwater prawn, because of its close resemblance to the indigenous *Macrobrachium lar*, an iconic species well known to Pacific island consumers, for which feasible hatchery technology does not yet exist.

Feasibility: 8

Impact: 8

Advantages:

- high local demand and good price;
- already tried in Cook Islands – technically feasible;
- potential hatchery infrastructure and pond sites exist.

Disadvantages:

- not currently present in Cook Islands – must be re-introduced;
- water and feed requirements need investigation;
- technical capacity needs to be built (especially hatchery skills).

Strategy:

Immediately:	Within 2 years:	Within 5 years:
Estimate existing market demand for freshwater prawn	Consistent supply of prawn post-larvae, feed, and technical advice available for private sector pond operators	Viable small-pond operators in public private partnership with government to produce prawns for local market
Survey and inventory of potential prawn pond sites, with respect to land and water requirements	Investigation of potential for prawn grow-out in Outer Islands, including possibility of cage culture in lakes	
Introduce prawn broodstock to Cook Islands		
Establish capacity for prawn hatchery production		
Survey and cost-effectiveness comparison of alternate feed sources, both local and imported	Trial these feeds during experimental phases	



Milkfish



Milkfish

The milkfish *Chanos chanos* is indigenous to Cook Islands, and is widely farmed in extensive culture in Asia for human consumption. Culture techniques are well-known, simple and low-cost. This warm water species is herbivorous and can graze on algae and seaweeds. Capture-based culture can be practised where fingerlings are seasonally abundant in lagoons or along beaches, and hatchery breeding is also relatively simple though less economic. Fish grow faster if fed on a formulated fish pellet, but careful management of stock density can make aquaculture possible with zero added-feed. Marketable size can be reached in around one year of pond culture.

Feasibility: 7

Impact: 8

Advantages:

- highly sought-after species in Cook Islands;
- easy to rear in ponds.

Disadvantages:

- survey required on fingerling abundance and seasonality for capture-based culture;
- high cost and low survival for fingerling translocations from the Northern to Southern Cook Islands.

Strategy:

Immediately:	Within 2 years:	Within 5 years:
Conduct market research to find out the market value, market size, and product forms of milkfish	Conduct an experimental trial of milkfish capture (i) for culture in ponds and (ii) for acclimation and release into freshwater lakes	Regular flow of farmed milkfish into local fish markets
Survey and scientific research on the seasons and locations for milkfish fingerling capture in Southern Cook Islands		
Desk-top literature review and in-country trial of fingerling translocation techniques by sea from Northern Cook Islands to Southern Cook Islands		
Local feed sources for milkfish to be surveyed	Trial these feeds during experimental phases	



Mantis shrimp



Mantis shrimp

Trials of post-larval fish capture and culture (PCC) in Cook Islands has revealed high catches of mantis shrimp which can be transferred into tanks for aquaculture. Because these fish are a popular delicacy when captured from the reef, a local market exists for them. Not much is known about the best culture and feeding requirements, which will need more research.

Feasibility: 7

Impact: 7

Advantages:

- easily caught as juveniles in crest nets;
- a commonly farmed species in Asia;
- grow to 3 inches in 6 months.

Disadvantages:

- cannibalistic (special tank design needed);
- requires expensive high-protein feed (shrimp pellet);
- only seasonally available for capture (Oct–Apr);
- needs research on (i) capture (ii) food and grow-out.

Strategy:

Immediately:	Within 2 years:	Within 5 years:
Develop suitable low-cost tank designs that reduce cannibalism during grow-out; (research grow-out methods used in Asia)	Conduct research on juvenile-capture methods and seasonality to develop more efficient capture techniques	Several small businesses in operation capturing and fattening mantis shrimp for local sale and export
Conduct survey of locally-available high-protein feed sources, such as saw-meat	Review the scientific and marketing research results and assess the socio-economic viability of mantis shrimp aquaculture in Cook Islands	
Conduct market research to establish size of market demand and prices to be paid		
Conduct survey to establish suitable areas/habitat for growing	These areas may need to be managed with a plan	



Sea grapes



Sea grapes

The seaweed *Caulerpa racemosa* is a popular delicacy in Cook Islands and fetches high prices for the small quantities that can be obtained by reef gleaning. Aquaculture of sea grapes warrants investigation, to reduce pressure on the limited wild stocks, and increase availability to consumers.

Feasibility: 6

Impact: 7

Advantages:

- easy to grow in tanks;
- popular in local market;
- easily transplanted;
- high social impact.

Disadvantages:

- perishable and expensive to airfreight for export;
- skill needed to avoid pest algae taking over;
- only seasonally available.

Strategy:

Immediately:	Within 2 years:	Within 5 years:
Desk-top review of culture and shipment techniques	Explore potential of translocation to establish sea grapes beds in new places or where stocks have diminished (e.g. in Mangaia, Mitiaro)	A small industry supplying the local market with 200–300 kg of sea grapes per month
Transfer of culture techniques to Cook Islands and experimental trials to demonstrate technical feasibility	Research on processing, handling and transportation techniques to develop best-practice methods.	
Marketing study to identify quantity and quality requirements of local and potential export markets	Assess available varieties to select the most suitable one for culture and market requirements	



Eel



Eel

Anguillid freshwater eels are naturally present in streams, ponds and lakes and are a sought-after delicacy. The size of the natural resource in Cook Islands is small and not very productive, however. There may be some scope for capture of juveniles for on-growing and fattening, but such a project needs research to establish the feasibility and sustainability of capture-based culture under local conditions.

Feasibility: 6

Impact: 7

Advantages:

- locally available, has local market;
- can export it alive;
- very hardy, can grow it anywhere there is water.

Disadvantages:

- difficulty obtaining seed for pond stocking;
- cannibalistic, so needs continual size-grading;
- requires expensive high-protein feed (butcher's saw blade-meat available);
- needs a feasibility study.

Strategy:

Immediately:	Within 2 years:	Within 5 years:
Identify at least one source of juvenile eels for grow-out	Identify additional sources of juvenile eels	
Market survey of eel consumption patterns and demand	Subject to the outcomes of Year 1 studies, conduct a small trial of capture-based culture and evaluate its feasibility	
Literature review and resource survey to establish the species, and the seasonal and site abundance, of juvenile eels in Cook Islands for on-growing		
Feed source survey to find out local supplies of suitable feed-stuff (e.g. saw-meat)		
Desk-top review of eel capture-based culture practices in the Pacific and elsewhere		

Part 5: Strategies for cross-cutting issues

Many of the constraints and opportunities facing aquaculture are not necessarily species specific. Recognising that aquaculture straddles agriculture and fisheries, means accepting the complexity of the problems faced by this whole sector.

A wide range of cross-cutting issues was identified for aquaculture in Cook Islands. These fundamental issues will underpin the sustainability of the sector and should not be ignored.

Technical capacity

Immediately:	Within 2 years:	Within 5 years:
Access know-how from regional and international aquaculture organisations	Public private partnerships in R&D to increase critical mass	Local expertise available for all major facets of aquaculture enterprise, development and statutory management
Mechanism for work attachments and training to acquire specialist skills	Alignment of Human Resources Development with aquaculture development priorities	
Scholarship opportunities for study in aquaculture	People trained in aquaculture are applying their skills within the aquaculture sector	

Market research

Immediately:	Within 2 years:	Within 5 years:
Assistance to be made available, for preparing aquaculture venture business plans, beginning with market assessments	Research on aquaculture product diversification, consumer preferences, and value-adding	A range of appealing aquaculture products locally available for which there is high market demand
Conduct market surveys for major aquaculture commodities, to provide a sound basis for investment	Develop aquaculture product standards for consumer health and satisfaction	Certification scheme in place for consumer recognition of aquaculture product quality standards

Cost of feeds

Immediately:	Within 2 years:	Within 5 years:
Compile a national inventory of local feed ingredients or agricultural and fish-processing by-products with potential for fish feed formulations	Lobby for import duty exemptions on major aquaculture inputs which cannot easily be sourced locally, such as fish feeds or feed ingredients	Local capacity to manufacture national fish-feed requirements
Compile a register of cost-effective regional or international suppliers for imported fish feeds	Identify and source appropriate feed-making technology and machinery to formulate feeds using local ingredients	
Estimate projected feed requirements in terms of quantity, quality and physical properties	Investigate potential of local species for hatchery live food production, such as micro-algae or rotifers	

Cost of freight

Immediately:	Within 2 years:	Within 5 years:
Facilitate cooperation among farmers to source aquaculture inputs nationally or internationally, e.g. bulk-buying of feeds, equipment, or materials	Investigate best practice techniques for sea transport of milkfish fingerlings from Northern to Southern Cook Islands	A fair deal for aquaculture investors who depend upon transport links to source farm inputs or to access markets

Finance

Immediately:	Within 2 years:	Within 5 years:
Compile and publish a list of sources, and application guidelines, of grants or loans for which aquaculture ventures are eligible to apply	Increase awareness among politicians and financiers about aquaculture as a business or investment opportunity	A stand-alone financing facility created specifically for aquaculture ventures
Increase capacity in business planning, and general understanding among farmers of aquaculture as a business	Strengthen aquaculture's cross-sectoral links, for example with tourism, to broaden the base of support for aquaculture investments	

Environment

Immediately:	Within 2 years:	Within 5 years:
Develop site selection criteria and best farming practice guidelines to minimise environmental impacts of the main forms of aquaculture in Cook Islands	Develop strategies for waste management in aquaculture, including re-cycling of waste, re-circulation of water, and synergies with agriculture for use of aquaculture by-products	A responsible aquaculture industry, resilient to environmental or climatic threats
In collaboration with other relevant agencies, develop clear process and guidelines for environmental impact assessment of new aquaculture ventures, including guidelines for scoping whether such assessment is deemed necessary	Increase capacity in biosecurity measures such as quarantine protocols, and Import Risk Assessment procedures for importation of live aquatic organisms	
	Review and, where appropriate, adopt renewable sources of energy (such as solar or wind) for aquaculture projects	
Maintain a watching brief on <i>seawater acidification</i> as one climate change problem with potentially serious long-term effects on the pearl industry in the Cook Islands	'Cyclone-proofing' of farm infrastructure to be explicitly factored into aquaculture business plans and operating procedures	

Governance

Immediately:	Within 2 years:	Within 5 years:
Facilitate formation of a dedicated aquaculture industry association, to represent the interests of aquaculture stakeholders and strengthen working relationships between the private sector and national and local government	A code of conduct for best farming practice (BFP), drafted via participatory processes, for each of the major aquaculture commodities in Cook Islands	Make substantive progress toward achieving the vision and objectives for the Cook Islands aquaculture sector
Review current aquaculture legislation and regulations, to identify gaps and areas for improvement	Implement a sound basis for collecting and publishing aquaculture statistics, as a basis for managing the sector and increasing awareness of its contribution to the national economy	
Agree to hold a national aquaculture forum every 3 years to review progress and set priorities		

Access to land, water and labour

Immediately:	Within 2 years:	Within 5 years:
Land use planning and survey techniques applied to identify zones suitable and appropriate for aquaculture	Effective partnerships between land-owners and aquaculture investors	A responsible aquaculture industry, which can obtain sufficient resources for development while avoiding user conflicts
Survey to accurately establish existing farm boundaries in the marine environment, to provide a sound basis for aquaculture planning and investment, and avoid user conflicts	Land use planning, to provide opportunities for responsible aquaculture industries	
Develop policies on appropriate levels of foreign labour or investment in Cook Islands aquaculture industries	Sustainable sources of groundwater identified for freshwater aquaculture	

Part 6: Cook Islands Aquaculture Contacts

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