



Tonga

Aquaculture Commodity Development Plan

2010-2014



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Produced by the Ministry of Fisheries
with the assistance of the Secretariat of the Pacific Community



SPC
Secretariat
of the Pacific
Community

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Secretariat of the Pacific Community

BP D5

98848 Noumea Cedex

New Caledonia

Tel: +687 26 20 00

Fax: +687 26 38 18

spc@ spc.int

www.spc.int

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Experimental grow out of Pteria penguin in Tongatapu

Foreword from the Minister of Fisheries

The Aquaculture Management and Development Plan is a five-year “road map” for the future of aquaculture in Tonga. The plan is a tool that will assist government and local entrepreneurs as well as foreign investors on what type of aquaculture development they should pursue.

Marine resources have always been a source of livelihood for the people of Tonga. In terms of export, agriculture has often been the bigger contributor. Fisheries, however, is becoming the “new frontier” in Tonga for export revenue, and aquaculture is seen as a way forward in terms of enhancing the economic contribution through employment, trade and skills development, and ensures food security for its people.

Aquaculture is not new in Tonga, although it is new to most Tongans. Before this plan came into reality, the main aim of aquaculture in Tonga for over 20 years was to restock the reefs and assist the aquarium trade through culturing and rearing of giant clams. Now, the experiences and results of trials have encouraged the government and the Fisheries Department to move Tonga’s aquaculture capacity into commercialization.

The plan has outlined how licenses shall be allocated, categorised and managed. This also provides avenues for communities to utilize their adjacent waters for aquaculture purposes. But it is important that communities, aquaculture business owners, and foreign investors and government work together to ensure that this plan reaches its full potential.

Malo e ngaue to the Aquaculture Research and Development Section, and the Fisheries Policy and Management Section of the Fisheries Department for their efforts in facilitating workshops and consultations and in drafting this work. I would also like to extend my gratitude to the Secretariat of the Pacific Community for its expertise and assistance in putting this plan into draft form, and editing its contents.



HSH Prince Tu'ipelehake

Minister Responsible for Fisheries



photo by Andrew Beer

Tonga fisheries staff member holding giant clam spat at Sopa mariculture station, Tongatapu

Part 1: History and Current Status of Aquaculture

Chronology of aquaculture development milestones

- » In the mid-1950s: **Tilapia** was introduced in an unsuccessful attempt to control mosquitoes. Later it was trialed for fish culture in the Sopu fish ponds, as part of an integrated farming system project with a piggery.
- » Early 1960s: **Pearl oyster** culture trials began. In 1975, an experimental venture was set up by the Tongan government. Broodstock of the winged pearl oyster (*Pteria penguin*) was imported from Japan for initial culture trials. Culture trials were conducted in Vava'u with imported species *Pinctada margaritifera* and *P. maxima*. In 1989, the South Pacific Aquaculture Development Project (SPADP) of the Food and Agriculture Organization (FAO) provided assistance in carrying out stock assessment, spat collection surveys, and grafting techniques. In 1993, a project called the “Commercial Feasibility of Pearl Farming in Tonga” was initiated.
- » Late 1960s: **Milkfish** that spawned naturally in Lake Ano Ava were polycultured with tilapia and mullet.
- » 1971: A demonstration pond was established by the US Peace Corps at Sopu on Tongatapu Island. In 1978, a mariculture centre was established with assistance from Japan.
- » 1971: An experimental **turtle** hatchery was established at Sopu in an effort to restore the hawksbill turtle population to its former status.
- » 1973: **Edible oyster** culture was initiated. Several species were introduced from Japan, New Zealand and the USA: *Ostrea edulis*, *Saccostrea commercialis*, *S. glomerata*, *Crassostrea gigas* and *C. belcheri*. In 1981, a project to investigate the culture of local oyster species was terminated due to poor growth rates and low market prices.
- » 1974: With the onset of the pole-and-line fishery for skipjack tuna, **mollies** (*Poecilia vittata*) were introduced at Sopu to meet the demand for tuna bait. The project was terminated in 1978.
- » **Mullet** had high priority in the country's development plans. Fry, mostly *Liza macrolepis* and some *Valamugil seheli*, were collected and stocked into pens for grow-out. The fisheries department and the Japan International Cooperation Agency (JICA) were responsible for these trials. Experiments investigating feed and growth were carried out to determine whether the importation of *Mugil cephalis* fry would be a feasible undertaking.
- » 1974: A project to cultivate local and introduced **mussels** started but ended inconclusively by 1979. In 1983, assistance from New Zealand's bilateral aid programme was provided to support mussel culture.

- » 1980s: A concerted effort was made to enhance **giant clam** stocks. “Clam circles” were created on reefs in Tongatapu and Vava’u, and managed by local communities. The Australian Centre for International Agricultural Research (ACIAR) funded construction of a giant clam hatchery and ocean nursery, and provided technical training for government fisheries staff in collaboration with James Cook University in Australia. The new facility enabled the reintroduction of *Hippopus hippopus*, and the establishment of the newly described species *Tridacna tevoroa*. This project was then continued by JICA.
- » 1982: Experimental trials of **seaweed** farming for *Eucheuma spinosum* and *Kappaphycus alvarezii* were initiated. Seed stock was imported from Fiji by a private company from New Zealand, and planted at a farm in Vava’u. The fisheries department set up experimental farms at Tongatapu with seed from the Vava’u farms. By 1987, 14 farms were operational, each with 50 lines. In 1998, techniques for farming mozuku seaweed (*Cladosiphon* sp.), known locally as *limu tanga’u*, were described by SPADP.
- » 1990s: The government mariculture centre at Sopo has been one of the pioneering institutions for **green snail** and **trochus** aquaculture in the Pacific. Regional training courses have been held at the centre, and green snail broodstock has been distributed to various countries in the Pacific.

Current status of aquaculture commodities

- » **Marine ornamental species:** There are four commercial operators involved in exporting marine ornamental species under a license provided by Tonga’s Ministry of Agriculture and Food, Fisheries and Forestry. With the exception of giant clams, all of the products are harvested from the wild, although some commodities such as coral, fish and live rock could be substituted by cultivated products. Most, if not all, of the giant clam seed stock is produced at the government mariculture facility at Sopo. Approximately 5,000 pieces worth TOP 17,500 are exported per year.
- » **Seaweed:** Wild stocks of the seaweed mozuku (*Cladosiphon* sp.) are exported to Japan depending on seasonal demand. On occasion, some spores are cultured to supplement the wild harvest. About 300-500 tonnes are farmed.

- » **Pearl:** Low level *Pteria* pearl oyster farming occurs at Vava'u. Oysters are ear-hung using submerged longline techniques. The oysters are either collected from the wild or by artificial spat collectors. In some cases, a half-pearl “mabe” is inserted on the inside shell valve. The oysters are harvested for their mother-of-pearl shell or mabe and used for handicrafts that are sold locally. More than 500 pieces annually are thought to be sold domestically. *Pteria* pearl oysters have been successfully bred at the Sopa mariculture facility, and trials for spat nursery grow-out have been conducted in Vava'u.
- » **Live rock and coral:** Trials with a private-sector company have begun to test the feasibility of using an artificial base for live-rock culture, and the growth rates of cultured coral.
- » **Sea cucumber:** Government staff have been trained in hatchery production techniques for the sea cucumber *Holothuria scabra*, and preparations are underway at the Sopa mariculture facility for a spawning run.



photo by Andrew Beer

Cockles are a popular seafood in Tonga

Part 2: Legislation, Policy and Management for Tonga's Aquaculture Sector

Aquaculture Management Act (2003)

Tonga's Legislative Assembly passed the Aquaculture Management Act in 2003. The Act has six parts that aim at providing legal guidance for aquaculture development. The main purpose of the Act is to:

“provide for the management and development of aquaculture in the Kingdom and other matters incidental thereof...”

The Act defines aquaculture to mean:

“any operation involving husbandry, cultivation, propagation or farming of fish, during the whole or part of its life cycle and includes any operation in preparation for any aquaculture or other related activity.”

The responsibilities of the Minister shall be:

“the control, management and development of aquaculture and any related activity, whether on land or in any aquatic area including marine area.”

The Act requires that there be a Management and Development Plan for the nation's aquaculture industry. The Act requires that there be an Aquaculture Advisory Committee to advise the Minister on matters related to aquaculture – such as policy, planning, management and development. The terms of reference for the Committee's workings and members are provided for by the Act. The Committee is a government and private sector initiative.

The Aquaculture Management Act states that persons, businesses or communities undertaking aquaculture must be licensed. It further states the requirements for renewing and refusing licenses or authorizations. The Act provides a system for resolving grievances. The Minister will give reasons (in writing) to the applicant, and the grievant applicant can appeal the decision to the Minister within 30 days of the Minister's decision. An aquaculture development license will be valid for the period stated in the license, which may not exceed 10 years. Should the license holder die, the heirs of the license holder may apply to the Minister for a new license.

The Secretary for Fisheries will maintain a register of aquaculture development licenses under this Act. The register is a public document. Should a licensee and/or authorized holder choose to cease operations before the end of their license's validity date, they must inform the Secretary at least 30 days prior to ceasing activity.

The Act requires that all applications should be accompanied by an environmental impact assessment. There is a concern expressed within the Act on the import of live fish and genetically modified species into Tongan waters. Such imports require written authorization from the Secretary for Fisheries, and the Minister.

The Act provides scopes for penalties and fines. It provides for regulations to be made by the Minister, with the consent of Cabinet, as necessary for the proper and efficient administration of the Act. The Act empowers the Minister to designate any officer of the Ministry of Fisheries or Police to be an aquaculture officer for the purpose of enforcing the Act.

Aquaculture Management and Development Plan

In pursuing the purpose of the Act, the Minister will prepare and keep the Management and Development Plan under review. The Management and Development Plan must be gazetted, and will be a guide and control mechanism to supplement the Act for aquaculture in the Kingdom of Tonga. The Management and Development Plan states that aquaculture should be based on six objectives:

- 1) The aquaculture industry will contribute to the economic development and social well-being of the people of Tonga.
- 2) The aquaculture industry will be environmentally sustainable.
- 3) The aquaculture industry will be managed in a manner that considers and balances economic and social gains against environmental costs.
- 4) The aquaculture industry will be managed within a transparent and explicit regulatory framework.
- 5) There will be broad community consultation on aquaculture developments that have the potential to impact on specific communities.
- 6) Aquaculture products grown for human consumption will be safe and disease free.

Including these objectives in the Management and Development Plan gives direction to managing aquaculture according to the Regulations of the Aquaculture Management Act. The Management and Development Plan provides for ways to process licenses.

Authorisation of land-based aquaculture on Crown Land requires that the proponent demonstrates that the applicant has a valid lease of the land under consideration, and that the Minister of Lands and Cabinet has approved the availability and use of that land for aquaculture. Under the Aquaculture Management Act and Regulations the Minister for Fisheries has the power to give leases (in the form of Permits to Occupy) for aquaculture areas in a manner equivalent and parallel to that allowed for terrestrial areas under the provisions of the Land Act.

Land and marine area tenure for aquaculture development licensing

The Aquaculture Advisory Committee has endorsed the option of the Ministry of Fisheries issuing Permits to Occupy in intertidal and subtidal areas for the purpose of aquaculture, subject to final agreement being reached between the Ministry of Fisheries and Ministry of Lands about this arrangement.

License applications are to be classified into three categories.

Category A classification includes proposals that involve little risk to the environment, and minimal risk of adverse social or economic impacts to communities in the immediate vicinity of the proposed aquaculture operation. This category is designed to cover largely self-contained operations. For example, freshwater raceways, freshwater cage culture of indigenous fish and self-contained ponds with no discharge outside the proponent's property boundaries.

Category B classification includes proposals that involve some impact on the social or economic welfare of adjacent communities, and may have some environmentally adverse consequences. The risks for the operation to cause long-term environmental perturbation should be low. For example, intertidal stick and rack culture, hanging bag culture (indigenous species), marine longline culture that involves no feeding (indigenous species), coastal marine hatchery (land based), and open marine water restocking with indigenous species.

Category C classification involves proposals that involve some impact on the social or economic welfare of adjacent or regional communities, and/or may have some environmentally adverse consequences. The risks for the operation to cause long-term environmental perturbation may be uncertain or moderate. For example, freshwater stocking with non-indigenous species, land-based pond culture using seawater (e.g. prawn farms, estuarine fish culture), marine longline culture that involves no feeding (non-indigenous species), cage culture of hatchery reared spat and/or fingerlings, and controlled on-growing of juveniles taken from the wild (indigenous species).

Licensing considerations

Assessment and approval or rejection of an application for an aquaculture license and/or permit to occupy should be risk-based, and reflect the potential environmental and social risks and costs, and economic and social gains associated with a particular aquaculture venture. More stringent demands for information, assessment and approval should be required for aquaculture ventures that carry more risk of imposing environmental, social or economic costs on third parties than simple, self-contained proposals.

All applications should include a business development plan that contains information on the following:

- » location and area of the proposed business;
- » nature of the operation, in terms of species to be cultured and method of aquaculture;
- » area of land or water proposed to be used for aquaculture;
- » infrastructure associated with the proposed aquaculture operation;
- » time over which the proposed aquaculture project is to be established, and phases in which the development is to occur;
- » proposed annual production schedule;
- » description of employment over the project's lifetime;
- » detailed management plan that describes procedures for dealing with disease, predators, biofouling, machinery breakdown, equipment failure, theft and other contingencies;
- » detailed, time-structured budget that estimates costs, income and cash flow throughout the proposed project's life;
- » markets for aquaculture product, market size, price structure of market;
- » details of the proponent's technical and management experience; and
- » summary of how the proposed aquaculture venture is to be financed.

Aquaculture Regulations 2008

His Majesty's Cabinet members passed the Aquaculture Regulations in 2008. The Aquaculture Regulations 2008 provide interpretations of aquaculture phrases and terms necessary for its management and development. They further provide mechanisms required for certification of aquaculture products by an aquaculture officer. The Aquaculture Regulations provide "Forms and Schedules" for applications for licenses or their renewal, and outline information related to production required by license owners, and the fees associated with applications and permits.

Part 3: Aquaculture Commodity Development Plans

Public workshops to formulate aquaculture commodity development plans were held in Tongatapu and Vava'u. These workshops were hosted by the Ministry of Fisheries and facilitated by the Secretariat of the Pacific Community.

Prioritization of commodities

A short-list of priority commodities was made from the potential candidates for aquaculture in Tonga. These commodities were scored as having the most potential to provide returns to livelihoods, food security and the environment because of their 1) *impact* in terms of widespread benefits and suitability for farming, and 2) *feasibility* in terms of capacity to access information technology and skills as well as the capacity to utilize regulations and infrastructure. Each commodity ranking in terms of impact and feasibility scores is shown in the table below.

Of the commodities that were assessed, those rated in the “high” category were: sea cucumber, coral and live-rock, mozuku seaweed, mabe pearl, trochus, kappaphycus seaweed, marine finfish and giant clam.



Table 1. Commodity ranking by Tongan aquaculture stakeholders

Prioritization of commodities		
Impact	High	<p>Sea Cucumbers</p> <p>Kappaphycus Seaweed</p> <p>Trochus</p> <p>Coral and Live Rock</p> <p>Mozuku Seaweed</p> <p>Mabe Pearl</p>
	Medium	<p>Marine Shrimp</p> <p>Sea Urchin</p> <p>Tilapia</p> <p>Giant Clams</p> <p>Marine Finfish</p>
	Low	<p>Freshwater Prawn</p> <p>Post-larval Capture</p> <p>Mud crab</p>
		Feasability
		Low Medium High





Wild caught seacucumber being processed



Sea Cucumber

Culture requirements and costs: Hatchery and nursery techniques well-developed and use simple technology; low investment; suitable for multi-species facility; grow-out – limited information on time for grow-out to attain harvestable size; grow-out may be restricted to seagrass areas.

Primary market: Strong market demand from Asia for dried and high quality processed product.

Advantages of aquaculture: Ease of export into existing marketing channels; potential polyculture with other species; possibility that grow-out costs will be low; could be incorporated into a community management programme in conjunction with wild harvest.

Disadvantages of aquaculture: Cost of hatchery juvenile production; lack of established technology for full-term grow-out; centralized hatchery and nursery; tenure and ownership issues for grow-out.

Immediate action	Within 2 years	Within 5 years
<p>Animals have relatively complex biology so initial emphasis on understanding life cycle</p> <ul style="list-style-type: none"> » Spawning trials, larval culture » Refining culture techniques to improve product quality » Minimize environmental impacts » Investigate ideal grow-out areas » Support fisheries restrictions » Get community involvement » Carry out market analysis 	<ul style="list-style-type: none"> » Review farm-gate prices » Increase export opportunities » Expand farming sites and areas » Refine processing techniques 	<ul style="list-style-type: none"> » 10-20% of market saturation from cultured product » Identify environmental risk factors such as poor water quality, nutrient levels, habitats damage » Specify designated culture areas » Ensure policy and regulatory guidelines for marine farm tenure and resource conflict issues



Tonga fisheries staff transferring artificial live rock to the ocean grow-out site



Coral and Live Rock

Culture requirements and costs: Use of second-generation coral fragments as seed stock; local materials can be used for live-rock base; simple technology.

Primary market: Live export to aquarium trade; dried for curio market.

Current production status: Cultured coral and live rock is exported from several Pacific Islands.

Advantages of aquaculture: Low technology; low cost; suit family-based operations; consumer preference for cultivated product versus wild product.

Disadvantages of aquaculture: Risks and costs associated with air freighting a live product; availability of coral species; susceptibility of farms to storm damage.

Immediate action	Within 2 years	Within 5 years
<ul style="list-style-type: none"> » Conduct site surveys » Identify capable partners » Compile a list of farm equipment and materials » Identify appropriate coral species » Conduct scientific literature review of sustainability issues for live rock » Re-establish live rock quota with a commitment to consider the outcome of studies in years 2 and forward » Establish a code-of-practice » Limit aquaculture licenses to competent companies » Establish and stabilize market price paid to contractors » Investigate duty and tax concessions in place for similar industries (5-year period) » Establish realistic community expectations of market value of ornamental products 	<ul style="list-style-type: none"> » Support ecotourism » Evaluate the market size to assess production limits » Review the Fisheries and Aquaculture Act to see if changes are necessary » Explore different shapes and sizes for market variety » Review existing legislation to assess the practicality of possible restrictions » Review industry goals and future market » Fisheries and industries to continue community awareness programmes » All industry players should complete environmental impact assessment prior to wild harvest » Fisheries to assist private sector to meet OIE¹, CITES² and requirements of other trade regulatory organizations 	<ul style="list-style-type: none"> » Stabilize the market and explore the possibilities of new product » Identify those species that are good for aquaculture with the idea of focusing on wild harvest quota with a limited number of species » Look at the realistic possibilities of slowing and/or phasing out of wild harvest quota for live-rock in favour of aquaculture production. » Develop a national quota for wild harvest

1. OIE - World organization for animal health

2. CITES - Convention on International Trade in Endangered Species of Wild Fauna and Flora



Cleaning mozuku seaweed prior to packaging and export



Seaweed (Mozuku and Kappahycus)

Culture requirements and costs: Hatchery and nursery – no requirement due to collection of cuttings as seedstock or spores; grow-out techniques have been developed; low-cost operation.

Primary market: Mozuku is used in Japanese cuisine. Dried kappahycus seaweed is refined to extract carrageenan.

Current production status: Tonga is the only Pacific Island exporter of mozuku. Kappahycus seaweed has been widely farmed in the region for several decades.

Advantages of aquaculture: Low technology; low-cost operation; suits village production; non-perishable nature of product once dried; large number of lagoon areas for potential grow-out.

Disadvantages of aquaculture: Highly competitive sometimes, volatile market; potentially high freight costs; grazing by fishes; maintaining quality against moistures and debris; sun-drying requires protection from the rain.

Immediate action	Within 2 years	Within 5 years
<ul style="list-style-type: none"> » Establish a regulatory environment, quotas » Analyze constraints and opportunities for industry <p>Harvesting:</p> <ul style="list-style-type: none"> » Conduct workshops to ensure quality controls and standards » Register divers and farmers » Formalize the role of communities and ensure that quality standards are adhered to <p>Processing:</p> <ul style="list-style-type: none"> » Identify the processes for export marketing » Assess different processing techniques (e.g. fresh, dried) » Investigate value-added opportunities (For example, take into account that it costs \$7/150 g in New Zealand for green salad) <p>Marketing/Export:</p> <ul style="list-style-type: none"> » Undertake a market survey (e.g. Japan, USA) » Review overlap with other agriculture (e.g. squash, fertilizers from pressed seaweed) 	<p>Harvesting:</p> <ul style="list-style-type: none"> » Register of harvesters in place » Local groups formally established » Investigate need for an private-sector group association <p>Processing:</p> <ul style="list-style-type: none"> » Assess the capacity and type of processing plants applicable to Tonga » Investigate integration of aquacultural, agricultural and fisheries processing so that products are continuously available <p>Marketing/Export:</p> <ul style="list-style-type: none"> » Markets clearly identified and the type of products most suited 	<ul style="list-style-type: none"> » With processing plants established there will be a share of wild and farmed product harvested » Premium grounds for harvesting are identified and grid for quotas established » Formalized contracts in place between harvesters and processors to maintain quality, beach-price in relation to market price, demand » Processing plants are established and markets solidified » Quota management system to be reviewed on a yearly or regular basis » More input of scientific information regarding seasons and life cycle for collection » Tongan seaweed is viewed as a high-quality brand



Pearl farmer in Vava'u, holding a grow out panel net with adult Mabe shells



Mabe Pearl

Culture requirements and costs: Hatchery and nursery – hatchery breeding is possible; spat collection from the wild is possible; grow-out techniques developed; medium-cost operation. Mabe culture from the winged pearl oyster (*Pteria*) requires a half-pearl bead being glued on the inside of the shell, which is a simpler and less costly operation than producing round pearl.

Primary market: Pearl jewelry and handicrafts. Good domestic market, and potential to grow the international market for high quality pieces.

Current production status: Tonga is the only producer of *Pteria* mabe pearl in the Pacific.

Advantages of aquaculture: Low-cost operation; suitable for family groups; non-perishable and easily transported product; hatchery breeding of *Pteria* is simple; economic and marketing factors are known; short period between startup and harvest; opportunities exist to diversify and create value-added pearl products.

Disadvantages of aquaculture: Quality control required; regular supply of spat requires a hatchery; small business skills and acumen are essential; secure marine tenure (property rights) required; onsite security to prevent poaching.

Immediate action	Within 2 years	Within 5 years
<ul style="list-style-type: none"> » Fisheries to continue providing hatchery spat » Training in mabe pearl seeding » Information on materials and equipment list, costs, suppliers » Experimental license provided » Formulate a business plan template » Fisheries to support project proposals for research and development of the industry (ACIAR project/EU grants) » Conduct a survey of areas to find most suitable locations (taking into account depth, water quality, currents, etc.) 	<ul style="list-style-type: none"> » Pearl farmers association operating and transparent » Farmers move to proper licensing class (protect their tenure) » Assess market demand, size, domestic versus international market and carry out trial exports 	<ul style="list-style-type: none"> » Establish Tonga pearl brand and trademarks (needed for the pearl guild) » Assess the viability of relocating the pearl hatchery to Vava'u » Establish industry quality standards (thickness of nacre, pearl grades A, B, C, etc.) » Tonga is providing high-quality pearl mabe and shell carving products compared with black pearl mabe, shell in Cook Is., French Polynesia, etc. » Deal with poaching problems (license pearl sellers?)



Tridacna derasa broodstock in a tank



Giant Clam

Culture requirements and costs: Hatchery techniques are well developed and simple; low investment; suitable for a multi-species facility. Nursery techniques are well developed. Grow-out – low-cost technology, mortality from predation can be high; long timeframes for grow-out if larger sized clams are desired.

Primary and secondary markets: Live for aquarium market; fresh meat sold as delicacy; clams can be used for ecotourism dive spots; adults returned to the wild to support restocking programmes.

Current production status: About half a dozen Pacific Islands export ornamental giant clams, including Tonga.

Advantages of aquaculture: Low technology; low cost; suits a family-based operation; good export demand; cultured clams are exempt from CITES export quota.

Disadvantages of aquaculture: Regular cleaning and maintenance of farm grow-out required to prevent predators; risks associated with live export; common marketing required; trade certification requirements; availability of broodstock; damage from rough seas; poaching of edible clams.

Immediate action	Within 2 years	Within 5 years
» Re-establish and maintain the central giant clam hatchery at Fisheries	» Begin grow-out of giant clam in communities for ornamental species » Develop ecotourism in association with coral	» Investigate prospects for transferring technology and education to enable communities to breed (simple, static-flow hatchery) and grow their own clams



Marine fish for sale at Nukualofa market



Marine Finfish (Capture-based Aquaculture)

Culture requirements and costs: Hatchery and nursery: capture of wild juveniles is required; hatchery breeding is possible. Grow-out: cage culture techniques widely known; medium-cost operation; good quality fish feed is required; aquaculture training required. Capture-based aquaculture relies on sustainably trapped juveniles from the wild being farmed in ponds or lagoon cages. Species most applicable to Tonga include milkfish (*Chanos chanos*) and rabbitfish (Siganidae).

Primary market: Local or niche markets available; live milkfish juveniles can be sold as baitfish.

Current production status: Capture-based aquaculture of milkfish is a traditional activity that is widely practised in the region. There are few commercial operators in the region farming marine finfish.

Advantages of aquaculture: Can benefit areas where juveniles recruit *en masse*; suitable for family units; farmed product can avoid seasonal gluts and can be harvested when prices are high.

Disadvantages of aquaculture: Juvenile recruitment patterns need to be known; assessment of site suitability for farming; aquaculture training needs; weak marketing analysis of food and bait demand; poaching from cages.

Immediate action	Within 2 years	Within 5 years
<ul style="list-style-type: none"> » Understand recruitment process of juvenile fish for capture-based aquaculture » Control illegal and destructive fishing practices that impinge on juvenile capture » Enforce net size restrictions to protect broodstock » Provide education on ways to reduce environmental impacts » Investigate ideal grow-out areas and their environments » Market analysis » Community security involvement 	<ul style="list-style-type: none"> » Refine diet and husbandry techniques to improve growth rates » Identify environmental risk factors such as poor water quality, nutrient levels » Review markets and/or economic importance of cultivated species » Expand farming sites and areas » Refine post-harvesting techniques and value-added products 	<ul style="list-style-type: none"> » Re-evaluate the point for market saturation from cultured product » Identify designated culture areas » Address tenure issues



Holding juvenile trochus underwater



Trochus

Culture requirements and costs: Hatchery: simple technology; low investment; suits multi-species facility; grow-out – juveniles are simply released into the wild.

Primary market: Established international shell market. Trochus shell (mother-of-pearl) is used for jewellery inlay and handicrafts.

Current production status: Enhancement programmes have been trialed throughout the Pacific Islands.

Advantages of aquaculture: Established fishery and market; simple hatchery and nursery technology; trochus enhancement often used as tool for community management programmes.

Disadvantages of aquaculture: Low survival rate of juveniles in release stages.

Immediate action	Within 2 years	Within 5 years
<p>Awareness:</p> <ul style="list-style-type: none"> » Awareness programme and/or activities carried out on trochus, value-adding opportunities, aquaculture, etc. <p>Harvesting and Processing:</p> <ul style="list-style-type: none"> » Draft a management plan » Draft license agreements » Provide training in farming, harvesting, processing, etc. <p>Export/market:</p> <ul style="list-style-type: none"> » Search for market prices and best available markets » Training provided in value-adding, handicrafts, etc. <p>Monitoring and Management:</p> <ul style="list-style-type: none"> » Survey the stock resource » Implement management plan » Approve licenses 	<p>Awareness:</p> <ul style="list-style-type: none"> » Review awareness programmes and activities <p>Harvesting and Processing:</p> <ul style="list-style-type: none"> » Review Management Plan » Review license agreements <p>Export/market:</p> <ul style="list-style-type: none"> » Review market prices and best available markets <p>Monitoring and Management:</p> <ul style="list-style-type: none"> » Re-survey trochus resources to assess sustainability of harvests » Review the Management Plan and implement recommended changes » Review license conditions 	<ul style="list-style-type: none"> » Trochus management regime is assessed to have no detrimental environmental impacts and is ecologically sustainable » Best export market opportunities are being utilized

Overarching Issues to be Addressed

Some overarching issues raised by government and industry stakeholders include:

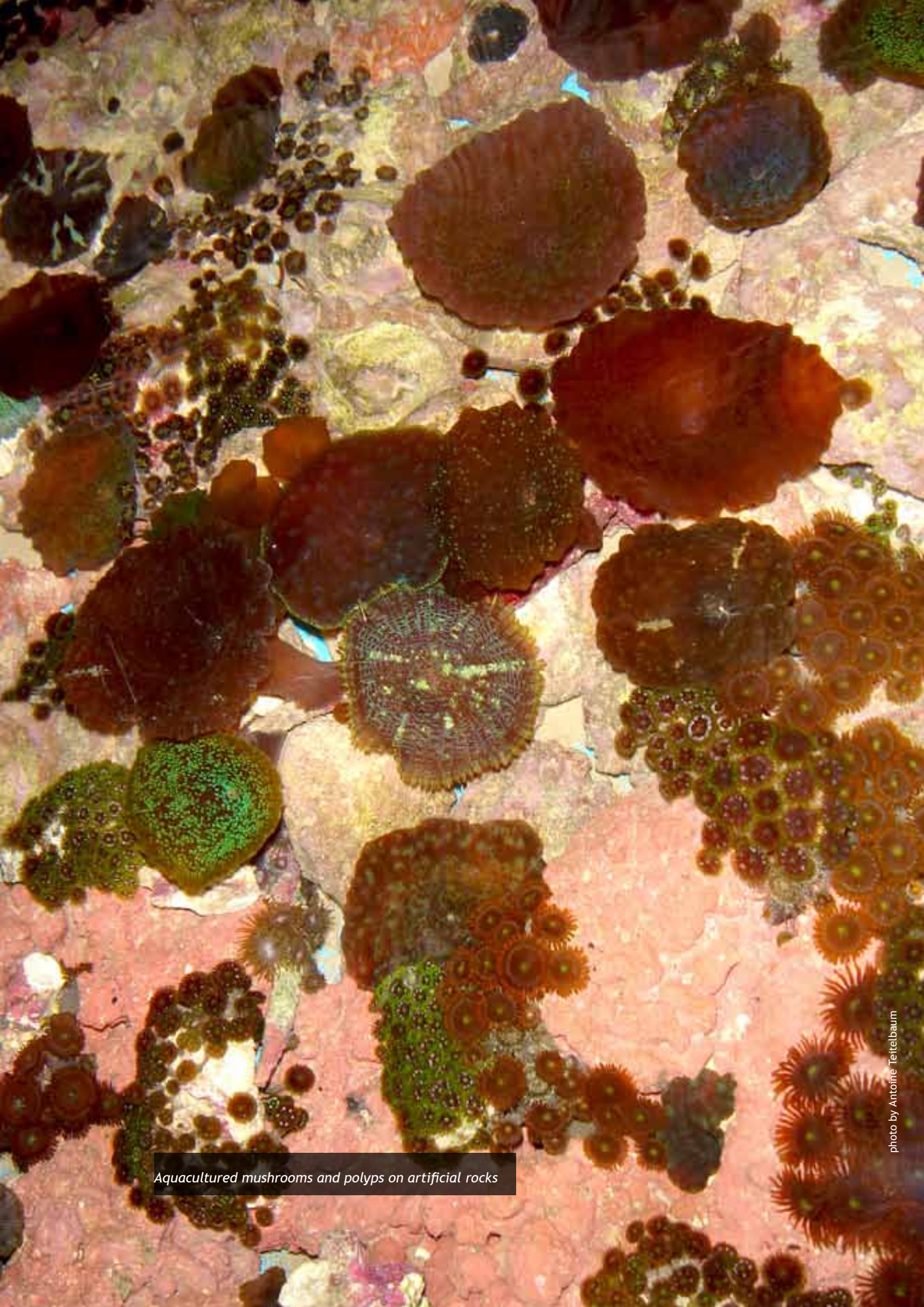
- » How to access funding and if there are lessons to be learned (e.g. from the squash council).
- » What synergies can be explored between agriculture (an established sector and political base) and aquaculture?
- » What taxation system should apply, and would there be any industry concessions (e.g. is there an overlap with tuna fisheries)?
- » Can the high cost of scientific studies for industry be met by regional organizations or NGOs if the government supports these applications?
- » How will aquaculture help diversify and support export industries in Tonga (what will be the impact of policy decisions from the National Export Strategy and National Economic Development Council)?
- » What role should government departments play (e.g. inter-related fisheries and trade issues)?
- » How can government reassure the public that the aquaculture industry is a sustainable opportunity?
- » Is the licensing regime able to keep pace with research, development and commercialization processes (i.e. restrict entry and control quality standards)?
- » In which areas can government provide financial assistance (e.g. fuel)?

A timeframe to address these concerns was outlined.

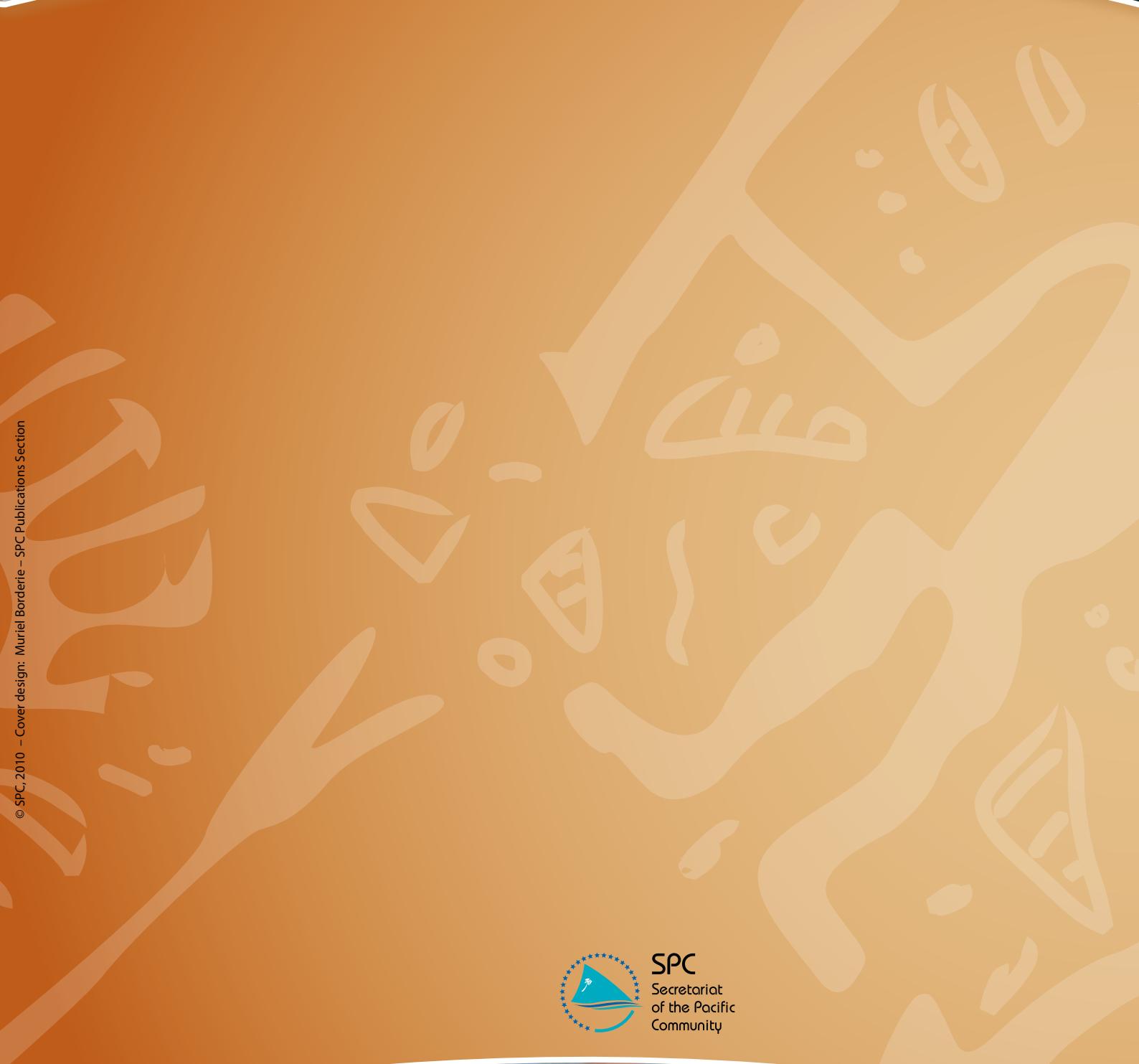
Table 2. Actions to address overarching concerns

Immediate action	Within 2 years	Within 5 years
<ul style="list-style-type: none"> » Involve communities by providing training and raw materials for various aquaculture products » Limit participation (aquaculture licenses) to those companies involved in the industry, with adequate knowledge of farming and market demands » Establish a code of ethics for all participants » Develop ways and means to apply for duty and tax concessions for aquaculture equipment and materials, as are now in place for similar industries (5-year period) » Seek donor support in acquiring financial assistance with financial institutions and labor and commerce » Re-establish quota with a commitment to consider the outcome of studies in years 2 and forward » Get all industry players to commit to their involvement in aquaculture » Involve communities by providing training and raw materials for various aquaculture products » Develop awareness programmes through an appointed fisheries representative (for consistent message) » Make use of the media to explain the use of a natural renewable resource for the benefit of communities 	<ul style="list-style-type: none"> » Review existing legislation to access practicality in terms of possible restrictions » Review industry goals and increased market demand (if any) » Develop ecotourism » Support educational work combining fisheries and industries to work with community awareness » Work on sustainability issues with Fisheries, and conduct scientific literature review of sustainability issues » Commitment from Fisheries to move forward with involvement in OIE and CITES³ and other trade regulatory organizations » Make use of the media to explain the use of a natural renewable resource for the benefit of communities » Establish guidelines for realistic market demand » Ensure communities have realistic expectations of market value 	<ul style="list-style-type: none"> » Look at the realistic possibilities for slowing and/or phasing out the wild harvest quota, in favour of aquaculture production » Fisheries management plans ensure that wild harvest does not affect broodstock or juveniles used for capture- based aquaculture » Market quality control standards adopted and enforced

3. OIE - World organization for animal health; CITES - Convention on International Trade in Endangered Species of Wild Fauna and Flora



Aquacultured mushrooms and polyps on artificial rocks



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