Fisheries Newsletter

Number 121 (April – June 2007)

Editorial

Welcome to the latest issue of the *Fisheries Newsletter*. We present a very interesting feature article on a canoe building and inshore fish aggregation device project in Nauru. The aim of this project is to reduce pressure on the overexploited nearshore fishery resources and to provide food security for Nauruans.

I also draw your attention to page 34 to a contribution by Wesley Garofe and Gideon Tiroba on the impact of the recent tsunami on aquaculture activities in the Solomon Islands, particularly on marine coastal areas of central Western and Choiseul provinces. The photos shown with the article speak for themselves.

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Grading of humpback grouper (*Cromileptes altivelis*) at Krabi Coastal Fisheries Research and Development Center, Thailand

in This Issue

SECRETARIAT OF THE PACIFIC COMMUNITY
Prepared by the Information Section of the Marine Resources Division and printed with financial assistance from France.

REEF FISHERIES OBSERVATORY

Staff of the coastal component of the EU-funded Pacific Regional Oceanic and Coastal Fisheries Development Programme (PROCFish/C) and the Coastal Fisheries Development Programme (CoFish) conducted fieldwork in the Republic of Palau. In addition, SPC's Live Reef Fisheries Specialist was involved in several projects, including training an attachment, and analysing data collected from a marine aquarium trade fish resource survey at Funafuti Atoll, Tuvalu.

Fieldwork and surveys in Palau

Finfish, invertebrate and socioeconomic surveys were conducted in four locations in Palau (Ngarchelong, Ngatpang, Airai and Koror, see Fig. 1) from April–June 2007. The sites were selected by Palau's Bureau of Marine Resources, in consultation with CoFish staff. Palau is the 16th country/territory to be surveyed as part of the PROCFish/C and CoFish project.

The PROCFish/C and CoFish team consisted of Kim Friedman, Kalo Pakoa, Emmanuel Tardy and Ferral Lasi (invertebrates); Silvia Pinca, Pierre Boblin, Ribanataake Awira and seconded field officer from Conservation International in Alatau, Papua New Guinea, Noel Wangunu (finfish); and Mecki Kronen (socioeconomics). The PROCFish/C and CoFish team acknowledge and thank the following people who assisted and/or worked with the team at one or more locations: Theofanes Isamu, Director of Marine Resources; Evelyn 'Anna' Perez and Lora B. Demei from the Bureau of Marine Resources; Adalbert Eledui, Manager of the Koror State Rangers; Rengechel Dlutaoch and Davis Rekemesik from the Department of Conservation and Law Enforcement of Koror State; boat skippers and helpers, including Harvey Renguul, Elizer Ngotel, Lorenzo Osilek, Gerda Darrow, Takao Teriong, Wenceslao Niones, McCarthy Kotaro and Sorens Meyar; Sam's Tours Dive Shop for equipment support; Chief Marcelino Augustine, Valentino Kloulchad, Jackie Emmanuelle, Elizeder Elendui, Roger Rumong, Roy Fransiso and Cleoffas Iyan for their excellent support during the socioeconomic fieldwork; the Governors of the four States; the Youth Department of the State of Koror; Anne Kitalong and the Women's Group from Airai; and the elders, community members, fishers and people from the four survey sites for their support and cooperation.

Field logistics and the availability of vessels meant that the CoFish disciplinary teams worked independently of each other, with the invertebrate team going to and working with local counterparts at each of the four sites. As the invertebrate team finished their work, the finfish team arrived in Palau and used the same approach, with each site being surveyed in three to four days. Socioeconomic surveys were also conducted separately after the completion of invertebrate and finfish surveys. Counterpart officers were rotated during the different surveys to maximise training and skills transfer.

NGARCHELONG

Ngarchelong village is located at the extreme north-northwestern tip of the island of Babeldaob, the main island of the Palau archipelago. Ngarchelong has a com-

Figure 1: The four survey sites in Palau

plex reef system that extends 30 km outward (in a NE and NW direction) from the main island. The fishing area, which extends north about 13 nautical miles, is an open access area. Figure 2 shows the location of invertebrate survey dive sites.

The southern lagoon receives little terrigenous influence from the rivers, however, this is not the case in the northern lagoon. The coastal reefs are generally bordered by small areas of mangroves. Intermediate reefs are more abundant in the northern area. Eastern area reefs, as well as all back reefs, are very sandy. A 90 km^2 marine conservation area is located in the northwest of this area, and this reserve has been in effect since 1994.

The general status of corals was fairly good at both coastal and intermediate reefs, although it was very poor at some sites, with coral rubble covered in encrusting brown sponges, algae and turfs (Fig. 3). Better coral coverage was found at sites in front of the northern islands, where there were many table and branching corals. On the outer reef, coral coverage was fairly high in the shallows (flat reef) with many soft corals (*Lemnalia*), and branching (*Pocillopora*) and tabulate (*Acropora*) hard corals. Coral cover varied, however, with areas of barren bedrock with some rock boulders covered with turfs and encrusting algae, mixed with diverse, massive and submassive *Porites*, tabulate, encrusting and digitate corals that were abundant, especially at depths greater than 20 m.

Ngarchelong's fish biodiversity was very high, although density was rather average, and mean fish sizes were small (Fig. 4). At first sight this area appeared heavily exploited by fishermen. Fish everywhere reacted warily, including inside the reserve, suggesting that spearfishing is very common. Only rarely were large-sized species of parrotfish observed (e.g. *Scarus altipinnis*, *Chlorurus microrhinus*, *Hipposcarus longiceps*). Similarly, a total absence of large groupers

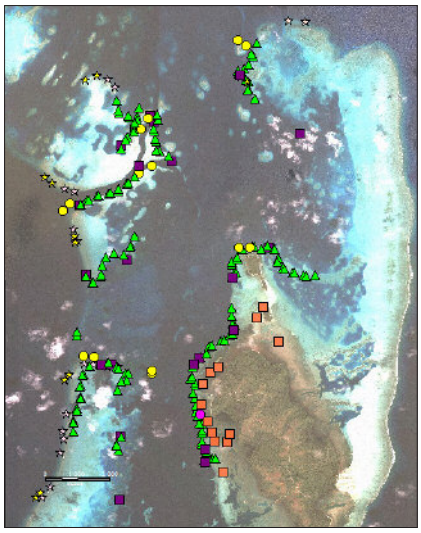


Figure 2 (top): Ngarchelong invertebrate survey locations

Figure 3 (middle): Porites coral in Ngarchelong's lagoon

Figure 4 (bottom): *Lutjanus gibbus*, *Hipposcarus longiceps*, *Naso lituratus* and *Acanthurus* spp.

and Napoleon wrasses was noted, as well as other carnivores. *Lutjanus gibbus* was present but was very wary, and *Lethrinus harak*, *L. xanthochilus*, and *L. olivaceus* (see Fig. 4) were present only in small numbers. Apex predators were extremely rare.

At Ngarchelong, seven species of Tridacnidae were recorded during broad-scale surveys (manta tows) and more targeted invertebrate assessments of reef and soft benthos. Despite the low density of the true giant clam, *Tridacna gigas* (Fig. 5), this species was more numerous at this site than at any other (this was also true for *T. derasa*). In addition, both large adults and new recruitments were recorded on the reefs. The commercial topshell, *Trochus niloticus*, was unevenly distributed across the reefs in Ngarchelong (414 individuals recorded), with the highest numbers found close to shore. The average basal shell measurement of trochus was 90.2 mm. False trochus, *Tectus pyramis*, was also recorded in low densities, while the blacklip pearl oyster, *Pinctada margaritifera*, was relatively common (32 individuals recorded).

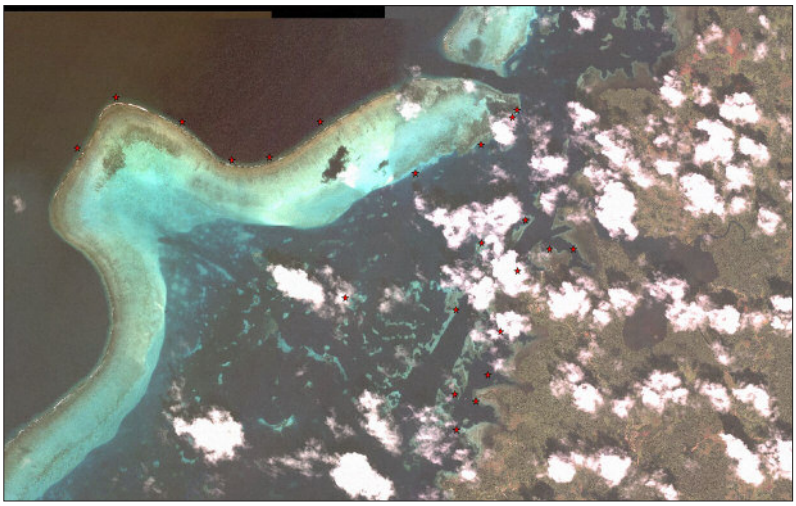
This site had a high number of sea cucumber species (22 species), which reflected the diversity of habitats present and the level of protection given to this resource (i.e. no commercial exporting activity allowed). Seven lobster species were noted and, burrows of the banded prawn killer, *Lysiosquillina maculata*, were regularly recorded on sandy bottoms.

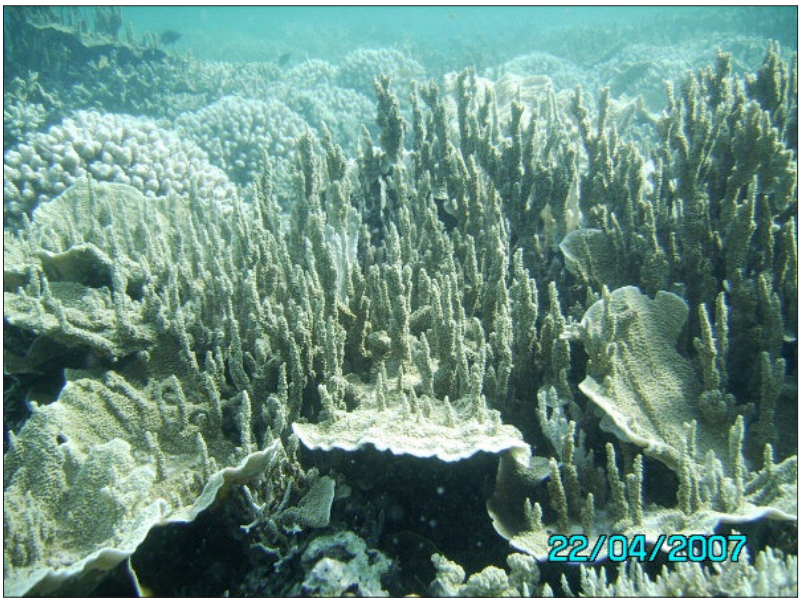
Socioeconomic surveys in Ngarchelong were conducted among 25 households, covering 87 people. In addition, surveys were conducted with 23 finfish fishers (16 men and 7 women) and 15 invertebrate fishers (5 men and 10 women). Around 55% of the surveyed households listed salaries as their first income source, while fisheries only accounted for around 12%. However, 24% of those surveyed listed fisheries as their second source of income. Seafood consumption in Ngarchelong was moderate at 57 kg/capita/year; finfish were consumed on average 4.3 days/week, invertebrates consumed 0.6 days/week, and canned fish 1.6 days/week.

The average household size in Ngarchelong was three people, with 1.2 fishers/household. About 48% of all men and 14% of all women surveyed targeted finfish only. No men specifically targeted invertebrates, while 10% of all women surveyed did.

About 10% of all men surveyed and 17% of all women surveyed were involved in both finfish and invertebrate fishing. Finfish catches were primarily for sale (over 80%, some of the catch was sold cooked; Fig. 6), while less than 20% was for home consumption. The vast majority of invertebrates collected were for home consumption, with only a small number sold (Fig. 6).

Figure 5 (top): *Tridacna gigas*
Figure 6 (bottom): Ngarchelong women selling cooked fish (left) and clam meat (right)





Ngatpang

The second survey site was in Ngatpang State (Fig. 7), 28 km southwest of Ngarchelong. Ngatpang is on the western side of Babeldaob Island. The fishing area, which is open access, is approximately 9.5 km long and 6 km wide. Figure 7 shows the finfish dive sites in Ngatpang. A small 1.5 km^2 reserve is located within this fishing area.

The four typical marine habitat types were present at this location (i.e. back reefs, inner reefs, outer reefs, and lagoon). However, the diveable back-reefs were only found in the northern part (80% of back reefs were sandy and were unable to be surveyed by the divers). The lagoon was subject to heavy terrigenous influence due to the numerous rivers that flow into this area. As a consequence of the high levels of sediment entering the water, a high number of filtrating sponges were present.

Corals were fairly diverse and healthy, especially on the coastal and back reef habitats, with many different forms present (submassive, digitate, foliose, encrusting and branching; see Fig. 8) as well as several types of soft corals (e.g. *Lemnalia* and *Dendronephtya*). On the outer reefs, coral cover was high at depths greater than 10 m, with many tabulate (Fig. 9), massive, branching, and encrusting forms, as well as some soft corals. Less coral cover was found at the intermediate reefs, especially on the reef flat.

Figure 7: Ngatpang finfish dive locations

Figure 8: Branching and submassive corals on Ngatpang's intermediate reefs

Figure 9: Tabulate *Acropora* at Ngatpang's outer reefs

In general, fish at Ngatpang were very wary and were small in size. There was no difference in the number of fish observed inside the reserve vs outside the reserve, despite the fact the reserve has been in effect since 2003. There were very few large Scaridae (*S. altipinnis*, *C. microrhinus*, *Hipposcarus longiceps*), and *Bolbometopon muricatum* was basically non-existent. Lethrinids were represented by *Lethrinus xanthochilus*, *L. obsoletus* and *Monotaxis grandoculis*. Lutjanids were represented by Lutjanus gibbus and *L. fulvus* as well as *L. biguttatus* and *L. lutjanus* (Fig. 10). Fish biodiversity was high, although apex predators were very rare.

Tridacnidae were common, with seven species recorded. The fluted giant clam, *Tridacna squamosa*, was relatively abundant (52 individuals noted). The commercial topshell, *Trochus niloticus*, was not common at this site (only 33 individuals noted) nor was the false trochus, *Tectus pyramis*, which has a relatively similar life strategy. Blacklip pearl oysters, *Pinctada margaritifera* (23 individuals) were relatively common.

Sea cucumber diversity was high (24 species), reflecting the range of habitats present and the positive affects of marine protected areas, which ban artisanal fishing activities in seagrass areas close to Ngatpang. Fishing and processing of sea cucumbers (Fig. 11) is still practiced in this area. Although specific night-time searches of reef fronts were not made, four lobsters were observed.

Socioeconomic surveys in Ngatpang were conducted among 25 households, covering 116 people. In addition, surveys were conducted with 23 finfish fishers (19 men and 4 women) and 16 invertebrate fishers (10 men and 6 women). Around 85% of the surveyed households listed salaries as their first income source, while fisheries only accounted for around 8%.

However, 20% of those surveyed listed fisheries as their second source of income. Seafood consumption in Ngatpang was moderate (62 kg/capita/year): finfish were consumed on average 4.1 days/week, invertebrates consumed 0.6 days/week, and canned fish 1.7 days/week.

The average household size in Ngatpang was four people, with 1.3 fishers/household. About 60% of all men surveyed primarily targeted finfish, while none of the women surveyed fished for finfish. Only 4% of all men surveyed specifically targeted invertebrates, while 12% of women did. Those people that were involved in both finfish and invertebrate fishing consisted of 13% men and 13% women. Finfish catches were primarily for sale (around 60%), while around 40% were for home consumption. The majority of invertebrates collected were for home consumption, with only a small number sold.

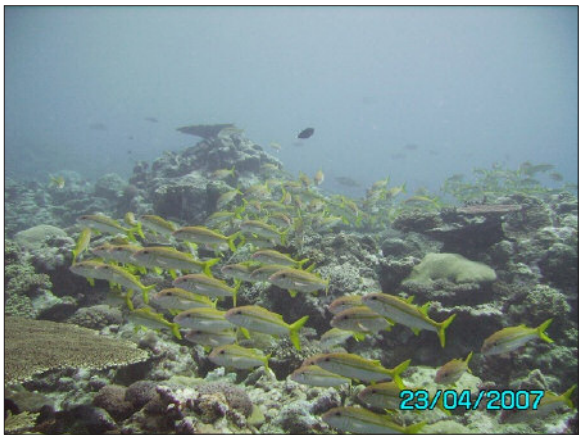


Figure 10 (top): *Lutjanus lutjanus*, outer reefs

Figure 11 (bottom): Processing sea cucumbers at Ngatpang

Airai

Airai village is in the south-southeastern side of Babeldaob Island (Fig. 1). The fishing area (Fig. 12) is delimited in the north by the southern part of Ngemelachel Pass, and in the south by an east–west line extending eastward from the southern channel of Babeldaob. There are two reserves in this area, one established in 1994 (1 km^2) and the other established in 1997 (1 km^2).

Airai has the four main marine habitats (i.e. back reefs, inner reefs, outer reefs, and lagoon). The lagoon was relatively shallow (30–40 m) with few intermediate reefs, which were mostly found in the extreme northern and southern areas. Corals were rare and unhealthy in the lagoon, but appeared more abundant and healthy on the outer reefs and in the northern back reefs, although they were limited in number and area. Often the reef, especially in the coastal area, consisted of coral slab covered in coralline algae and turf. In the intermediate habitats, the coral was covered in macroalgae (e.g. *Sargassum*, *Padina*, *Halimeda*) and seagrasses.

As with the other two sites, fish were wary of divers, indicating that spearfishing was one of the main fishing methods. Fish biodiversity as well as abundance appeared to be less than at the other sites, and fish sizes were generally small. Very few scarids were recorded, and *Bolbometopon muricatum* and *Cheilinus undulatus* (Fig. 13) were represented only by small juvenile individuals. Carnivores (lethrinids and lutjanids) were rare and apex predators very rare. Most transects were dominated by herbivorous *Ctenochaetus striatus* and *Chlorurus sordidus*.

All endemic Tridacnidae were recorded at Airai (seven species noted), although the total number in records was moderate compared with other sites. The commercial topshell, *Trochus niloticus*, was common at this site (604 individuals noted) as were false trochus, *Tectus pyramis* (134 individuals noted). The average basal shell measurement of trochus was 96.4 mm. Blacklip pearl oysters, *Pinctada margaritifera*, were less evident at both of the southern sites of Airai and Koror (17 individuals).

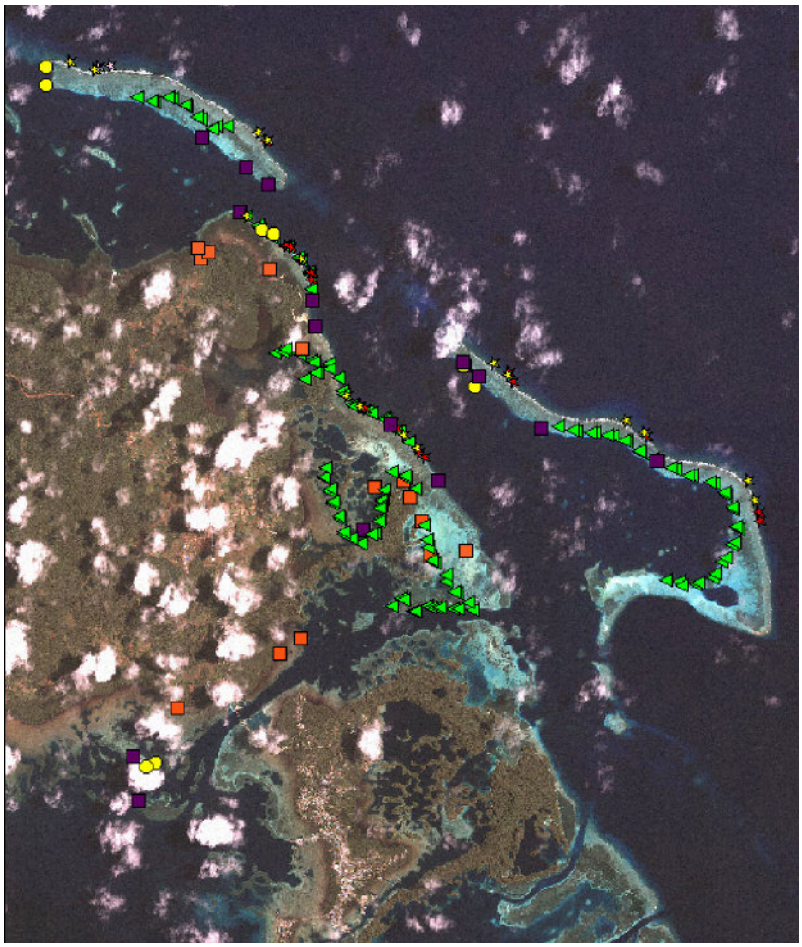


Figure 12 (top): Airai invertebrate survey locations

Figure 13 (bottom): Juvenile *Bolbometopon muricatum*

Sea cucumber diversity was high (23 species; see Fig. 14), reflecting the range of habitats, from inshore seagrass beds, to the oceanic-influenced barrier reef. Despite not conducting specific night-time searches of reef fronts, 14 lobsters were observed.

Socioeconomic surveys in Airai were conducted among 27 households, covering 134 people (Fig. 15). In addition, surveys were conducted with 25 finfish fishers (17 men and 8 women) and 14 invertebrate fishers (5 men and 9 women). Around 52% of surveyed households listed salaries as their first income source, while fisheries only accounted for around 14%. Another 15% of those surveyed listed fisheries as their second source of income. Seafood consumption in Airai was high at around 70 kg/capita/year; finfish was consumed on average 4.0 days/week, invertebrates consumed 0.9 days/week, and canned fish 2.1 days/week.

The average household size in Airai was four people, with 1.3 fishers/household. About 45% of all men surveyed primarily target finfish, while only 3% of women target finfish only. No men specifically targeted invertebrates, while 8% of women did. Those people that were involved in both finfish and invertebrate fishing consisted of 20% men and 23% women. Finfish catches were primarily for sale (around 80%), while around 20% were for home consumption. The majority of invertebrates collected were for home consumption, with only a small number sold.

Figure 14 (top, middle): A range of sea cucumber species in seagrass areas at Airai

Figure 15 (bottom): Survey in Airai

Koror

Koror Island is the capital of Palau and is located south of Babeldaob Island (Fig. 1). The general fishing grounds extend from Koror in the north to Peleliu Island in the south, although specific areas were requested and identified by the Conservation and Law Enforcement Department of Koror State to be surveyed for fish (Fig. 16). The Koror area has a range of reserves and protected areas.

Corals were in poor condition, either broken, diseased or attacked by crown-of-thorns starfish, especially in intermediate and back reef habitats. Most inner coral reefs still showed evidence of recent bleaching events. Outer reef corals were in better condition with good cover at German Channel (Fig. 17).

Only three habitat types were surveyed here: back reef, intermediate reef and outer reef. Although these habitat types are normally abundant in fish, this survey found fish at this site to be small and in low to moderate densities. No surveys of reserve areas were allowed, so we were unable to make comparisons of fished and non-fished areas. The survey site with the most abundant and diverse fish species was at German Channel, which is a well known dive site for tourists.

All species of Tridacnidae were recorded at Koror (seven species noted), including large numbers of mature sized *T. maxima* (1020 individuals noted) and the endemic *Hippopus porcellanus*, which has a restricted range in the Pacific (Fig. 18). The commercial topshell, *Trochus niloticus*, was common (720 individuals noted) as were false trochus, *Tectus pyramis* (165 individuals noted). The average basal shell measurement of trochus was the same as at Airai, at 96.4 mm.

Sea cucumber diversity was high (21 species), reflecting the

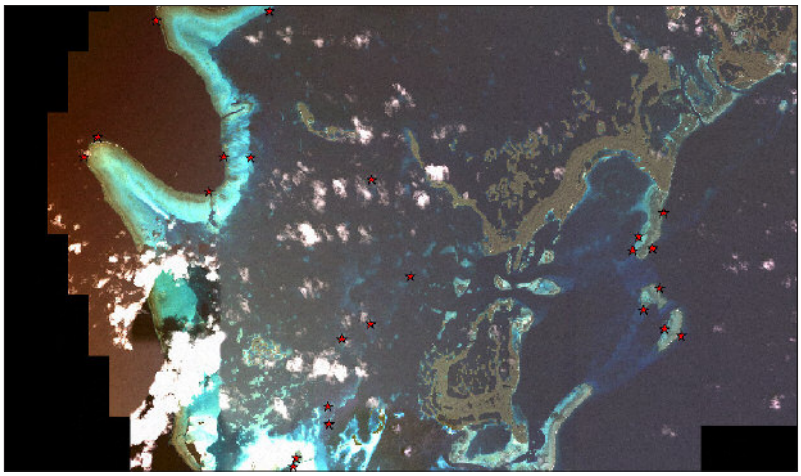


Figure 16 (top): Finfish survey locations
Figure 17 (middle): Corals at German Channel
Figure 18 (bottom): First PROCFish/C record of *Hippopus porcellanus*

scale and range of habitats present and the protection afforded to the fishery, although generally, density was not as high as at northern survey sites. Despite not conducting specific nighttime searches of reef fronts, 24 lobsters were observed.

Socioeconomic surveys in Koror were conducted with 51 households (25 from Meyuns and 26 from Ngermid), covering 244 people (Fig. 19). In addition, surveys were conducted with 30 finfish fishers (24 men and 6 women) and 15 invertebrate fishers (6 men and 9 women). Around 72% of surveyed households listed salaries as their first income source, while fisheries only accounted for around 5%. Another 5% of those surveyed listed fisheries as their second source of income. Seafood consumption in Koror was the highest, at around 75 kg/capita/year; finfish were consumed on average 4.5 days/week, invertebrates consumed 0.8 days/week, and canned fish 2.2 days/week.

The average household size in Koror was four people, with 0.9 fishers/household. About 58% of all men surveyed, primarily targeted finfish, while only 2% of surveyed women targeted finfish only. No men specifically targeted invertebrates, while only 5% of women did. Those people who were involved in both finfish and invertebrate fishing consisted of 19% men and 13% women. About 70% of finfish catches were primarily for sale, while the remaining 30% were for home consumption. The majority of invertebrates collected were for home consumption, with only a small number sold.

Figure 19: Local counterpart Harvey Renguul conducting a finfish survey

The Live Reef Fisheries Trade (LRFT) Initiative

Results from Funafuti Atoll's marine aquarium resource survey

A survey of Funafuti's marine aquarium resources was conducted in 2005, with Mr Tupulanga Poulasi from Tuvalu's Fisheries Department, attached to SPC (see SPC *Fisheries Newsletter* #120) in March/April 2007 to complete data analysis. The results were presented to the Government of Tuvalu in a technical report.

Overall, 74 species from 12 families — recorded during a survey of both lagoon reefs and outer reefs — were found to have potential for the marine aquarium trade. On the outer reef, the pomacentrids (damselfishes) were very well represented with *Pomacentrus vaiuli* being the most common species with an average density of 48 individuals/1000 m^2 of reef. Other pomacentrids with significant densities included *Pomacentrus pavo* (38 ind/1000 m^2), *Chromis iomelas* (23 ind/1000 m^2), *Chromis margaritifer* (22 ind/1000 m^2) and *Plectroglyphidodon johnstonianus* (15 ind/1000 m^2). Among the pomacanthids (angelfish), two species were quite common, *Centropyge flavissimus*, known more commonly in the aquarium trade as the lemon peel had an average density of 17 ind/1000 m^2 of reef and *C. loriculus*, flame angel, had an average density of 8 ind/1000 m^2 of reef.

On the lagoon reefs, the pomacentrids were very well represented but this time with *Chrysiptera cyanea* being the most abundant species with an average density of 166 ind/1000 m^2 of reef. *Pomacentrus pavo* was also very common with an average density of 117 ind/1000 m^2 of reef. The most common chaetodonid (butterflyfish) in the lagoon was *Chaetodon trifascialis* with an average density of 19 ind/1000 m^2 of reef, and the most common pomacanthid was *Centropyge flavissimus* with an average density of 15 ind/1000 m^2 of reef.

Using the mean densities of the different species from the survey, it was possible to estimate the stock of each fish species in the two different reef habitats (i.e. the lagoon reefs and the outer reefs), by multiplying the density of each fish species for each habitat per 1000 m^2 by the total area of lagoon reefs and outer reefs, respectively.

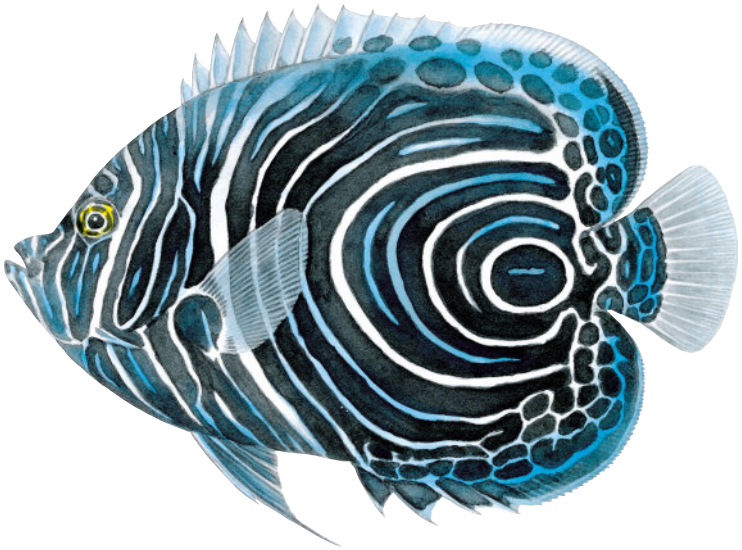


Figure 20: *Pomacanthus imperator*, emperor angel

Table 1: Stock estimates by fish family (all reef habitats) in Funafuti

Family	No. Species	Stock Estimate	StdErr_Stock
Acanthuridae	4	568,680	330,857
Balistidae	4	141,360	87,892
Blenniidae	1	111,067	79,366
Chaetodontidae	21	2,451,440	960,941
Cirrhitidae	1	67,253	51,902
Gobiidae	1	59,120	47,279
Labridae	20	1,929,267	1,134,216
Microdesmidae	1	34,267	27,898
Mullidae	1	154,013	108,141
Pomacanthidae	5	2,204,493	772,692
Pomacentridae	13	23,998,943	14,042,804
Zanclidae	1	57,293	27,892
Total	**73**		

Table 2. Stock estimates of Funafuti's 10 most important marine aquarium trade species

Species	Stock Estimates	StdErr_Stock	10% of stock
Pomacanthus imperator	3,427	3,427	343
Centropyge loriculus	235,480	83,484	23,548
Centropyge flavissimus	1,177,200	303,229	117,720
Labroides bicolor	450,800	229,890	45,080
Nemateleotris magnifica	30,840	24,471	3,084
Ctenochaetus strigosus	396,253	182,765	39,625
Gomphosus varius	231,640	102,644	23,164
Pomacentrus vaiuli	3,278,533	1,144,037	327,853
Plagiotremus laudandus	111,067	79,366	11,107
Thalassoma lunare	225,560	135,070	22,556

Looking at the stock estimates by fish family and number of species (Table 1), the four most abundant groups included pomacentrids — the most dominant group — with a total stock of about 24 million individuals, followed by chaetodontids with 2.5 million, pomacanthids with 2.2 million, and labrids with 1.9 million.

Of the 10 most valuable species recorded, Pomacanthus imperator (Fig. *20)*, with the highest potential value, has the smallest standing stock of about 3400 individuals. There were good stocks of *Centropyge loriculus* and *C. flavissimus*, two very popular species in the marine aquarium trade (235,000 individuals and 1.2 million individuals, respectively). *Pomacentrus vaiuli*, with its very high abundance of 3.3 million individuals, could also become an important species for the marine aquarium trade.

A calculation of sustainable yields will require good catch and effort data, which is not available as this is a new fishery under consideration. For such an unexploited fishery, the rule of thumb for harvesting is 10% of the calculated stock estimates per year, which is considered conservative enough as a start to allow the different fish species to be exploited in a sustainable manner. Table 2 presents the estimated stock harvest numbers for the top 10 species.

The results of the survey indicated that in Funafuti, there are at least 74 species that have potential for the marine aquarium trade. Given that no marine aquarium trade operations have existed there in the past, the stock estimate from the survey will provide an initial baseline of the standing stock of the different species. Stocks of some species, especially *Pomacentrus vaiuli* and *Chrysiptera cyanea*, are very abundant. The chaetodontids, pomacanthids and labrids are also quite abundant.

Given the current stock levels of the 10 most valuable species found in the survey, harvesting 10% of these stocks every year should support some marine aquarium trade operations. The 10% harvestable stock should be spread out over the year to dilute fishing pressure on the resources, and a limit should be set on the number of exporting companies. These two restrictions should be included in the development of a management policy and plan, which is necessary before any operations are allowed to start.

It is also very important for the Government of Tuvalu to note that, even though a resource might be available, it does not mean that a marine aquarium trade will be feasible to develop. An important consideration is the infrastructure and transport required to support such an export industry. The most obvious factor is the availability of airline connections from Funafuti to the market, including air cargo space available per flight, the number of transits and connecting times between flights, and freight costs. The availability of oxygen and packing materials, a reliable source of electricity for land facilities, and costs in general, are also important considerations. To fully understand the extent of these problems, the Government of Tuvalu should consider conducting an export trial.

KIRITIMATI ISLAND BONEFISH MANAGEMENT UPDATE: OUTCOMES OF THE BONEFISH MANAGEMENT CONSULTATION WORKSHOP

As part of the new plan of action (see *Fisheries Newsletter #120*) for the completion of the bonefish management plan, a public consultation workshop was coordinated and conducted by SPC's Live Reef Fisheries Specialist in association with Kiritimati's Ministry of Fisheries and Marine Resources Development (MFMRD) in mid-March 2007. Funding was provided by the Government of Kiribati.

The aims of the workshop were to identify major stakeholder issues and concerns, and to discuss these issues with regards to available technical and economic information, in order to develop the most appropriate and effective consensual management regime. The information would then be integrated into a bonefish management plan and regulations, where necessary.

The workshop was organised into three sessions. The first session included presentations by key speakers. The second session identified major issues and concerns, introduced and explained the Ecosystems Approach to Fisheries Management (EAFM) concept, and applied the approach for developing a management system for the bonefish fishery. The third session examined regulatory measures to address the major issues of concern.

Following the presentations of socioeconomic and biological information relevant to the bonefish fishery in Kiritimati, the EAFM concept was used to define the scope of the management plan, identify main issues and prioritise them using risk analysis, and develop a management system and framework from the results. Figure 21 presents the results of this exercise.

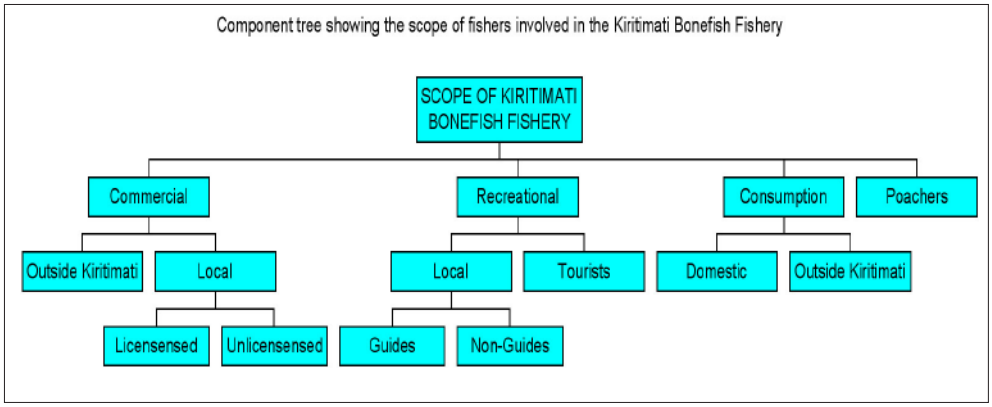


Figure 21: Fishers involved in Kiritimati bonefish fishery

Scope of the management system

A. ***Fishers involved***: There are four main categories of fishers involved in the bonefish fishery. This includes commercial fishers who fish in order to sell their bonefish catch; recreational fishers who catch and release bonefish; fishers who catch for their own consumption only; and poachers who fish illegally in closed fishing areas.

B. ***Fishing methods***: flyfishing rods, spinning and conventional casting rods (baited hook and line), gillnets – drive in nets and set nets, throw net, '**te ororo**' – very destructive form of gillnetting and hook and handline.

C. ***Fish species caught***: bonefish, milkfish, mullet, goatfish, trevally and pufferfish.

D. ***Management agencies and authorities***: Ministry of Line and Phoenix Group (LINNIX) for general administration of Kiritimati Island. The Fisheries subdivision, MFMRD for fishing licenses, permits, and enforcement of fisheries regulations under the Fisheries Act, the Wildlife Division, Ministry of Environment, Land and Agriculture (MELAD) for surveillance and enforcement of Designated Closed Areas (bird nesting grounds), under Wildlife Ordinance, the Kiritimati Island Council for local business licenses and enforcement of by-laws under the Local Government Act, the Attorney General's Office for legislation of new management initiatives, the Tourism (MCTTD) Subdivision, Ministry of Communications, Transport and Tourism for the regulation of tourists, tour packages, tourist fees, the police department for the enforcement of law and prosecution of law breakers.

E. ***The area to be covered by the management system***: Whole of Kiritimati lagoon, specific ocean reefs, especially important spawning sites, conservations areas in the lagoon, and fisheries closed pond areas.

Six main issues of concern were identified and prioritised using risk analysis in relation to three factors. These three factors include:

1. Sustainability: keeping biomass levels above Bmsy;

2. Tourism and economy: maintain catch rates at a level that keeps tourists coming (source of employment and income);

3. Food source: maintain stocks for food

The six main issues of concern are listed below.

1. ***Justification***: Gillnets are very effective in catching bonefish in great numbers and are therefore often used by commercial fishers. Research has confirmed that bonefish caught in gillnets have no chance of surviving if they are released. Gillnets can easily result in overfishing of bonefish stocks in Kiritimati's lagoon.

2. ***Operational objective***: To ensure the bonefish stock is sustainable and able to maintain catch rates at a level that will keep tourists coming, as well as to provide a protected portion of the bonefish population that will provide a source of recruits.

3. ***Indicators***: Catch rates from tourists inside the lagoon and from local fishers outside the lagoon, number of tourists per flight, the level of return visits by tourist fishers, the size of bonefish and the results of fisheries household surveys every few years.

4. ***Performance measure limits***: Decline in catch rates, decline in bonefish size, increase in fishing effort by tourist fishers and local fishers, and declining trends from fisheries surveys.

5. ***Evaluation***: Monitoring catch rates of tourists and catch sizes, and conducting regular fisheries household surveys every two years.

6. ***Management response***: There is currently no management response, but in the future this would include at a minimum, a restriction on or banning the use of gillnets in the lagoon, banning the sale of bonefish, banning the export of bonefish from Kiritimati, limiting the number of tour guides, and restricting fishing effort in the spawning areas three days before and three days after a full moon.

If performance limits are exceeded, drastic regulatory measures would then be added. These might include a seasonal ban on using gillnets outside the lagoon, and a total fishing closure of selected parts of the outer reef areas where bonefish are known to occur.

To oversee and implement the management plan, a management body that included the main stakeholders based in Kiritimati, was proposed (Fig. 22).

The responsibilities of the management body would be to oversee the management plan administration and implementation including reviews, management of funds for management activities, and the coordination of monitoring and enforcement efforts through relevant authorities such as the Fisheries Department, Wildlife Division, police and the bonefish guides.

Various issues that were raised during the workshop in setting

up the bonefish management system included:

- Financial support for the management plan and enforcement should come from the license permits and fees collected from bonefish tourists and other bonefish related revenues (e.g. fines and penalties). The government's agreement to allocate these funds exclusively for supporting the management of bonefish in Kiritimati is needed.

- A Bonefish Management Authority should be established. This could be empowered through the Fisheries Act or through the bonefish management plan. A full-time manager, accountant, secretary, and two bonefish wardens would form the core staff of the Management Authority. Hoteliers indicated their willingness to provide funding support for one warden for at least one year, in the initial implementation.

- There is a strong need to undertake a major public awareness campaign to properly inform people on the importance of the bonefish fisheries and the need for regulations. The Chairman of the US-based 'Friends of Kiritimati Island' stated that they can provide the financial support for the production of public awareness materials such as posters, pamphlets, T-shirts, hats etc.

- Bonefish guides are out on the sand flats everyday with their tourists and, therefore, could be used to assist enforcement at no cost.

- Although the aim is to for the Bonefish Management Authority to self-finance its management activities through bonefish fishing permits, guide licenses, and fines, some initial funding may be necessary for building an office, buying office equipment and supplies, purchasing a boat and engine, and producing awareness materials.

The outcome from the workshop will form the basis for the bonefish management plan that is being developed.

AusAID approves funding to set up the SPC regional live reef fisheries (LRF) Integrated database

After years of grant seeking, AusAID has kindly agreed to provide funding for a regional LRF database. The LRF database will provide member countries and territories the support they need for monitoring their live reef fisheries (both food fish and marine aquarium fish). The required database framework for data entry and storage as well as the integrated analytical tools, will allow instant analysis of data, which will provide the required information for making management decisions to support sustainable live reef fish trade operations.

Work on developing the database has begun with assistance and advice currently being provided by the PROCFish Reef Fisheries Information Manager. A short-term database specialist will, however, be hired to work on the development of the required portal and the LRF database. The hired database specialist will work in close association with the Reef Fisheries Information Manager to ensure a link to and use of the existing Reef Fisheries Observatory Database as the basis.

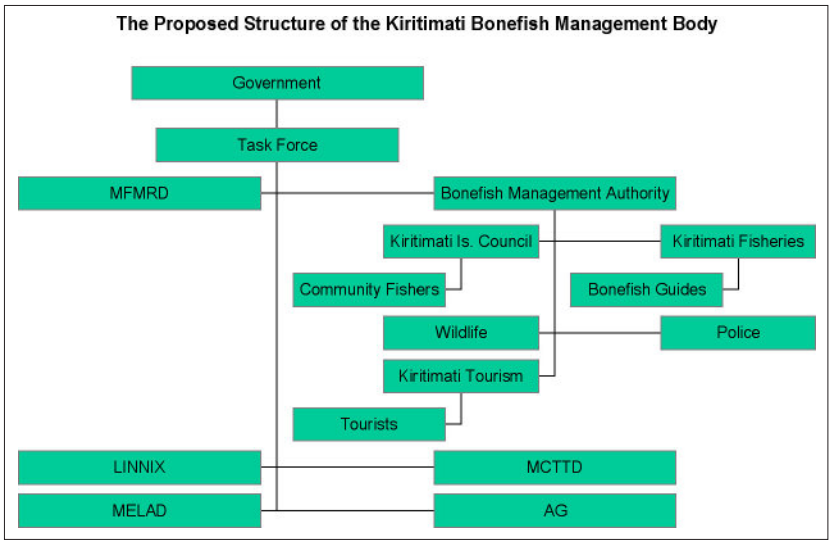


Figure 22: Proposed structure of the Kiritimati Bonefish Management Body

FISHERIES MANAGEMENT SECTION

Refresher programme for Niue's community-based fisheries management plan

In response to a request from the Fisheries Division of Niue's Department of Agriculture, Forestry and Fishery, SPC's Coastal Fisheries Management Section (CFMS) set up Niue's community-based fisheries management plan (CBFMP). Initial consultations and meetings with various government and community stakeholders were conducted in 2003 and 2004 before a workshop for local facilitators was carried out in August 2004.

The main goal of the CBFMP is to assist village communities develop their own individual fisheries management plans. With the development of village fisheries management plans, the Fisheries Division anticipates achieving the objectives set out in the National Coastal Fisheries Management Plan — to better manage and sustainable use Niue's coastal marine resources so that they benefit the current population and future generations); or, in other words, meeting the needs of the present population without compromising the needs of future generations.

In February 2007, SPC's Coastal Fisheries Management Adviser conducted a review for Niue's CBFMP. One of the recommendations was to conduct a refresher workshop for CBFMP staff and relevant stakeholders. The workshop aimed at training individuals on community facilitation processes and to create awareness among village communities on the status of inshore fishery resources. This workshop was conducted by SPC's CFMS from 26–30 March followed by a week of assessing the existing village fisheries management plans.

An update from Nauru

SPC's Coastal Fisheries Management Officer visited Nauru in June. The visit's objective was to work with the SPC Joint Country Strategy mission to Nauru, and to follow up on the progress of CBFMP activities and provide technical advice where necessary.

Meetings with District Executive Committee members and the staff of the Nauru Fisheries and Marine Resources Authority (NFMRA) revealed a need to facilitate the approval of community by-laws and related legislations for monitoring purposes. Three communities have now developed district fisheries management plans with others showing interest.

The highlight of the activities was the launching of the canoe-building project coordinated by SPC's Nearshore Fisheries Development and Training Section and NFMRA's Coastal Fisheries Section. The project began with preliminary consultations with various district communities in developing their respective district fisheries management plans. During the consultation process, most communities requested assistance from NFMRA to develop offshore fishing opportunities in order to sustain food security and reduce fishing pressure on inshore resources. NFMRA requested assistance from SPC's Coastal Fisheries Programme, which resulted in the implementation of the canoe project.

The main goals of the canoe-building project are to sustain food security, divert fishing pressure from coastal fisheries resources, and to provide income generating activities for local district communities. (See article by Michel Blanc and William Sokimi on p. 49)

A Review of the Marshall Islands Management Programme for Island Communities

From 11–15 June, SPC's Coastal Fisheries Management Adviser (CFMA) conducted a review of the Marshall Islands' community-based fisheries management plan (CBFMP). This review is a joint undertaking between the CFMS and Marshall Islands Marine Resources Authority (MIMRA).

The review focused mainly on developing a draft fisheries management plan for Ailuk Atoll. Fisheries management plans had been developed for some of the other atolls since the inception of the programme in 2000, although new and improved information was needed in order to finalize some aspects of the plans before they were approved. One outcome of the review was the need for additional information in order to improve the quality of the fisheries management plans to attract external funding for community projects

The following is a summary of the review conducted by the CFMA.

- The Marine Resources Act 1997 empowers MIMRA's Director to approve fisheries management plans prepared by local government councils for the management of atoll marine environmental and fisheries resources.

- An Atoll Fisheries Management Plan (FMP) should be treated as a guide (prepared by community members with assistance from MIMRA) that contains community responsibilities and undertakings that obligate an atoll community must carry out for the purpose of managing its fisheries resources and marine environment. The FMP also outlines technical services and supporting services that MIMRA must provide in order to support community undertakings and management actions.

- It should be remembered that an Atoll FMP belongs to the atoll community that prepares it.

- An FMP must be established through the information gained from discussions at community workshops. This will involve a lengthy process because the MIMRA staff may need to pay several visits to the atoll to run community workshops in order to obtain proper information to draft a management plan. MIMRA staff must ensure that the content of the plan reflects the community's interests.

- It is important that community workshops are conducted in the Marshallese language so that the community clearly understands the discussion. The first draft FMP must be written in a local language and later translated into English for international communities and donor agencies.

- The drafting of an FMP should be done on behalf of the entire atoll community. Quite often community members have differing backgrounds and levels of education. An FMP must be written in simple language so that it can be easily understood by all community members.

The following are some of the issues suggested to be included in an atoll FMP. Some are required by the Marine Resource Act 1997:

i. ***FMP name***: Some communities will decide to give special names for their FMP. This can be done during community workshops.

ii. ***Vision***: the community needs to outline what it wants with regards to the management of its marine environment and fisheries resources.

iii. ***Introduction/Background***: A brief description of the atoll and community. This may include the location, population, religion, school and any peculiar or unique feature of the atoll. This section could also include a brief description of how the FMP programme began within an atoll and who the person was driving programme efforts. This is useful information, especially for outside donor agencies.

iv. ***Objectives***: Should state what the community want to achieve with the FMP (this is required by the Marine Resources Act).

v. ***Status of the fishery***: This includes fish species, fishing methods, state of exploitation, etc. This information will allow a comparison of what happened in the past with what is going on at present. For example, "What fishing methods were commonly used in the last 10–20 years?" "Which are no longer practiced and why?" You may find out from very old community members that some fish or shellfish that were plentiful in the past years are no longer found today. This is useful information and is required by the Marine Resources Act.

vi. ***The process of developing a FMP***: This must detail how MIMRA facilitators collected the information and facilitated the preparation of the FMP. It may reveal the number of community workshops undertaken to obtain all the information required to prepare the FMP. This is very important as it reflects the degree of community involvement in the preparation of the plan.

vii. ***Strategies to achieve the plan's objectives (required by the Marine Resources Act):*** These should outline how the plan may proceed and ways the FMP should be implemented in order to achieve its objectives and goals. It should cover the responsibilities of the community and those of MIMRA and other partners. This part of the FMP forms the key subject matter of the FMP as the undertakings of both parties will make them obligated to perform their respective assigned responsibilities. This section could be subdivided into:

a) community responsibilities: should be taken out from agreed results of community workshops and discussions with the local fisheries committee. These are mainly management actions that the community needs to perform

for the purpose of managing its fisheries resources.

b) MIMRA responsibilities: normally include technical services to support the undertakings and management actions of the community.

viii. ***Management Area***: There is a need to explain the coverage for which the FMP will apply in terms of activities and the imposition of rules and restrictions.

ix. ***Establishment of a Local Fisheries Committee***: This will cover how committee members are chosen and lists committee responsibilities.

x. ***Institutional Arrangement***: It is important to give a brief account of how the FMP operates in terms of the involvement of MIMRA, the Local Fisheries Committee, local government council, and other related partners. A flow chart will help with the explanation.

xi. ***Monitoring and Evaluation of the FMP***: This is important as it advises on the successes and achievements of the plan and is required by the Marine Resources Act)

xii. ***Review of the Plan***: A brief account of how the plan will be reviewed and the frequency with which it needs to be reviewed (This is required by the Marine Resources Act).

xiii. ***Conclusion***: The FMP can conclude with a short statement on the expectation of the community as a result of its plan.

xiv. ***Appendices***: It is important to keep detailed records of community discussions, a list of community members involved in the preparation of the plan, and other important information that is used during the preparation of the plan. Such information can be included as appendices to the FMP.

xv. ***Extra flavour (optional)***:

a) *Statement by Mayor*: A statement by someone very important in the community (e.g. a very high chief or mayor) adds weight and value to an FMP. Usually, when a high-ranking person in the community makes a commitment, then he or she will ensure that commitment is followed through on. Such a statement should appear at the beginning of the FMP.

b) *Pictures or drawings*: Usually illustrations, especially colour ones, catch the eyes of readers, particularly those who do not have much formal education. Such illustrations or pictures could include that of a high chief or mayor, the atoll itself, community workshops, etc.

The above information was developed not only to help MIMRA's Director in approving several FMPs, but also to assist the programme staff for the revision of the FMPs that are yet to be approved.

AQUACULTURE SECTION

Update on aquaculture activities in the Marshall Islands

Aquaculture in the Marshall Islands is relatively diverse. Although much of it occurs on a small scale, there are a number of interesting developments on Wotja Atoll. Ben Ponia and Antoine Teitelbaum report on the situation in the Marshall Islands.

The Wotja hatchery: Spawning pearl oysters and diversifying to finfish

The pearl oyster hatchery at the Marshall Islands Marine Resources Authority (MIMRA) on Wotja (formerly owned by Black Pearls of Micronesia) is the main source of spat for pearl farms operating in the country. This hatchery has struggled to produce sufficient numbers of spat — a major bottleneck to pearl development in the Marshall Islands.

The hatchery has recently been fully refurbished and equipped with water quality treatment equipment such as a settlement tank and UV filters. Plumbing and pumping systems were also renewed and hatchery tanks rearranged to make the hatchery more efficient.

Unfortunately, even after refurbishment, MIMRA's first spawning runs crashed continuously at the larval stages. After a lengthy process of elimination, and trial and error, it was discovered that a dosage of EDTA (a heavy metal chelating agent) was necessary for successful spat settlement. However, the use of EDTA still points to discerning signals in lagoon water quality. The last hatchery batch produced by MIMRA consisted of several thousand oysters and was provided to the Robert Reimers Enterprises farm (on Jaluit) and Black Pearls of Micronesia farm (on Arno). Technically, the hatchery has the capacity to produce several hundred thousand spat, which is enough to meet the needs of the Marshall Islands. A two-year grant by the Center for Tropical and Subtropical Aquaculture has just been approved

to overcome bottlenecks in spat production and run experiments on transportation methods to increase survival.

MIMRA expatriate staff member, Provan Crump, based at the Wotja hatchery has trained local technicians in operating the hatchery and carrying out larval rearing. As a result, the operation is now mostly run by skilled Marshallese staff.

Recently, the Australian company, Good Fortune Bay Fisheries, a large and reputable aquaculture operation based in Bowen, Queensland, has imported juvenile humpback groupers (*Cromileptes altivelis*). The intention is to collaborate with MIMRA on an aquaculture joint venture for growing-out humpback groupers in cage systems in Majuro's lagoon.

MIMRA has been holding the fingerlings in a simple quarantine facility located at the Wotja pearl oyster hatchery. So far, the trial has demonstrated that shipping by air from Australia to the Marshall Islands is a success as there was virtually no mortality and the fingerlings have adapted very well and shown good growth rates. No signs of disease have been observed.

Floating cages are being put together by Good Fortune Bay Fisheries and MIMRA experts. The fish will be grown-out in Majuro's lagoon near passes on the northern side, an area with pristine water quality and permanent oceanic water exchanges.

At this stage MIMRA still lacks aquatic biosecurity capacity for importing marine finfish and so have been working with the Marshall Islands Environmental Protection Agency on an import risk analysis. MIMRA will work with FAO on biosecurity training with SPC's assistance.

Ongoing efforts in diversifying aquaculture at College of the Marshall Islands

The College of the Marshall Islands (CMI) science station has a simple hatchery with an algae lab and several 10-ton concrete tanks onsite. Recently, a five-year US Department of Agriculture project granted monies for pearl transshipments to other atolls, triploidy experiments, and monitoring plutonium levels in the oysters at Bikini atoll to assess radiation impacts from nuclear testing during World War II.

MIMRA and CMI could potentially be involved in a regional project, possibly involving Kiribati, Fiji and Cook Islands, to grow half pearls (mabe).

Marine ornamentals at the Marshall Islands Mariculture Farm

The Marshall Islands Mariculture Farm — owned by Ocean Reefs and Aquarium (Florida), and formerly owned by Robert Reimer Enterprises — operates 24 large concrete raceways and 48 smaller fibreglass troughs. Some lagoon grow-out is also coordinated by the technical staff of a farm on Arno Atoll. Giant clams (Tridacnae) are one of the mainstay export products although the farm also exports coral fragments (soft and hard corals).

Marine ornamental stocks also come from the outer Marshall Islands (e.g. clams from hatcheries at Likiep and Arno). The farm also holds and exports products from other countries such as soft corals from Pohnpei (Federated States of Micronesia).

High mortality levels in recent years have decreased the farm's exports. These mortalities are blamed on a viral disease and on poor water quality; the farm's water intake pipes are located just a few kilometres downstream from Majuro's dump.

Taiwan stepping into aquaculture in the Marshall Islands

The Taiwan Technical Mission in Majuro has recently begun construction of a fish hatchery in Laura. So far, four large (~ 20-ton) concrete tanks (to be used for spawning) and about 20 five- and two-ton tanks (to be

Taiwanese marine fish hatchery under construction

used for larval rearing and as nurseries) have been built.

This project aims at culturing groupers (Epinephelidae) and rabbitfish (Signidae). There is also an interest in propagating tiger prawns (*Peneus monodon*). All of these could be grown for the small existing local markets for a start, and there may be potential for exporting them to markets in Hawaii, in the future.

First commercial harvest of red tilapia in Vanuatu

Red tilapia culture in Vanuatu began in 2007 with Teuoma Prawns, a local shrimp farming company that is collaborating with the Vanuatu Fisheries Department (VFD) and Vanuatu Quarantine Department in importing sex-reversed red tilapia from Thailand.

Several importations have been made and information at hand received from VFD's Principal Biologist, Robert Jimmy, is that red tilapia are farmed in cages (see Figures) in a lake near Port Vila, which is infested with Mozambique tilapia and surrounded by a cattle farm. The fish are fed on a locally formulated diet based on copra meal, meat meal and wheat bran produced by VFD. This feed is also used by local farmers for Nile tilapia (*Oreochromis niloticus*) culture.

Approximately 19 t of fish were ready for harvesting in July 2007, and the company was carrying out partial harvests of 100 kg/week to promote the product in Port Vila. The fish are sold fresh on ice at local municipal markets and kava bars for VUV 550/kg and to restaurants and hotels for VUV 600/kg (1 USD = 104.05 VUV). According to Robert Jimmy, the price of tilapia may be reduced once the market is established, and may also depend on the demand and operating costs of the farm.

Red tilapia

Red tilapias have become an economically important food fish. They exhibit many qualities that make them well-suited for aquaculture. They are enormously adaptable and capable of reproducing under a wide range of conditions, they exhibit excellent growth rates on a wide variety of natural and low protein diets, they are resistant to handling and disease-causing agents, and are highly palatable and have broad consumer appeal as a food fish.

The genetic heritages of the existing varieties of red tilapia are not well documented. Their derivation is generally attributed to the crossbreeding of mutant reddish-orange *O. mossambicus* (a normally black species) with

Red tilapia cages

other species, including blue tilapia (*O. aureus*), Nile tilapia (*O. niloticus*) and *O. hornorum*. There is some evidence of the presence of genes from *Tilapia rendalli* and *Sarotherodon melanotheron*. Among the popular hybrids are 1) Florida red, a species cross between *O. aureus* and *O. mossambicus*, 2) a hybrid between *O. aureus* and *O. niloticus*, and 3) Taiwanese red tilapia, a cross between *O. mossambicus* and *O. niloticus*. There is also the Philippine red tilapia, Thai red tilapia and several other variants.

The presence of a red colour has been commercially important in terms of marketing because red tilapia resemble reef fish. Red tilapia is often preferred over wild-type tilapia and the price for red tilapia is usually higher than that of wild types. The promotional price of red tilapia (average USD 5.52/kg) in Vanuatu is comparable with prices elsewhere, where red tilapia is a high-value species sold mostly in urban markets. For example, in the Philippines, the domestic price is USD 6.15/kg, which is roughly twice as much as the Nile tilapia.

Despite the reputed salt tolerance of tilapias, research into their culture has been limited to freshwater in the Pacific Islands. In Fiji, research on the culture of the Taiwanese strain of red tilapia — a *Oreochromis mossambicus* x *O. niloticus* hybrid — involved genetic strain evaluation in growth and other economically important traits such as fecundity, survival and red colour inheritance.

National Pearl Workshop — Republic of the Marshall Islands

Consultation is a key ingredient in industrial development that is often overlooked. The Marshall Islands national pearl workshop was an opportunity to hear the aspirations of stakeholders and to assess the opportunities and constraints facing the pearl industry. An outcome of the workshop was a draft strategy identifying the most urgent issues that need to be addressed.

The Marshall Islands was one of the first countries in the northern Pacific to trial pearl farming. Pioneering efforts were carried out by Black Pearls of Micronesia and Robert Reimers Enterprises in the early 1990s. Much of the research and development efforts have been supported by grants provided through US agencies such as the Center for Tropical and Subtropical Aquaculture based in Hawaii.

The national pearl workshop, which was held from 29–31 March, was organised by the Marshall Islands Marine Resources Authority (MIMRA), College of the Marshall Islands (CMI), University of Hawaii at Hilo, and SPC. The key organiser and workshop facilitator was Simon Ellis. Assistance was provided by Glen Joseph, Don Hess, Maria Haws and Ben Ponia. There was a strong turnout of representatives from various government, private sector, financial institutions and community bodies. Representatives from Likiep, Mili, Rongelap, Ebon, Ailuk and Bikini Islands travelled to Majuro for the workshop.

The majority of presentations were delivered by Simon, Maria and Ben, and covered topics such as regional and global trends of the pearl industry, basic fundamentals for pearl farming techniques, pearl marketing and pearl economic modelling. The workshop also had a panel discussion from past and present pearl farmers sharing their experiences. MIMRA staff member Virgil Alfred, one of the Marshall Islands' most experienced pearl farmers, also prepared a mock-up of a pearl farm line for demonstration to outer island participants.

The workshop highlighted that pearl development in the

Maria Haws and Simon Ellis - two of the workshop organisers

Marshalls has not been easy. The pearl development strategy drafted by the workshop recognised several critical issues that need to be overcome in the very near future in order for the industry to be sustainable and profitable.

- ***Pearl seeding technicians***: Pearl grafting is the most critical aspect of producing a pearl. However, the expense of hiring a foreign technician and the logistical difficulties of organising their services is a major constraint to development. Options for training a local technician or securing a long-term arrangement for a seeding technician were raised.

- ***Spat supply***: Another major bottleneck to development has been the inconsistent and trickle supply of juvenile oyster spat. Without new seed stock the farmers have found it difficult to expand. MIMRA is aware of the issue and is putting considerable effort into rejuvenating its hatchery programme. CMI also has a small hatchery at Arak that produces spat for outer island projects. One positive development is that hatchery training has been well supported and local MIMRA technicians are becoming competent to run all aspect of the operations.

- ***Financing***: Private sector operations have struggled to maintain the investment and cash flow required for pearl farming. Possible sources of funding include local financiers, grants, micro-credit and traditional credit schemes.

- ***Other niche opportunities***: There are suggestions that the domestic market for finished pearl pieces on Majuro has not been fully saturated. This is an opportunity for the small pearl producers in the Marshall Islands who struggle to compete on the competitive international market. The pearl workshop identified low investment, risk options such as mabe pearls as a potential niche product for smaller community-based operations in the outer islands.

Top right: Virgil Alfred showing participants a demonstration pearl farm line
Bottom left: Black pearls from the Marshall Islands

18th NACA Governing Council Meeting, Bali, Indonesia

The 18th Governing Council Meeting of the Network of Aquaculture Centres in Asia-Pacific (NACA) was held in Bali, Indonesia from 2–5 May. It was hosted by the Government of Indonesia, and was attended by 75 people representing 15 member governments, one associate member, and five other organisations. SPC was represented by its Aquaculture Adviser, Ben Ponia. The meeting's welcoming address was provided by the Hon Minister for Marine Affairs and Fisheries of the Republic of Indonesia, Mr Freddy Numberi.

The meeting was called to order by IR Iran, the outgoing Chair of NACA's Governing Council. Indonesia was elected as the Chair of the meeting and Nepal was elected as the Vice-Chair. NACA Director-General Prof Sena De Silva led the overview of the NACA work programme. Delegates raised some issues regarding the NACA programme in the Pacific region, and these are highlighted below.

Shrimp farming, better management practices and aquaculture

The main activities of the shrimp programme during the past year have been the finalisation by the Consortium Program on Shrimp Farming of the "International Principles for Responsible Shrimp Farming", and the adoption at the 3rd meeting of the FAO Sub-Committee on Aquaculture in New Delhi, India (September 2006). There was general consensus that the document should become a global point of reference for aquaculture policy and development and best management practices. This work was recognised by the World Bank's Annual Green Award in November 2006.

Marine finfish aquaculture

The NACA Grouper Hatchery Training Course that was conducted in Situbono, Indonesia (20 November–9 December 2006) had the greatest number of participants to date and included some from the Pacific Islands. This annual course will run again in 2007. There are plans to develop best management practices for marine finfish aquaculture in the Asia-Pacific region.

Aquatic animal health

Delegates from Indonesia reported that around 40% of shrimp broodstock imports were from a specific pathogen-free (SPF) supplier in Hawaii. However, despite the SPF status of these animals, it was found that the shrimp were carrying a new virus against which they were not certified. The lesson from this experience is to exercise great caution in importing live animals from external sources for aquaculture production, and to follow appropriate quarantine, risk assessment and biosecurity procedures.

The Australian delegation reported that the Department of Agriculture, Forestry and Fisheries is collaborating with NACA to produce an Asia-Pacific regional field guide for the identification of aquatic animal diseases

Biosecurity

Australia advised that a proposal on biosecurity arrangements for the aquarium trade had been raised at the recent meeting of the Asia-Pacific Economic Cooperation (APEC) Fisheries Working Group. The proposal's objective was to 1) review best practices for the ornamental fish trade in the movement of live specimens; 2) enhance members' capacity to implement biosecurity arrangements and respond to incursions; and 3) identify high-risk species and new diseases to consider for listing by the World Animal Health Organisation.

Environment

An FAO global review of environmental impact assessment (EIA) procedures and environmental monitoring is being conducted. A workshop to compile guidelines for coastal aquaculture EIAs will take place in 2008.

Certification, markets and trade

Indonesia expressed concerns over proposals to list the family Pristidae (sawfish) and the genus Anguilla (eels) under CITES. It was quite likely that such genus- and/or family-level listings could impact on future aquaculture developments of these species. FAO recently signed an MOU with CITES that will allow it to provide advice on the listing of species for fisheries and aquaculture purposes. This would provide members with an avenue to provide feedback on related CITES issues.

FAO also reported that it intends to conduct a workshop on technical guidelines for food safety in aquaculture.

Aquaculture information services

NACA's ongoing publishing activities will continue, including publication of the *Aquaculture Asia magazine* (quarterly; and the NACA Newsletter, also quarterly). All publications will continue to be made available for free download in electronic form.

Further improvement of the NACA website will include:

- Development of topic-specific sub-portals for work programmes. These will bring together the news, publications, and project summaries specific to each programme element, making it easier for people with specific interests to find information.

- Pilot of a regional 'training calendar' of activities offered by NACA centres, to facilitate inter-institutional training and exchange.

- Development of a 'donors' section that will recognize the contribution of current donor agencies contributing to NACA activities.

- Establishment of a more comprehensive photo library of key species and production systems as a resource for network scientists and production of publications.

Aquaculture updates from Nauru

*In May 2007, SPC's Aquaculture Adviser visited Nauru and was updated on the aquaculture situation of this small country. Farmed milkfish (*Chanos chanos*) has traditionally played a significant role in the diet and social customs of Nauruan people, but during the economic boom of the phosphate-based economy, much of the knowledge and many of the practices associated with milkfish farming were lost. Building capacity in aquaculture will hopefully contribute to rehabilitating the tradition of fish farming on Nauru.*

There has been quite a revival of aquaculture activity occurring in Nauru. Faced with an economic crisis, Nauruans are becoming more self-sufficient in providing food, and aquaculture is one of the options that is stirring interest.

Aquaculture development is being supported by the Coastal Fisheries and Aquaculture Division of the Nauru Fisheries and Marine Resources Authority (NFMRA – in particular, Margo Dieye, divisional head, and aquaculture officers Ricky Starr and Lucky Buraman). Support has been provided by SPC's Aquaculture Section from small trials funded by an ACIAR mini-project, tilapia fish training workshops, and several staff attachments with Naduruloulou aquaculture station in Fiji in 2006. In addition, FAO provided a short-term adviser from China.

There are about 30 small ponds that staff have been restocking with Nile tilapia and milkfish.

- **Site 1**: A backyard earthen pond (run by Junita, an elderly grandmother). This was the site where SPC ran the Mozambique tilapia eradication and pond rehabilitation mini-project in 2006. After the project ended, the fisheries staff assisted with several restockings of fish and one harvesting. However, much of the extension support reportedly ceased because of the lack of logistic support for fuel and transportation from the government. However, since the end of the project, Junita has had to resort to cheap, poor quality feed, such as expired chicken grower pellets, to feed her fish because she is unable to afford good quality feed. This highlights the importance of taking into account the socioeconomic aspects of

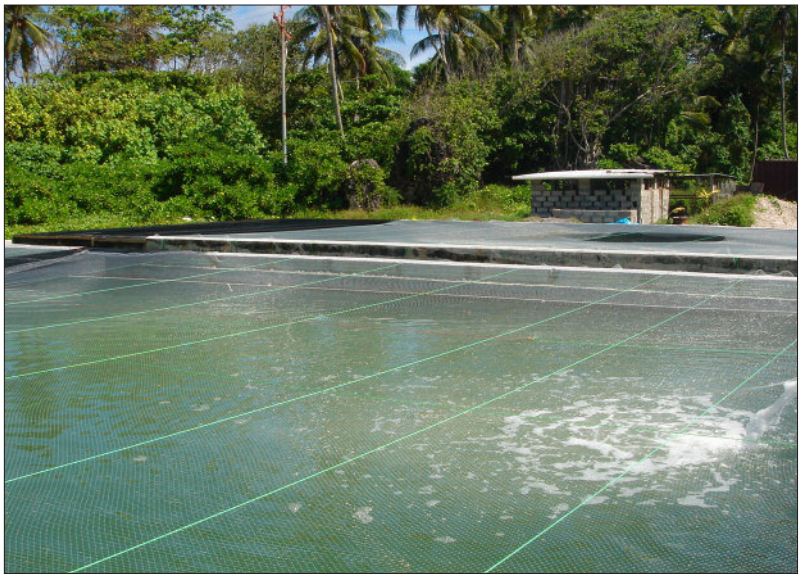
Fish pen in Buada lake

fish farming and how impoverished households with little cash flow will be able to sustain their fish ponds. One potential mini-project that was discussed was investigating low-cost, readily available feed ingredients. Poor farm management practices were also apparent at Junita's pond (e.g. the presence of numbers of juvenile fish, which will compete for food). This emphasises the need to continue to support fish farm training workshops. According to NFMRA aquaculture officer, Lucky Buraman, one positive sign was that the Nile tilapia harvested from her farm received a very good taste-test reaction from the public at the National Agro Fair.

- **Site 2**: A backyard concrete pond stocked with Nile tilapia. Occasionally, the owner sells his fish at AUD 7.50 per kg. His fish are left to breed in the tank and excess fish fingerlings are removed periodically.

- **Site 3**: A concrete swimming pool no longer in use. It was decided to turn it into a fish pond, and was stocked with an all-male tilapia population in order to achieve faster growth rates. The fish are fed a diet of whatever is at hand, including arrowroot leaves, pawpaw, and bread scraps. The fish appear to be growing reasonably well.

Buada Lake is the largest inland water body on Nauru. Traditionally, milkfish fry caught in the



Top: Junita and Lucky at the tilapia fish pond

Middle: Unused swimming pool becomes a fish pond

Bottom: Taiwanese project - milkfish tanks

lagoon were stocked into the lake where they were later harvested under a communal system. Unfortunately, fry are no longer abundant in the wild and so in the past, fry have been sourced from nearby Tarawa Atoll in Kiribati. After the most recent restocking, several thousand milkfish fish were harvested. Several of the fish farming units now have enclosures and these have since been stocked with Nile tilapia. It may be interesting to conduct some research trials for polyculture of milkfish and Nile tilapia.

There are two associations that have an interest in fish farming in Buada: the Nauru Aquaculture Association (NAQUA), which has been established to assist farmers on an individual basis, and the Buada Land Owners Association (BLOA), which supports communal efforts.

A Taiwanese aquaculture aid project in Auobar, which mainly focuses on farming milkfish, will establish a hatchery for breeding. The site has two large concrete raceways supplied with seawater from the nearby lagoon. Tanks are stocked with one-year-old, 500 g milkfish fry from Kiribati. Thousands of juvenile surgeonfish have also been recruited into the raceways and are growing quite well. For reasons unknown to NFMRA, some Penaeus monodon shrimp were also imported from a Taiwanese project in Kiribati. The project (which is managed by the Ministry of Commerce) seems to lack coordination within Nauruan government agencies and the Taiwanese themselves were unclear about the objectives and timelines. The facility has the potential to serve as a national hatchery, broodstock management, and quarantine centre for finfish aquaculture.

In later discussions with Margo, Charleston Deiye Chief Executive Officer for NFMRA and Hon Roland Kun, Member of Parliament and Minister of Fisheries, it was reiterated that the rejuvenation of milkfish farming is an important priority, and Buada Lagoon is still the prime location for this development. It was also recognised that farming Nile tilapia provides a quick solution to addressing food security issues, which are becoming more important to households under the current economic crisis. Technical support will be needed. Margo also mentioned that there was interest in reseeding the reefs with trochus to provide another source of nutrition.

FAO workshop on Understanding and Applying Risk Analysis in Aquaculture

Aquaculture is the fastest growing food sector globally, but this rapid pace introduces biosecurity concerns that can impact on the industry's development, on its surrounding aquatic environment and the society we live in. In June 2007, SPC's Aquaculture Adviser participated in an expert workshop organised by FAO in Thailand to provide guidelines on risk assessment for aquaculture (i.e. the process of identifying hazards, their consequences and mitigation measures).

Aquaculture is a risky business. Government and the private sector are often forced to make decisions without having all the facts in hand, and under circumstances that may have a high degree of uncertainty. Furthermore aquaculture is a diverse sector, involving a range of species, culture systems, physical environments, markets and social strata. Risk management is an important tool for addressing biosecurity concerns, and involves cross-sectors that deal with food safety, aquatic animal health, and the environment

"Risk" can be broadly defined as the potential for an adverse outcome, which is the product of the probability of occurrence and severity of consequence. Risk assessment typically seeks to answer four questions:

- What can go wrong?
- How likely is it to go wrong?
- What are the consequences of it going wrong?
- What can be done to reduce the likelihood or consequences of it going wrong?

The scope of the workshop in Thailand was to consider risk assessment for seven major risk sectors: pathogenic, food safety and public health, ecological (pest and invasives), genetic, environmental, financial and social.

Surprisingly, there is a relatively small body of knowledge within the aquaculture sector and to a certain extent other primary production sectors (perhaps excluding crops) on risk assessment. However, among workshop participants there was an immediate appreciation of the principles and basic methodologies for assessing risks, despite the various geographical areas and interest groups present.

Workshop organisers, Drs Rohana Subasinghe and Melba Renataso from FAO Rome, have been close collaborators with SPC in strengthening biosecurity measures (e.g. Melba was part of an SPC consultancy to develop a model template for aquaculture import risk analysis).

This workshop will serve as a useful backdrop for the SPC regional workshop on Ecosystems Approach to Fisheries and Aquaculture (EAF) and Aquatic Biosecurity planned for October 2007. It also supports an SPC Governing Council directive in 2006 for its Marine Resources Division to build regional capacity in the area of aquatic biosecurity.

Workshop outcomes are to be developed into an FAO Manual on Understanding and Applying Risk Analyses in Aquaculture.

NEARSHORE FISHERIES DEVELOPMENT AND TRAINING SECTION

Technical assistance to a New Caledonia domestic longline fishing company

The New Caledonian fishing company, Navimon[1] , has been in the business of longline fishing, processing, wholesale local marketing, and export marketing of fresh longline caught fish since the mid-1990s. Navimon's initial fishing operations, which began with four French-built 16-m aluminium longliners, operated with varying degrees of success. Since 1996, however, Navimon has divested itself of all of the original 16-m vessels and has gradually acquired a fleet of eight 20-m steel vessels that are better suited to the type of fishery they are involved in. In 2002, the company was restructured and efforts were concentrated on fishing alone. Since then, processing and marketing of Navimon's catch is carried out by other New Caledonia-based companies under contract arrangements.

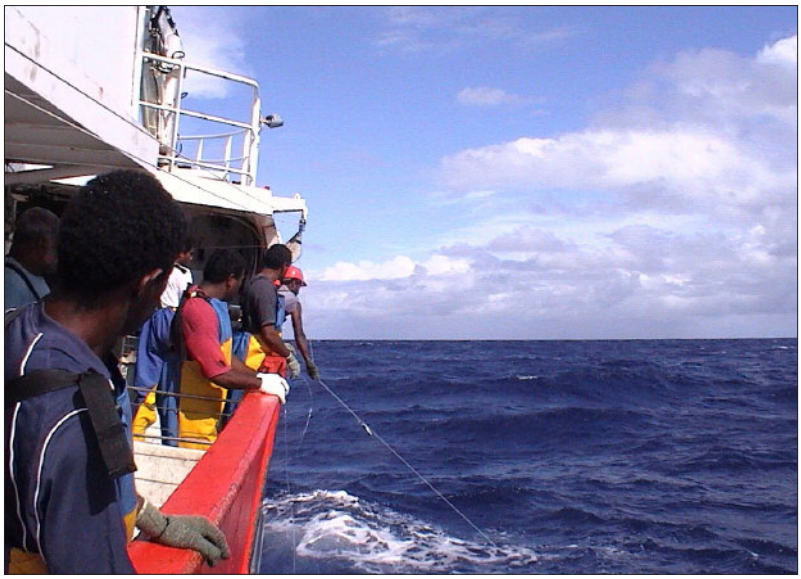
Despite this attempt at restructuring, the company experienced difficulties, due partly to a downturn in overall catches that was experienced by many SPC member countries in the early 2000s. By 2005, fishing had began to return to more normal conditions but Navimon was still facing the recurring problems that affect most longline fishing operations in New Caledonia and elsewhere in the Pacific: rising operating costs, diminishing returns due to market fluctuations and currency exchange rates, and difficulties in attracting and retaining competent captains and crew members. With a high turnover of vessel personnel, crew training become a priority, at least as a short-term solution.

In late 2006, Navimon asked SPC to provide some short-term monitoring and training of the newer captains and crews in their fleet. SPC's two Fisheries Development Officers (FDOs), Steve Beverly and William Sokimi, accompanied some of the newer and less successful captains on regular tuna longline trips to determine why they weren't as successful as their counterparts with more experience. (The fleet's eight boats were identical and had the same infrastructure and ground support.) Steve and William worked with Navimon crews between February and June 2007, making four fishing trips on four separate vessels: F/V *Katia*, F/V *Keitre*, F/V *Lanesera*, and F/V *Gossanah*.

In addition to providing onboard advice and training to Navimon's skippers and crew, the FDOs held debriefing meetings with Navimon's management and skippers, and offered specific advice and information on how to improve the vessel performance, fishing strategies, and fish quality. On completion of the project, a report highlighting the FDOs' findings and providing general recommendations was submitted to. Insights into the

Preparing a longline buoy for deployment during line setting

[1] Navimon is owned by SODIL (Société de développement et d'investissement de la Province des Iles Loyauté, the investment organisation of the Loyalty Islands Province of New Caledonia)



F/V *Lanesera* crew freeing a tangled branchline during the hauling process

problem of retaining captains and crew were also given.

The project report has been finalised will soon be submitted to Navimon's management. The report makes some recommendations which, if implemented, may improve the company's overall profitability. Recommen-dations are broad ranging and include improving fishing gear and strategies, experimenting with longline setting parameters, skippers providing onboard training to crew, adjusting onboard catch handling procedures, changing vessel management methods, introducing a Safe Operational Plan on the company's vessels, and improving crew welfare.

Economic benefits of a domestic tuna longline fishery

Tuna longlining is a commercial tuna fishing method that targets large deep-swimming tunas. Most Pacific Island countries have domestic and locally based fleets because the capital cost of longliners is lower than for other large commercial tuna boats, and because the highest prices are paid for fresh fish, which must be landed near the fishing grounds and sent to markets by airfreight. There is also a large fleet of distant-water longliners, mainly from Korea, Taiwan and China, which fish on the high seas and under access arrangements with some Pacific Island countries. Although the access fees paid by these vessels are normally higher than the fees charged for licensing domestic vessels, it is generally agreed that a domestic fishing fleet brings much greater benefits to the local economy. However, no one has actually measured these benefits across the region, or compared different fishing and processing operations.

Measuring economic benefits

There are different ways of measuring the benefits of an economic activity such as fishing. Some economists believe that the most important measurement is the economic rent, which is the difference between the value of the catch and the cost of production. While this is a good measure of efficiency, it does not consider the question of who benefits. A national tuna fishery could have a high economic rent, but with most of this taken offshore as profits by foreign companies. Most Pacific Islanders would consider this a poor deal for their country because they are more interested in benefits to the national economy. It is also important to use measures that can compare different fishery development approaches in different countries (e.g. a small fishing boat will not earn as much as big one) and to convert values to a common currency.

In this study, the key measurement used is value added, which is calculated in US dollars for each tonne of tuna. It is a measure that tells us the net economic impact of an activity such as fishing. It includes not only the profit made by a fishing operation, but also the wages of the crew (an important factor in most Pacific Islands where there are not enough jobs). It can be measured not only for fishing, but also for processing and other activities after the fish is landed. In the United States, value added is measured for different fisheries at each stage of production from catching to the final consumer, and this information is used to calculate the impact on the economy of changes in the fishery.

Value added

Value added is an economic term to express the difference between the value of goods and the cost of materials or supplies used in producing them (intermediate costs). Value added is thus defined as the gross sales of a firm minus the cost of goods and services purchased from other firms.

Five other measures were also calculated, all in US dollars per tonne of tuna:

- Net local purchases – this added up the value of supplies bought by fishing companies, less the cost of import of supplies from overseas;
- Employment earnings – the wages paid to crew and onshore workers who are resident in the country;
- Gross profit – measured as earnings before interest, tax, depreciation and amortization (earnings before interest, taxes, depreciation and amortization – EBITDA);
- Contribution to the balance of payments – the value of export sales less the cost of imported goods used; and
- Government revenue from licence fees and other charges.

Collecting information

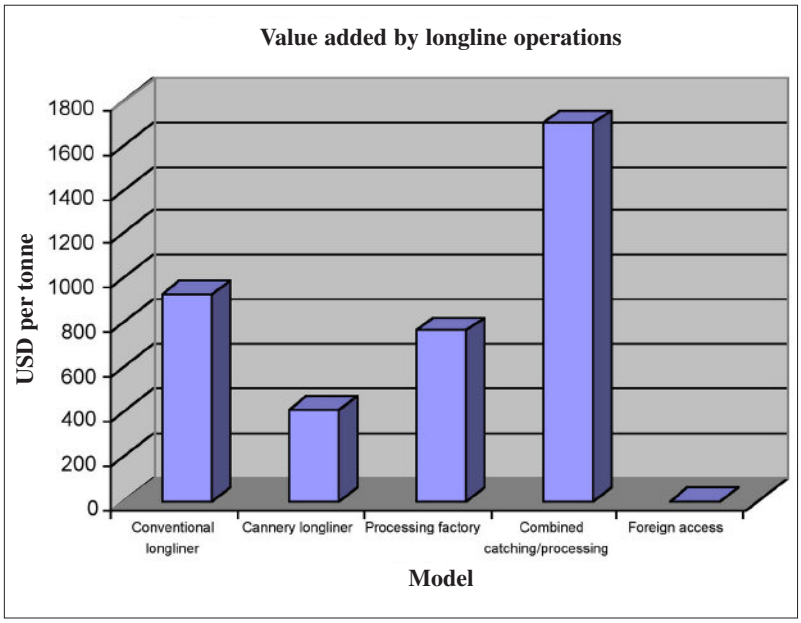
Data were collected from tuna fishing and processing companies in four countries: Cook Islands, Fiji, Marshall Islands and Papua New Guinea. These enterprises operate some 70 longline vessels, catching around 15,000 tonnes of tuna per year, as well as most of the larger processing plants for longline caught fish in the region. Unlike some previous studies, we used actual financial results for 2005 – not data from elsewhere in the world – and few assumptions were made.

The study found that the tuna longline fishing and processing companies in the region fit into one of five models, depending on how they operate:

- A 'conventional' domestic longliner exporting most of the catch as chilled whole fish;
- A domestic (local flag) longliner that is based at, and lands fish directly to, a foreign cannery;
- A factory that processes tuna and bycatch for export as loins, steaks, etc;
- A combined longline fishing and processing operation; and
- A foreign vessel fishing under an access agreement and landing its catch overseas.

Each of these has different impacts on the local economy.

Value added by processing can also be worked out



Economic benefits

The graph above shows the value added to the national economy, per tonne of tuna, for each of the operational models. These are average values, across several companies, and typically for more than one country. The study found that the average value added by a conventional longline operation, although substantial, is only about 20% of the final value of the catch (more in some countries, less in others). Processing of the catch, however, can add value to the national economy — nearly as much as fishing — and a combined fishing and processing operation provides the greatest benefits to the country.

Other measures are shown in the table below. The combined fishing and processing model shows the greatest benefits for most of these. Access agreements give relatively poor returns, except in the area of government revenue, although most domestic fishing and pro-

Model	Net local purchases	Employment earnings	Balance of payments	Gross profit	Government revenue
Longliner – conventional	525	562	1,830	365	174
Longliner – foreign cannery	0	0	416	416	13
Value added processing	602	201	1,364	602	46
Combined catching and processing	602	763	1,110	968	220
Foreign access longliner	0	0	350	n/a	350

All values in USD per tonne of tuna (catch or factory throughput)

cessing companies only reported direct payments to the government in the form of licence fees and port dues. When income tax, import duties and other charges are taken into account, revenues are somewhat higher from domestic operations. It is also interesting to note that the conventional longline model, on average, is the least profitable domestic operation. Although the export of sashimi grade fresh fish still gets the best return for a small proportion of the most valuable tuna, companies that can process the remainder of their catch are performing much better than those which rely on the export of whole fresh and frozen fish.

Conclusions

There are four main findings of the study.

- An integrated fishing/processing/ marketing longline sector returns the greatest benefits to the national economy. Most government policies focus on developing the catching sector. This study found that catch processing provides important extra benefits. Most large-scale processing operations have involved foreign investment, and governments may need to attract this kind of investment if they want to capture maximum economic benefits.
- National longline fleets were largely established when the conventional model was highly profitable, however this is no longer the case. Although the highest returns can be made from exporting whole fresh sashimi grade tuna, the economics of the industry have changed over the last 10 years, and it is often only profitable to export a small proportion of the total catch in this form. Companies that can process the remainder of the catch into value added products are more profitable, and many small companies that relied on the conventional model are struggling to survive.
- Domestic ownership of the fishing boats is not important in terms of national economic benefits. Although government licensing regimes tend to favour locally owned and flagged vessels, the economic benefits depend mainly on having the boats based locally and landing their catches at a local port. Benefits can be increased by ensuring that the industry employs national, or at least resident, workers and that local companies are able to provide services and supplies.
- Although there is value in a regional assessment, each country is different and there is need for analysis at the national level.

This is based on a report by Peter Philipson, which was commissioned by the DevFish Project of the Forum Fisheries Agency (FFA). A copy of the full report can be downloaded from FFA's website at www.ffa.int. A printed copy can be requested from: Jonathan Manieva, DevFish Project, Secretariat of the Pacific Community, BP D5, 98848 Noumea Cedex, New Caledonia.

A longliner offloads in Majuro, Marshall Islands

Sea safety posters for Tokelau and Nauru

At the request of the fisheries departments in Tokelau and Nauru, SPC has produced its small boat safety checklists in the vernacular language of each country. In line with Mike McCoy's 1991 recommendation that "education through publicity campaigns, repeated and reinforced over a long period of time…seems to offer the best chance for improving the safety at sea for artisanal fishermen", SPC's Nearshore Fisheries Development and Training Section relentlessly promotes small boat safety in the Pacific. After producing a number of awareness-raising materials in English and French in the late 1990s, the Section has started to translate the same materials into the vernacular language of its member countries and territories. The Tokelau (Figure on the left) and Nauru (Figure on the right) checklists have been printed in both poster form and A-4 size. While the posters will be displayed in government offices and villages, it is intended that the laminated A-4 placards will be distributed to individual fishermen as an ongoing reminder of the things to do and the safety items to take onboard before going to sea.

Work is underway to produce a Cook Islands-specific safety checklist in the Maori language. This will accompany the small boat regulations currently being developed in that country.

Development of an innovative training programme

The development of a new training course — Fisheries Evidence Training and Investigation Course (FETIC) for Pacific Island Fisheries Officers — is the result of a joint initiative between the Pacific Islands Forum Fisheries Agency (FFA), the Australian Fisheries Academy (AFA) and SPC. The FETIC programme is adapted from the Australian Basic Evidence Training and Investigation Course (BETIC) programme, which is a major component of the nationally accredited Certificate III in the Seafood Industry (Fisheries Compliance).

Early in 2007, the Port Adelaide-based AFA was contracted by SPC to develop a training curriculum for Pacific Island Fisheries Compliance Officers.

AFA liaised with staff of the FFA Fisheries Operations Unit to adapt the Australian BETIC course for the Pacific, and develop lesson plans, learners' materials and assessment guidelines. A complete training package was completed at the end of July, and AFA staff were ready to deliver a three-week pilot course at the PNG National Fisheries College in Kavieng (6–24 August). Sixteen Fisheries Officers have been selected by FFA to attend the course.

The will enhance Pacific Island Fisheries Officers' skills in:

- fisheries management principles and legislation;
- monitoring fish catches;
- patrol operations, including methods and resources; and
- investigative techniques, including evidence gathering, note taking, chain of evidence, interviewing and statement taking, brief preparation, and court procedures.

A report on the 2007 FETIC programme will be published in the next issue of the SPC *Fisheries Newsletter*.

Start Your Fishing Business (SYFB) training in Polynesia

Regular readers of Fisheries Newsletter are aware of the Start Your Fishing Business (SYFB) project jointly coordinated by SPC and the Commonwealth Secretariat. The purpose of this project is to facilitate the establishment in the region of a pool of certified trainers in small fishing business planning and management. Following the successful introduction of the SYFB training programme in Vanuatu and the Solomon Islands, a training needs analysis (TNA), funded by the Commonwealth Fund for Technical Co-operation (CFTC), determined there was a need to train fishing communities in small fishing business planning and management in Polynesia. Funding to facilitate the export of the SYFB programme to Polynesia was subsequently approved by the Commonwealth Secretariat.

Based on the TNA findings, and in collaboration with training institutions in Papua New Guinea, SPC's Nearshore Development and Training Section arranged for a sub-regional Training of Trainers (TOT) SYFB course. Early in 2007, SPC invited nominations from relevant institutions in Polynesia to participate in the TOT course. Fifteen nominations were received from three Polynesian countries and 12 participants were selected: four from the Cook Islands, five from Tonga and three from Samoa. In addition, SPC invited one participant from Kiribati, following a request from that country for assistance in small fishing business management training. The TOT course was held in Apia, Samoa, from 16 April–2 May.

The resource persons were Brenda Sainol from Papua New Guinea's National Fisheries College (NFC) and Peter Piawu from the Small Business Development Centre (SBDC). Both Brenda and Peter are accredited SYFB master trainers. Their assignment with SPC included:

- Liaising with trainees to assess individual training needs and fine-tune course content as required;
- Conducting a two-week TOT course in small fishing business management (SYFB);
- Planning in-country SYFB training programmes with participants;
- Distributing relevant documentation and course materials to participants;
- Adapting the PNG SYFB course materials to the small-scale fisheries sector of participating countries.

SPC Fisheries Training Adviser Terii Luciani travelled to Apia to assist with course coordination and supervise its implementation. He noted the high quality training and great motivation of participants. After the successful delivery of the TOT course, participants seemed well prepared for the implementation of the follow-up SYFB workshops in their respective countries. Those workshops will be conducted by the TOT course participants under the supervision of the PNG Master Trainers. They are scheduled in July and August and will be reported on in the next issue of *Fisheries Newsletter*.

SPC and the Commonwealth Secretariat thank the PNG National Fisheries Authority and Small Business Development Centre for their inputs into the development of networks of SYFB trainers in the Pacific region. Both organisations are also grateful to the individuals and local institutions that are supporting and making possible the introduction of the SYFB training programme in the Cook Islands, Tonga, Samoa and Kiribati.

In brief

- Fisheries Development Officer Steve Beverly is currently in the Cook Islands providing technical and training assistance to the local tuna longline industry. This project, which is similar to one that was recently implemented in New Caledonia (see p. 26), will involve a number of fishing trips onboard domestic (Rarotonga-based) longliners engaged in the southern fishery. A side-trip to Aitutaki is also envisaged in order to assist a couple of small-scale longliner operators entering the fishery. This project follows and complements a series of three tuna handling workshops (two in Rarotonga and one in Aitutaki) implemented by the Neashore Fisheries Development and Training Section earlier in July. As part of the project, Steve is expected to provide onboard training and advice to vessel skippers and crew. Follow-up recommendations on ways to improve fishing efficiency and vessel profitability will be made to company managers during post-trip debriefings. Details on the project will be available in the next issue of the *Fisheries Newsletter*.

- Nearshore Fisheries Development and Training Adviser (NFDTA) Michel Blanc represented SPC's Marine Resources Division in the Cook Islands during an official SPC visit from 25–29 June. The purpose of the visit was to develop the Cook Islands/SPC Joint Country Strategy (JCS), a document that will guide SPC programmes' inputs into the 2006-2010 Cooks Islands National Sustainable Development Plan. The SPC Marine Resources Division component of the joint strategy highlights planned and potential assistance from both the Oceanic and Coastal Fisheries Programmes of SPC for the period 2007–2010. This was developed during a one-day consultation between the NFDTA, the Secretary for Marine Resources, Ian Bertram, the team leader of the NZAID-funded Cook Island Marine Resources Institutional Project (CIMRIS), Geoff Mavromatis, and key Ministry staff including Joshua Mitchell, Peter Graham and Koroa Raumea. A number of activities listed in the JCS document have been implemented earlier in 2007, or are underway. These include the surveys undertaken by the PROCFISH team in Palmerston and Aitutaki, the facilitation by the DEVFISH project of an industry study tour in Tahiti, the training of local trainers in small business management, the printing of two posters on local reef fish, some ongoing assistance in relation to the production country reports to the Western and Central Pacific Fisheries Commission, as well as the above tuna handling workshops and technical assistance to the domestic tuna longline industry.

- Fisheries Development Officer William Sokimi and Fisheries Training Adviser Terii Luciani have started working on arrangements for the forthcoming Practical Safety and Fishing Course for Fisheries Officers to be held at the Vanuatu Maritime College (VMC), in Santo (1–26 October). Logistical arrangements are being looked after by William in close collaboration with VMC fisheries instructors Nare Wolu and Joseph Ouma. This includes setting-up the college's vessels and ordering gear for the fishing methods that will be demonstrated on the course on small-scale tuna longlining: both horizontal and vertical, tuna handlining, trolling, deep-bottom snapper fishing with reels and bait netting. The FAD that SPC helped deploy for the 2006 course disappeared so a new deployment will have to be made prior to this year's course. This will be a joint effort and cost-sharing exercise between SPC, the Vanuatu Fisheries Department and VMC. Terii is coordinating other arrangements, including the selection of course participants, correspondence with countries, travel arrangements and shore logistics at VMC (booking of classrooms, workshops, accommodation and meals for the trainees). The assistance provided by Norman Davies (VMC Head of Administration) in facilitating the above arrangements is much appreciated by NFDTA Section staff.

- The work programme for Steve and William for the last quarter of 2007 will include three FAD fishing skills workshops. Steve will start in October with a one-week training workshop in Lifou (Loyalty Islands Province of New Caledonia). The training will be conducted in collaboration with provincial and territorial fisheries officers and will partly occur onboard the F/V *Darmad*, the training and research vessel of Service de la Marine Marchande et des Pêches Maritimes (territorial fisheries administration). The participants will be five selected commercial fishermen of the Loyalty Islands who will use their own vessel during the workshop. Training will focus on

safety aspects of FAD fishing, FAD fishing technology, and practical fishing trips to demonstrate commonly-used techniques such as vertical longlining, handlining and trolling. This training is part of efforts by the Loyalty Islands to promote small-scale tuna fisheries. After the Lifou workshop, Steve will conduct a similar workshop for small-scale fishermen from Wallis and its sister island Futuna. It is envisaged the training will be two weeks in duration and that it will occur during the first half of November. William is scheduled to go to Kavieng in November to conduct a two-week handline training project in collaboration with staff of the Institute for Sustainable Marine Resources (ex-National Fisheries College). The project was supposed to be implemented during the mid months of this year but the logistics for the fishing operations were delayed due to unforeseen circumstances so it was agreed to conduct the project later in the year after all the logistics are put in place. This project aims at exporting the successful Morobe 'pumpboat' fishery to the New Ireland Province. William and Samol Kanawi (National Fisheries College instructor) will train local fishermen in FAD fishing methods and sea safety. The DEVFISH project will contribute to this training by funding the FAD that still needs to be deployed off Kavieng, ahead of the workshop. It is envisaged the vessels used for the practical fishing trips will include the institute's F/V *Leilani* as well as a couple of boats constructed as part of the recent EU-Rural Coastal Fisheries Development Project.

- The DevFish project is in the process of providing assistance to the Samoa alia fishery with the installation of an ice-making machine at the new wharf in Apia and also with funding for the construction and installation of a prototype sail to be trialled on alia vessels by the Samoa Fisheries Division. These activities are expected to be completed by the end of the third quarter of 2007. DevFish is also facilitating a session in the September Heads of Planning and Statistics meeting. This will be an opportunity to provide participants with an overview of domestic tuna industries in the region and to promote the inclusion of new and value-added tuna products in the development of national economic and trade statistics. The DevFish/USP scholarship was finalised in July with Monte Depaune from Nauru selected to take part in the whale depredation study in Fiji for the next two years.

Original text: English

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IMPACT OF TSUNAMI ON SOLOMON ISLANDS AQUACULTURE ACTIVITIES

An earthquake-generated tsunami, measuring 8.1 on the Richter scale, devastated the coastal areas of the Solomon Islands' central Western and Choiseul provinces on 2 April 2007 (see map below).

The coastal communities in these provinces depend greatly on marine resources (both farmed and wild caught) for both food and income, and the level of destruction wreaked by the tsunami has serious implications for many people. Aquaculture and related activities in these provinces include seaweed farming, culturing of ornamentals for the aquarium trade (clams, corals and various crustaceans), and small-scale pearl farming. There is also a small aquarium fish industry in the Western Province.

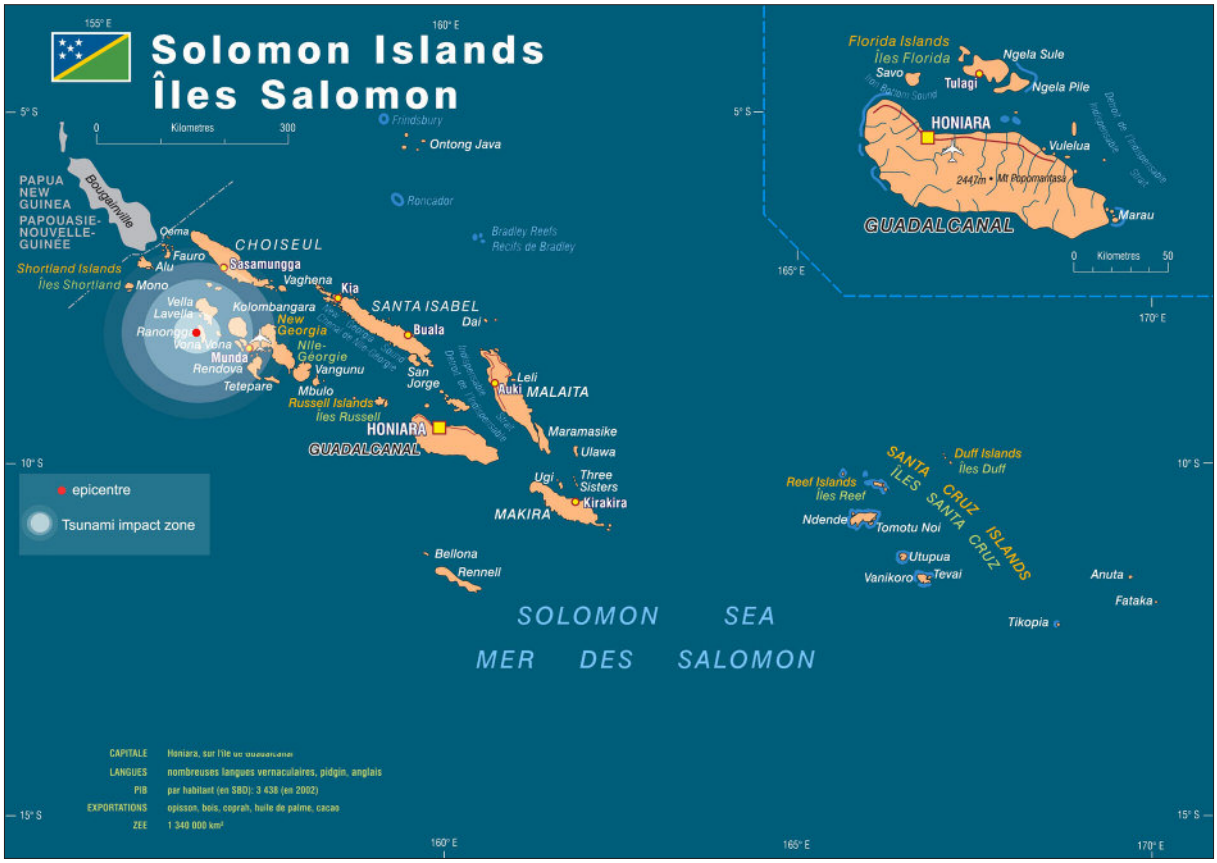
Seaweed farms in the Gizo area (capital of the Western Province) were destroyed, and an inspection of all farms determined a total loss. The only evidence remaining of farming activities are the posts and stakes used to support the seaweed at Olosana Island. There have been enquiries from some farmers in the affected areas regarding recovery programmes. The plan is to bring seeding material from Wagina Island (Western Province) to Gizo in order to re-start a nursery and at the same time supply some seed stock to those farmers wishing to begin immediately. Seed material is available from Wagina, although this island was also impacted by the tsunami.

Titiana village, a Gilbertese community in Gizo, has lost all of its farms (seaweed and coral farms). Titiana was the hardest hit community: the tsunami claimed more than a dozen lives and there are no traces or remains of any farming activities.

Similarly, Rarumana suffered total loss, not only of its seaweed, but also the farming site. It appears that the reef area, which was being farmed, has been raised as a result of the earthquake and the area is now too shallow to farm. In fact, the site dries out at low tide. There are alternative sites nearby and farming might begin as soon as seed material is available.

Other localities within the area, such as Sagheragi, have experienced similar catastrophes. This community there had established clam farms, and harvests of ornamental fish for the aquarium trade were waiting to be shipped to Honiara market when the tsunami hit.

The World Fish Center (Solomon Islands branch) and the Commercialisation of Seaweed Production in the Solomon Islands



(CoSPSI, Gizo sub-office) have had their capacity reduced (i.e. due to damages to facilities and a loss of assets) and it has taken several months for operations to return to normal. WorldFish Center and CoSPSI have been working hard to assist in the recovery of aquaculture-related activities. Other NGOs working closely with the Ministry of Fisheries and Marine Resources (MFMR) to set up marine protected areas at designated sites have also reportedly experienced a set back in their activities.

MFMR is currently working with SPC and other partners on developing an aquaculture strategic plan. The tsunami has undoubtedly modified some of the strategies described in the draft plan, but the document will remain in line with the needs for reconstruction in the Western Province. This will not disrupt strategies for developing aquaculture in other areas of the Solomon Islands. For example, the Ngella Islands of the Central Province experienced-was no effects from the tsunami, and the area was identified as a promising site for aquaculture activities given its proximity to markets in Honiara. Potential aquaculture activities include coral culture, sustainable capture and harvest of ornamental fish for the aquarium trade, clam and pearl farming.

An immediate result of the tsunami is the lifting of a one-year-old moratorium on beche-de-mer harvesting, which has partly helped people earn much needed income. However, the future of wild caught sea cucumbers cannot be anticipated with certainty. This leaves a clear and indicative mission to continue with assessing and developing an aquaculture development plan that is aimed at improving the lives of people from affected communities and the rest of the rural population that makes up 85% of the total population of the Solomon Islands.

Source: Wesley Garofe, MFMR (Ministry of Fisheries and Marine Resources), Aquaculture Officer, and Gideon Tiroba, CoSPSI (Commercialisation of Seaweed Project, Solomon Island) Manager

Gizo (left) was badly hit by the tsunami. Reefs (bottom right and left) were severely damaged

EU CHECKS ON CONTAMINANTS

This article was written by Chris Leftwich, Chief Inspector at London's wholesale Billingsgate Market, and is reprinted with permission from Seafood Processor.

Seafood products exported to the European Union must satisfy strict legislative requirements. Consignments will be checked at the point of entry and tested for a whole range of possible contaminants before being allowed free passage.

Developed societies have an increasing desire for seafood, a product that is wholesome, nutritious and has many health benefits. However, this desire cannot be satisfied by domestic sources alone and requires product to be sourced from far afield. Many developing countries are in a position to satisfy this demand as it brings much needed money into the local economies. However, they need to be careful not to cut corners as far as contaminants are concerned.

Contaminants can be separated into two main groups: chemical and microbiological. The main chemical contaminants can be further sub-divided into heavy metals, antibiotics, fungicides, sulphites, histamines, carbon monoxide, and various fish poisons such as ciguatera and puffer fish.

The two main bacterial contaminants are salmonellas and vibrios. However, it must be understood that these are by no means exclusive.

Heavy metals

The two main heavy metals that are causes for rejection of seafood products are cadmium and mercury. Problems related to cadmium are generally associated with industrial pollution, which can occasionally give rise to problems in shellfish. A particular concern is brown crabmeat as this can concentrate cadmium. In reality, though, problems with cadmium are isolated and do not create too much consternation.

The same cannot be said of mercury, which creates an incredible amount of adverse publicity. But is there a problem with mercury, or is it more of a perceived threat? Various authorities around the world would say there is a problem, whilst others would take the opposite view point.

Under EU law there is, of course, a legal requirement in relation to mercury with certain species of fish required to have no more than 0.5 ppm (parts per million) in the edible parts, and in other species no more than l ppm.

Furthermore, there is a lot of advice given out by various authorities. For example the Food Standards Agency in the UK states on its website that in relation to mercury people should not eat more than 140 g of shark, swordfish or marlin per week, or two portions of tuna of not more than 140 g, or 4 x 140 g of canned tuna.

The advice continues by saying that pregnant women, women intending to become pregnant, or children under the age of 16 should avoid eating shark, swordfish or marlin, but can eat two tuna steaks a week or four medium cans of tuna. Whereas the advice from the American FDA is not to eat shark, swordfish, king mackerel or tilefish. People can eat up to 12 oz (340 g) of fish and shellfish low in mercury per week. But this begs the question is the advice correct or fair.

Probably the two major pieces of evidence on the subject of mercury are studies undertaken in the Seychelles and the Faroe Islands. The Seychelles study was undertaken by a team of scientists during a 15 year period.

The scientists investigated the affects of mercury on a population that is consuming, on average, 12 portions of fish per week. The diet of the average person in the Seychelles would include plenty of fish with high levels of mercury.

The results of the study concluded that there were no adverse reactions on the population due to 'maternal' mercury. In other words, children born to mothers consuming fish contaminated with mercury were in no way affected. There were no visible outward signs of any child deformities and no less efficiency in brain capabilities.

The second study involving the Faroe Islands was on a population where fish makes up 44% of all meals and whale meat 10% of meals. This study was slightly less conclusive in that it was being done without the prior knowledge and consent of the population. Problems arose when people became aware that they were being used as unwitting guinea pigs. Once alerted to the fact they refused to cooperate further.

However, there is no evidence to suggest that the population was, or is, in any way compromised or affected by their diet.

So why are the authorities so concerned? It is probably because they tend to adopt a precautionary approach and build in huge margins for error. As problems occur when levels exceed more than 10 ppm they have built in a ten-fold margin for error.

However, this does tend to ignore the evidence that the main risks are from massive pollution events such as

Minamata and Nagato in Japan where seed was treated with mercury based products to prevent fungal damage.

It also ignores the effects of selenium. Most fish have a much higher concentration of selenium than mercury, and selenium has the ability to combine with mercury to prevent it from causing problems.

So this still leaves the question of mercury very much in the air with the authorities being extremely cautious and most of the evidence suggesting the problem is nowhere near as serious as the authorities would have us believe.

Antibiotics

There has, during the past 20 years or so, been a massive increase in intensive aquaculture around the globe. This has led, in turn, to an increase in the use of various chemicals such as antibiotics to control potential disease, and insecticides to control insects and parasites. There are permitted antibiotics that are quite legitimately used, but there are others that are banned such as nitrofurans and chloramphenicol.

The EU passed a ruling that there would be a zero tolerance policy on the use of these two substances. However, at the time of the ruling the detection capability was around 1 ppm. Technology moved on quite quickly and detection became possible at much lower levels down to parts of 1 ppb (parts per billion), which raises the question as to what is zero!

The answer being that zero becomes smaller each time technology improves. Unfortunately for developing countries their technology was not as sophisticated as in the EU, which meant they could not detect contaminants down to this level.

This meant a lot of product was being rejected, which in turn meant whole consignments being destroyed. The difficulties faced by producers were that some of these substances are permitted for use in products being produced for domestic consumption.

Furthermore, it has been shown that these antibiotics have electrostatic properties, which means that minute traces would remain in the feed production mills for several batches even though none had been used. Thus a legitimate company could unwittingly introduce them into its production without realising that it had a problem.

The EU did relax its policy slightly a couple of years ago and is now enforcing at 1 ppb as opposed to zero, which as mentioned earlier gets smaller all the time.

The problem with this standard is that the legislation does not specify what constitutes a sample, how big it should be and where it should be taken from. It is well known that in a large directorate is conducting an ongoing survey on non permitted contaminants and is still finding the odd consignment coming through. When this happens the Food Standards Agency is alerted and it, in turn, contacts the EU authorities in Brussels who put out a food alert.

What this means is that the next ten consignments from a particular source are targeted. If problems persist it could result in the EU sending out inspectors to the country in question and this could result in a ban on that country.

Conversely, if no problems are found then normal sampling is resumed.

Histamines

Of all the problems that can be experienced with regards to fish, it is possibly histamines that cause the most headaches. Although, when considering the amount of tuna now being consumed in the EU, the reality is that incidences are quite rare.

Problems occur because certain species of fish naturally contain a chemical, histidine, and if subjected to temperature abuse, bacteria can convert this into histamine. Any person who inadvertently eats the product then gets an adverse reaction commonly known as scombroid fish poisoning

This usually comes on within a few minutes to an hour of eating the fish. It has no lasting affect and will usually pass off within a few hours to about 24 hours, but is very unpleasant for the sufferer in the intervening period.

Histamine production can occur at temperatures as low as 6°C and under certain circumstances even down to 2°C, but this is extremely rare and is usually associated with high temperature abuse.

Most problems in the UK probably occur in the kitchen where the chef or housewife leaves the fish out of refrigeration for a few hours prior to cooking without realising the potential risk they are creating. The advice is to keep the product below 4° C at all times prior to cooking and the problems do not occur.

The fish that are implicated in scombroid fish poisoning are the scombroids (mackerel, tuna, kingfish, etc.), the engraulidae (anchovies), clupeidae (herring family) and the coryphaenidae (mahi mahi). However, in the UK problems are almost exclusively related to tuna.

Legislation requires nine samples to be taken from a batch and that no sample must contain more than 100 ppm of histamine. It does allow for two failures of between 100 ppm and 200 ppm, but any sample above 200 ppm will necessitate the batch being destroyed.

The problem with this standard is that the legislation does not specify what constitutes a sample, how big it should be and where it should be taken from. It is well known that in large fish such as a tuna, different levels of histamine are present in different parts of the fish, particularly if a fish has not been properly iced.

Rapid, cost effective test kits do exist, but an accurate reading of the histamine content could be expensive if it has to be obtained from a public laboratory. But it is important that anyone in the trade handling any of the fish mentioned above only purchases them from bona fide sources that can provide full traceability and temperature records.

Fungicides

Fungicides are used extensively in aquaculture to control fungal growths and parasitic infections in fish and shellfish. The two most commonly used are malachite green and its metabolite, leucomalachite green.

Both of these substances are banned for use by the American FDA, in Europe and in many other countries around the world.

However, because of the unavailability of alternatives there is still misuse of these chemicals and occasionally they can still he detected on testing of aquaculture products coming into the EU. If found the products are subject to destruction.

Sulphites

Sulphites are often used in the shellfish industry to control melanosis (black spot) in prawns and other crustaceans. This is where the shell start to blacken either because of ageing or temperature abuse.

Once melanosis starts it will spread and eventually the black penetrates into the flesh rendering it unsaleable. In order to retard this process producers often dip prawns in a solution of sodium metabisulphite. Some producers lend to use it indiscriminately and exceed the legal dose levels of 150 ppm.

Under recent EU law, which was introduced in 2005, there is now allergen legislation that makes it a requirement to label any product treated with sulphites. This is because it has been known to trigger asthmatic attacks in people.

However, I personally do not see much evidence of products being correctly labelled at the moment.

There are now other chemicals available to control melanosis, which do not require to be labelled as allergens as they are made from natural products. The drawback is that the industry still tends to go for the cheapest option and these other products are slightly more expensive.

Source: *Seafood Processor*, April 2007, pp 22–23 (http://www.seafoodprocessor.com/heighway/home.htm?site=sfp)

(Note from Ed: This article will be continued in the next issue of the SPC Fisheries Newsletter)

EXPERIMENTAL STOCKING AND COMMUNITY MANAGEMENT OF TILAPIA IN LAKE SATOALEPAI, SAMOA

Satya Nandlal[1], Cathy Hair[2] and Tauvae Sua[3]

Introduction

In Samoa, fishing has been a traditional practice, providing food, employment and economic benefits to many people. However, in recent years, it has been realised that fisheries resources, although renewable, are not infinite, and need to be properly managed if their contribution to the nutritional, economic and social well-being of the growing population is to be sustained.

The report 'Samoa Aquaculture Development Plan 2005–2010', states that,

> *…aquaculture development in Samoa has mostly been in the trial stages. Setbacks to progress include poor maintenance and management, limited manpower and facilities and insufficient funding. In addition, there have been high costs associated with the importation of organisms and feeds, limited suitable land area for construction of culture ponds, as well as unforeseen natural disasters.*

Similar scenarios in aquaculture development are present in many Pacific Island countries and territories with the exception of a few (e.g. New Caledonia, the lead shrimp farming area in the region).

In 1999, a project by AusAID and the Samoa Fisheries Division (SFD) developed a framework for the better management of fisheries resources. This framework enabled SFD to reduce fishing pressure on the overexploited nearshore fishery resources by initiating aquaculture projects, which included the stocking of natural lakes and ponds. In addition, the first SPC programme visit on aquaculture to Samoa (in late 2003), recommended that new approaches to fisheries management, embracing conservation and environmental, as well social and economic considerations, were urgently needed. SPC was asked to develop a proposal for the better utilisation and management of lakes and ponds, including Lake Satoalepai on Savaii. Subsequently, a mini project entitled, 'Experimental stocking and community management of tilapia in Lake Satoalepai, Samoa' was developed by SFD in collaboration with SPC, and conducted as part of the ACIAR-funded project, 'Sustainable aquaculture development in the Pacific Islands Region and northern Australia'. The mini project provided support for SPC's regional aquaculture initiatives in PICTs, where stocking tilapia fingerlings is a means of increasing fish production to improve food security.

Background to Lake Satoalepai

Lake Satoalepai is situated between the villages of Safai and Satoalepai in the Matautu District on the southwestern coast of Savaii Island. There are no reports regarding the formation of this lake, although according to SFD staff and others, it was formed as a result of the removal of soil and sand for road construction that was intended to link the villages to the port town of Salelologa in the late 1970s. Later, a feeder road was constructed through the centre of the lake to link the villages in the area, thus dividing the lake into two parts (Fig. 1). The lake area downstream near the sea (with an outlet that opens into the sea, thus exchanging seawater during high tide) is owned and managed by Safai village. The upstream area is owned and managed by Satoalepai village.

Upstream of the feeder road the lake is 100 m long at the roadside, 210 m on the opposite side, and about 250 m wide, giving a surface area of approximately 4 ha, with an average depth at mid low tide of 40 cm. The bottom of the lake at the road side consists of rocks and boulders and the inland side is muddy (30–40 cm deep) with remnant coral/limestone pinnacles. Three culverts, each approximately 1 m in diameter, were built into the road to allow water flow between tides and the continuous downstream flow due to spring water and also after rain-

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Figure 1: Aerial view showing the upstream and downstream sections of Lake Satoalepai, which is divided by the road. The black arrow indicates approximately where Lake Safa'i begins

fall. Freshwater springs are abundant in the lake on both sides while the seaward side (of feeder road) remains tidal and brackish.

Fresh fish is an expensive commodity and often in short supply in the area. Nearby lagoon reef resources are subject to high fishing pressure and are overexploited. Consequently, inland fisheries offer an alternative source of fish protein. Mozambique tilapia (*Oreochromis mossambicus*) was initially stocked in the lake in 1966. In 1994 and 2003, Nile tilapia (*O. niloticus*) was introduced into the lake to increase fish biomass as part of the SFD aquaculture extension programme. Subsequently, tilapias have become the most significant component of the lake's fish population and a major protein source and income earner for local people. Fishermen regularly catch tilapias using gillnets, fishing lines, cast nets, and with bare hands. Fishing activities have been banned for certain periods in the past. This occurred usually when the tilapia being caught was small and the fishing bans were imposed to allow stocks to recover. However, these bans or controls were not always strictly enforced.

According to SFD staff, some constraints to management of tilapia fishery in the lake include:

- Non-availability of information regarding past tilapia stockings (and so a difficulty in estimating stock size and also in setting management guidelines for the fishery in the lake);
- Lack of set guidelines for managing the tilapia fishery;
- Overexploitation of the lake due to its use by almost all community members with no controls or regulations or quotas;
- No consistent supply of tilapia fingerlings for restocking; and
- Lack of skilled extension staff and capital.

Collaborative work involving SFD and SPC's Aquaculture Section began as part of a small grant to purchase tilapia hatchery equipment in December 2003. This led to improvement in tilapia fingerling production. SFD staff also attended tilapia training workshops (conducted by SPC) in various aspects of tilapia and freshwater prawn culture in Apia as well as in Fiji. Tilapia fingerlings are now produced in tanks, hapas and earthen ponds in sufficient quantities for stocking ponds and lakes.

In the past, restocking tilapias in the lake was not monitored and there were no controls or guidelines on fish harvesting practices or established protocols for managing the lake's fishery. This mini project was developed in order to:

1. evaluate growth performance and survival of stocked *O. niloticus* in Lake Satoalepai;
2. conduct village consultations to develop a co-management regime for the SFD tilapia restocking programme; and
3. increase SFD staff skills in tilapia restocking, including hatchery operations, fingerling grow-out, and fingerling transport.

Project activities

The project began in late July 2006 by a visit from SPC staff who supervised and assisted in carrying out the following activities.

- Consultations with Satoalepai village council. Council members agreed to participate and assist in the implementation of project activities, which involved banning all fishing in the lake for the duration of the trial, and providing manpower for sampling, measuring water quality parameters, and security for the fish. Following this meeting, a survey of the lake was carried out, which indicated that *O. mossambicus* was the most dominant species present followed by freshwater prawns, probably *Palaemon* species. Several indigenous species were also present, including mullet, half-beak and mud crabs.

- Preparation of equipment for seining, holding, conditioning and transport of fingerlings were carried out in Apia. A total of 10,000 fingerlings were seined, graded, and conditioned in hapas (for 36 hours) in cement tanks at SFD's hatchery. The fingerlings were transferred to a 2000-L fibreglass tank, filled with 1,500 L of fresh water and fitted with air hoses connected to an air pump. The tank was loaded on a 7-t truck and transported to the lake.

- Fingerling tagging (clipping of the right pelvic fin with a pair of scissors) was carried on the lake's bank in the compound of the village mayor's residence. Members of the village council released the first set of tagged fingerlings into the lake (Fig. 2).

- Individual weights and standard lengths of a sample of 200 fingerlings were recorded, and fingerlings were afterwards released into the lake. This sampling exercise was carried out monthly for the duration of the trial by SFD staff.

- Tissues samples from 30 individuals of *O. niloticus* and *O. mossambicus* were collected and preserved in 70% ethanol. These were sent to Queensland University of Technology, in Brisbane Australia for genetic studies (i.e. to determine whether there has been any introgression of *O. mossambicus* genes into *O. niloticus* or vice versa).

Figure 2: Release of tagged *Oreochromis niloticus* fingerlings into Lake Satoalepai

The final sampling of the stocked Nile tilapia was carried out in April 2007 by two of the authors (Satya Nandlal and Cathy Hair), SFD staff and Satoalepai villagers. Prior to sampling, consultations were carried out with the village council. We were informed that the lake flooded in October 2006, and that the flood water flowed over the road (from the stocked section of the lake to the lower side of the lake) and the fencing screens from the three culverts were broken and washed away, allowing fish to move freely in both directions. After the flood, the ban on fishing was partially lifted, with handlining allowed in the lake (inland side of feeder road) and gillnets in the lower side of the lake.

Tilapia harvesting was carried out over three days using a 100-m gillnet (mesh size 3 in) on both sides of the lake. All *O. niloticus* that were caught were sampled for total length and body weight. Wild *O. mossambicus* (bycatch) were counted and their total weight recorded. All other bycatch species were identified and recorded.

Additional sampling was restricted because of spring tides, which prevented sampling in the lake during the night as scheduled. Furthermore, the lake water was too deep to allow for cast netting and too murky to be able to see fish clearly.

Results

Final sampling results are summarised below.

1. Nine netting drives were carried out resulting in a total catch of 138 Nile tilapia: 121 tagged fish with a mean weight of 141 g (see Fig. 3), 14 large fish from previous stockings (i.e. 2005 or earlier)

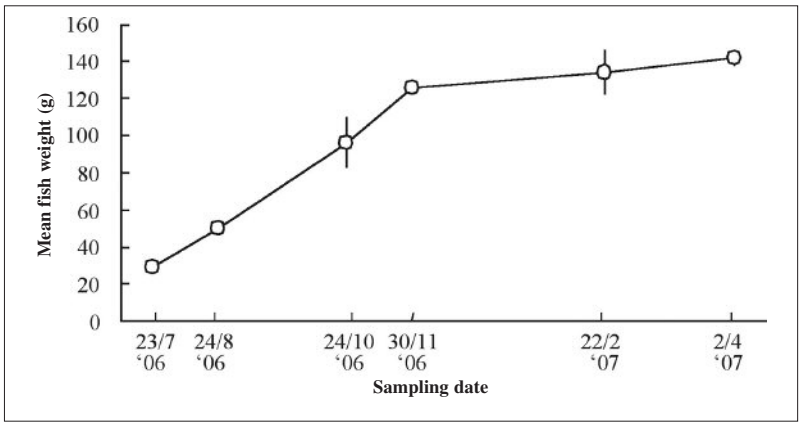
and 3 fingerlings. Netting drives involved partially seining a portion of the lake whereby the fish were driven into the nets by beating the water. Some fish hide in the mud at the base of the lead line and are caught by hands. This is the preferred method of catching tilapia in 1–1.5 meter deep water by the local fishers.

2. A total of 171 wild *O. mossambicus* were caught, with a mean weight of 160 g each. Other smaller fish were caught (e.g. juvenile mullet, milkfish, trevally and half beaks).

3. From visual observations, there appeared to be an increase in the population of *O. niloticus* following the restocking.

4. The average weight of tagged *O. niloticus* (141 g) is an acceptable size considering the lake environment and more so importantly, the people consider this an edible size. Smaller *O. mossambicus* (50–80 g) are regularly caught and consumed by villagers, and residents of Satoalepai village expressed a preference for *O. mossambicus*.

5. A complete technical report is being prepared and will be available on request.



Discussion

Growth of tagged fish in the lake was 0.44 g/day. This growth rate is low but is an acceptable size given the overall condition of the lake environment (i.e., clear water indicating less primary production in the lake). The total weight at stocking was approximately 298 kg and based on average size at final sampling of 140 g, a net gain of 1,143 kg was achieved which is a significant volume of fish for the local people. There was also an increase in population of *O. niloticus* after the stocking based on our observations during the final sampling and was also obvious from the enthusiasm and happiness of the villagers of saying there is 'more fish' in the lake now. From the data collected, it was difficult to estimate survival rates of the stocked tilapia; however, the observation of large numbers of *O. niloticus* is a good indicator of high survival rates.

It should be noted that *O. mossambicus* is a pest species in many areas due to its rapid growth and reproduction; it quickly populates water bodies with large numbers of small fish. Interestingly, the *O. mossambicus* harvested during the final sampling (mean weight 160 g) were quite large. There were people seen catching *O. mossambicus* by hand, cooking and consuming these fish. The fishing ban that had been in place (although not properly enforced) may have also contributed towards allowing Mozambique tilapia to grow to larger sizes in the lake.

Figure 3: Growth of tagged tilapia in Lake Satoalepai during the study

Figure 4: *O. niloticus* (right), *O. mossambicus* (left) and a hybridized tilapia (centre) collected from Lake Satoalepai during the final sampling trip

SFD staff raised concerns that introduced *O. mossambicus* prey on native fish fry and eggs, thus reducing their populations. More data would be needed to quantify the effects of *O. mossambicus* on ecological processes occurring in the lake such as food web structure and energy flows. This needs to be ascertained scientifically, but was beyond the scope of this project.

During the final survey, we observed some *O. niloticus* showing signs of hybridisation with *O. mossambicus* (Fig. 4). This may be due to breeding between *O. niloticus* (stocked prior to this project) and *O. mossambicus*. Further investigations would need to be carried out to confirm this.

Nile tilapia was selected as a suitable species for stocking because it has a faster growth rate and matures at a larger size compared with other tilapias. Other factors contributing to the choice of *O. niloticus* include: it was already present in the lake; fingerlings were available; and this species is part of SFD's strategy to develop tilapia culture and demand for fish by villagers. In this project, 10,000 tilapia juveniles were stocked. SFD stocked a further 5000 three months after the sampling trip. There is a need to collect data (fish size and numbers caught) on the catch resulting from the restocking effort in order to monitor its success. It is not known if the tilapia stocked in the lake could become a self-sustaining population. Several *O. niloticus* fingerlings were caught after considerable effort using a seine net, which was problematic due to debris and the uneven nature of the lake bottom. More effort should be made to quantify the *O. niloticus* fingerling population in the lake. This will not only help determine if a self-sustaining population is present, but will also assist with setting management guidelines for the lake and its fish resources. The local fisheries officer should be trained to work with the villagers and be responsible for collecting the data.

One result of this project is an interest in tilapia aquaculture by villages. Several farmers are interested in developing tilapia pond culture. The study provided an opportunity for SFD staff to improve their skills in many aspects of stocking, including hatchery operations and transport of fingerlings, as well as sampling and monitoring. The impacts of the present project are not fully known and it is advisable to develop a plan and carry out activities for pond culture in stages. Before embarking on pond culture, prospective farmers need to consider local inputs (especially feed) that can be made by the villagers, since any project that involving heavy subsidies may not be sustainable in the long term.

This study provides baseline data to assist in the development of a management regime. As a result of the stocking, monitoring and sampling activities, Satoalepai villagers are in a better position to make well-considered decisions regarding the future of their tilapia fishery. Benefits could be gained from the establishment of a village committee with technical competence to oversee the lake's management and fishing practices, catch distribution and production systems suitable for the community under their local conditions. Appropriate management options include the use of larger mesh sized gillnets (> 3"), increased effort in catching all sizes of *O. mossambicus*, regular stocking of *O. niloticus*, placing moratoriums on fishing for certain periods, and enforcing a minimum size limit for *O. niloticus*. These techniques could be adapted with very little capital expenditure and may bring about an increase in fish yields from the lake. SFD and SPC can contribute to the development of a management plan by helping to develop a fishing accord into which all stakeholders should have input. It is critical that villagers benefiting from the project make the decisions and are involved from the initial stages.

PACIFIC ISLANDERS GAIN SPECIFIC KNOW-HOW ON GROUPER HATCHERY TECHNIQUES

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Marine finfish hatchery training for Pacific Islanders

Six Pacific Islanders received training in marine finfish hatchery techniques in Thailand between 12 May and 2 June 2007. Organisation and sponsorship was mostly provided by the Secretariat of the Pacific Community (SPC) with local support provided by the Network of Aquaculture Centres in Asia-Pacific (NACA). Participants were from New Caledonia, Papua New Guinea, French Polynesia, and Fiji. Training was held at the Krabi Coastal Fisheries Research and Development Center (KCFRDC) on Thailand's Andaman coast, and included field trips to the provinces of Satun, Songkla, Phuket and Phang-nga.

Groupers were the focus of the hatchery training. Tiger groupers (*Epinephelus fuscoguttatus*) were induced to spawn and participants followed up on larval rearing and larvae development for the duration of their three-week stay in Krabi. The training included hands-on work, lectures on all topics relevant to grouper/tropical marine finfish aquaculture, and field visits to governmental and commercial ventures in southern Thailand.

Researchers from aquaculture centres around southern Thailand gave 15 lectures on various topics including health and disease, feeds and nutrition, specific grouper culture, and broodstock management.

Overall, participants were given a broad perspective of the constraints in and potential for developing marine finfish and grouper aquaculture in the Pacific. This was made possible by a daily exposure to the successes and achievements in this type of venture.

Thanks to the very knowledgeable and helpful staff of KCFRDC, the SPC/NACA participants gained tremendous practical knowledge on techniques of grouper culture, larvae handling and rearing, which will have direct application to the development of finfish aquaculture in their respective island countries.

KCFRDC, a prime training centre

KCFRDC was identified as a suitable facility for the SPC/NACA training because of its ability to mass produce tropical fish species (mostly grouper species, seabass and cobia) in a hatchery environment. KCFRDC was also chosen because of its:

- accessibility (there are direct flights to Krabi from Bangkok),
- large size and available space for training purposes (both theoretical and practical), and
- skilled staff who are able to communicate in English.

KCFRDC was also ideal because of the variety of tropical finfish that are cultured there and the number of relevant commercial and governmental aquaculture facilities that are close by.

KCFRDC has several fish hatcheries and nursery rooms: a food fish hatchery (grouper species, seabass and cobia), nursery room and broodstock areas area; a shrimp hatchery and nursery room; and an ornamental fish hatchery and grow-out area.

Several earthen ponds are also used for holding broodstock of large fish species (e.g. *E. lanceolatus*). Cage culture systems are placed in some of the ponds for holding broodstock and juvenile fish.

Hands-on training for technical participants

The main aim of the training was for participants to observe the spawning of grouper species and the early days of larval rearing — the life stages that present the most difficulties when culturing these fish.

Hormone stimulation and spawning induction were performed by all six participants at the beginning of the training. A mix of Superfact® and Motilim-M® was used to induce the fish to spawn. Before injection, *Epinephelus fuscoguttatus* broodstock were anaesthetized using quinaldine, and checked for gonad ripeness by stripping or cannulation for females. Then, several mature broodstock were injected with the hormone preparation.

Forty-eight hours after induction, the fish spawned and participants were invited to collect the eggs using a seine net. Good quality eggs were collected, disinfected, and placed into a 200 L incubator for 24 hours, until hatching. Each participant was assigned to a 4-t tank that was

thoroughly cleaned with iodine and domestic detergent, and then rinsed with fresh water.

Once the larvae hatched, they were gently transferred to the larval rearing tanks, at a density of 80 larvae per liter. Each tank was stocked with 250,000–300,000 larvae. Participants observed the larvae under microscopes and then calculated yolk size, lipidic globule size and total length. For two days, larvae were fed on yolk so that no external feeding was needed at that stage.

In Thailand, a green water technique is used for grouper culture. Green micro-algae are mass produced (e.g. *Tetraselmis* sp. or *Nannochloropsis* sp.) and then used for feeding zooplankton (rotifer). The algae tint the water in the larval rearing tank, which reduces visibility and diminishes the brightness of incoming light. The result is that stress levels in the fish are reduced. To keep the algae and rotifer populations balanced in a larval tank, fresh algae must be inoculated every day. A small strain of rotifers is used for feeding small grouper larvae. For the first few days of the grouper larvae feeding, only the smallest portion of the rotifer population is harvested through a 100 µm mesh. Smaller rotifers and rotifer eggs are used for the first feedings of the grouper larvae.

The very early stages of grouper larval development require little care and attention. The larvae are lecithotrophic. It takes around two days for the larvae to absorb the yolk and for their mouths to open. For the first two days of larval rearing, participants measured the volume of the yolk sac and the size of the lipidic globule in order to evaluate the absorption of the yolk sac and estimate the time the mouth opens.

After day 3, larvae were fed daily by maintaining the algae population in the tank. On day 4, grouper larvae entered a critical developmental stage (days 4, 5 and 6) and many larvae died or were trapped in the surface. During these three days, fresh algae were inoculated daily and the rotifer population maintained at around 10 rotifers/ml.

On day 6 of the larval rearing, the first dorsal spine appeared. Tanks were cleaned to remove waste products and to increase the water quality. For the following five days, routine feeding and larval observation took place. On day 12, tanks were harvested and larvae were counted and restocked into new tanks that were filled with algae and rotifers.

Usually, after day 12, grouper larval survival is more than 10–12%. Larval rearing from day 14 up to the weaning stages is not as problematic as during the early stages, and mortality decreases during the second half of grouper larval life. Basically, routine feeding with chlorella and rotifers continues until days 15–20, after which larvae are fed *Artemia* nauplii.

Top: Injecting a tiger grouper broodstock (photo Sih Yang Sim)

Bottom: Participant checking the quality of the eggs after spawning (photo Sih Yang Sim)

Once the nauplii have hatched, they are enriched with highly unsaturated fatty acids (HUFA), which are essential to grouper larval survival.

Rearing juvenile groupers to market size

Although nursery techniques were not the main focus of this course, participants were exposed daily to nursery practices, including grading and sorting for deformities, feeding, culture methods and culture tanks, packaging and transporting. While at KCFRDC, numerous *Cromileptes altivelis* of around 5 g were stocked in the nursery tanks and participants observed and assisted in all handling activities.

Thai grow-out techniques were observed during the numerous field trips around Krabi and in the other provinces. Participants studied single floating or multiple floating cages in ponds or at sea. Participants also participated in daily feedings of adult fish held in KCFRDC facilities.

It takes about six months to two years to rear groupers to commercial size, depending on the species and the culture methods used.

A study tour through southern Thailand

In addition to the routine daily hatchery training, participants made numerous field visits

Floating farms

Participants visited floating farms in Koh Ya Noi, an island between Krabi and Phuket, and another one in the mouth of the Krabi River. The floating set ups were similar and each farm had around 50–60 nets measuring 3 m x 3 m x 2 m. Most of the fish grown in these cages (*Epinephelus areolatus*, *E. coioides*) were collected from the wild as juveniles, but others, such cobia or sea bass, were purchased from hatcheries. Also, lobsters (*Panulirus ornatus*) were generating most of the interest of these cage farmers.

In Phuket Province, participants visited a floating cobia farm comprising three large (10 m in diameter) circular cages stock with 4–5 kg fish. Cobias were fed artificial feed and were ready for sale (filet and export) in approximately one year. It takes about 15 people to lift the nets or to proceed with any major operations (e.g. harvesting, changing the net). This particular cobia farm buys fingerlings from the government hatcheries in Krabi, Phuket and Phang Nga. Near the cobia farm, there is a co-owned Thai-Taiwanese floating grouper farm that operates approximately 200 square cages 5 m x 5 m x 2 m and one large floating work house. Fingerlings are mostly imported from Taiwanese and Indonesian hatcheries. Once the fish reach market size, most of them are exported live to Taiwan. This cage farm mostly focuses on high value species such as coral trout (*P. leopardus*), gold spot grouper, giant grouper, mouse grouper, and aereolated grouper.

Top: Cobia in a floating cage in Satun area
Middle: Floating cages in the mouth of the Krabi river
Bottom: Grading and treating fish with fresh water on a floating cage set up in Phuket area

throughout southern Thailand to the provinces of Satun, Songkhla, Krabi, Phang Nga and Phuket. Private floating fish farms, an abalone hatchery and grow-out facility, a prawn hatchery and prawn farms were visited. Participants also had the opportunity to visit government aquaculture centres in Satun, Songkhla, Phuket and Phang Nga, all of which had hatcheries and large finfish areas available for research and development or production work. Food fish and ornamental fish are commonly cultured and technologies transferred to the private sector.

Global characteristics of grouper farming and their application for the Pacific region

Marine fish farming in Southeast Asia has been developing at a rapid pace, especially in Indonesia, Malaysia and Vietnam. This is the result of improved farming techniques (hatchery) and the inclusion of aquaculture in all government strategic plans. International markets are still healthy and most of the production is aimed at exports.

The marine finfish sector and especially grouper production face particular problems relating to seed production (i.e. some species have low survival, supply can be inconsistent and seasonal, seed supply still rely a lot on wild caught juveniles), feed availability (whether it's trash fish or artificial feed), and fluctuating market prices (i.e. excess supply, price fluctuation, niche markets, seasonality).

The training at KCFRDC in Thailand was highly relevant to Pacific Islanders because:

- Systems used in Thailand are simple and do not involve high-tech equipment. Most set ups are made of concrete, PVC and fairly simple piece of equipment that are readily available throughout the Pacific.

- Techniques used in Thailand base their success on low input, low output. Survival rates of some delicate species remains low but the costs of producing them are also low.

- Mechanization of aquaculture facilities in Thailand is at a minimum and many stages of aquaculture production are done by hand. As a result, the processes are more labour intensive but costs and risks are kept low.

- There are numerous local markets in Thailand for finfish species. Thai producers seem to be targeting the domestic market rather than export market, where they would otherwise place themselves in competition with other countries (e.g. Vietnam, China).

In the Pacific Islands, marine finfish production should primarily be oriented towards the domestic market for local consumption. Increasing human populations and a stable demand for fish will help reduce the risks associated with export markets.

Because the demand for high quality products remains high, exporting might also be considered for Pacific Island countries. However, higher production

Table 1: Comparison of hatchery and farming practices among three countries.

Country	Hatchery practices	Farming practices
Indonesia	Small-scale low investment & low cost backyard hatcheries	Mainly floating cages
	Fast return	Medium- to large-scale
	Increasingly capital intensive: medium- & large-scale hatcheries established	Concrete tank culture
	Groupers (humpback, tiger, orange-spotted, coral & coral trout), milkfish, trevally, snappers, etc.	Capital intensive & high investment
		Mix of trash fish & artificial diets
Malaysia	Capital intensive	Floating cages & ponds
	Medium- & large-scale	Medium- to large-scale
	Mix of tank & pond systems	Relatively capital intensive
	Limited species produced	Mix of trash fish, artificial diets, bakery products,
	Majority of marine finfish species farmed rely on imported fingerlings	
Thailand	Commercial production limited to seabass	Mix of floating cages & ponds
	Grouper species from government stations	Small- to medium-scale
	Many marine fish species farmed in Thailand	Low investment capital
	Still rely on imports or wild seeds	Mainly trash fish

and shipping costs in the Pacific (vs those in Southeast Asian countries) will make competition difficult for Pacific region.

Good water quality, availability of land and sea area for farming, availability of labour and (relatively) low labour costs, and availability of broodstock from valuable species are assets to the Pacific Islands region and developing marine finfish aquaculture seems a viable option for the near future.

Farming aquarium fish

Eleven species of anemone fish are successfully being reared at KCFRDC using traditional larval rearing protocols. These include *Amphiprion ocellaris*, *A. percula*, *A. ephippium*, *A. sebae*, *A. polymnus*, *A. clarkii*, *A. frenatus*, *A. melanopus*, *A. akallopsios* and *A. perideraion* and *Premnas biaculateus*. Most of the fish are sold to small-scale Thai ornamental operators before they are exported.

Three species of seahorses are also cultured and larval rearing protocols are being developed for other species such as damsel fish (*Chrysiptera* sp.) and blue ring angel (*Pomacanthus annularis*), as well as silver angel (*Monodactylus argenteus*) and batfish (*Platax orbicularis*).

***Premnas biaculateus* broodstock at KCFRDC**

Diversified aquaculture

Participants of the KCFRDC training also visited two abalone hatcheries and grow-out farms, one in Phuket and the other one in the Krabi area. The abalone species that is cultured is *Haliotis diversicolor*, which is relatively fast growing and has a high market value in Taiwan. Abalone broodstock are fed *Gracilaria* sp. for maturation and then induced to spawn. Larvae are lecitotrophic, and at settlement they are fed artificial feed. After incubation, larvae are stocked directly in grow-out tanks with corrugated tiles and harvested when they reach commercial size.

The Lookmee prawn hatchery in the Krabi area uses highly hygienic practices to achieve a production of 200 million post larvae per year. A commercial grow-out farm rearing *Litopenaeus vanamei* was also visited. Productivity from this farm was high: seven ponds, each 1 ha, could produce around 400 t/harvest. Most Thai farms are very cautious of environmental issues. Use of settlement ponds and large buffer ponds is common. No antibiotics are used during the culture cycles.

Top: Juvenile abalone ready to export to a grow-out farm
Bottom: Intensive white shrimp farm in the Krabi area

AN INNOVATIVE CANOE BUILDING AND INSHORE-FAD PROJECT IN NAURU

Michel Blanc[1] and William Sokimi[2]

In May, the Secretariat of the Pacific Community (SPC), in collaboration with the Nauru Fisheries and Marine Resources Authority (NFMRA), hosted a workshop in Nauru on canoe building. This workshop resulted from consultations with NFMRA, SPC's Coastal Fisheries Programme (Nearshore Fisheries Development and Training Section and Coastal Fisheries Management Section) and community leaders regarding sustainable food security, reducing pressure on overfished inshore resources, and providing alternative fishing opportunities to the district communities on Nauru. An agreement was reached between SPC and NFMRA to work towards implementing a project focussed on canoe building and inshore FAD fishing. SPC's Nearshore Fisheries Development and Training Section (NFDTS) Adviser, Michel Blanc, was instrumental in formalising a project proposal that was approved and funded by the Republic of Taiwan's regional development assistance programme.

The project's objective was to alleviate fishing pressure on the inshore resources and enhance food security for locals through a canoe building training programme and the deployment of fish aggregating devices (FADs) close to communities' foreshore for their canoe fishermen to capitalise on.

The project was carried out in two phases.

Phase I consisted of two components that were run concurrently: a FAD deployment component and the canoe building training component. SPC's Fisheries Development Officer (FDO), William Sokimi, implemented the FAD component from 29 April–12 May. Wiliam assisted with setting up the canoe building training component by organising tools and building materials in preparation for the workshop, which was conducted by Kiribati-based boatbuilder, Mike Savins (5–30 May). During phase I, the FDO also conducted a classroom presentation on FAD fishing methods, with a focus on mid-water jigging and chum-bait fishing.

Phase II of the project was implemented by the FDO from 24 June–7 July and consisted of:

- three workshops on canoe safety awareness and practical mid-water fishing methods for the communities selected by NFMRA;
- a performance assessment of the canoes under practical fishing conditions;
- the construction and deployment of one additional inshore FAD off Baitsi District;
- the monitoring of the FADs deployed earlier in May;
- the development and introduction of a logbook for monitoring the fishing activities undertaken by the canoe fishermen.

CANOE BUILDING WORKSHOP AND RELATED ACTIVITIES

Nine local boatbuilders from the communities of Anetan, Anibare, Bauda, Boe, Denig and Meneng have been trained in modern canoe building techniques by Mike Savins. SPC ordered building materials and tools for the workshop while NFMRA provided the venue and managed the logistics.

At the end of the training, four canoes had been built: three, one-man FAO KIR 7 (4.7 m) design (Fig. 1) and one, two-man FAO KIR 6 (6.5m) design (Fig. 2).

Design and construction

The FAO KIR 6 and KIR 7 canoe designs were recommended for the workshop as they suit local conditions and Nauruans are familiar with them because many I-Kiribati and Tuvaluan fishermen on the island have used similar canoes for many years. Those canoes are light and so are easy to launch and retrieve. The one-man canoe weighs approximately 40 kg and can be carried by a single person, while the two-man canoe weighs approximately 65 kg and requires two people to carry it. This is especially advantageous for communities that do not have launching ramps. The fishermen can carry the canoes over the reef flats to launch at the reef edge and lift the canoes back for storage onshore instead of having to keep the canoe anchored.

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The canoes were constructed from 4 mm marine plywood using a compounded plywood construction technique in which the canoe's inner keel is shaped exactly to the design by using a hog placed on a construction jig (Figs. 3, 4 and 5). The hull was then sheathed on the outside with a layer of fibreglass to further strengthen it. This technique was perfected during an FAO project in Kiribati.

The construction technique used for the outrigger of the one-man canoe follows an innovative concept developed by consultant boatbuilder, Mike Savins. This technique provides the canoe with an outrigger with higher floatation properties than traditional outriggers made of timber or plywood. These outriggers were constructed from five 2.2 m pieces of 25 mm thick polyurethane foam. The five pieces of foam were glued together to produce the outrigger (2.2 m x 0.125 m x 0.125 m) with the two ends bent during gluing to develop a raised profile. The outriggers were then machined to the required shape and a timber insert glued at both ends into the foam, similar to normal outrigger beam attachments. Finally, the whole outrigger was glassed with two layers of 450 g glass mat on the bottom and one layer on the top.

The outrigger for the two-man canoe was constructed from plywood as specified for the KIR 6 design and was glassed on the outside. The plywood outrigger has greater buoyancy than the original outrigger used on the same type of canoe, eliminating any undue drag result-

Figure 1: KIR 7 one-man canoe

Figure 2: KIR 6 two-man canoe

Figure 3: Construction jig for shaping the canoe hull

Figure 4: Canoe hull takes shape

Figure 5: Canoe hull clamped to the construction jig

ing from the paddling action of two people. It is also an additional safety factor for maintaining stability.

Future canoe building activities

It is envisaged that communities wishing to build additional canoes will require some logistical support from NFMRA. To facilitate this, the full set of canoe building tools will remain the property of NFMRA. The tools will be lent out to interested communities under a controlled and monitored system that will guarantee the retention and maintenance of the tools for continuous use.

It is also likely that communities will require assistance in importing materials. Orders will need to be coordinated either through NFMRA or a private enterprise. NFMRA should consider liaising with the government customs and duty department to explore the possibility of a tax exemption (or reduction) on canoe materials so as to make them more affordable to local boat builders, thus promoting small business development in Nauru.

Canoe safety awareness briefings

These briefings, done by the FDO during the second phase of the project, addressed safety issues relevant to canoe fishing activities. The FDO informed community fishermen about the importance of maintaining a pre-departure checklist as part of a Safe Operations Plan (SOP). Such a checklist ensures that measures are put into place to counter any challenging situations or emergencies that may arise while on a fishing trip. SPC has developed and promoted a standard safety checklist card for small craft, but this is directed at power-driven vessels rather than paddle-driven craft. However, most of the recommended items on the card, especially those not related to the use of small engines, can be adapted to suit canoe safety (Fig. 6). Although most of these concepts are common knowledge for regular fishermen, it is a handy reminder for them and is important information for new fishermen. One important consideration in relation to canoe fishing safety is that the fisherman should carry the

Figure 6: Canoe safety checklist card

essential fishing gear and safety items in one or several sealed containers that can also serve as floatation devices in case of emergency.

Part of the safety briefings included some discussions on canoe handling, and participants were briefed on safe procedures for boarding canoes and how to recover from accidents such as capsizing and foundering. Participants were given a general idea of how these accidents happen, how to prevent them and how to react if they do occur.

Overall, the canoes constructed for the project proved ideal for the Nauruans. The one-man canoe can safely take the load of two people without any problems and still have ample freeboard to maintain some buoyancy. The two-man canoe is able to seat three people and still maintain ample safe freeboard.

Inshore fish aggregating devices

FAD construction and deployment

Seven inshore FADs were constructed and deployed to support the coastal communities' canoe fishing activities. The materials and tools for the FADs were supplied by SPC, and the FDO carried out the construction and deployment work with staff from NFMRA's Coastal Fisheries section. NFMRA provided information on the FAD deployment locations FADs and the remaining logistics, including workshop space for construction and vessel deployment. The first six FADs were deployed during phase I of the project while a seventh FAD was deployed during the FDO's second visit to Nauru in July.

Five types of FAD design are being trialled as part of this project. The designs include two all-wire mooring, two combination wire/rope mooring (Fig. 7), one sub-surface FAD (Fig. 8), one cheap, all-rope mooring (Fig. 9), and one combination subsurface/surface FAD (Fig. 10).

The surface component for the combination wire/rope and all-wire FADs consisted of five 200 m rating pressure floats of 20 kg buoyancy, and four Polytech M-700 purse-seine floats of 7 kg buoyancy. A purse-seine float


7

Figure 7: Inshore FADs with grapnel anchors being prepared at the NFMRA workshop


8

Figure 8: Flotation section for the sub-surface FAD

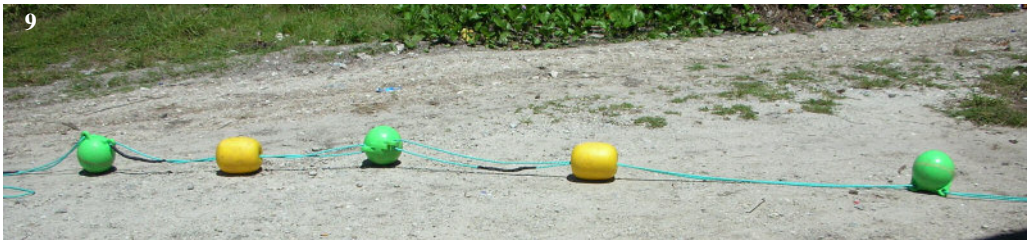
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Figure 9: Mooring section for the cheap all-rope FAD before aggregators were connected

was positioned between two consecutive pressure floats to avoid damage from the hard plastic pressure floats knocking against each other. The nine floats were strung on 10 m of 3-strand 22 mm nylon rope. Similarly, the upper section of the sub-surface FAD consisted of three pressure floats and two purse-seine floats between them. The surface component for the all-rope cheap FAD consisted of three ear-lugged 1000 m pressure-rated trawl floats buffered by two purse-seine floats in between them. The trawl floats were used due to their availability at NFMRA, but other pressure floats could have been used instead.

The middle section of the mooring for the combination rope/wire and all-wire FADs used a 5 mm stainless steel wire in the wire sections, and 3-strand 12 mm polypropylene rope in the rope sections. The combination mooring was constructed with an additional length (equal to 25% of the depth at the site) to account for current and weather fluctuations. The all-wire mooring, however, had only 13% additional scope, which is sufficient to absorb the forces in the middle section, yet not so long as to become tangled on the sea bottom. The sub-surface FAD had an all-wire middle section that is supposed to be stretched taut by the five floats making the upper section of the FAD.

Large grapnel anchors were used in the anchoring system of all FADs (Fig. 11). This made their transport to the deployment site easy and was effective in ensuring that the anchors settled quickly into position on the steep bottom slope. Two grapnel anchors were used for each FAD. The anchors were linked to each other by a 10 m length of 12 mm galvanised chain and 1 mm galvanised shackles. The upper grapnel was linked to the middle mooring by another 10 m length of 12 mm galvanised chain, a 12 mm galvanised forged swivel, and 12 mm galvanised shackles. Each anchor was constructed using two 6 m lengths of size #8 (25 mm) building rebar rods thrust through a metal pipe 1.5 m long and 160 mm in diameter.

The inshore FADs were deployed using NFMRA's surveillance vessel *Doguo* (Fig. 12). This is different from previous FAD deployments in Nauru when barges or tugboats of the Republic of Nauru Phosphate (RONPHOS) company had to be used because of the weight of the anchors and mooring depths of over 1000 m requiring almost twice as much rope than for the inshore FAD deployments on this project.

Figure 10: The sub-surface section alongside the surface flotation of the combination sub-surface/surface flotation inshore FAD deployed at Baitsi

Figure 11: Grapnel anchors and inshore FADS lined up on the Anibare wharf apron ready for loading

All the inshore FADs were successfully deployed (Fig. 13). The combination rope/wire FADs were deployed off Meneng and Denig in 300 m. The all-wire FADs were deployed off Ijuw in 290 m and Ewa in 270 m. The sub-surface FAD was deployed off Anibare in 230 m with the upper section settling 50 m below the surface. The cheap, all-rope FAD was deployed off Meneng in 320 m, and the combination sub-surface/surface FAD was deployed off Baitsi in 306 m.

The inshore FADs deployed in May were visited by the FDO early in July, during the second phase of the project. At that time, all FADs were still in place and were aggregating fish. The most productive FADs were the two FADs off Meneng (combination rope/wire and all-rope) and the FAD at Ijuw (all-wire). Large, mixed fish schools, including yellowfin tunas and wahoos, were spotted in the vicinity of those three FADs. The FADs at Ewa, Anibare and Denig were also aggregating schools in their vicinity, predominantly rainbow runners, skipjack tunas and frigate mackerels.

The FADs at Meneng and Denig were riding well in the water with all floats visible throughout the tidal phases. However, the FAD at Ijuw (Fig. 14) tended to submerge during strong currents until only three floats were above water at high tide. The FAD at Ewa submerged to a point where only one float was above water at high tide and sometimes momentarily disappeared (Fig. 15). This


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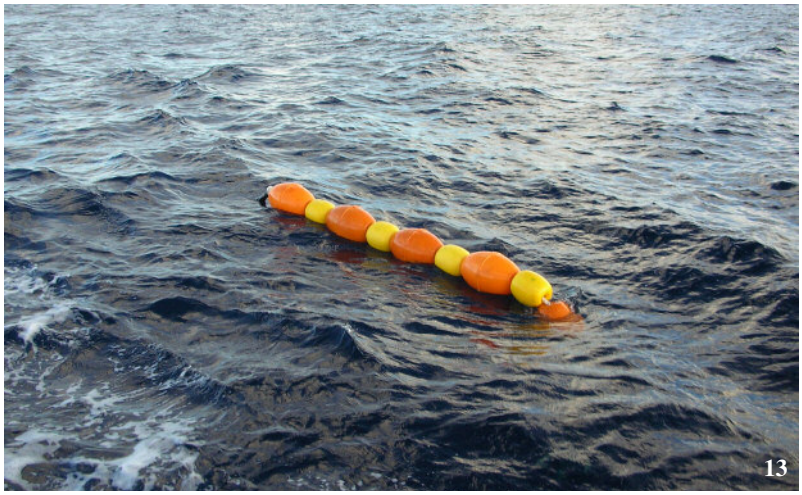
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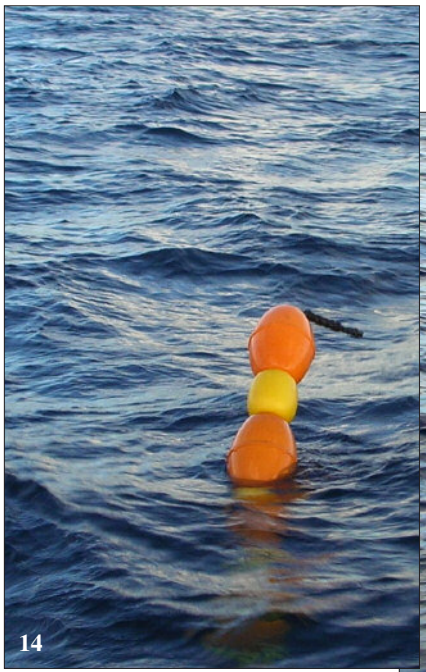
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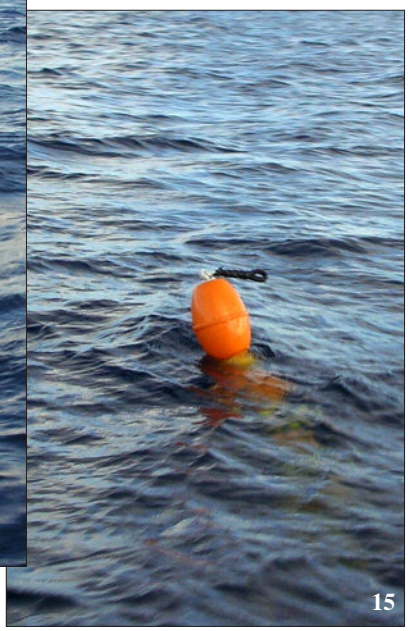
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Figure 12: Inshore FAD and grapnel anchors loaded on the *Doguo* for deployment

Figure 13: Inshore FAD settled in the water after deployment

Figure 14: Ijuw FAD submerged to 3 floats at high tide

Figure 15: Ewa FAD submerged to one float at high tide

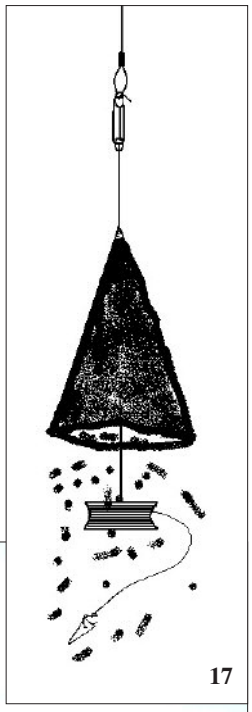

Figure 16: Surface indicator floaters for the sub-surface FAD

Figure 17: The main components for scatter-bait fishing method

Figure 18: A workshop participant with an 8-kg tuna caught using the scatter-bait method

phenomenon is most likely due to a lack of buoyancy in the upper component of those two FADs. Therefore, NFMRA was advised to attach additional floats. FADs at other locations were riding well on the surface with all floats clearly visible. The sub-surface FAD at Anibare was still in position with its surface indicator (two purse-seine floats) clearly visible (Fig. 16).

Practical canoe fishing exercises

The practical fishing exercises were conducted by the FDO early in July. Training took place at the Denig FAD and around the mooring buoys of the RONPHOS company. FADs on the eastern side of the island were not used for training because the weather conditions there were not considered suitable for beginners, although they would have been appropriate for experienced canoe fishermen.

Although participants were keen to fish at the Denig FAD because of the presence of 'easy-to-catch' rainbow runners, the FDO encouraged them to target the bigger and deeper-swimming yellowfin tunas using the scatter-bait jigging method (Fig. 17). This was the main fishing method used during the fishing exercises. Secondary methods included jigging for smaller pelagic fish and trolling with lightweight gear. Chum bait contributed significantly to the success of the scatter-bait fishing method. Chum bait is usually made from waste food ground into a moist, almost paste-like form or made from discarded fish and animal offal ground into minced pieces. However, because of the large volume of chum material needed each day for the training, boiled rice mixed with canned mackerel and soy sauce was used (effectively) during the practical fishing exercises.

Overall, three practical fishing exercises were conducted, for a total of 18 hours of fishing time resulting in a catch of 150 kg of yellowfin tuna (12 fish), 12 kg of rainbow runner (7 fish), 12 kg of skipjack tuna (6 fish), and 5 kg of frigate mackerel (2 fish). Only three of these fish were retained and sold after each day in order to purchase ice and bait for the next fishing trip. The rest of the catch was shared among the fishermen to take home as proof of their newfound abilities (Fig. 18).

Canoe monitoring logbooks

A basic but comprehensive logbook had been produced by SPC prior to the second phase of the project. A logbook is an essential tool for monitoring the use of fishing canoes and related catches in Nauru. Many logbooks were printed and taken to Nauru before the practical fishing exercises began.

NFMRA currently assigns a person to record the movements and catches of canoe fishermen operating out of Gabab Channel and the NPC (Nauru Phosphate Corporation) harbour. The data related to use of the community canoes built during this project are recorded separately by a community representative specifically assigned to that task. At the time of the FDO's visit in July, the need to monitor inshore FAD catches and canoe use was quickly catching on with most of the canoe fishermen, including those who attended the workshops and others who were voluntarily coming forward to the NFMRA officer to have their catches recorded.

Conclusion

The canoe project is an ongoing activity that will be monitored and expanded as events dictate. So far, the project is generating considerable interest in Nauru and has started off on a high note.

After each phase of the project, SPC made several recommendations to help NFMRA make this project a success for Nauruan communities. The onus is now on NFMRA as it will need to continue to assist communities with their canoe activities. This assistance will include the management of the canoe building tools, the coordination of materials procurement for future canoes, the ongoing monitoring of canoe use and FAD catches, the management of the inshore FAD programme including regular maintenance and replacement of lost FADs and, very likely, the organisation of additional canoe safety and fishing workshops for communities. SPC is very keen to monitor the lifespan of the various FAD types used in this project. The concept of using inshore FADs to provide alternative fishing and food-security or small income opportunities is one that is increasingly relevant in the region, and the Nauru project may become a model to follow.

CANOE/FAD MONITORING LOGSHEET			
DISTRICT:		NAME OF CANOE:	
NAME OF FISHERMAN:		SIGNATURE:	
DATE:			
TIME OUT:		NAME OF FAD(s) FISHED:	
TIME IN:			
FISHING METHODS:		DID YOU CATCH ANY FISH TODAY?	
CATCH			COMMENTS
SPECIES	PIECES	WEIGHT	
FISH RETAINED	Pieces :	Weight :	
FISH GIVEN AWAY	Pieces :	Weight :	
FISH SOLD	Pieces :	Weight :	Income :

Figure 19: Logbook used for monitoring canoe use and inshore FAD catches in Nauru