Fisheries Newsletter

Number 118 (July – September 2006)

Editorial

Phase 1 of the new Regional Tuna Tagging Project began in August 2006. The chartered pole-and-line vessel F/V *Soltai 6* spent two months in the Bismark Sea, Papua New Guinea, tagging nearly 12,000 tuna, mainly skipjack (~ 60% of the overall catch). A detailed report of the first results is presented in page 36. An interesting feature article by Ben Ponia is published on page 58. Ben describes the new aquaculture developments taking place in the northern Pacific, and identifies a number of institutional partners for future collaboration with SPC.

Jean-Paul Gaudechoux
Fisheries Information Adviser (jeanpaulg@spc.int)

Well-known tuna scientist, Tony "Dr Fish" Lewis in action. Tony obviously has not lost his tagging skills over the years !

in This Issue

SECRETARIAT OF THE PACIFIC COMMUNITY
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REEF FISHERIES OBSERVATORY

Staff changes

During the third quarter of the EU-funded Pacific Regional Oceanic and Coastal Fisheries Development Programme (coastal component – PROCFish/C) and the Coastal Fisheries Development Programme (CoFish), two staff resigned and one new staff member was appointed. Mr Samasoni Sauni, Senior Reef Fisheries Scientist (finfish) left after four years with the programme to take up the position of Fisheries Management Officer with the Forum Fisheries Agency. Mr Laurent Vigliola, Senior Reef Fisheries Scientist (finfish) left after four years to take up the position of Research Scientist with the Institut de Recherche pour le Development (IRD) based in France. The PROCFish/C team wish both Sam and Laurent well in their new positions.

The PROCFish/C and CoFish teams welcome a new Senior Reef Fisheries Scientist (finfish), Dr Silvia Pinca, who took up the position in late September. Silvia received her PhD in Marine Environmental Science from the University of Genoa, Italy in 1994. She worked for four years as the Marine Science Project Coordinator with the College of the Marshall Islands, coordinating and conducting natural resource assessment surveys on seven atolls around the Marshall Islands. While there, Silvia also co-founded a locally based non governmental organisation, which specialises in capacity-building and marine underwater assessments to support the Marshall Islands Marine Resources Authority. Silvia has also worked at the Scripps Institution of Oceanography (California) as a biological oceanography research assistant, and at the Department of Ecology and Evolution at the University of Chicago. Silvia has also worked in the Philippines as a conservation researcher, carrying out surveys, and conducting awareness raising and training sessions, and she has been a university lecturer in Italy and Indonesia.

Figure 1: Laurent Vigliola (top left) and Samasoni Sauni (bottom left)

Figure 2: Silvia Pinca

Survey work in the Solomon Islands

Survey work was undertaken in four locations around the Solomon Islands (Fig. 3) from June to September: Marau and Nggela on the first visit, and Rarumana and Chubikopi/Chea on the second visit. The PROCFish/C survey teams consisted of Aliti Vunisea (socioeconomics), Samasoni Sauni and Ribanataake Awira (finfish), and Ferral Lasi and Emmanuel Tardy (invertebrates). The teams acknowledge and thank the following people who assisted or worked with them at one or more locations: Sylvester Diake, Under Secretary of Fisheries; Eddie Oreihaka, Director of Fisheries; Rosalie Masu, attachment to the programme; Francis Kera, Peter Lausa, Wesley Garofe, John Laqata, and Francis Tofuakalo, Solomon Islands Fisheries Officers; Peter Ramohia, Extension Officer, The Nature Conservancy; and the chiefs, elders, and community members and people from the four sites surveyed.

Marau

Marau, located off the main island of Guadalcanal, comprises several small islands and villages. Marau is one of the main fish supply areas for Honiara. Almost 90 per cent of Marau's population was found to be actively engaged in fishing. Men, women, and children all participate in finfishing or invertebrate collection, or both. Men target all habitats, but especially the outer reef areas. Women, on the other hand, prefer the more protected fishing grounds that are also less distant from the shore (i.e. sheltered coastal reefs, lagoons and mangrove habitats). The main fishing methods are spearfishing, gillnetting, handlining and invertebrate collection by hand. Marketing of fishing produce is via middlemen who regularly visit the various villages, usually once or twice a week.

Surprisingly, fishing is not the first source of income, but is the second most important, followed by agricultural production. In addition, some small-scale tourist operations provide supplementary income for a number of families on Marau's islands. Seafood is also an important component of the Marau people's diet. Finfish is eaten more often than invertebrates (i.e. three and two times per week, respectively).

Fisheries management takes place and certain areas are banned for fishing (total ban for a longer time period, usually > 5 years, for invertebrate and finfish harvesting). Nevertheless there was a consensus among respondents that reef resources are declining. This perception may be due to the fact that although the banned areas are respected by most people, they are small in size compared with the areas that are fished regularly.

Finfish resource surveys revealed significant differences in the distribution of species across the different habitats that

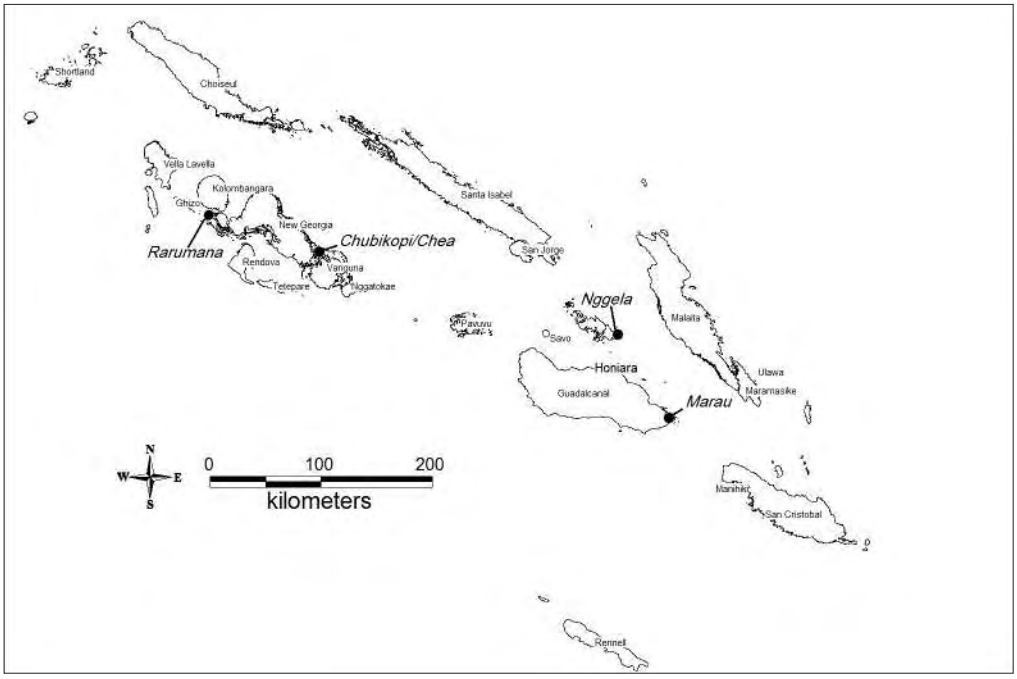


Figure 3: Survey sites in the Solomon Islands

are considered to be mainly targeted for commercial purposes. The number of groupers, emperors and snappers was estimated to be low to medium, probably as a result of widespread handline fishing for these prime species. Larger numbers of parrotfish, surgeonfish and wrasses were observed, indicating lighter fishing pressure (spearfishing) on these species. The diversity of fish species was considered high, and this might be attributed to the fact that the Solomon Islands is closer to the centre of biodiversity. The state of the coral reef in this area was relatively unhealthy with only an estimated 20 per cent of live coral coverage (Fig. 4).

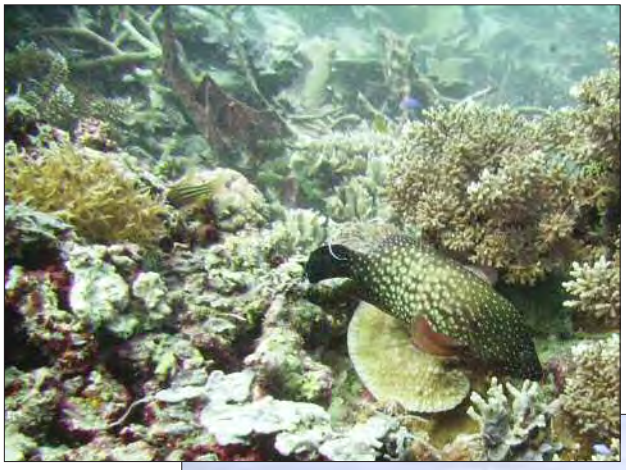
Invertebrate surveys revealed a high diversity of resources in Marau, including *Trochus niloticus*, 11 sea cucumber species, gastropod snails (*Turbo* spp.), anemones (*Stichodactyla* spp.), black and gold-lip oysters (*Pinctada* spp.), 6 giant clam species, lobsters, and edible urchins and gastropods (e.g. *Thais* and *Vasum* spp). The density or abundance of most resources was low despite excellent habitat. Suitable habitat for *Trochus niloticus* was mainly found on the outer reefs and was not extensive. Stock densities were fairly low. The green snail *Turbo marmoratus*, which was present in previous years (according to fisheries staff), was not found. It is apparent that high fishing pressure has led to severe depletion of invertebrate stocks in Marau.

Nggela

Survey work in Nggela covered villages in the Sandfly Islands. Fishing and marketing of seafood produce was found to be similar to other sites in the Solomons. Here also, fishing is only the second most important source of income, while agriculture comes first. Nevertheless, fishing is done by men, women and children and on an almost daily basis. As with Marau, Nggela women prefer the more protected fishing grounds — dominating the gleaning activities in reef and mangrove areas — while men are more inclined to fish the outer reef or pelagic waters. In the Nggela survey sites, commercial live coral harvesting for the international aquarium trade was reported. Also, trochus was reported as a commercial fishery. Because the capital city, Honiara, is only a half-hour boat ride away, seafood marketing occurs more intensively and more frequently than at the other sites surveyed. A community-based fisheries management system is in place, and certain areas are banned for seafood collection. In Nggela, compliancy with taboo fishing areas is high.

Like Marau, Nggela's finfish resources showed low numbers of groupers, emperors and snappers, probably as a result of handline fishing for these species. Parrotfish, surgeonfish and wrasses were observed in larger numbers, indicating lighter fishing pressure (spearfishing) on these fish species. Fish diversity was also considered high, and the coral reef in this area was relatively unhealthy and comparable to conditions found at Marau. Several local counterpart divers (Fig. 5) were trained in data collection, survey technology, and species identification during the finfish survey work.

Important invertebrate resources recorded in Nggela include *Trochus niloticus*, eight sea cucumber species, five giant clam species, black-lip pearl



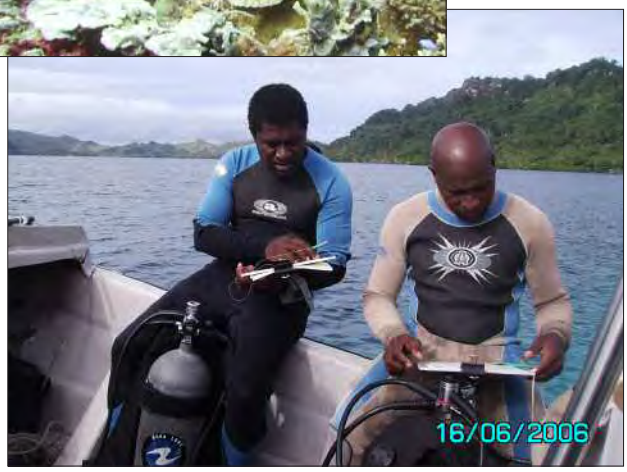


Figure 4 (top): Coral cover in the Marau area

Figure 5 (bottom): Local counterpart divers, Peter Ramohia from The Nature Conservancy and Peter Lausu from the Fisheries Department

oyster (*Pinctada* spp.), anemones (*Stichodactylas* spp.), lobsters, and edible gastropods (*Vasum* spp, *Turbo* spp, *Thais* spp, and *Strombus luhuanus*). As in Marau, stocks of various invertebrate resources were low. Most of the coastal reefs are narrow with steep drop offs. Nggela has moderate areas of suitable habitat (high relief and complexity) for trochus, but the stock density was very low. It has become apparent that high fishing pressure has reduced stock levels. A significant number of black-lip pearl oysters were found on the shallow inner areas of the reef flats. Dives for high valued sea cucumbers revealed the presence of white teatfish, although stocks were low. Giant clam resources were dominated by *Tridacna crocea* and *T. maxima*, which were found on almost all reef flats surveyed, although densities were moderate to low. Few specimens of *T. squamosa*, *T. derasa* and *Hippopus hippopus* were found.

Rarumana

The Rarumana site, located in the Western Province, includes several small villages and settlements on one island. People are involved in both finfishing and invertebrate collection, although finfishing seemed to be more targeted, especially by men. Women were the driving forces for most invertebrate collection. Fishing is a regular, almost day-to-day activity and mostly done using locally built paddle canoes. In fact, Rarumana was found to be the site with the highest boat ownership rate: 90 paddle canoes and 12 outboard engine powered boats were recorded in the 50 households of the main village surveyed. Fishing methods include gillnetting, spearfishing, and handlining. No fisheries management system was reported or established. The reef and lagoon areas are owned by the greater Rarumana community and people belonging to this community have free access to any reef resource around the island.

Seafood marketing opportunities are limited due to the lack of access to major markets, stores or agents, and therefore, marketing mainly targets the local community. Fresh or cooked seafood is sold door-to-door to individual community members or to one of the logging companies. Finfish consumption is high. Fish is eaten, on average, about five times per week. Invertebrates are less frequently consumed, on average twice a week.

The outer reef exhibited an abundance and density of finfish dominated by surgeonfish and parrotfish, with a lower density of wrasses, rabbitfish and butterflyfish. Finfish resources on sheltered inshore reefs, coastal, intermediate and back reefs were much lower and showed signs of intense fishing pressure. The coral reef was unhealthy in many places, with higher live coral cover in the back and intermediate reef areas.

Figure 6: Pineapplefish sea cucumber, *Thelenota ananas*

Invertebrate resources found in Rarumana include *Pinctada margaritifera*, *Trochus niloticus*, *Turbo* spp., urchins, edible gastropods (*Thais* spp, *Vasum* spp, *Strombus* and *Lambis* spp, *Anadara* spp.), giant clams, sea cucumbers, and abundant organ corals (Fig. 6). There are only a few species of sea cucumbers (eight) and giant clams (four) present. Density of most of these various invertebrate resources was low. Rarumana has the most extensive areas of ideal habitat (high relief and complexity, with high percentage of coralline algae) for trochus found at any of the Solomon Islands study sites. However, the stock was low, indicating severe depletion. Giant clam resources in Rarumana are dominated by *Tridacna crocea* followed by *T. maxima*, which are found in moderate quantities on almost all reef flats surveyed. Deeper reefs in the lagoon contained exceptionally high densities of *T. crocea*, which act as a "reservoir" due to the difficulty in accessing it. Very few specimens of *T. squamosa* and *Hippopus hippopus* were found. Only a few specimens of white teatfish were found, implying a low stock level. Moderate numbers of *Bohadschia vitiensis* were seen during night dives.

Chubikopi/Chea

The fourth study site includes the villages of Chubikopi and Chea, which are located in the Marovo Lagoon area. Chea is predominantly a Seventh Day Adventist community and the prevailing religion imposes a taboo on the consumption or harvesting of invertebrates. Chubikopi is a mainly Methodist community, and does not impose any food taboos.

Almost every household in both villages reported having at least one fisher. Understandably, people from Chea, due to their religious beliefs, do not engage in invertebrate collection, but

instead focus on finfishing. In Chubikopi, however, men, women and children pursue both finfishing and invertebrate collection. People from both villages go frequently to the sea to catch finfish. Frequencies were reported to range between four and five days a week. As with the other study sites, women focus more on the sheltered lagoons and mangrove areas, while men target the outer reef and pelagic areas. Compared with the other study sites, the reported catches from Chea and Chubikopi were large, and was the average size of finfish caught. However, marketing of seafood produce is limited to middleman transactions, which are regular, but occur only once a week at both villages.

No sound fisheries management system was reported, although some initiatives were observed, such as the recently established International Waters Programme conservation site on one of the small islands in the lagoon.

The finfish surveys for this area were postponed until later in 2006, due to staff changes at PROCFish. It is expected that these surveys will be conducted in December.

Invertebrate resources recorded in Chubikopi include *Trochus niloticus*, 19 species of sea cucumbers (including two unknown species), *Turbo* spp, *Pictada margaritifera*, 4 giant clam species, lobsters, *Tripneustes gratilla* and several gastropods. The number of low- to medium-value sea cucumber species was low. The number of nocturnal species (*Stichopus horrens* and *Bohadschia* spp.) was an exception in that moderate to high numbers were seen during night dives. White teatfish stocks are rated as low and concentrated mostly in the deep channels that linked the lagoon to the ocean. A fair number of the giant clam *T. crocea* and *T. maxima* were seen throughout the surveyed areas (Fig. 7), their densities — *T. crocea* in particular — are higher than the other sites surveyed in the Solomons. Densities of other giant clam species were low. *Trochus niloticus* stock density was very low or severely depleted. There were no extensive trochus habitats seen in the sites surveyed.

Figure 7: Manta-tow survey in the Marovo Lagoon area

Survey work in Papua New Guinea

The first two sites in Papua New Guinea — Andra on Manus Island and Tsoilaunung (Tsoi) in the New Ireland Province (Fig. 8) — were surveyed from June to September 2006 (split schedules for different disciplines). The PROCFish/C survey team consisted of Mecki Kronen (socio-economics), Kim Friedman and Kalo Pakoa (invertebrates), and Pierre Boblin and Ribanataake Awira (finfish). The PROCFish/C team acknowledges and thanks the following people who assisted or worked with the team at one or more location: Augustine Mobiha, Executive Manager Fisheries Management, National Fisheries Authority (NFA); Leban Gisawa, Fisheries Manager – Inshore, NFA; Philip Polon, Fisheries Manager – Sedentary, NFA; Ian Liviko, NFA/PROCFish/C attachment officer to the programme; Hon. Hubert Molean, Chairman, Provincial Education (Manua Provincial Assembly); Paul Lokani and Tapas Potuku, The Nature Conservancy; John Aini, Ailan Awareness; Garry Preston and Hugh Walton, Gillett, Preston and Associates; and the elders, community members and people from the two survey sites.

About 30 households, and over 20 finfishers and invertebrate fishers were interviewed (Fig. 9) in each of the two islands. While the people on Andra island are highly dependent on fisheries (i.e. fisheries provide 50 per cent of all households with a primary source of income, and the other 50 per cent with second source (this half gets their major income from coral lime production for betel nut chewing), people living on Tsoi have other alternatives. About 45 per cent of all households interviewed on Tsoi quoted fisheries as first and another 24 per cent as a sec-

ond source of income. A considerable number of households are involved in lime production and handicraft selling (28%), salaried jobs (22%), and agriculture (mainly copra, 6%) as a primary source of income.

Both communities are characterized by high seafood consumption (36–40 kg of finfish/person/year), when taking into account that people on both islands have either agricultural production or access to agricultural produce. Living costs are low, but Andra was twice as high as Tsoi. This may be explained by the fact that people from Andra must purchase everything but seafood, while Tsoi's population has agricultural potential.

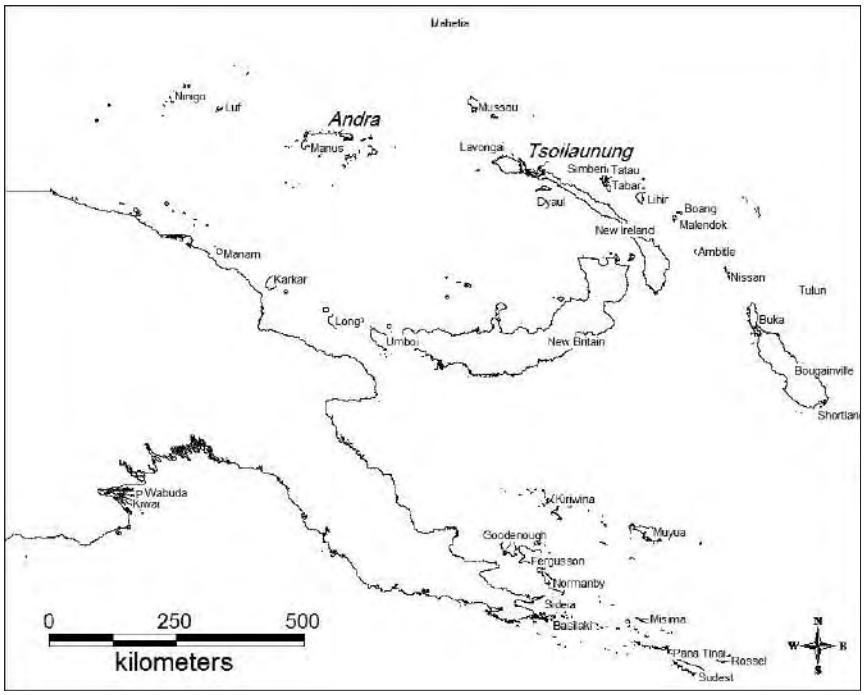


Figure 8: The two survey locations in Papua New Guinea

Figure 9: Conducting a socioeconomic survey with invertebrate fishers

The high dependency on harvesting marine resources and the lack or limited potential of alternative sources of income generation in either community was seen in the engagement of fishers in commercial fisheries, particularly beche-de-mer, trochus and crustacean (lobster and mud crabs). For both communities, government-controlled harvesting seasons and quotas apply. However, in the case of Andra, where strong traditional social networking and organisation apply, the community further narrows down harvesting periods and limits exploitation levels of beche-de-mer and trochus.

Finfish surveys were conducted over 42 transects between the two sites. The absence of sharks in both locations (none sighted at all at Tsoi) was noted, and this could have been attributed to the recent high level of shark fining by foreign operators in these areas. There was also an obvious lack of some important species, including groupers and emperors, as these were highly sought after and targeted by handline fishers. Good stocks of surgeonfish, wrasses, parrotfish and snappers were observed at Tsoi. Surveys on the outer reef area at Andra recorded mass schools of some surgeonfish (*Acanthurus blochii*), wrasse (*Bolbometopon muricatum*) and parrotfish (*Scarus quoyi*). Gillnets were used in shallow reef and lagoon areas (Fig. 10) to harvest inshore species. In both locations, the state of the coral reef was healthy, except for *Acropora* coral, which had been extensively harvested for making lime, and now had a very low coverage.

The reef and lagoon environment of Andra was excellent, rich in nutrients and with high water flow across the lagoon and barrier reefs. Invertebrate species recorded during the survey show rich diversity; most commercial species of sea cucumber were represented and five species of giant clams were recorded. Gold-lip pearl oysters (*Pinctada fucata*) and black-lip

pearl oysters (*P. margaritifera*) were observed; gold-lips were found predominantly in the deeper waters on the lagoon side. Only the commercial green snail (*Turbo marmoratus*) was absent, although low densities are anecdotally reported. Despite the presence of a great diversity of species, distribution of most was patchy and densities were generally very low.

White teatfish (*Holothuria fuscogilva*) was still present in moderate numbers in deeper waters, although most areas were accessible to divers, and we noted that fishers tended to fish-out aggregations when they were found. The presence of aggregations in some areas, and the records of juveniles of this valuable species, suggests that stocks can recover if effective management of fishing is practiced. Stocks of shallow water species, including the lollies (*Holothuria atra*), and greenfish (*Stichopus chloronotus*) were exceptionally low, possibly some of the lowest recorded in the region. Sea cucumber processing was done locally (Fig. 11). Giant clam stocks are also exceptionally low, with clam "gardens" observed in the shallows close to houses, where the only recorded *Tridacna gigas* clam was found. *T. squamosa* and *Hippopus hippopus* were rarely found in shallow reef areas.

The Tsoi islands were adjacent to a large and rich shallow lagoon. Water flow in and out of the lagoon and large sandy shallow water areas provided excellent habitat for high-value sand fish (*Holothuria scabra*) and other associated species. The people from both Andra and Tsoi are heavily dependent on the sea for their livelihood. Sea cucumbers, in particular sandfish, around Tsoi are recognised as a declining stock by local fishers. Although most adults have already been fished, there were a good number of juveniles, which presents a positive sign that some spawning still occurs. Strong management is critically needed to protect this valuable resource.

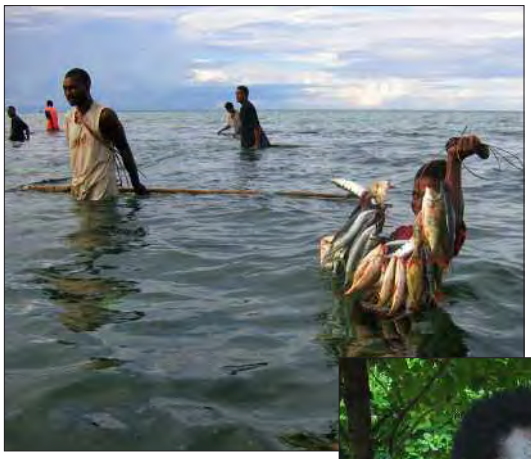


Figure 10: Finfish catch from gillnetting in shallow lagoon areas

Figure 11: Locally processed sea cucumbers

Figure 12: Trochus catch

Trochus resources likewise returned a very poor result, with fewer than 15 shells recorded during surveys. Despite the low stock, fishing pressure was still heavy (Fig. 12). No green snail (*Turbo marmoratus*) was recorded, but a single freshly killed shell was found near the village, indicating the species is still present. Giant clam stocks (*T. derasa*, *T. maxima*, *T. squamosa*, *T. crocea* and *H. hippopus*) were very low. A few large *Tridacna gigas*, held in a shallow water clam garden, were the only large specimens recorded, and these clams were in a stressed condition. Manage-ment of these and most invertebrate species is urgently needed.

Improvements to the PROCFish/C web portal

In the last issue of the SPC *Fisheries Newsletter* (#117), the outcomes of the PROCFish/C Steering Committee meeting (held in April 2006) were presented. One of the main concerns raised was that information was not getting back to countries in a timely manner following fieldwork activities, and this needed to change. In response to this, the PROCFish/C portal (http://www.spc.int/coastfish/Sections/reef/PROCFish_Web/default.aspx) has been updated so that there will be two types of data available on the website in future: those that are in the public domain, and those that are restricted to nominated fisheries staff for each country or territory.

The public domain information includes reports, GIS and satellite imagery. The portal will continue to be updated with additional information as it is located.

Only those people specified by the fisheries department in each country or territory will have access to the restricted data, and this will be controlled by individual passwords. This has been done to provide each country or territory with their data and draft reports, by site or by discipline, as soon as these are produced, rather than waiting until a full report has been compiled. Countries and territories will be informed regularly about additional information placed on their country page on the PROCFish/C web portal.

FISHERIES MANAGEMENT SECTION

Tuvalu's Coastal Fisheries Management Programme

The Tuvaluan Fisheries Department requested SPC's Coastal Fisheries Management (CFM) Section to assist in the development of a framework for the management of its coastal fisheries. Initial consultations and meetings with various government and community stakeholders were carried out by CFM Section staff in 2004, followed by a workshop for community facilitators in which a model for community-based fisheries management was developed in 2005.

Fisheries legislation review

In February 2006, Tuvalu's coastal fisheries legislation was reviewed through a joint effort by the Commonwealth Secretariat and the CFM Section. The review was conducted by Prof. Martin Tsamenyi from Wollongong University, who was assisted by CFM Officer Etuati Ropeti. The review was part of an effort by the Fisheries Department to properly address the importance of the coastal fisheries sector and the issues that affect it. Community involvement in fisheries management decisions was acknowledged. The review involved consultations with senior policy makers, community representatives, members of the various island Fale Kaupules, and stakeholders, to ascertain the key legal and management issues that require consideration.

As a result of the review, a Draft Island Community Fisheries Management Regulations 2006 is now in Parliament for further deliberations.

An island fisheries management plan

A First for Tuvalu

In March 2006, SPC's CFM Officer assisted the Tuvalu Fisheries Department with the implementation of its Coastal Fisheries Management Programme. The island community of Nukulaelae was selected by the Fisheries Department to be the first island to have its coastal fisheries management plan in place.

Nukulaelae is one of nine atolls that form the Tuvalu group, and is situated south of the capital of Funafuti (about eight hours by boat). It has 19 islets and a wide lagoon with an estimated population of 350. The island has two religions, the Tuvaluan Congregational Church and the Bahai Faith. It has a health clinic that serves basic medical needs, while serious cases are transferred to Funafuti. Nukulaelae also has a primary school where education is compulsory for all children.

The people of Nukulaelae have traditional knowledge of their coastal marine resources, and have their own customs and cultures to manage them. Despite these management cultures, the sudden change in lifestyle on Nukulaelae is believed to have a serious impact on the atoll's fisheries resources. Sometimes these are difficult to regulate given the introduction of modern fishing techniques.

The Fisheries Management Process

The work in Nukulaelae began with a meeting with the Kaupule (elected island council) to seek their blessing with the intended work. This was fol-

lowed with a meeting with the Falekaupule (community elders) where the fisheries staff was given the task of explaining the need for a community-based fisheries management programme, and how such a programme helps minimise existing problems with coastal fisheries. Discussion also covered the importance of island communities as resource users, working together with the fisheries department in instigating precautionary measures for the sustainable utilisation and management of the marine environment and its resources.

On the second day, three separate community consultations and workshops were conducted in accordance to the established groups within the island community:the Falekaupule, the women's committee, and the youth group. The issues discussed were mainly on assessing the degree of change in fishing, seafood catches, and the marine environment during recent years, and analysing the present condition of their marine environment and fish stocks, identifying the various causes of the problems, and considering the most practicable and possible solutions. Consultations took three days, and the information collected was combined for the selected committee to draft the Island Community Fisheries Management Plan.

The meetings were facilitated by the fisheries staff who participated in the CFM workshop on "Training Community Facilitators", held in 2004 as one of the CFM Section's inputs to Tuvalu's request.

The Nukulaelae Fisheries Committee

At the end of the group consultations, three representatives were nominated from each group to work with the fisheries staff in drafting the Island Fisheries Management Plan. The committee further considered the problems and solutions identified by each group and decided how the solutions could be implemented with the type of support that will be required. The committee was also given the responsibility of

Top left: Meeting with the Falekaupule (community elders)
Top right: Meeting with the womens' group
Bottom left: Meeting with the youth group
Bottom right: The Fisheries Committee drafting the Fisheries Management Plan

liaising with the Fisheries Department to ensure that both the community and the department performs their functions as stipulated in the Management Plan.

Below is a brief outline of Nukulaelae's Fisheries Management Plan

Vision

"A proper conservation and management of Nukulaelae's marine environment and its inshore fisheries resources with sustainable harvest of its fish stocks by its generations".

Undertakings

During the meetings with the various community groups, three key problems were identified:

- decreasing numbers of fish and shellfish in coastal areas,
- too much rubbish on the island, and
- increased numbers of dead corals.

In order to minimize the cause of the major problems identified by the Nukulaelae community, the plan now compelled its people to carry out the following undertakings, and the Fisheries Department is obligated to provide supporting services.

Decreasing number of fish and shellfish in the coastal areas

The major causes identified by the community during the group consultations were overfishing, due to the increased population on the island in the last 5–10 years; lack of land-based activities resulting in people tending to fish as a hobby rather than for consumption; communal gatherings and functions where turtles, octopus, other fish species and shellfish are harvested as they are of cultural importance; the overharvesting of fish for sale at the Fisheries Department operated Community Fish Centres; fishing activities by visiting passenger liners and Naficot boats; and lack of awareness of fisheries problems.

In viewing the above causes, the community has decided to put into place the following restrictions, with the assistance of the Fisheries Department, in order to manage their coastal fisheries resources and possibly minimise the concerns raised.

- Declare part of the lagoon area as a Fish Reserve Area.
- Declare closed seasons based on scientific advice from fisheries experts.
- Introduce appropriate community rules for fishing activities in Nukulaelae coastal waters.
- Introduce size limits for commonly fished species.
- Reduce fishing pressure by applying traditional management practices.
- Monitor fishing (with the possibility of introducing license systems) for visiting ferries and fishing boats.
- With assistance from the Fisheries Department, conduct awareness programmes for all sectors.

Too much rubbish

Due to the lack of available land and the increasing dependence on imported goods, the disposal of rubbish is a great concern for the citizens of Nukulaelae. Solid wastes, especially plastics and empty cans, were identified as the major sources of rubbish on the island, causing troubles to marine life. In that regard, the community agreed to the following undertakings to solve the problem.

- Conduct community workshops on waste management.
- Implement a community programme on the proper disposal of solid wastes.
- Community to participate in a clean-up day for the whole island.
- Ban the dumping of rubbish onto coastal areas.
- Impose traditional penalties.

The Fisheries Department works jointly with other national and non-national authorities with the implementation of waste management projects for the island community of Nukulaelae.

Increased numbers of dead corals

Changes to the marine environment, especially the loss of major coral colonies, has been observed by some fishers and has become a major concern for the island community. The Nukulaelae people are conscious of climate change and sea level rise issues that are considered to be the main cause of coral stress that leads to high mortality of reef colonies. However, anchor damage from boats, and pollution (fuel/oil from boats) in the lagoon areas are deemed to be the major causes of coral damage. The utilisation of sand and beach materials for construction projects has led to erosion, and has also been highlighted as an issue to be addressed. Coastal erosion is seen in many parts of Nukulaelae, especially where the seawater cuts into the shoreline during high tides.

In mitigating these causes, the Nukulaelae community undertakes the following activities.

- Works in partnership with the Environment Department, Fisheries and other relevant authorities in conducting environmental impact assessments for any development projects on the island.
- Plants trees along beaches and most affected areas for coastline protection.

- Conducts community workshops to raise awareness about coastal zone management.
- Sources government support for the construction of mooring facilities.

Future activities

The Fisheries Department will be responsible for:

- coordinating activities stipulated in the Nukulaelae Island Fisheries Management Plan,
- liaising with other government departments for their inputs in implementing the necessary actions pertaining to the management of Nukulaelae's coastal fishery resources,
- sourcing external assistance for community projects, and
- extending the management programme to cover other island communities in Tuvalu.

Programme review

The programme should be reviewed every six months.

Community–based Fisheries Management Programme in Nauru

In April 2006, a preliminary assessment was carried out for Nauru. The assessment was in response to a request from the Nauru Fisheries and Marine Resources Authority (NFMRA) for the CFM Section's assistance with the development of its Community–based Fisheries Management Programme.

The assessment highlighted a series of recommendations.

- NFMRA should review the organisational structure of the Coastal Fisheries Division and consider moving current extension staff to the Community Fisheries Section.

- NFMRA should arrange for its programme staff to undertake training in facilitating community workshops and in applying other specialised tools used in Community-based Fisheries Management Programmes.

- NFMRA should develop and implement extensive national awareness programmes to increase the knowledge of local communities about the marine environment and ensure long term support for the coastal fisheries management programme.

- NFMRA should review its existing legislation to cater for the needs of coastal fisheries management programmes and consider how local community rules can be legally recognised. The review should consider the delegation of management responsibilities to local communities and the obligation of the national authority to assist with the preparation of District Fisheries Management Plans.

- NFMRA should develop a co-management approach to fisheries management through maximum community participation that results in the ownership of the district fisheries management plans as well as providing alternatives for local communities.

- The Community Fisheries Section should be equipped with the basic equipment and materials if CBFMP is to be implemented.

- NFMRA should seek outside assistance to implement this programme given the financial difficulties the government is currently facing.

These recommendations are now been implemented by NFMRA and the Coastal Fisheries Management Section, and it will be reported in detail in the next issue of the SPC *Fisheries Newsletter*.

AQUACULTURE SECTION

Cook Islands National Pearl Economics Workshop and Industry Seminar

The Cook Islands pearl industry is ailing. Exports in 2000 were NZD 18 million, accounting for 90 percent of the total national value. Since then, there has been a dramatic decline in production, mostly due to a pearl oyster disease in Manihki Lagoon, the centre of production. Current-ly pearl exports are worth about NZD 2 million (Fig. 1). The gross revenue from lost production in the past five years is somewhere on the order of NZD120 million.

However, despite the decline in exports there appears to be an increase in the number of small pearl retail outlets servicing the domestic demand. Approximately 80,000 tourists visit the country per annum. The increase in domestic sales may have offset some of the reduced exports, although there are no statistics to prove this trend.

Pearl farming is an intensive investment, requiring good business acumen. One of the underlying issues that the industry must deal with is that it continues to be fraught with small-scale "hobby" farmers who, a decade ago, perceived quick lucrative gains when black pearls were still an expensive novel jewellery item. Under the current competitive economic climate, these farms are operating below the minimum scale of investment, which often leads to low quality pearls being dumped on the market and poor farming practices, which add more strain on the lagoon environment.

Pearl economics workshop, 24–26 August

The objective of the workshop was to design an economic model relevant to the Cook Islands' situation. This model can then be used on individual farms to assess key factors affecting profitability, and to plan for different management scenarios. The basic pearl model was developed by Mr Bill Johnston, an economist with the Queensland, Australian government and the Aquaculture Adviser during an economics workshop held in Fiji in 2003.

Key organisers of the workshop — SPC, the Cook Islands Ministry of Marine Resources (MMR), the Cook Islands Pearl Authority (CIPA), and the New Zealand Agency for International Development — funded a marine institutional strengthening project (CIMRIS). MMR Secretary, Ian Bertram and CIPA CEO, George Ellis, were heavily involved. Bill Johnston was engaged as the consultant trainer.

The opening session was carried out by the Minister of Marine Resources, Dr Wilkie Rasmussen, and the Chairman of the Pearl Authority Board, Tina Browne. Other Cook Islands participants included pearl farmers from Manihiki and Penrhyn atolls, pearl retailers, development bank officials, economists from the Ministry of Finance, representatives from the Small Business Enterprise Centre, and development officers from the Ministry of Outer Islands Affairs. There were also participants from Fiji, Marshall Islands and Micronesia.

As a result of the workshop, some modifications to the Cook Islands model were made. These included, several different options for the payment of pearl seeding technicians, a more elaborate pearl marketing pricing structure, a more detailed farm layout table, more informative graphs, and greater flexibility in setting parameters such as discount price.

From past experience it was noted that users of the model have struggled with the risk assessment component. An extra effort was made to explain risk assessment theory and some exercises were carried out to quantify risk

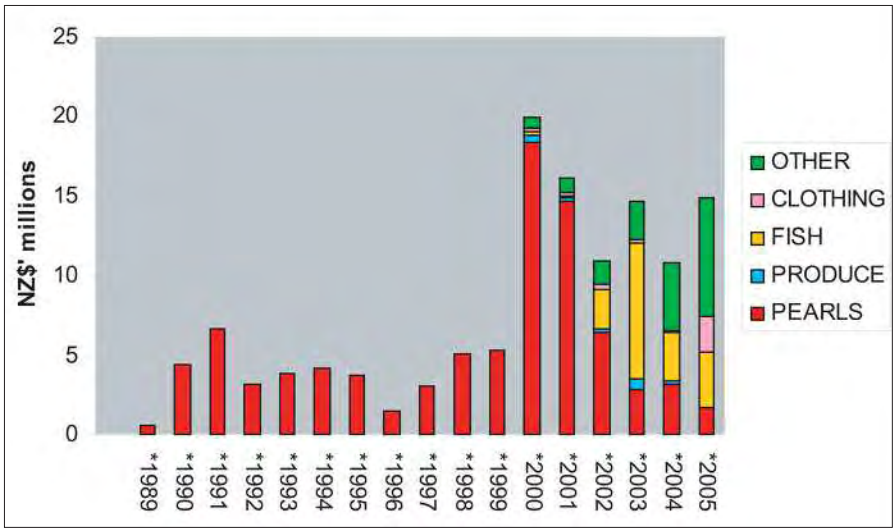


Figure 1: Major export commodities from the Cook Islands, including pearls

factors such as risk of production and risk of market price.

The model will be finalised and field tested before the end of the year 2006 under a work program funded by CIMRIS. This will also help the Cook Islands government to benchmark key economic parameters of the industry so that future trends can be plotted from an economic perspective (Fig. 2).

National pearl industry seminar, 28 August

There has been a somewhat lack of strategic direction for the Cook Islands pearl industry. This situation makes it difficult to establish industry standards and draw upon resources collectively. With industry representatives and regional resource persons present for the economic workshop, the seminar was a public opportunity to broadly identify some key priority areas, future directions, and responsibilities.

	Tahiti	Cook Is
Pearl Production	1998 – 6.0 t	1998 – 36 kg
	2000 – 11.4 t	2000 – 300 kg
	2005 – 8.1 t	2005 – 100 kg
Farm Nos.	2002 – 2,745	2000 – 210+
	2005 – 893	2005 – 80-85
	2006 – 792	2006 –
Prices	1998 – US$22.21/g	1998 – + NZ$100/pc
	2000 – US$13.97/g	2000 – + NZ$60-100/pc
	2005 – US$15.81/g	2005 – NZ$15-20/pc

Source: CIPA

Figure 2 (top): Pearl model
Figure 3 (bottom): Comparison between Cook Islands and French Polynesia

In spite of drawbacks, MMR has undertaken some proactive measures to ensure the continuity of the industry. Examples of these include drafting a lagoon management plan and code of conduct, developing digital farm maps and a census database for management purposes, installing an advanced remote water quality monitoring station, and regular monitoring of pathogens and marine bacteria.

As a sign of its commitment to rejuvenate the pearl sector, the government has re-established the Cook Islands Pearl Authority, which was disbanded a decade ago. The presence of the CIPA will greatly improve the institutional capacity of the Cook Islands to develop industry strategies and improve the marketing of its pearls. CIPA CEO George Ellis, provided a status report on the Cook Islands situation. An interesting comparison was made between the Cook Islands and French Polynesia, in terms of production and price per gram (Fig. 3). While production in French Polynesia has declined, the price per gram has increased. Evidently, French Polynesia has been able to influence market prices through controls on production and quality.

SPC's Aquaculture Adviser presented a regional overview of the pearl farming situation, noting that while pearl farming continues to expand across the Pacific, there are still opportunities in terms of technology and diversification of the product range. Justin Hunter (Hunter Pearls Ltd) and Simon Ellis (Mid Pacific Consultants) outlined their experiences in Fiji and Micronesia, respectively. Justin presented how his company had applied good business planning skills, coupled with the necessary financial investment, in all stages from production to marketing. The farm has been able to quickly return dividends and

production at their Savu Savu farm is larger then most farms in the Cook Islands. In contrast, the Bank of Cook Islands pointed out that the pearl loans portfolio is considered a high risk venture. Simon's presentation demonstrated how a small pearl farm in Nukuoro Island had developed a working model for commercialisation without any financial inputs from government.

Geoff Mavromatis from the CIMRIS secretariat provided excellent facilitation services during the seminar, and assisted participants in drafting a short list of priorities for further development. The workshop and seminar ended on a positive note, emphasizing that there is a way forward for the rejuvenation for the Cook Islands pearl industry (Fig. 4).

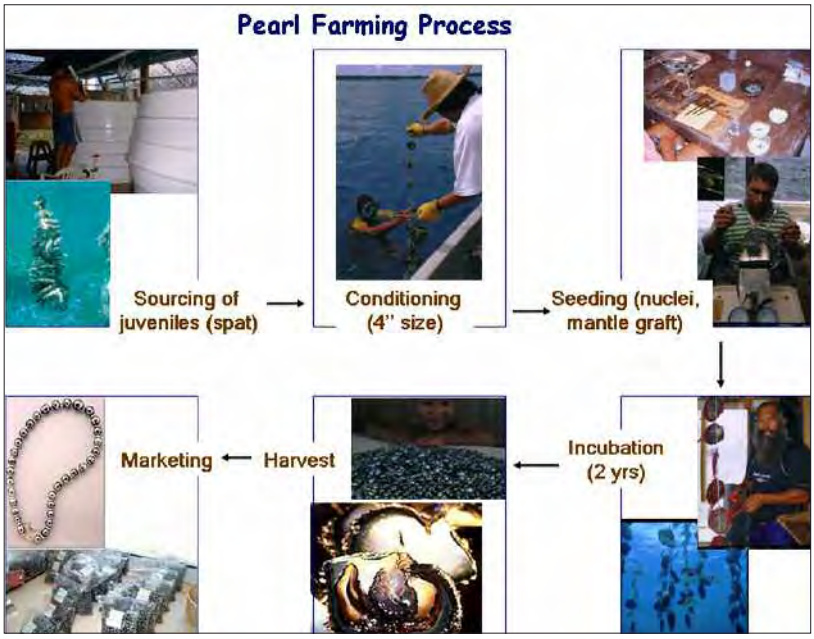


Figure 4: Pearl farming practices

FAO sub-committee meeting on aquaculture
New Delhi, September 2006

The Aquaculture Adviser represented SPC at the third session of the FAO Committee on Fisheries (COFI) on aquaculture held in New Delhi from 4–8 September. This inter-governmental body reviews the FAO aquaculture programme and advises the COFI governing body on priority issues. FAO is a useful forum to gauge the global trends and political issues arising. Unfortunately, the Pacific is often poorly represented. At the third session, the only delegate from the region, among 50+ countries present, was Palau.

Key agenda items for the sub-committee included:

- further progress regarding the implementation of the Code of Conduct for Responsible Fisheries,
- the status and trends for global aquaculture development,
- the challenge of increasing socioeconomic impacts,
- how to incorporate aquaculture in planning and policy development,
- how to encourage better management practices, and
- prospective analysis and the role of aquaculture sub-committee.

A constant theme underlying the debate at the sub-committee was the contrasting strategies behind development for commercial or food security purposes. African countries are lagging behind the most in terms of aquaculture development. It was felt that aquaculture could help alleviate the poverty in African countries, and there was pressure for donors and international organisations to prioritise efforts in that region.

One issue raised was how to improve the quality of statistical information and reporting systems. SPC was invited to a working committee to assist the aquaculture statistics database. One anomaly already pointed

out is that pearl statistics are lodged with capture fishery statistics. Another important area where FAO assistance will be of benefit to the Pacific region is in the area of bio-security, and in 2007 it is anticipated that SPC will collaborate more closely with FAO in this area. At the meeting, a draft copy of the "State of World Aquaculture: 2006" report was released. This document incorporates the information gathered from the regional reviews and global trends expert workshop in China in 2006, which SPC was involved in.

Indigenous Aquaculture Session, Australasian Aquaculture Conference: 2006
Adelaide

The indigenous aquaculture theme seeks to explore opportunities for indigenous people to be involved in aquaculture, particularly at the small-scale level and in remote and rural locations. At the first indigenous session, held at the inaugural Australasian Aquaculture Conference in Sydney 2004, it was decided to maintain the theme in future Australasian Aquaculture conferences.

The Adelaide conference was organised by the state government and the National Aquaculture Council (NAC) under the umbrella of the World Aquaculture Society (WAS). SPC also played a minor role because the Aquaculture Adviser is a current board member of the WAS Asia-Pacific Chapter, which hosted the conference.

The opening address by Federal Minster for the Department of Agriculture, Forestry and Fisheries, emphasised the indigenous aquaculture theme, noting the relevant experiences of the Pacific Islands to communities in Australia.

At the Indigenous Aquaculture Session, the SPC Aquaculture Adviser gave an opening presentation of indigenous aquaculture in the Pacific region. There were several other presentations from the Pacific. Figa Boga, from Papua New Oki Tedi Mine, described the mine's role in developing the remote Western Papua Province and Fly River system. Masahiro Ito presented pearl development work being carried out in village communities in Micronesia. A roundtable discussion was convened by Dennish Ah-Kee from the Department of Fisheries and Forestry (DAFF) indigenous aquaculture unit. The small-scale of aquaculture development within indigenous communities has proven to be a challenge in terms of government bureaucracy and financial sourcing. This is unlike the situation that the Pacific faces, and there are many lessons that can be shared.

At the conference, a WAS annual general board meeting was convened. One of the activities on the calendar for 2007 is an aquaculture conference in Vietnam. Vietnam may be of interest to the Pacific because it possesses one of the most dynamic aquaculture sectors, and may provide an opportunity for a Pacific Islands study tour for commodities of high interest to the region, such as rock lobster.

Country visit to French Polynesia and update on aquaculture activities
June 2006

In June, SPC's Aquaculture Adviser visited French Polynesia to coordinate a marine seminar at the 1st Pacific Youth Festival, and to take the opportunity to meet with aquaculture staff and make site visits. The aquaculture scene in French Polynesia is relatively advanced. New programmes in marine finfish mariculture are being developed while the pearl industry still remains a significant economic sector.

1st Pacific Youth Festival, Tahiti, French Polynesia, 17–22 July 2006

More than 1000 young people from 25 islands around the Pacific gathered in Tahiti for the inaugural youth festival. The Aquaculture Adviser coordinated a one-day marine seminar, involving speakers from the Ministry of Fisheries (Service de la Pêche), the CRIOBE laboratory in Moorea, University of the South Pacific, and SPC staff. Two presentations on aquaculture were provided, one by the Aquaculture Adviser and the other by aquaculture staff from the Ministry of Fisheries.

Aquaculture meetings

The Aquaculture Adviser was able to meet with key persons, particularly within government, involved in the aquaculture industry. The purpose of these meetings was to introduce the activities and roles of SPC, assess national priorities, and

explore possibilities for regional collaboration.

The first call was to the Ministry of Fisheries. This service is headed by Terii Vallaux and is the national agency responsible for aquaculture. Georges Remoissenet heads the small, but active, aquaculture unit; several of his staff (Rarahu David, Vaiana Joufoques and Moana Maamaatuaiahutapu) provided updates on their work activities. We were later joined by Arnaud Lerebours, President of the Aquaculture Syndicate and a businessman involved in the marine ornamental trade.

The Aquaculture Adviser and SPC Director-General, Dr Jimmie Rodgers, later paid a courtesy call on the Ministers of Fisheries office. The Minister, Honourable Keitapu Maamaatuaiahutapu and Advisers Sandra Langly (research), Mainui Tanetoa (fisheries and aquaculture), and Cabinet Secretary (Vanina Tsoi) were present. Noting that marine fish mariculture was quite advanced in French Polynesia, one concept that was raised was the possibility of Tahiti hosting a regional centre of excellence for mariculture. This would support SPC's strategy to decentralise its services.

A visit to the Ministry of Pearl Culture was made to meet with the Director Anne-Sandrine, Cabinet Secretary Henri Luduc and Adviser Fabienne Domby. The pearl industry is a significant economic sector to French Polynesia. Housed within the ministry is the national pearl quality control laboratory, which screens all pearls individually to ensure they meet export standards. Between 30,000 and 80,000 pearls are processed daily.

Site visits

Tahiti-iti, Tahiti Island

AquaPac Ltd is the largest prawn farm in Tahiti and raises *Litopenaeus stylirostris* prawns. According to the manager, Teva Sui, the farm produces about 30 tonnes per annum. The company has a fish hatchery and raceways. A barramundi hatchery supplies fingerlings to private farmers who grow them out with a cumulative annual harvest of around seven tonnes. Hybrid tilapia also reared at the farm. Other marine finfish such as groupers, trevallies and mullets are also kept on site for research trials (Fig.1).

The IFREMER station at Vairao mostly targets pearl culture. There are around 30 staff involved in this programme, divided into three main streams: 1) reproduction: larval settlement cues, producing triploid oysters; 2) pathology: viral diseases; and 3) pearl quality: genetics, grafting operation. The pearl programme is well resourced in terms of laboratory, pearl oyster hatchery, and grow-out facilities (Fig. 2).

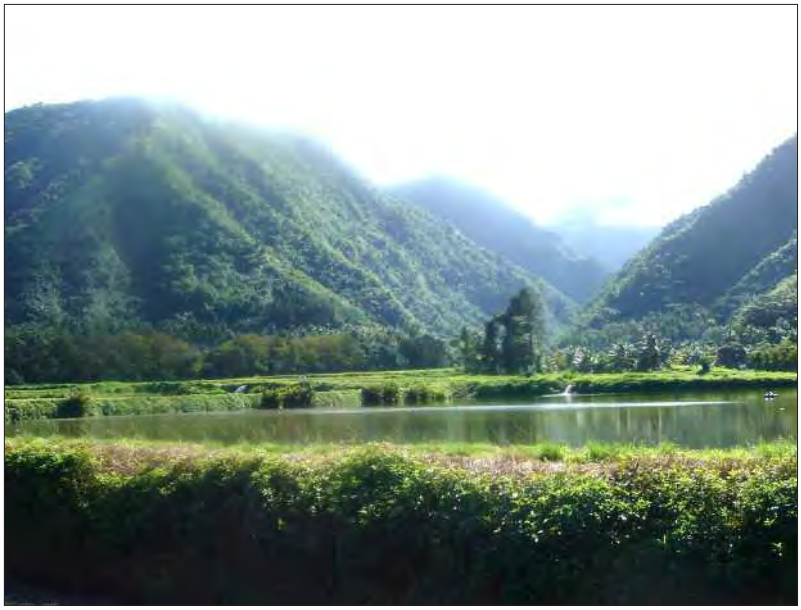


Figure 1 (top): Aquapac farm

Figure 2 (bottom): IFREMER station

The Ministry of Fisheries has established their fish mariculture facilities at the same complex as IFREMER. The batfish (*Platax orbicularis*) and moi (*P. sexfilis*) are the main species under research and development. The batfish is a prized local delicacy and because of heavy fishing pressure it is difficult to source broodstock. There is a strict quarantine protocol for broodstock brought in from the outlying islands after a Nodavirus positive sample was detected in earlier work. Since the quarantine was put in place, the facility is now free of the virus. So far, the fish have shown good growth characteristics and staff are examining different cage culture designs. A prawn hatchery — with a capacity of 10 million post-larvae production — is being established. Recent trials in Bora Bora lagoon, involving prawn cage culture for hotel markets nearby, have shown promising results (Fig. 3).

The government is about to undertake a large project initiative that aims to transfer research and development technology to the commercial sector. The programme will be known as Centre de la Mer. It may, for example, bulk purchase feed ingredients for fish farmers. The centre will take over some of the existing government facilities on a contract basis and will run initially for several years (Fig. 4).

Rangiroa Atoll

Mereani Bellais, manager of pearl hatchery run by the Ministry of Pearls was our counterpart in Rangiroa Atoll. This atoll has one of the world's largest lagoons, stretching 78 kilometers across.

Gauguin Pearl Farm Ltd, is one of the pearl farms operating on Rangiroa. The farm has two million pearl oysters on its farm and produces about 300,000 pearls per year (Fig. 5).

Rangiroa also has a pearl farmer and seeding technician training school. This facility is designed to equip Tahitians with the broad range of skills needed for pearl farming. Consultant seeders also teach students the art of grafting pearl oysters, although Japanese technicians are still considered among the best in the trade (Fig. 6).

The government pearl hatchery is currently undergoing some refurbishment to a larger com-

Figure 3 (top): Batfish, *Platax orbicularis*

Figure 4 (middle): Centre de la mer

Figure 5 (bottom): Gauguin Pearl Farm Ltd.

mercial scale as the previously smaller research tanks were difficult to manage.

Tropical Fish Tahiti Ltd is the largest commercial operator using the post-larval capture technique and has set crest nets on the reefs around Rangiroa lagoon. About 160 species of marine fauna are handled. The company has occasionally trapped and raised edible marine fin fish. For example, there is an abundance of larvae of the camouflage grouper *E. polyphekadion* (hapuku) during its annual spawning migration. Several thousand of these fish were raised to plate size for eating. The company is also conducting trials with black-banded manta shrimp. According to chief biologist Emmanuanuel Malpot, staff have accumulated a high level of specialised knowledge in fish larvae identification and larval settlement cues.

Figure 6: Pearl seeding school

Figure 7: Crest nets

Figure 8: Tropical Fish Ltd.

Eradication of Mozambique tilapia (*Oreochromis mossambicus*), restocking of Nile tilapia (*O. niloticus*), and improved aquaculture pond management in Nauru

Following the implementation of this project (see SPC *Fisheries Newsletter* #117), the last activities were carried out by SPC's Aquaculture Officer in September, and the final report is being prepared. This research was designed to utilise the existing Nile tilapia resource to stock grow-out ponds after eradicating unwanted fish. The research forms an integral part of a larger aquaculture initiative within the region, which seeks to address the problems of degradation caused by Mozambique tilapia and food security.

The specific objectives of the project are to:

- develop and trial protocols for eradication of unwanted fishes, primarily *O. mossambicus*, in two derelict freshwater ponds;
- evaluate growth and production of stocked *O. niloticus*; and
- improve capacity of farmers and government aquaculture staffs in pond restoration, restocking, feed production and fish husbandry skills

Activities carried out

Harvesting

The fish harvest in pond 1 was carried out on 14 September. During the harvest, the water in the pond was pumped out until it dropped to a depth of 5 cm. The majority of fish were seined by a drag net made of shade screens. Thereafter, all water was pumped out and the fish collected. All fish were washed, counted and transferred to holding tanks fitted with aeration tubes, and placed into several hapas installed in an adjacent pond. Fingerlings and fry were also harvested and stocked into separate hapas. Length and weight of 250 individual fish were measured.

All fish were kept in holding facilities with aeration for purging overnight before sales. The majority of fish were missing on the following day, except for fish — which were to be used as future broodstock — held in containers that were transferred to cement tanks at the Nauru Fisheries and Marine Resources Authority (NFMRA) office.

Harvesting of fish at pond 2 was carried out on 15 September. The water was pumped out, and all fish were harvested with a push net, then washed and sampled for body weight and length.

Training

Nauru Fisheries staff, pond owners, and members of the local aquaculture association attended a workshop that provided hands-on training in seining tilapia fingerlings, holding fish in containers, transporting, counting, acclimatization and stocking, pond rehabilitation, and management techniques. Simple feed preparation techniques were demonstrated including hapa, tank and pond hatchery methods. Additional demonstrations were given in spawning and juvenile rearing, broodstock management, simple feed production and feeding strategies, manual sexing, and fish pond management.

Results

The temperature in pond 1 ranged from 27–32°C. Salinity was below 5 ppt, pH ranged from 7.85–8.04, and dissolved oxygen (DO) levels ranged from 1.7–5.3 mg/l (see Fig. 1). The average water temperature in pond 2 was 29.4°C, pH was 7.6, and DO was 4.4 mg/l.

The average weight of fish in pond 1 was 41.43 g, and was 71.5g in pond 2 (see Fig. 2). The total fish yield in pond 1 was 54 kg, and 18.3 kg in pond 2. Survival in pond 1 was close to 100%. In pond 2, more fish were harvested than the number stocked, indicating someone had added more fish. Fish counts were about 24/kg in pond 1, and 13/kg in pond 2. The gross feed conversion ratio was not calculated as there were no records of feed kept.

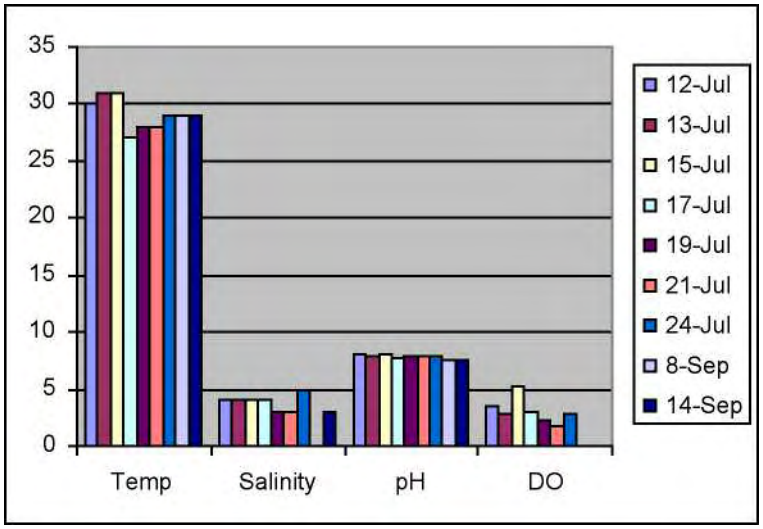


Figure 1: Temperature, salinity, pH and dissolved oxygen level in pond 1 over the trial period

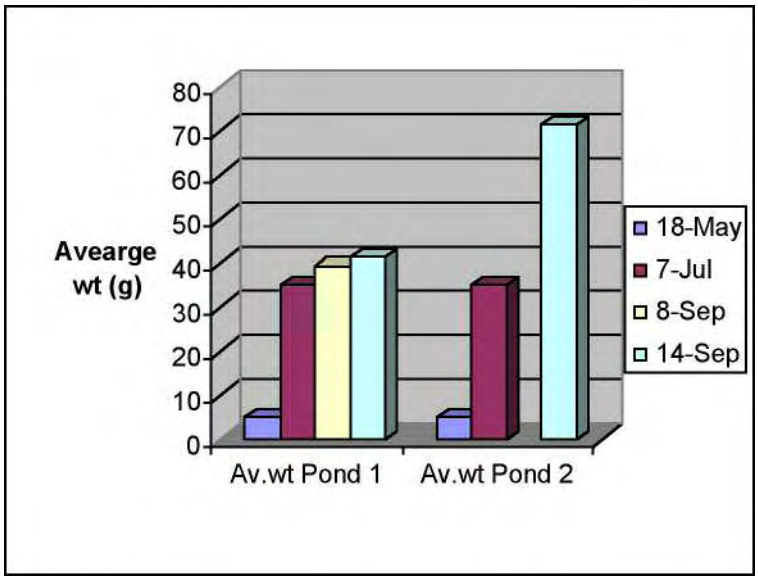


Figure 2: Average weight of fish from pond 1 and pond 2

Most of the female fish harvested had spawned. About 20,000 fry and fingerlings were collected from pond 1, and about 1000 fingerlings from pond 2.

Results indicate that a hectare of pond will yield, on average, 650 kg; and 7176 kg in tanks with a stocking density of 1 fish/m^2 and 6–10 fish/m^2, respectively.

There were no *O. mossambicus* or any other fish observed or harvested in the ponds, indicating the successful eradication of unwanted fish.

During harvest, the fish — including fry and fingerlings — were seined (Fig. 3), washed and transferred to holding hapas (Fig. 4) and tanks with almost 100% survival. Marketing of the harvested fish was not carried out as most of the fish were missing from the holding facilities.

The ponds were prepared again (i.e. cleaned and tea seed cake solution applied, then refilled and restocked with fingerlings harvested from the ponds).

Discussion

Results show that tea seed cake (and pond de-silting) successfully eradicate unwanted fish, especially *O. mossambicus* and *Gambusia* spp. in ponds. This is important as fishpond management requires the elimination of fish competitors or unwanted fish in ponds as part of pond preparation for stocking with desired fish. In Nauru, imported tea seed cake successfully eradicated unwanted fish without affecting the main crop. Tea seed cake is expensive. According to NFMRA staff, however, there is a native source of fish toxicant in Nauru that is equally effective as tea seed cake for pond management. A proper scientific assessment of this toxicant should be carried out, and data supporting the approval of this toxicant should be similar to that for tea seed cake or rotenone. At present, no information is available on the extent of its use or on its effect on humans as well as fish. Caution, therefore, should be applied.

Tilapia growth rate was 0.35g/day in pond 1, and 0.6g/day in pond 2, indicating the significant effects of different stocking densities (pond 1.5 fish/m^2, and 6.27 fish/m^2 in pond 2, and a harvest of 10 fish/m^2). Growth rates may also have been affected by management protocols, fingerling quality, and protein levels in diets. The water temperature, pH, salinity and DO levels were within acceptable levels for tilapia pond culture.

The feed used in this experiment was prepared from available commercial stock feed in Nauru, with a crude protein level of 16.5%. It should be noted that supplemental feeds with 25–32% protein are generally used, and usually results in average weights of approximately 180–250g, and a total production of 10 t/ha for a stocking rate of 50,000/ha. Expected survival is 98%. Efforts to develop a better feed should be continued so that Nauruan fish farmers can produce tilapia competitively and profitability.

It should be noted that fish size obtained at harvest did not discourage or dampen the efforts of NFMFA staff, as the fish were similar or bigger in size than some of the fish species currently caught by spear fishing on the reefs. Production of over 7 t/ha from pond 2 is a good result, despite the poor quality of feed used.

In the experiment, a mixed-sex population of fingerlings (collected from a swamp) were cultured together and should have been harvested before, or soon after, they reached sexual maturity, thereby eliminating or minimizing recruitment or overcrowding in the pond. A restricted culture period limits the size of fish that can be harvested. In addition, in mixed-sex culture, tilapia are usually stocked at low rates to reduce competition for food and to promote rapid growth. In practice, one to two-month-old, 3–5 g fingerlings are stocked at 20,000–50,000/ha in grow-out ponds for four to five months. Newly raised fingerling should be used because older, stunted fish, such as those used in this experiment, reach sexual maturity at a smaller size. If the present source of fingerlings is

used, then manual sexing should be carried out. Manual sexing consists of separating males from females by visual inspection of the external urogenital pores. Secondary sex characterstics may also be used to help distinguish sex. Reliability of sexing depends on the skill of the workers and fish size.

The technology necessary to bring about significant improvements in tilapia yields from existing pond structures has already been acquired by NFMRA staff. This technology includes the use of tea seed cake in eliminating unwanted fish, the use of pumps and excavators for pond improvement, fingerling collection and transportation, pond preparation and management, sampling and harvesting, and feed preparation and feeding. Other practices, such as breeding tilapia in hapas, tanks and ponds, and broodstock management, requires more resources.

Demonstration farms should be constructed at districts where the Nauru government desires tilapia culture to become established. Pond 1 should be retained as a demonstration unit. NRMRA staff should be trained to obtain post-graduate qualifications in freshwater aquaculture, and assigned to the demonstration unit. Attempts should also be made to look into possibilities of aquaponics.

The government should begin a programme of research to determine the types of aquaculture that will work in Nauru.

The SPC Aquaculture Section sincerely appreciates all those who contributed to the completion of this project, especially the Australian Centre for International Research and SPC for funding, and to NMFRA and the Department of Primary Industries in Queensland, Australia. The Section also appreciates the opportunity to participate in this project and thanks the pond owners and others who helped out with this project.

Figure 3: Transferring fish after seining – Lucky, Ricky, Joe and Satya

Figure 4: Fingerlings stocked in hapas

Progress report on experimental stocking and community management of tilapia in Lake Satoalepai, Samoa

Background

Fishing has always been a major source of food, income, recreational activity, employment, and various other economic benefits to the people of Samoa. It is also becoming a very important developing sector of the food industry, and the Samoan government has made strides to take advantage of this new opportunity by investing in infrastructure, such as hatcheries for seed production, in response to the growing demand for fish and fishery products. However, in recent years, with increased population and urbanisation, the need to properly manage fisheries has been realized. SPC's Aquaculture Officers, while on a programme visit to Samoa in 2003, were informed by Samoa Fisheries Department (SFD) staff that the inshore fishery is heavily exploited and may not sustain continued increases in exploitation. They noted that new approaches to fisheries management were urgently needed. As a result, SPC has developed a joint project between SFD, SPC, the Australian Centre for International Agricultural Research (ACIAR), and local communities of Matautu District on Savaii Island. The goal is to increase fish production through by restocking *Oreochromis niloticus* fingerlings in Lake Satoalepai, and by managing these stocks through community co-management.

Fresh fish in Matautu District is an expensive commodity and often in short supply, and nearby lagoon reef resources are subject to high fishing pressure. Consequently, inland fisheries offer an alternative source of fish protein. Fish stocking in Lake Satoalepai were carried out in 1994 and 2003 as part of the SFD aquaculture extension programme. Mozambique tilapia (*O. mossambicus*) and Nile tilapia (*O. niloticus*) were introduced into the lake to enhance fish biomass and to increase catches for communities. Subsequently, tilapia has become the most significant component of the lake's fish population and these introduced species have become a major protein source and income earner for local people. *O. niloticus* was imported from Fiji in 1996 for aquacultural purposes. SFD officers trialed tilapia grow-out in ponds at Chanel College on Upolu Island, and in ponds and cages in the lake.

The results of the trials are not available, although the species is now used for stocking ponds and has proven popular among communities in Samoa. In the lake, tilapia are regularly caught using gillnets. At present, there are no controls or regulations on catching tilapia, and there are already signs of over exploitation. Fishermen are spending longer hours to catch tilapia, and the size of those caught is small (50–100g).

Constraints to the development of tilapia culture in the lake include:

- lack of general knowledge on historical catch records of management options for the tilapia fishery;
- no controls, regulations or quotas (which has lead to over exploitation); and
- an inconsistent supply of tilapia fingerlings for Lake Safai.

Collaborative work, involving the aquaculture sections at SFD and SPC, began as part of a small grant to purchase tilapia hatchery equipment in December 2003. This collaboration has grown steadily and SFD now has the capacity to produce fingerlings required for stocking the lake. In the past, restocking tilapia was not monitored, and there were no management controls or fish harvesting practices in place by local communities. SFD staff is considering the establishment of a tilapia stocking programme in the lake, which will lead to sustainable production of fish in the long term.

It is hoped that this study will help SFD staff improve their knowledge of tilapia restocking

Lake Satoalepai, Matautu District

and management and, if successful, it will reduce reliance on already overfished marine fish species. This project will also enable the local community to understand tilapia stocking and become strong decision makers for future management and the appropriate and equitable use of the lake. The proposed research forms a part of aquaculture initiatives and activities in the region, where stocking tilapia fingerlings is a means to increase fish production, thus leading to food security.

Specific objectives are to:

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

Progress so far

In late July, SPC's Aquaculture Officer and SPC's Community Fisheries Officer carried out field activities with SFD staff. The main activities included working with SFD staff to prepare fingerlings and facilities, conducting consultations with lake owners (Safai and Satoalepai villagers), and stocking tagged tilapia.

Project site

The lake is divided into two portions by a feeder road passing across the centre of the lake. The lower side is owned by Safai village and the upper side by Satoalepai village. The lower side has culverts opening to the sea. The upper side has three culverts of approximately one-meter in diameter, allowing water exchange between tides and during heavy rainfall between the two portions. This upper side is the project site, which is about four hectares in area. The average depth at mid low tide is 40 cm. The bottom half of the lake contains rocks and boulders, and the upper half is thick with mud and covered with coral pinnacles.

The lake currently has tilapia, mullets, trevallies, prawns and mud crabs, with tilapia being the most abundant species. Fish and crustaceans are caught mainly by gillnets, spears, and fishing lines.

Lake survey

Visual observations indicate that *O. mossambicus* is the most abundant species. A team comprising residents from 20 villages, SFD staff and SPC staff, seined portions of the lake using an old seine net. Several medium-sized mullets, trevallies, half-beaks and some *O. niloticus* were caught. At the upper end of the lake, members of the team beat the water, which forced fish into a waiting gill net. A considerable number of *O. niloticus* and some *O. mossambicus* were caught. One reason for fewer numbers of *O. mossambicus* could be because they are smaller in size — about 30% of the size of *O. niloticus* — and so may have escaped the gillnet, which had a mesh size of three inches.

A night survey of the lake indicated a considerable number of freshwater prawns, *Macrobrachium lar*, and an abundance of (possibly) *Palaemon* species. The villagers were unaware of this resource and requested information on catching them.

Village consultation

Members of both Safai and Satoalepai villages attended meetings organised by the team and participated in discussions. Villagers informed us that fishing in the lake forms an important source of food and income, and that it had been had been closed for the last five months to allow for the recovery of stocks (i.e. the sizes of fishes especially tilapia caught were small and thus fishing activities were stopped to allow stocks to recover). Key outcomes of discussions are given below:

- Given the importance of the lake in providing food for the villages, the members

Checking catch from the lake with Satoalepai villagers

acknowledged they were happy that consultations were taking place between various parties in a formal manner.

- Villagers agreed to participate fully in the project. They have implemented a ban to stop all forms of fishing for the duration of the project.

- Villagers would provide (free of charge) support for monitoring, security, sampling activities and any other activities related to the project.

- Some individuals would like some form of regulation to manage the fishery in the lake such as licensing, control of net mesh size, setting closed seasons, introduction of *O. niloticus* on a regular basis, and cage culture.

Fingerling preparation and transport to Lake

Preparations (at Apia) and transportation (from Apia to Lake Satoelepai) of fingerlings were carried out successfully with virtually no mortality.

Tagging and releasing of the fingerlings

Tagging (clipping of right pelvic fin) was carried on the banks of Lake Satoalepai with the assistance of villagers. Village elders released the first set of tagged fingerlings into the lake. A total of 9000 fingerlings were tagged and released.

Top: Catch from the lake, small *O. mossambicus* and big *O. niloticus*

Middle: Demonstration of tagging – fin clipping with aid of a pair of scissors

Bottom: Releasing tagged fingerlings

Sampling

Procedures for carrying out monthly sampling and related activities will be carried out by SFD staff. The final sampling will be carried out at the end of October or early to mid-November (after 100–130 days), depending on the maturation of female fish based on the monthly sampling data and visual observations.

Stocking into cages

A sample of tagged fish and a similar number of *O. mossambicus* collected from the lake have been stocked in two separate cages to provide comparative results at the end of the experiments.

Tissue sample collection

Tissues samples from 30 individuals of *O. niloticus* and *O. mossambicus* have been preserved in 70% ethanol, and these will be sent to Associate Prof. Peter Mather of the Queensland University of Technology to carry out genetic studies (i.e. to determine whether there has been any introgression of *O. mossambicus* genes with *O. niloticus*, or vice versa).

Regional women's training workshop in aquaculture at CETC

Background

Women around the Pacific Islands region, especially in Fiji, Papua New Guinea, Solomon Islands and Vanuatu, are involved in several types of aquaculture activities. It is generally women who feed the fish and manage the ponds. Yet, aquaculture is almost universally considered men's work, and women's role has gone largely unrecognized. Women have almost no direct access to training or to extension agents, which would enable them to acquire the necessary knowledge to increase productivity. Very few participants in training courses around the region are women, and the number of female extension agents is even lower. Past studies do not mention (or reveal very little) about women's involvement in aquaculture, and very few development project reports make specific references to women's participation.

The Community Education Training Centre (CETC) at Narere, Fiji was established in the 1960s. It contributes to SPC's Social Resources Division's mission to "maximize the development potential of Pacific Island people in health, culture and information, and enhances the empowerment of women and young people". CETC conducts various trainings for women, and at present, a seven-month, live-in training programme for 35 female community workers from the region is underway. The programme will focus on various skills and knowledge in community development, using non-formal, practical, participatory methods of learning.

According to Dr Lia Maka, the Head of CETC, women have proven to be competent in adopting new technologies, but their role tends to be very restricted, and often ignored in Pacific Island countries. One of the major reasons is the location of their homes, villages and farms, and several sociocultural taboos against women who strive to earn for their family's subsistence in rural and peri-urban areas. To ensure that women utilise their full potential in profitable activities, it is necessary to provide capacity building support to women, which will eventually lead to their empowerment. One such activity — backyard fish farming — offers immense scope for improving the livelihood of rural women. In response, CETC has established a demonstration fish culture facility with the intention that it will give some practical tips for the dissemination of fish farming technology, particularly for rural women. SPC's Aquaculture Section helped establish this project in mid-2006, and as a follow-up, the Aquaculture Officer conducted a week-long training course in October in basic aquaculture. Thirty-one regional participants attended this workshop.

The overall objectives of the workshop were to:

- provide participants with an overview of aquaculture in Pacific Island countries;
- outline basic tilapia biology, including environmental requirements, seed production, and simple broodstock management methods; and
- describe and demonstrate tilapia hatchery and pond grow-out technology, fish handling, including pond site selection and construction, and simple farm business plans.

Lectures were conducted in the mornings followed by practical sessions in the. Lecture topics included:

- Aquaculture in Pacific Island countries and territories (past and present).
- Basic biology and environmental requirements of tilapia.
- Tilapia seed production technology, larval rearing, and growth.

- Pond site selection (soil, water and topography, and pond construction)
- Pond preparation.
- Feed, feeding and fertilization, pond management, sampling and harvesting.
- Tilapia diseases and quarantine protocols/requirements for introductions.
- Simple farm business plans.

Practical sessions included fish handling, sex identification, checking the maturity condition of female fish, measuring length and weight of fish, pond preparation, installing hapas and fed trays, feeding methods, counting and packing fingerlings, developing pond models, and preparing simple feeds.

Exercises and assignments included determining stocking densities, feeding ratios and amounts, and calculating capital and operating costs, including profits. Participants were divided into groups to make presentations. At the end, a course evaluation was carried out whereby participants commented on what they liked and disliked about the workshop, including any other comments they had.

Summary and recommendations

The status of tilapia aquaculture development varies from country to country, and in some countries it is non-existent. Overall, participants recognize that tilapia aquaculture is an emerging technology that is trying to establish its foundation in Pacific Island countries.

In Fiji and Papua New Guinea, where tilapia culture has been established, women have become involved at some levels, but the degree of recognition and opportunities for training is limited, even though women commonly perform the routine activities of pond management.

Participants recognize that the information and knowledge gained from the workshop is still far from complete. They would like to see the women the development of simple tilapia pond pilot projects in their respective countries.

Training and education is required at all levels in order to increase the opportunities for women's participation in the economic sector with particular attention given to training in basic activities and extension in locations where women are active producers.

Information prepared and distributed for aquaculture projects, including in-country opportunities for attending trainings, should reflect the participation of women at all levels.

Acknowledgments

SPC's Aquaculture Section thanks CETC's previous and current management for establishing an aquaculture demonstration facility for women and others in the region. Specials thanks are also due to Aminiasi Driu, Aliti Sema (CETC staff), and others for their support and assistance during the demonstration project and the workshop.

Top: Examination of maturity condition in female tilapia – a demonstration

Bottom: "ready to spawn" – female maturity condition displayed by Aunofo Mohetu from Tonga, reconfirmed after dissection

NEARSHORE FISHERIES DEVELOPMENT AND TRAINING SECTION

Tuna loining workshop and training needs assessment in New Caledonia

Adding value to tuna caught by domestic fishing vessels is increasingly popular in the Pacific. One way of doing this is to prepare chilled or frozen quarter-loins for export to the European Union or USA markets. Last September, New Caledonia called upon the services of the SPC Nearshore Fisheries Development and Training Section to address some training needs in that area that were recently identified following consultations with local tuna processors and exporters. A training strategy was developed by Section staff in collaboration with relevant institutions in Noumea (e.g. Le bureau des Pêches de la Direction du Développement Rural de la province Sud, and the New Caledonia Foreign Investments Office – ADECAL). The strategy included the development of a partnership with seafood processing specialists from the Fare Tautai, a fisheries training institution in Tahiti. Claude Davio, director of Fare Tautai and Patrick Gaboriaud, an experienced fish processor and trainer from a private Tahitian seafood company, came to Noumea in September to assist the local tuna processing industry.

During the first three days of their mission, Claude and Patrick conducted a workshop at the processing plant of the company PESCANA. Training targeted local fish cutters and focused on loining methods for albacore tuna, and was aimed at improving the efficiency and safety of local fish cutters. (The first SPC tuna loining workshop was held in Fiji Islands in July 1999 and a comprehensive description of the Tahitian method for quarter-loining albacore tuna can be found in *Fisheries Newsletter* #90). The fish cutters, quality and process supervisor, and the company manager were all pleased with the high-quality training delivered by the Tahitian tutors at the workshop. It is expected that as an outcome of the workshop, fish cutters will obtain greater yields, thereby increasing the profitability of this tuna processing operation.

After the workshop, Claude and Patrick used the last three days of their trip to carry out a rapid assessment of the training needs of the Noumea-based tuna processing industry. Various visits to local fish exporters, seafood processors and retailers, as well as meetings with fisheries administrations and training institutions were organised. Among the priority needs identified during this survey was training in tuna handling for vessel crew and the development of a fish cutting course for new entrants into the industry.

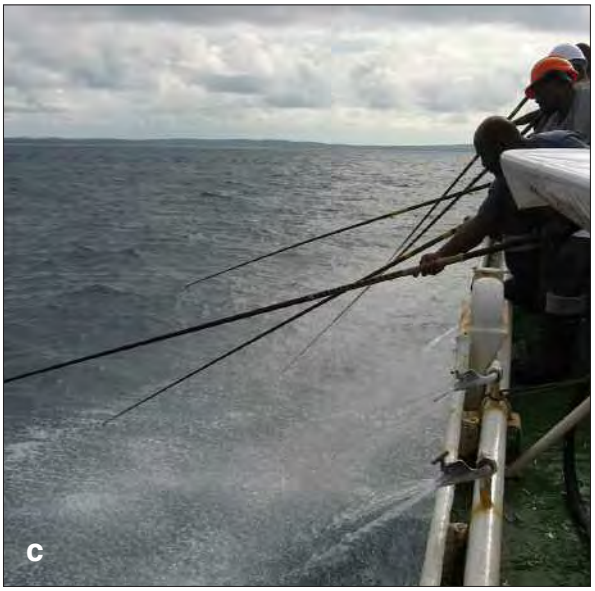
Onboard training of Soltai pole-and-line crew for the PNG tuna tagging project

Safety survey

A tuna tagging project in Papua New Guinea required upgrading the fishing vessel *Soltai 6* in Noro, Solomon Islands. Improvements included a full makeover of the wheelhouse, galley, accommodation area, a top overhaul of engine room machinery, and an upgrade of the wheelhouse electronics. An office unit was built and placed on the aft bridge deck to provide a working space for scientists to carry out tuna tagging data compilation and processing; a flat platform was also built to house the vessel's aluminium work dinghy. SPC's Fisheries Development Officer was requested to provide advice to the vessel's officers regarding appropriate actions to be taken in order to have proper equipment and safety measures in place for a ship safety survey.

Safety and comfort were foremost considerations throughout

Figure 1: *Soltai 6* at Noro during upgrading work



the renovation, but proved to be a challenge to implement on a 28-m vessel that is required to accommodate 29 personnel and five scientists. The SOLTAI Company, however, has a shore-based operation (including a Japanese supervisor) that is set up to undertake such tasks, and has tradesmen that are quite proficient in carrying out the renovations. The main difficulty turned out to be the time frame in which to complete all tasks.

Safety and sea survival upgrades were also made at the same time because of the institutionalised regulations that govern equipment and requirements for safety standards of a vessel the size of the *Soltai 6* on international voyages.

These safety regulations focus on:

- the manning structure of the vessel to ensure that appropriately qualified personnel are in place to carry out safe watch keeping and ship handling requirements;
- the safety equipment survey to ensure that the vessel is appropriately equipped with fire fighting equipment and sea survival gear to counter disasters such as fires, flooding, and sinking;
- sea survival compliance to ensure that appropriate life saving equipment is onboard in case the crew needs to abandon ship;
- navigation and bridge equipment conducive to the vessel's operations as well as to provide the best possible means of ensuring safe navigation and fishing operations;

Figure 2 a, b, & c: All systems working during first baiting and fishing operations

- medical supplies consistent with the manning structure and class of vessel;
- engine room condition with special attention to the operational conditions of the main engine, gear box, auxiliaries, generators, bilge pumps, bilge valves, bilge alarms, valves in the fire main systems, and piping arrangements; and
- the condition of the ship's hull, casings, superstructure, hatch coaming, companionways and bulwarks.

All tasks were addressed simultaneously, but systematically. The primary aim was to lay out a plan of action so that work could progress without having to repeat jobs or get in the way of other work being carried out. Fortunately, the Japanese supervisor had good onsite management skills and was able to direct operations effectively.

The main concern for SPC's Fisheries Development Officer was ensuring that the appropriate equipment listed in the Solomon Islands marine survey form was in place onboard before the marine survey actually took place. Attention was given to making certain that the appropriate fire extinguishers were installed in the correct compartments (i.e. CO_2 fire extinguishers were installed in enclosed compartments, dry powder extinguishers near electrical areas, and foam extinguishers in the engine room). The bridge electronics equipment was tested, including compiling the necessary Mercator charts to cover all the areas that would be frequented by the vessel during the tuna tagging project. Special attention was given to acquiring the large-scale charts to cover the baiting grounds as well as the small-scale regional charts for transitory travel. The vessel had to be equipped with a country of registry flag (flown on the aft mast of the vessel), the flag of the country(s) to be visited (flown on the port wing of the top mast), as well as all alphabet and signalling flags (flown on the starboard wing of the top mast) listed under the international code of signals. The vessel's name and port of registry had to be stencilled onto liferings and liferafts, and two liferafts — capable of holding 25 persons each — were installed to provide for the full ship's complement.

Three days before the end of the renovations, two marine surveyors from the Solomon Islands marine department began carrying out the final examinations. The engine room survey concluded satisfactorily after the first survey day, with only minor infringements that were easily rectified. The deck survey, however, had to be conducted progressively with other work being undertaken onboard. But this was successfully completed on the day before departure and the surveyors endorsed the vessel's safety certificate as "fit for international trade".

Port clearance and foreign vessel movement protocol

Although the deck officers, engineers and crew of *Soltai 6* were fully competent to "man" the vessels in the fleet, and capable of expediently carrying out successful pole-and-line fishing operations within the Solomon Islands, they lacked experience in conducting fishing operations in foreign waters and were not familiar with foreign vessel movement protocol. This protocol basically involves vessel clearance at port of entry, vessel responsibilities while in foreign waters, and vessel clearance at secondary ports. SPC's Fisheries Development Officer was given the task of briefing the officers on the standard protocol measures to be carried out at each port of entry and each port of call.

The *Soltai 6*'s first port of entry in Papua New Guinea was Rabaul. At least 24 hours prior to arrival, the captain of *Soltai 6* was coached in how to inform the Rabaul Harbour Master of the vessel's estimated time of arrival (ETA) at the pilot station. The ship's agent was also contacted to arrange for all port clearance formalities, which includes clearance for immigra-

Figure 3: Approaching Rabaul harbour for clearance

tion, customs, health, and quarantine and agriculture, as well as port dues.

Normally a shipping agent at the destination port is engaged well before the vessel arrives. The agent arranges for the vessel's arrival and liaises with the vessel's skipper and owner (or charterer) on the arrangements being carried out. On arrival at a port of entry, the skipper proceeds directly to the pilot station and informs the port master's office of the vessel's ETA at the pilot station. All foreign vessels are obliged by law to engage a harbour pilot to guide and berth the vessel safely to the arrival port unless special exemption is issued by the port master's office; however, a pilot fee is charged whether there is a pilot on board or not.

On arrival at the pilot station, the ship's officers must ensure that the vessel is flying the flag of the vessel's country of registry on the aft flagstaff, a flag of the country of destination on the port arm of the main flagstaff, a "Q" code yellow flag denoting "my vessel is healthy I request free pratique" on the outside of the starboard arm of the main flagstaff; and a "G" code flag denoting "I require a pilot" on the inside of the starboard arm of the main flagstaff. The G flag is lowered and replaced by an "H" code flag once the pilot has boarded the vessel. The H code flag signals "I have a pilot on board".

At the quarantine clearance station the vessel is boarded by representatives of immigration, customs, port health, and the quarantine section of the agriculture department. Here the skipper goes through the tedious role of filling out forms and signing declarations. He is also briefed on special areas of concern and additional clearance measures that are part of the country's statutory laws. In Papua New Guinea, the laws require that the vessel go through all clearance procedures at its first port of entry in the country; after that, at each port of call within the country, the vessel's skipper must notify the port's local authorities of their arrival and departure.

The SPC Fisheries Development Officer informed the skipper and officers of the *Soltai 6* that it would be prudent to know all the necessary details of port clearance before travelling to the country of destination. This would enable the skipper to request the ship's agents at the destination port to forward all the necessary clearance papers well before hand and to have all forms filled out before arriving at the port of entry. The experience at Rabaul served the ship's officers well and contributed to their development as ship's officers.

Specialised navigational skills to transit baiting grounds at any time

The skipper and officers of *Soltai 6* were familiar with the baiting grounds in the Solomon Islands because most of them have spent their entire working life in the pole-and-line industry there. However, when discussing baiting grounds in Papua New Guinea, the skipper and chief officer said they would need time to familiarise themselves with the passages to most of these baiting grounds, and so they would prefer the baiting grounds to be visited during daylight hours and to return before dusk. Most of the best baiting grounds are unmarked with navigational aids, beacons or lights.

Being a successful pole-and-line skipper requires good navigational skills that will enable him to transit passages and baiting grounds at any time of the day or night, whether the passages are marked or unmarked. This gives the skipper the advantage of being at the fishing ground at the break of dawn and gives him more fishing time throughout the day if the morning operation isn't successful. Modern technology has given skippers an advantage to achieve this with relevant ease if they know how to use the equipment well. The global positioning satellite system (GPS) and differential GPS are cherished modern equip-

Figure 4: Transiting Albatross Channel in New Ireland Province, Papua New Guinea

ment that enable the skipper to achieve this but in some cases, the negotiation of passages and course ways to and from the baiting ground requires more precision. A relatively new technology will be a boon to all pole-and-line skippers once it becomes readily available to the industry. This is the electronic chart display and information system (ECDIS), which is a real time navigational system that works off an electronic chart. It provides significant benefits in terms of navigational safety and improved operational efficiency. ECDIS is one of two basic types of electronic chart systems but is the only one that complies with the International Maritime Organization's requirements for Safety at Life at Sea (SOLAS) class vessels. However, to give the Soltai 6's skipper the best options with the equipment he has on board, SPC's Fisheries Development Officer introduced him and his chief officer to precision navigation using the ship's radar system and matching this with echo sounder and GPS plots.

Before approaching a baiting ground or when navigating through passages with unmarked navigation hazards, the skipper must peruse his chart thoroughly and lay off preset courses and pre-marked curves from clearly identifiable radar targets, such as land points and islands. If there is a target that can give a good curve entry for a passage entrance then this makes it easier to transit, otherwise the skipper must constantly mark his way in and out of the passage using preset position lines or using radar transit targets, if available, in conjunction with a GPS plotting system. In most cases, the passages have good targets that enable a curved entry and departure. This is more precise and safer than following GPS tracks in and out of the passage. Following GPS in and out of a passage is adequate if the passage is wide enough to allow for errors, but if narrower passages are tackled, then following the GPS tracks can pose a problem. However, one of the preparatory stages for using the radar marks is to test the marks out during daylight to adjust for any errors. Once the skipper has set a safe radar mark for transiting the passages, he can confidently manoeuvre his way to the baiting grounds.

During the first four baiting operations, this navigational technique was passed on to the skipper and chief officer until they were confident enough to negotiate new grounds on their own. To date, the skipper of the *Soltai 6* has continued to negotiate baiting grounds with ease and has added new baiting grounds to his list.

Fifteen priority issues for the tuna industry in Melanesia

The DevFish meeting for tuna industry participants from Fiji, Papua New Guinea, Solomon Islands and Vanuatu was held in Lami, Fiji from 4–6 September.

The key theme resulting from discussions was the need for Pacific Island states to maximize the economic benefits derived from their tuna resources. A concerted strategy to achieve this goal needs to be adopted. The development of strategies for domestic industry development is a major objective of the DevFish Project, and a regional framework is being developed by the Pacific Islands Forum Fisheries Agency as part of its current annual work plan.

Addressing the problems in more detail, the meeting identified 15 priority areas, which were ranked in approximate order of importance (using a scoring system). Many of these could be addressed in the broader regional strategy.

1. A coordinated approach to seafood safety and sanitary issues

Seafood safety and sanitary controls were recognized as crucial to securing access to major overseas markets. The meeting strongly supported the idea of a coordinated approach (by countries in the region) to seafood safety and sanitary issues, particularly with regards to requirements for export to the European Union. This could include harmonized regulations and standards, regional training of inspectors, and centralized laboratory facilities for testing samples.

Noting that teams from the 8th European Development Fund's Strengthing Fishery Products and Health Conditions project would be visiting the region within the next few weeks to identify the need for EU funded assistance in this area, the meeting agreed it would be wise to await the outcome of this visit before deciding what further action by the regional agencies would be necessary.

2. Sea freight and air freight services and costs

The meeting identified the high cost and often monopolistic nature of air and sea freight services as a major constraint to the development of the tuna industry. It was noted, however, that there have been recent studies on these issues, and there were no easy short-term

solutions. On the other hand, development of the industry will lead to economies of scale and high fuel costs increasingly favoured countries near to the resource. It was felt that it would be useful to carry out a study on the competitive advantage of the private sector tuna industry in the region and develop a strategy to improve competitiveness. DevFish will undertake this activity.

3. Fuel efficiency and alternative fuels for tuna fishing vessels

High fuel costs have greatly reduced the profitability of tuna fishing in the region, and there are both economic and environmental reasons for reducing consumption of petroleum products. Many of the vessels in the region are old and inefficient, and were built in an era of cheap fuel. Several countries in the region also produce large volumes of coconut and/or palm oil with potential for use as bio-fuels.

The meeting noted that the fishing industry in Papua New Guinea has requested a technical assessment of options for the longline fleet from the Centre for Development of Enterprise. If and when this is carried out, DevFish will make the report available to other interested fishing companies, and will follow up as appropriate.

4. Strengthening the Pacific Islands Tuna Industry Association (PITIA)

The meeting agreed that the need for strong representation of the tuna industry's position on regional issues had, if anything, increased since the 2004 meeting at which PITIA was formed. There has been some progress in formalizing the association's status — registration, a constitution, and bylaws — but there had still been no meeting of the membership or election of office bearers. It was noted that some national associations also needed strengthening in order to feed effectively into the PITIA process.

The following course of action was supported:

- Use of CDE funding of 5,000 to engage the chairman of the PITIA steering committee to develop a strategic plan;
- The application to CDE for funding of 50,000 for PITIA operations, with complementary funding of 33% from the Global Environment Facility project provided in kind;
- Funding of a general meeting of fishing industry association heads to, inter alia, review the strategic plan and elect office bearers (to be funded by DevFish);
- Continuing support for national associations by DevFish.

5. Specific proposals from the tuna industry for incorporation into the Economic Partnership Agreement and Fishery Partnership Agreement negotiating process

It was noted that the negotiation process for the Economic Partnership Agreement provided opportunities to negotiate for EU assistance that could directly benefit the tuna industry, including funding to improve competitiveness, and reorganization of CDE and EIB programmes to make them more responsive to the needs of the Pacific Islands. It was also learned that significant elements of the Pacific Islands' position on fisheries access for EU vessels had not been discussed with key industry players.

The Forum Secretariat representative to the meeting noted the views of industry participants. ForSec, working with PITIA, will increase efforts to inform the region's tuna industry on key issues before the November meeting of Trade and Fisheries Ministers, so that they can have input into the positions of their national delegations to this important meeting.

6. Development of a strong industry position on key trade issues, including tariff preferences into the EU market, relaxation of the rules of origin, and new efforts to secure duty free access for canned tuna into the US market

The importance of tariff preferences, particularly for canning and loining operations exporting to the EU, was stressed. Increased opportunities for onshore processing would be increased by relaxation of the rules of origin, allowing processors to source raw material from any fleet fishing in the region. Efforts to link market access to fishing access in the US tuna treaty have so far been unsuccessful, although the US does provide concessions to other countries.

FFA will widely circulate the relevant results of its study on trade and market access to inform industry and governments of the key issues. As noted under point 5, input from industry into the EPA process provides an important opportunity to move forward on these issues.

7. The high cost of regional registration and VMS for domestic vessels

Participants from Fiji raised the issue of the high charges levied by FFA for regional registration and participation in the regional vessel monitoring system (VMS) scheme — more than USD2,000 per year. This is a significant cost for local industry, particularly for smaller longliners that fish

only in Fiji waters. The high cost compares unfavourably with charges levied on the domestic industry in New Zealand for a similar service (USD117 per vessel per year), and may affect the fleets of other Pacific Island countries that do not have their own VMS for domestic vessels.

FFA officials noted the concern, but explained that the organization was committed to full cost recovery on these services. It was pointed out that the decision to include domestic vessels that did not fish outside Fiji waters in the scheme was an internal matter decided by the Fiji Government and not a regional requirement. If Fiji preferred to set up a domestic VMS system to cover these vessels, registration with FFA would not be necessary.

8. Strengthened regional efforts in monitoring, control and surveillance

The importance of regional cooperation to increase the effectiveness of monitoring, control and surveillance was recognized. Industry representatives believed that illegal, unreported and unregulated (IUU) fishing represents a major threat to the region's tuna resources and undermines stock assessments and management measures.

FFA staff informed participants of a number of initiatives (e.g. sharing of VMS data, joint enforcement patrols under the Niue treaty, and training and coordination of observer programmes) that help to address the issue, but acknowledged that more needs to be done. A project to reduce IUU fishing is also a priority for EU funding proposals under EDF10.

9. Greater transparency in access agreements and vessel licensing

It was noted that greater exchange of information on access agreements would generally benefit Pacific Island countries in their dealings with distant-water fishing interests, and that transparency would help to eliminate corruption. Disclosure of licensing arrangements to domestic operators was also important for the detection of illegal fishing.

Although certain countries seem to prefer secrecy in access matters, the trend is towards greater transparency; for example, all EU access agreements can be found on the Internet. FFA is also becoming more involved in bilateral negotiations. Greater transparency will be proposed in the strategy for responsible development of the region's fisheries, which is being prepared for approval by member countries as part of the FFA work programme for 2006–2007.

10. Port State measures to prevent IUU fishing

The meeting observed that some ports in the region, such as Suva, are used by many fishing vessels that fish on the high seas and in neighbouring zones. It is important that economic benefits of port calls, or the demand for fish for local processing plants, does not take precedence over national obligations to prevent IUU fishing.

Participants were informed that FFA continues to provide training for authorized officers in all Pacific Island member countries on dock-side boarding and prosecution of offences and is also assisting with the review and updating of national legislation to reflect international obligations. The meeting supported further strengthening of national capacity in this area.

11. Use of carbon monoxide in tuna products

The meeting discussed a proposal that suggested the use of CO in tuna products should be banned across the region. It was argued that this process is already banned in many importing countries, allows the misrepresentation of stale fish as fresh, and will undermine the reputation of producers across the region. On the other hand, some participants felt that it is a genuine value-adding process that allows the export of sashimi grade frozen fish without the use of ultra-low temperature, and should be permitted as long as major export markets (e.g. USA and Australia) demand it. There may also be a distinction between use of industrial CO gas and so-called odourless smoke processes that deliver lower concentrations of CO.

The meeting agreed that the use of CO should be closely monitored by the responsible authorities in different countries, and that changes in the policy of importing countries should be similarly monitored and complied with.

12. Crewing of vessels by Pacific Island nationals

The meeting noted that the tuna industry in many countries employed large numbers of crew from outside the region, and that efforts should be made to increase the employment of Pacific Islanders to retain economic benefits in the region.

13. A coordinated approach to bycatch issues

The meeting was briefed on moves by the Western and Central Pacific Fisheries Commission to mitigate the impact of tuna fisheries on other species, notably sharks and turtles. There is likely to be pressure for a ban on shark finning, and perhaps for the compulsory use of large circle hooks to prevent hooking of turtles.

The meeting was informed of a study on the economic impact

of a shark finning ban, which has been commissioned by FFA. The tuna fishing industry was asked to cooperate with the consultant carrying out this work. National industry associations and PITIA will work to develop a common industry position on these issues.

14. Depredation by whales

The meeting considered the problem of depredation by whales, which one company estimates to result in the loss of 6–7% of catches in Fiji waters. Previous meetings have recommended closer monitoring of these losses, including modification of the standard regional logsheet, but these have not been actioned. No representative from the Pacific Islands will attend the upcoming meeting in British Columbia on the issue.

The meeting suggested that the regional agencies should monitor international developments in quantifying and tackling the problem. An offer from Solander (Fiji) to assist any research scientist interested in studying the issue was noted.

15. A possible multilateral agreement for longline access between Pacific Island countries

This was rated the lowest priority by meeting participants. Most industry participants from Fiji have made satisfactory bilateral access arrangements for their vessels, and there is currently no demand for access into neighbouring zones from other Melanesian countries. Concern was also expressed over eligibility to participate in the agreement, which could act as a backdoor for foreign owned and controlled vessels to gain access to fisheries reserved for locals.

The meeting was informed, however, that there is a trend for countries to close their zones to access arrangements, which may restrict domestic fleets more in future; also there is more interest in such an arrangement in countries to the southeast of the region.

In brief

- A refresher Start Your Fishing Business (SYFB) training of trainers (TOT) course was conducted at Santo, in July. The course, which was delivered by two master trainers from Papua New Guinea, was attended by 2 Solomon Islands and 11 Vanuatu trainers. By successfully completing the TOT process, the participants are now officially recognized as national trainers under the International Labour Organization (ILO) certification framework. This refresher TOT course also marked the completion of SPC's and the Commonwealth Secretariat's assistance to Vanuatu and the Solomon Islands in the area of small fishing business management. The onus is now placed on local institutions and trainers to market and deliver the SYFB training programme in-country. With funding from the Commonwealth Secretariat, the Training Section will be coordinating (in 2007) a second sub-regional SYFB training programme that will aim at establishing a network of ILO-accredited trainers in Samoa, Tonga, the Cook Islands, Niue and Kiribati. This sub-regional project follows the training needs assessment, which was conducted earlier this year in the same countries. The initial TOT course is tentatively scheduled for February 2007 in Apia, Samoa.

- The third regional course on vessel operations management and electronic aids for commercial fishing skippers ran from 2–13 October at the New Zealand School of Fisheries. This training, which was attended by 10 participants from 8 countries and territories, has followed a similar programme to that of previous courses, with a combination of classroom-based sessions, presentations on specific topics by relevant guest speakers from the Nelson-based fishing industry, and field visits. The course was jointly sponsored by the governments of Australia, France and New Zealand and the European Union through the DEVFISH project. More on this training course in the next issue of the *Fisheries Newsletter*.

- Fisheries Development Officer Steve Beverly left Noumea on 15 October to conduct an in-country project in Papua New Guinea until the middle of December. The main project objective will be to provide onboard training and specific advice to improve the profitability of domestic tuna longlining operations. Steve will do several trips on local longliners in order to observe current fishing practices and onboard handling methods. Ways in which these could be improved will be highlighted in a report that will be submitted to the PNG National Fisheries Authority. The report will also identify steps that domestic operators need to take in order to implement any proposed changes. A secondary objective of this project will be for Steve to assist

the Port Moresby Game Fishing Club and the European Union's Rural Coastal Fisheries Development Project (RCFDP) in site surveys, rigging, and deployment of six fish aggregation devices (FADs) in the Central Province waters. Details on the implementation phase of this project will be reported in the next issue of the Fisheries Newsletter.

- Fisheries Development Officer William Sokimi will travel to Okinawa, Japan, early in November to take part in a regional course organised by the Japan International Cooperation Agency (JICA). The course, "Community-Based Fisheries Diversification in Pacific Island States", will run from 30 October to 8 December. Using the experience of fishing associations in Okinawa, the course will explore a range of possible alternatives to the increasing of fishing pressure on reef resources. Following a request from JICA, SPC has agreed to release the Fisheries Development Officer for a 10-day period to provide some teaching inputs into the course. In addition to presenting SPC's past and current FAD initiatives, William will also coordinate a session on national FAD programmes in the region. During the course, participants will be exposed to some innovative FAD technology, including the use of submerged FADs (it is hoped that a FAD will be rigged and deployed as a training exercise). Further collaboration between SPC and JICA is being discussed as the Okinawa course is the first component of a three-year training programme funded by JICA. While the exact content of future courses (in 2007 and 2008) has not yet been decided, it is possible they will focus on FAD technologies and programmes, in which case the Section could play a leading role in the training.

- A video/DVD to promote at-sea tuna loining and freezing operations was finalized during the reporting period. The video/DVD was produced in both French and English and, at the end of the reporting period, distribution had begun.

OCEANIC FISHERIES PROGRAMME

Regional Tuna Tagging Project
Phase 1: Papua New Guinea

Initial results

We presented this project and its objectives in *Fisheries Newsletter* #117. The initial tagging campaign began on 12 August and ended on 12 November when the F/V *Soltai 6* returned to its home port of Noro, located on the island of Munda in the Solomon Islands. Preliminary results after the first two months of catching tuna in the Bismarck Sea are presented below.

The ship

Pole-and-line fishing, using live bait, is the only way to catch and then rapidly release a large number of tuna with a minimum amount of stress. This fishing technique, which was still widespread in Papua New Guinea in the early 1980s, has now disappeared in favour of seine net fishing, which is more profitable and does not rely on fodder fish near the fishing grounds. So, for this tagging campaign in the waters of Papua New Guinea, we chartered the *Soltai 6*, a 27-metre, pole-and-line vessel, from the last shipping company in the region to use such vessels (i.e. Soltai F&PL, based in the Solomon Islands).

Certain indispensable renovations and additions were needed to adapt the boat to its new mission (e.g. bringing the 10-person crew accommodations up to date so as to comfortably house six scientists; renovating the kitchen and adding a fridge, freezer and washing machine; and installing a small prefab unit on the upper deck to serve as a data-entry station and a place to store tagging materials). Next to this "office", we took on a four-metre aluminium dingy. Three tagging tables were made in the shipping company's workshops and installed on board (i.e. two at the *Soltai 6*'s prow and one at the poop). The length of this expedition and the ship's distance from its home port did, of course, mean that the engines and navigation and safety equipment had to be overhauled.

The trip

After the normal race against time to get the boat ready and a moving departure ceremony, the *Soltai 6* left Noro on the afternoon of 12 August and headed for Rabaul, the port where entry procedures for Papua New Guinea were carried out after two days of uneventful sailing.

After another two days of government paperwork and filling up on fuel, water and food, we

left Rabaul to begin the real work (i.e. catching and tagging at least 15,000 tuna in three months).

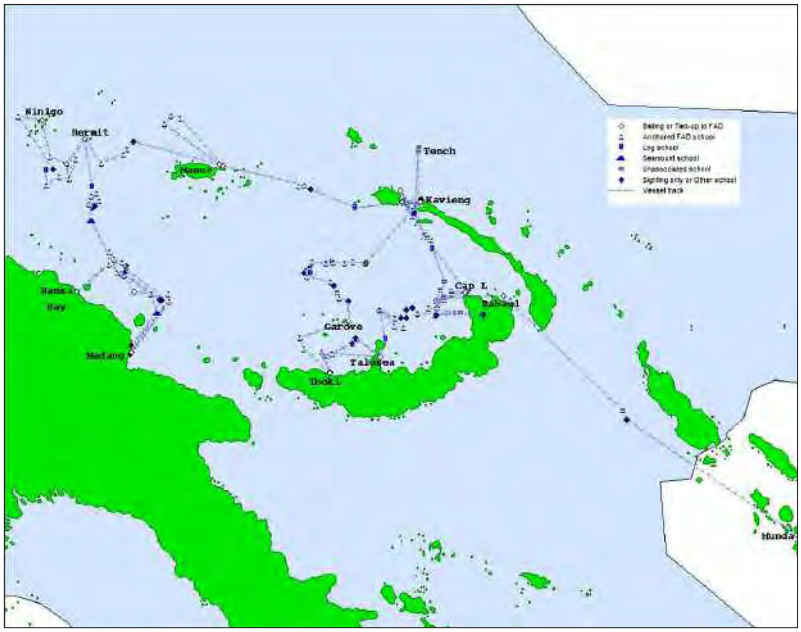
In order to ensure the widest distribution of tagged tuna possible, the boat went nearly the entire way around the Bismarck Sea in two months' time.

Fishing

The key to this kind of fishing is having enough live bait such as sardines, anchovies or other small fish, to attract schools of tuna encountered at sea and keep them near the boat. If there's no bait, then no fishing can take place, and therefore, no tagging is possible. The bait is caught near land in sheltered bays or lagoons. Papua New Guinea benefits from a large number of favourable sites for this type of fishing. The fish are attracted at night using strong underwater lights around the boat and then caught in "bouke-ami" nets. The fish are then stored in holding pens. The moon has a strong influence on the effectiveness of the fishing method as its light sharply decreases the fish's attraction to the underwater lights, making it impossible to use the method during the full moon. So, the boat uses those unproductive time periods to take on supplies and give the crew a bit of rest.

When the boat gets near a school of tuna, the bait is thrown into the water to attract the predators (tuna) to the boat.

Water is sprayed on the surface of the ocean to mask the fishers from the tuna and the fish are caught using lures moved around on fishing poles.



Top: Departure from Noro

Middle: *Soltai 6*'s itinerary from 12/08/06 to 03/10/06

Bottom: Bait fishing

Tagging

Regular tags

Regular tags are coloured plastic tubes stamped with a number and an address. The head of the tag is equipped with a nylon barb, which is inserted in between the bones located under the tuna's second dorsal fin using a stainless steel applicator. The tags, already in their applicators, are lined up in lots of 100 on wooden blocks with numbered holes.

After the fish are caught, they are taken to a tagging table. If the fish doesn't have any serious injuries, it is tagged, measured and released in less than 10 seconds. The data (species, length, state of the fish) are recorded by dictaphone. Several hundred fish from a single school can be tagged very quickly using this procedure.

Electronic tags

Electronic tags, which are also called archival tags, have been inserted in the abdominal cavities of certain tuna. These tags record and store in their memories data on the length, depth, water and fish temperatures and background light levels. These data (the tagged tuna has to be caught again) will make it possible to get a better picture of tuna behaviour and movements.

Sonic tags

Sonic tags, which are inserted in the same way as archival tags, emit a signal that can be picked up and recorded by underwater listening posts within a radius of about one kilometre. A certain number of these posts have been set up under FADs. Study

Top: Pole-and-line fishing

Middle: Tagging fish

Bottom: Biological sampling

of these data should provide information about how long tuna stay around FADs and about their movements.

Biological samples

Fish that have been injured too much during capture cannot be tagged. So instead we take samples of stomachs and pieces of muscle. These samples, which are stored in the onboard freezer, are taken back to Noumea in coolers for analysis each time an OFP agent goes back there.

Onboard data entry

A small local network of three laptops was set up in the "office" and an Access database was created especially for this project. The information recorded verbally during tagging is transcribed on paper before it is entered in the computer's database. The ship's position and weather information are recorded in the database three times a day. The position and type of association of each school of tuna encountered is noted even if there is no tagging. The database makes it possible to automatically generate reports and geo-referenced maps using these data.

Results

As at 3 October, 11,797 tuna were tagged (see table below), including 63 that also had archival tags and 29 that had sonic tags. A total of eight listening posts had been set up at eight FADs. Nearly 61% of the fish tagged were skipjack, 36.5 % were yellowfin, and 2.6% were bigeye. About 85% of the fish were caught near FADs and less than 6% in free swimming schools. This is a very different situation from the one observed during the last tagging campaign in Papua New Guinea 16 years ago, when 47% of the taggings took place on free swimming schools.

	Number of fish				Percentage		
Association	Bigeye	Yellowfin	Skipjack	Total	Bigeye	Yellowfin	Skipjack
Seamount	-	93	802	**895**	-	10.4	89.6
Anchored FAD	306	4126	5524	**9956**	3.1	41.4	55.4
Log	1	49	212	**262**	0.4	18.7	80.9
Free swimming school	-	45	639	**684**	-	6.6	93.4
Total	**307**	**43013**	**7177**	**11797**	**2.6**	**36.5**	**60.8**

CORAL FARM PROJECT HELPS VILLAGE IN AMERICAN SAMOA START BUSINESS, LEARN ABOUT REEF MANAGEMENT

Given the rapid loss of the world's coral reef habitats, the marine ornamental industry is in need of drastic change. So far the industry has returned very little to the habitats from which it derives its living products. Damaging practices and overcollection of rare species have added to the devastation of marine resources. Groups like the Marine Aquarium Council are approaching conservation by creating standards and certification for organizations involved in the collection and care of ornamental marine life. Yet, these broad attempts to create a sustainable industry, for many coral reef areas, are too little too late.

The island of Tutuila in American Samoa is one such place. The reefs near Tutuila are in poor to fair condition, and any collection of corals or fish would further strain a coastal habitat already in decline. What's needed, then, is a new type of business — one that is village run and that empowers communities to preserve coastal resources. With this view in mind, the American Samoa branch of the Coalition of Reef Lovers (CORL) together with the American Samoa Community College began a project that seeks to restore lost and degraded coral reef habitats and to develop community-based coral farming as a viable business. The project will also use coral farms to educate villagers about the importance of their local coral reefs and why they need to protect, preserve, and restore them.

Potent blend: Farming and rehabilitation

This project focused on one village: Alofau, a medium-sized village with a population of about 200 families in the Eastern District of Tutuila. The Coalition of Reef Lovers (CORL) selected Alofau as the best site for a demonstration coral farm due to its proximity to a large, shallow inner-reef area. Such a lagoon is rare in American Samoa. We also chose Alofau because the American Samoa Department of Marine and Wildlife Resources already had created a marine management area (MMA) through which the village restricts fishing to help the recovery of nearshore fish stocks.

Over the last 30 years, the coral cover has dramatically decreased in Alofau's lagoon and other areas around Tutuila. Contributors include pollution; destructive fishing; overfishing; coral bleaching; coral diseases; a devastating outbreak of crown-of-thorns, a starfish that preys upon corals; and hurricanes.

Propagating coral to reintroduce organisms where populations have declined isn't a new endeavor (Arvedlund et al. 2003). Still, very little has been done in the field of community-based coral reef rehabilitation. Mainly scientists and private companies have conducted coral reef restoration — at the cost of hundreds of thousands of dollars per acre restored (Spurgeon et al. 2000). Coastal communities have proven they can operate coral farms to generate products for export in the marine ornamental trade (Peletta 1999). Similarly, then, communities should be capable of rehabilitating colonies of primary coral species that provide critical cover for nearshore fisheries.

If a community is to take on a mission to restore degraded coastal habitats, then villagers must be provided with the necessary tools, skills, and knowledge. Filling these needs, along with establishing a coral farm, is the crux of this project.

Rehabilitation of any marine habitat involves three main steps: 1) educate the public about stressors; 2) initiate community action to eliminate or reduce them (Yap 2003); and, 3) with stressors corrected, prompt the community's active role in repairing damaged resources. The creation of an MMA or a marine protected area (MPA), a no-touch habitat left to natural recovery, could help with the final step. The Alofau project adds mariculture of corals to this step. Ultimately, the village will cover rehabilitation costs and other resource management needs with sales profits from the farm.

CORL has been working with the village of Alofau since 2003, conducting beach cleanups and helping address pollution issues. This long-term commitment has led to a high level of community involvement that continues with the coral farm project, begun this spring with funding from the Center for Tropical and Subtropical Aquaculture.

Both of the project's first two workshops, which focused on awareness and making an action plan, were attended by 17 villagers. Later, 24 people from Alofau and five more from nearby villages took part in a beach cleanup. The village is considering a no-littering rule and a recycling area.

The first eight of many planned training workshops have also experienced high participation levels. The project goal was to train at least four villagers in how to set up a farm and in coral propagation techniques, yet 14 volunteers continue to show up to these one-day-a-week workshops.

Establishing the Alofau coral farm required some initial analysis: assess the condition of existing coral reefs, determine the primary

coral cover species, and determine if the local variety includes enough desirable species to make a coral farm profitable. We selected a farm site with very few existing coral colonies and adequate water conditions. The site has low levels of nitrates and phosphates, moderate water flow throughout the day, no rip tides, and a water level higher than four feet at low tide.

Next, as part of the training workshops, we salvaged fragments from broken corals and began to propagate them in order to create future donor colonies. Given the large amount of injured corals available, we decided not to take cuttings from existing corals even though it's possible to do so without causing long-term harm. Volunteers started propagating several of the coral species most common to American Samoa's coastal waters, *Acropora formosa*, *A. nobilis*, *A. porites cylindrica*, and *Pavona frondiferas*.

These species, as do many other corals, propagate naturally by fragmentation. From donor colonies previously planted by CORL staff in 2003 and 2004, volunteers collected fragments of between 3 and 12 inches in diameter and cut them down to 1 to 2 inches using common wire cutters. Then, they either tied or glued these cuttings to a coral plug, a cement disk with a 2-inch diameter. They placed the plugs in trays made from 1-inch-square, PVC-coated wire mesh. Finally, they took these trays to the 12-foot-square rebar trestles that they had already constructed and anchored at the farm site.

Coral fragments will grow out for three to six months, then the village volunteers will relocate them to targeted rehabilitation areas or sell them to the marine ornamental industry. Only 20 per cent of corals grown will be sold. For each one sold, villagers will receive USD1.50, a solid profit for them given production costs of less than 10 cents. CORL will handle all marketing and shipping of corals.

Conclusion

The extraordinary community involvement in this project has been welcome if overwhelming. Support from the late Eastern District Governor Paramount Chief Faumuina S. P. Satele and coral farm volunteers, as well as donations from the American Samoan community, have helped create the Alofau Community Ecology Center and a coral farm office. The center, located on land adjacent to the farm, will serve as a resource for local schools (and tourism operations) and as a location from which to monitor the village's environment. Also, CORL is assisting the village in efforts to secure funding for water analysis that would identify nutrient pollution and their sources. Nearshore nutrient levels are high, causing algal blooms that are approaching the farm's reef area.

The coral farm has yet to make a profit. Farm volunteers and other community members, however, are realizing that the Alofau coral reef and lagoon have value beyond subsistence fishing. The more value they place on the lagoon and reef, the more effort they will put into protecting it. Plans now underway include creating a snorkeling trail, renting gear out at the new center, and using the lagoon and center for school trips focused on marine conservation. In the near future, we hope to add to the inside of the center a 180-gallon tank with a coral propagation system, so we can give hands-on demonstrations to students and visitors.

Will we be able to restore the Alofau coral reef to its former condition? It's doubtful. Global warming and rapid population increases in American Samoa reduce chances of a full recovery. We can, however, reduce local stressors causing coral reef decline and, thus, increase chances for a partial recovery that allows some functionality of the former coral reef ecosystem to survive. What's more, the Alofau community can eventually do so on its own, given proper training and sustainable management tools.

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Acknowledgment

Paramount Chief Faumuina S. P. Satele, who died on Aug. 15 at the age of 57, wished to make Alofau a model for other villages. His hands-on support was instrumental in the project's current success.

(Source: Center for Tropical and Subtropical Aquaculture, Vol. 17 No. 3, September 2006, http://www.ctsa.org/)

NEW CORAL REEF MANAGEMENT GUIDE PROVIDES STRATEGIES TO CONSERVE WORLD'S CORAL REEFS

Innovative strategies to conserve the world's coral reefs are included in a new guide released in October by NOAA, the Australian Great Barrier Reef Marine Park Authority, and the World Conservation Union. "A Reef Manager's Guide to Coral Bleaching" will provide coral reef managers with the latest scientific information on the causes of coral bleaching and new management strategies for responding to this significant threat to coral reef ecosystems.

"Coral reef managers can play a critical role in helping reefs survive coral bleaching events," said retired Navy Vice Adm. Conrad Lautenbacher, PhD, undersecretary of commerce for oceans and atmosphere and NOAA administrator. "The reef manager's guide lays out key actions managers can take before, during and after bleaching events to help reduce impacts of bleaching and promote resilience of the reef ecosystem to help it recover from severe bleaching events."

"The Australian Government is proud to share its expertise with reef managers worldwide in this highly anticipated publication. Australia is at the forefront of developing new strategies and tools to respond to mass bleaching events, minimize impacts and build long-term coral reef resilience to climate change," said Andrew Skeat, Great Barrier Reef Marine Park Authority executive director.

The reef manager's guide, developed in partnership with the US Environmental Protection Agency, The Nature Conservancy and other organizations, grew out of a 2002 resolution by the US Coral Reef Task Force calling for development of information and tools for coral reef managers to address threats from coral bleaching. The reef manager's guide can be found online and includes contributions from more than 50 experts in coral bleaching and coral reef management.

"By implementing actions suggested in the guide, coral reef managers are in a unique position to increase our understanding of the phenomenon of coral bleaching, to take meaningful action during a bleaching event, and to develop strategies to support the natural resilience of reefs in the face of long-term changes in climate," said David Kennedy, manager of the NOAA Coral Reef Conservation Program, which helped produce the guide.

The reef manager's guide reviews management actions that can help restore and maintain resilience of coral reef ecosystems. This review draws on a growing body of research on ways to support the ability of coral reef ecosystems to survive and recover from bleaching events. The reef manager's guide includes specific guidance and case studies on how to prepare bleaching response plans, assess impacts from bleaching, engage the public, manage activities that may impact reefs during bleaching events, identify resilient reef areas and incorporate information regarding reef resilience into marine protected area design.

The reef manager's guide also supports a major goal of the U.S. Administration's Climate Change Science Program — to "Understand the sensitivity and adaptability of different natural and managed ecosystems and human systems to climate and related global changes"—by providing managers with options for sustaining and improving ecological systems and related goods and services, given projected global changes.

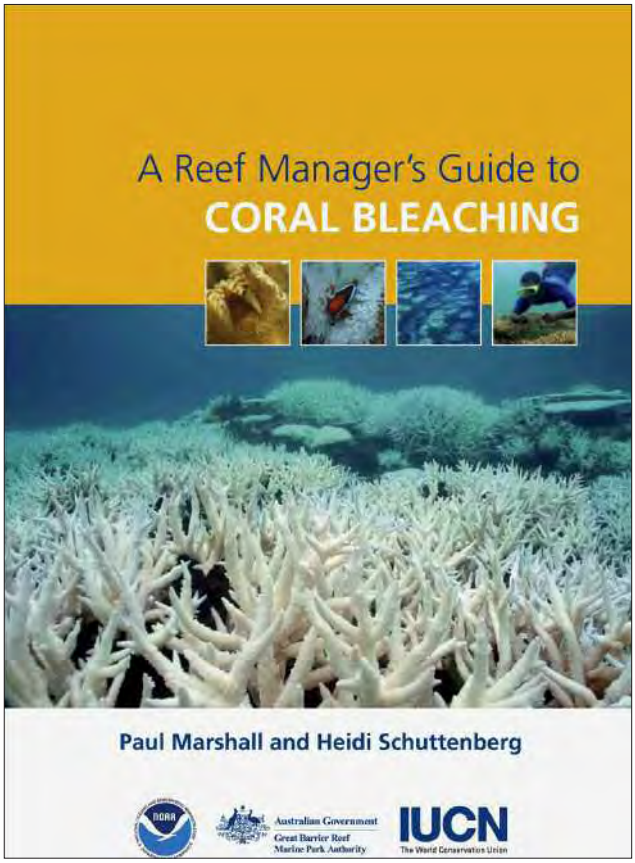
The guide identifies three key actions reef managers can take to help reefs survive and recover from mass bleaching events: 1) increase observations of reef condition before, during and after bleaching to increase information and understanding of impacts and areas that may be especially resistant to bleaching, 2) reduce stressors (e.g. pollution, human use) on reefs during severe bleaching events to help corals survive the event, and 3) design and implement reef management strategies to support reef recovery and resilience, including reducing land-based pollution and protecting coral areas that may resist bleaching and serve as sources of coral larvae for "reseeding" reefs.

Coral bleaching is associated with a variety of stresses, including increased sea surface temperatures. This causes the coral to expel microscopic algae living in their tissues — algae that provide corals with food. Losing their algae leaves coral tissues devoid of color and thus appearing to be bleached. Prolonged coral bleaching (over a week) can lead to coral death and the subsequent loss of coral reef habitats and the vital services they provide to coastal communities, including food, jobs and income, as well as protection from the impact of storms.

Mass coral bleaching events have increased in frequency and intensity since the first recorded event in 1982, resulting in significant coral mortality and other ecological, social and eco-

nomic impacts in many reef ecosystems. In 1997–1998, mass bleaching is estimated to have caused more than 90 per cent coral mortality in many reefs in the Indian and Pacific oceans, destroying 16 per cent of the world's coral reefs. These increases in coral bleaching over the past two decades have been attributed to ocean warming seen in tropical waters around the world. In 2005, Caribbean coral reefs experienced massive coral bleaching followed by coral disease outbreaks and high levels of coral mortality throughout the region. This was the most widespread and severe bleaching ever reported in the Caribbean Sea.

(Source: NOAA; http://www.noaanews.noaa.gov/stories2006/s2717.htm)



SPECIAL TRAITS AND PROMISES OF THE GIANT CLAM (*TRIDACNA MAXIMA*) IN FRENCH POLYNESIA

Antoine Gilbert[1], George Remoissenet[2], Laurent Yan[3] and Serge Andréfouët[4]

INTRODUCTION

Naturally drawn to the sea, Polynesians are traditionally fishers and lagoon or coastal seafood consumers. With an increasing population in the Society Islands (Fig. 1) and a corresponding increase in the demand for lagoon seafood products, certain islands have diversified their economic activities to meet the demand for seafood. In some French Polynesian islands, fishers are frequently seen collecting and cleaning giant clams on site before draining and freezing them for export to Tahiti, or exchanging them when ships arrive. In fact, many artisanal fisheries have developed over the past 30 years, targeting both fish and invertebrates; an activity that has been boosted by the arrival of ships with cold storage rooms and, more recently, by inter-island air transport.

French Polynesia's geographic distribution is wide and sparse (118 islands scattered out over an EZZ of some 5 million km^2), and its population spread is also very uneven: 87% of the population lives in the Society Islands with 75% on just two islands in the Windward group: Tahiti and Moorea (Anon 2002a). Modern transport methods, however, have made it possible to reduce the isolation of certain French Polynesian islands and have opened the door to new forms of inter-island exchange.

Recent work by the Ministry of Marine Affairs (MER) and the Fisheries Department (SPE) will make it possible to sustainably develop and manage the artisanal fisheries sector. Since 2001, the SPE has funded and participated in efforts to manage, exploit and repopulate certain echinoderm and mollusc species in French Polynesia's lagoons and reefs. Giant clams (Tridacnidae) are the primary molluscs of commercial interest. *Tridacna maxima* is the only one of the eight tridacnid species (Rosewater 1965) found in French Polynesia. Because of the popularity of its meat, *Tridacna maxima* is covered by a programme funded entirely by the second phase of the France/French Polynesia development contract.

A SPECIAL CONTEXT

The lagoon invertebrate populations of the eastern Tuamotu Islands include large numbers of giant clams, a vital protein and cultural resource for these atolls. Each island has its own name for giant clams, which are most commonly called *pahua* in French Polynesia as a whole, and kohea in the eastern Tuamotu Islands. Giant clam meat is eaten raw, cooked or sometimes smoked and dried.

Tridacna maxima is still abundant in French Polynesia, although this abundance is uneven. It reaches outstanding levels (Tab.1) in some of the Austral Islands (Raivavae and Tubuai) and in the closed atolls of the eastern Tuamotu Islands, including Fangatau, Fakahina, Tatakoto, Pukarua, Reao, Napuka, and Vahitahi (Salvat 1972; Andréfouët et al. 2005; Gilbert et al. 2005; Gilbert et al., in publication).

In contrast to the giant clam's abundance and dominance in the lagoons of these islands, its abundance in other French Polynesian

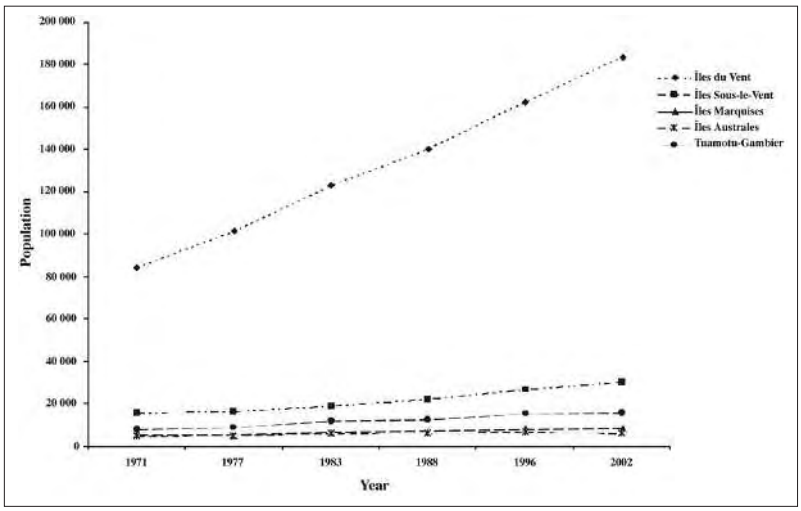


Figure 1: Demographic changes by island group from 1971 to 2002 (source: Institut Pacifique de Polynésie française.

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Table 1: Mean density (ind/m²) on Moorea (Society Islands), Tubuai, Raivavae (Austral Islands), Takapoto, Anaa (western Tuamotu Islands), Reao, Pukarua, Fangatau and Tatakoto (eastern Tuamotu Islands)

	Moorea (Laurent, 2001)	Takapoto (Laurent, 2001)	Anaa (Laurent, 2001)	Reao (pers. observ.)	Pukarua (pers. observ.)	Fangatau (Gilbert et al., submitted)	Tatakoto (Gilbert et al., submitted)	Tubuai (Gilbert et al., submitted)	Raivavae (pers. observ.)
Area and/or number of samples	20 000 m²	1150m²/6	2735m²/14	3200m²/303	1305m²/173	86m²/343	70m²/281	2950m²/326	5485m²/313
Sampling method	PCQM***	T*	T*	T*	T*	QSM**	QSM**	T*	T*
Mean density (ind/m²)	0.035	0.14	0.02	8.15	13.06	44.09	87.37	2.53	1.31

* Transect Sampling Method

** The samples are located in the live giant clam strata (for more details please refer to the methodology described in Andréfouet et al., 2005)

*** Point Centered Quarter Method

lagoons is much lower (Tab. 1), and certain lagoons are currently experiencing declines, sometimes significant, in their populations. While this is in part due to natural causes (Addessi 2001), the increase in fishing pressure, in response to the growing human population pressure, is certainly a major cause. While in the past, large numbers of giant clams could be found in the lagoons of the Society Islands, they are becoming increasingly scarce as they continue to be a popular species at the Tahiti market. With about 50 tonnes of meat marketed each year on this island (Anon 2002b), this "new" financial resource provides significant and direct income to the communities on the outer islands. Income generated from the giant clam market for all fishers has been roughly estimated to be between XPF 20 and 25 million annually. This is a fairly significant supplement to traditional resources, which are often limited to copra harvests (eastern Tuamotus) and agriculture (Austral Islands). In some cases, giant clams can account for the equivalent of nearly 40% of copra income.

As is notably the case on Bora Bora and Rangiroa, the harvesting of giant clams to supply the Tahiti market runs the risk of overexploitation, even in the richest islands, and in spite of regulations governing the minimum harvest size (a 1988 resolution set the minimum shell length at 12 cm for fishing, transport, holding, marketing and consumption). SPE has had to respond to the concerns of mayors and inhabitants of the islands involved. Against this background, several studies have been carried out since 2001. One study was a local market survey conducted by a consulting firm (Pacific Consulting). A range of other studies and surveys were carried out by various research institutions: studies on genetics (École Pratique des Hautes Études-French National Centre for Scientific Research), natural stocks (Institute of Research for Development and the University of French Polynesia), natural stock dynamics, a fisheries survey (Institute of Research for Development and the French National School of Agricultural Sciences in Rennes), a survey on fishers and related populations (University of French Polynesia), and a study on harvesting techniques, aquaculture, transport and reseeding (SPE).

UNIQUE STOCKS WORLDWIDE

A 1994 synopsis of existing data on giant clam stocks (all species combined) by Lucas (1994) showed that stock status varies significantly, depending on the country. The general trend, however, is towards a decline in stocks. Because of *T. maxima*'s size and the way it attaches itself, it continues to be the least endangered species worldwide.

Quantitative and qualitative inventories have occasionally been conducted in order to better understand stock status and to recommend management measures, notably in Palau, Micronesia (Hardy and Hardy 1969), One Tree Island, Australia (McMichael 1974), Rose Atoll, American Samoa (Green and Craig 1999), Milne Bay Province, Papua New Guinea (Skewes et al. 2003), and Reao, Takapoto and Anaa islands in French Polynesia (Salvat 1971, 1972, 1973; Richard 1977, 1982, 1989; Laurent 2001).

In 2003, remote sensing was used to estimate giant clam stocks in French Polynesia (as part of the SPE's giant clam programme: Andréfouët et al. 2005), using a refined version of the method initially proposed by Green and Craig (1999). Nowadays, a rising number of studies on tropical coastal systems (coral reefs, mangroves, sea grass beds: Green et al. 2000) include high resolution remote sensing, particularly for inventories of commercially sensitive species, habitats or invasive species (Bour et al. 1986; Long et al. 1993; Mumby et al. 1997; Andréfouët et al. 2004). Maps and numerical and weight estimations have been made for giant clam stocks from Fangatau, Tatakoto and Tubuai (Gilbert et al. submitted for publication) (Tab. 2), and similar work is currently underway on Reao, Pukarua, Fakahina and Raivavae.

Recorded densities in the Tuamotus were set at some 224 specimens/m² in Reao Atoll in the eastern Tuamotus (Salvat 1967). Since that time, Andréfouet et al. (2005) and Gilbert et al.

(2005) have reported maximum densities on Fangatau and Tatakoto of some 136 specimens/m² and 544 specimens/m², respectively (Fig. 2). At present, these two atolls have the highest densities of giant clams recorded anywhere in the world. These densities are linked to an aggregative spatial structure (Fig. 2) specific to *T. maxima* in certain semi-enclosed lagoons in the eastern Tuamotus. These agglomerations sometimes lead to the emergence of small biodetritic islands made of shells, locally called mapiko (Fig. 3). In contrast, in many other areas of the world (e.g. Papua New Guinea, Samoa, Fiji, Australia) and in most lagoons in French Polynesia, densities are much lower, at most a few specimens per square meter, and frequently, the figures are given in hectares (Lucas 1994; Green and Craig 1999; Skewes et al. 2003; Andréfouët et al. 2005).

A survey by SPC's PROCFish project, which covers most Pacific Island countries, is designed to obtain up-to-date information on the status of invertebrate and fish resources. The PROCFish team has conducted surveys on the islands of Raivavave, Tikehau, Tahiti and Fakarava in French Polynesia (Kim Friedman, pers. comm.). Comparative surveys of the countries studied by PROCFish, combined with the studies carried out by the SPE, will make it possible to determine where Polynesia fits, in terms of its nearshore resources, within the greater regional Pacific context.

Table 2: Numerical and weight estimations of giant clam stocks from Fangatau, Tatakoto and Tubuai

	Total number of giant clams (millions)	Total weight (tonnes)	Total weight of saleable meat (L > 12 cm) (tonnes
Fangatau	23.6 ± 5.3	9 194 ± 2 158	1 162 ± 272
Tatakoto	88.3 ± 10.5	13 135 ± 1 573	1 485 ± 177
Tubuai	47.5 ± 5.2	19 729 ± 2 109	2 173 ± 232

Figure 2 (top): Unusually high densities found in the reserve set up at Tatakoto (Photo Y. Chancerelle)

Figure 3 (bottom): Emerged area in Fangatau lagoon made of dead giant clam shells or Mapiko (Photo A. Gilbert)

FRAGILE GIANT CLAM POPULATIONS

Giant clam stock biomass and structure in French Polynesia's atolls, as studied by the SPE, cannot be considered critical at this time but the situation could change rapidly. We cannot predict how these exceptional giant clam populations grouped together in the shallow parts of the lagoon will react to sustained exploitation. Giant clams' shallow water distribution combined with their sedentary behaviour and the fact they are easily found by fishers, render them particularly vulnerable to fishing efforts. To this must be added other specific traits linked to their biology and method of reproduction. Giant clams, which are known to have erratic recruitment, maximise their chances of reproduction by synchronised spawning (Munro and Gwyther 1981; Braley 1985). It would appear that there are

chemical mediators or pheromones in the eggs and ovarian tissue (Wada 1954). The zones with the densest number of giant clams are the areas where mass spawning can be observed (Shelley and Southgate 1988), a phenomenon we also observed in situ. In sedentary organisms, which spawn en masse, the total stock's contribution to reproduction depends a great deal on these zones of high density. But it is precisely in such areas that fishing efforts are the highest. As soon as a high aggregation area becomes depleted, there is, in addition to the changes in mean density, an underlying effect on the population's spatial structure, which probably affects pre-dispersion processes that depend on density. Fishers then unwittingly target those specimens that have the best chance of reproducing, a recurrent phenomenon that contributes to overharvesting in benthic fisheries (Orensanz et al. 2004).

In general, overexploitation is linked to a combination of factors, including in French Polynesia:

- an increase in human population and fishing pressure;
- an increase in fishing effort, which is related to the availability of more effective fishing equipment (boats and diving equipment);
- the development of storage, transport and intra/inter-island communication resources;
- the difficulties that regulatory authorities face, and even a lack of response of their part, when confronted with regulation violations and unsustainable exploitation.

CITES AND INTERNATIONAL MANAGEMENT TOOLS

When overexploitation has been noted in most regions, it has led to measures designed to ensure the regeneration and protection of stocks.

At the international level, since 1983, all giant clam species have been listed in Appendix II of the Convention on the International Trade in Endangered Species (CITES), and are considered endangered species by the IUCN (World Conservation Union). Appendix II means that the listed species is not threatened with extinction, but could be at risk of becoming so unless the trade is regulated. International trade is permitted in Appendix II-listed species, provided strict authorisation and monitoring systems are in place. For that reason, export permits at departure and import permits at arrival are mandatory for every commercial operation.

Other regional initiatives have been undertaken. It is recommended that marine refuges or restricted use areas be established in all areas where stocks are at very low levels (Mitchell et al. 2001). It may take many decades to replenish stocks if the part of the reef involved is isolated or currents are not favourable (Braley 1994; Munro et al. 1993; Lucas 1994; Mitchell et al. 2001; Wells 1997). Reserves where fishing is prohibited have been set up

Figure 4 (top): Aerial photo of the enclosed eastern area of Tatakoto that has been declared a reserve (Photo A. Gilbert)

Figure 5 (bottom): Buoy marking the southern boundary of Tatakoto reserve (Photo F. Faana)

at Rose Atoll in American Samoa (Green and Craig 1999), Papua New Guinea (Kinch 2002), and Tatakoto in the Tuamotus (Figs. 4 and 5) (Gilbert et al. 2005).

Setting a minimum size that corresponds to sexual maturity is a frequently used measure that allows giant clams to reproduce at least once before they are harvested. Initial maturity has been observed in the eastern Tuamotus at between 5 and 6 cm (pers. observ.). The minimum size for this species varies depending on the region: 18 cm on Guam and Niue, 16 cm in Samoa, 15.5 cm in Tonga, and 12 cm in French Polynesia (SPC 2005).

Another approach consists of concentrating adult genitors so as to increase the probability of gamete fertilisation and increase recruitment within and outside the zone (Lucas 1994). Finally, while giant clam farming is highly developed in the Pacific (Bell 1999), specimens from hatcheries are rarely used for ecological purposes (e.g. repopulation) and are mainly destined for the aquarium trade (e.g. *T. maxima* is highly sought after for its colours), or the food market, in the case of larger species.

A RESOURCE MANAGEMENT PLAN BACKED UP BY AN INNOVATIVE SPAT PRODUCTION TECHNIQUE

Stock surveys are a necessary but inadequate approach to implementing sustainable exploitation plans. Stock dynamics (i.e. growth, natural mortality and recruitment) are also very important (Beverton and Holt 1957). Stock dynamics have been studied in situ during tagging/recapture experiments on Fangatau, Tatakoto and Tubuai (Faben 1965; Pauly 1983; Pearson and Munro 1991). The initial results showed wide variability, both within a single lagoon and between islands (Gilbert 2005).

Studies have also been conducted on this fishery in order to gain an overall view of the ecosystem. Exports were monitored on Tatakoto and Fangatau and are being estimated on Tubuai (Fig. 6). In 2004, exports reached 16.4 tonnes of marketable meat on Tatakoto, and 5.5 tonnes on Fangatau. On Tubuai, depending on the survey, estimates reached between 8 and 30 tonnes (Lehartel 2003; Larrue 2005). The price depends on the distribution network used and varies between XPF 300 and 500/kg. Monitoring of fishers has shown that the catch per unit of effort (CPUE) in kg of marketable meat/man-hour) are between 2.7 kg/hour and 4.9 kg/hour (Fig. 7). Collec-tion site depths and differences in population structures (density and size) make it possible to explain these differences in CPUE between islands and even between sites on the same island.

These data were used to formulate some initial recommendations. Beverton and Holt's model (1957) made it possible to analyse yield per recruit and, through that, biomass per recruit as a percentage of biomass per recruit in an untouched state. Some interesting preliminary diagnostic information is available. However, the specific characteristics of invertebrate biology and fisheries make it difficult to apply the con-

Figure 6 (top): Monitoring giant clam exports from Tatakoto by weighing before maritime shipping (Photo A. Gilbert)

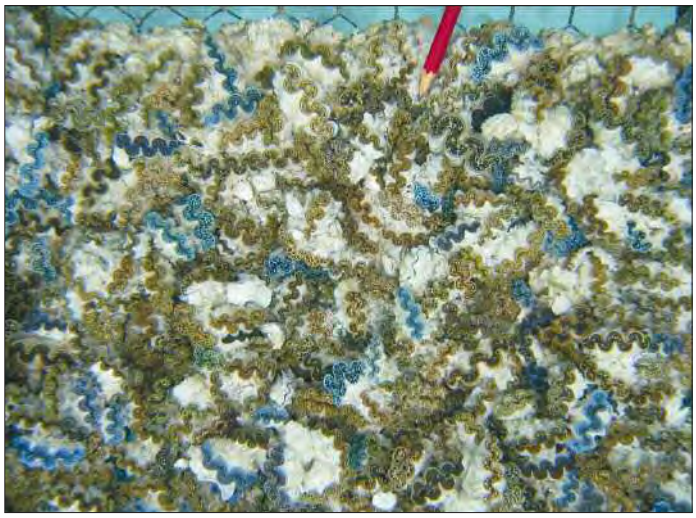
Figure 7 (bottom): Giant clam fishers-gathers in Fangatau lagoon (Photo A. Gilbert)

cepts and models used for finfish fisheries management, and so care should be taken with regards to the results from the Beverton and Holt model. Most invertebrate species have strong spatial structures, with adult stages that are only slightly, if at all, mobile but with large-scale larval dispersion. These characteristics contribute to a spatial structure of meta-populations, the dynamics of which have only just begun to be modelled. Given that, work should continue and a precautionary principle should be applied to promote a homogenous distribution of the fishing effort (i.e. through a rotation strategy, or *rahui* zones used in the past by the elders), in order to preserve source subpopulations (i.e. identify refuges for reproduction zones or *tapu* zones used in the past by the elders) and to monitor the integrated response of the system (i.e. monitoring the spatial structure by means of a co-management system). This group of measures should make it possible to apply the adaptive management needed for sustainable exploitation of this resource. In the same way as what has been done with giant clams elsewhere in the Pacific, a co-management project for giant clam stocks and fisheries is being conducted in the lagoons of Fangatau, Tatakoto and Tubuai.

At the same time, trials have been carried out on giant clam collecting, farming, transport and on restocking, using harvested giant clams. Low species richness and the giant clam's dominance in Fangatau and Tatakoto lagoons seem to indicate that Tridacna maxima is predominant in the pelagic larvae pool and, therefore, has an excellent capture or collection potential (local term from the pearl oyster industry). With a mean density of more than 400 specimens/m^2 (Fig. 8) and a collection rate of more than 80% two years after the installation of the collectors, this method is very promising. This is the first successful use in the world of giant clam collection techniques. This spat collection method has a number of economic advantages over other Pacific producers where a hatchery phase is required (Tisdell and Tacconi 1992). The growth rate was also encouraging with a mean size of more than 3 cm at the end of the first year of farming. Using collected spat may, then, facilitate the development of giant clam resources.

The low level of genetic differences between Tridacna maxima populations in French Polynesia (Planes et al. 2004) also makes it possible to plan transfers with no genetic risks. The low epibiont colonisation of young collected spat (7 cm or less), the existence of the same epibionts in the island groups where transfers are planned (Fauchille et al. 2004), and the possibility of conducting freshwater treatments before dry transfer, make it possible to limit the ecological risks during inter-island transfers. Inter-island transport trials involving an external freshwater treatment have been carried out using the Ellis method (2000), with a particularly high survival rate of 95% after 10 hours of dry transport (Yan 2005).

Finally, in Tatakoto and Fangatau lagoons, reseeding trials (Fig. 9) that used more than 36,300 spat



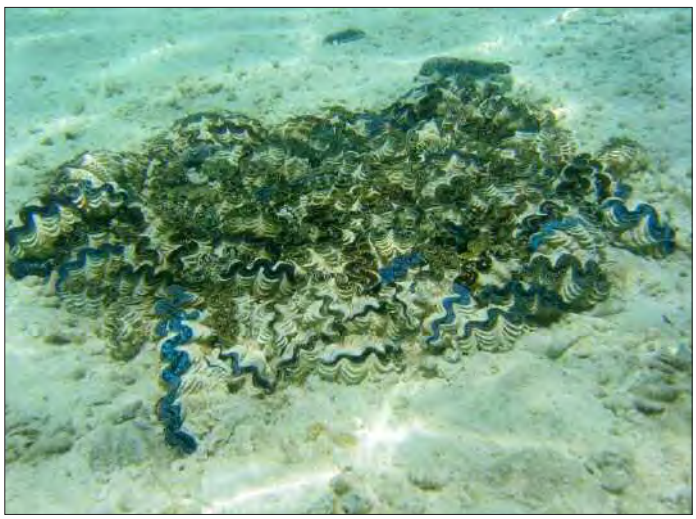


Figure 8 (top): Giant clam spat collected (Photo L. Yan)

Figure 9 (bottom): Small island of restocked giant clams (Photo A. Gilbert)

provided good prospects for reseeding projects. Survival rates in these two lagoons were 31% and 71%, respectively, more than 20 months after reseeding, and respective maximum rates during trials to improve the techniques were 57% and 91%. In addition, we noted that the new spat attached themselves to reseeded giant clams at a mean rate for both lagoons of 8.3% and 2.7%, and a maximum rate of 55% and 15%, respectively. This means that what is involved is not merely reseeding, but an actual lagoon restocking method. However, this method must be mastered in high island lagoons before the technology can be transferred.

Whether destined for ecological or fisheries (repopulation) projects, "ecotourism" (developing lagoons in front of hotels) or the aquarium fish trade, these giant clam collection and reseeding methods offer an alternate way to exploit and develop this resource, and offers a new economic activity for isolated island groups in the eastern Tuamotus. However, modifying local regulations and CITES permits is the final step to be taken before this new source of income can be fully developed. The economic development potential of the collection sector is also a tool that supplements management. Besides repopulation, it can contribute to raising an entire community's awareness of the richness and importance of this extraordinary resource, and can lead to sustainable exploitation.

Conclusion

The giant clam stocks of the populated islands in the Society group have clearly been over-harvested, but certain islands in the eastern Tuamotu and Austral Islands still have exceptional giant clam concentrations. French Polynesia has recorded giant clam stocks whose abundance, coverage and densities are the highest of any coral reefs in the world today. This is certainly one of the reasons for the success of an innovative technique for spat collection, an emerging sector of activity. But even in the case of these exceptional sites, the risk of overexploitation cannot be ruled out over the medium- to long-term due to the current rate of meat exports from the outer islands to Tahiti and projected increases in demand. Stock dynamics, and fisheries and population dynamics studies were carried out on three islands in French Polynesia in order to provide the initial information needed for sustainable exploitation. These studies allowed preliminary use of the Beverton and Holt model but this model is based on certain assumptions and does not take into account the importance of stocks' spatial structures. So, while taking a precautionary approach and giving due consideration to the giant clam's specific biological traits, management must take into account this spatial component. The methods proposed seem to be relatively well-adapted to the local context as they are similar to traditional management methods used in the past (e.g. the *rahui* strategy (rotation), the *tapu* (total fishing prohibition: reproduction refuges) and tomite toohitu strategies (using councils of elders to co-manage community property). However, the only way to ensure that future recommendations are followed is to have the involvement and support of local communities. Scientific and technical efforts currently underway must be backed up by meetings with island communities, listening to them, engaging in discussions, and attempting to find mutually acceptable solutions. The SPE should promote a changeover to multi-sectoral collaboration, the only realistic way to integrate and implement future recommendations with a view to involving all stakeholders in a joint project to sustainably co-manage stocks and fisheries.

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BAITED UNDERWATER VIDEO FOR ASSESSING REEF FISH POPULATIONS IN MARINE RESERVES

Tim Langlois[1], Pascale Chabanet[2], Dominique Pelletier[3] and Euan Harvey[4]

To study how fish are affected by fishing and other disturbances, we need to collect information on the length, density and diversity of their populations. For such studies, observational, non-destructive methods are preferred, particularly when studying fish inside highly-protected marine reserves or in ecologically sensitive areas. However, observational techniques often introduce biases, and it is important to understand these.

The most common observational method for studying shallow (< 20 m) reef fish is an underwater visual survey (UVS) made by scuba divers. Studies have summarized the advantages and disadvantages of this method (e.g. Harmelin et al. 1985; Samoilys 1997; Bortone et al. 2000) and it has been noted that certain commonly fished species are not recorded well by divers. This is because fished species tend to be behaviourally adaptable, which means they may rapidly alter their response to divers (Kulbicki 1998). Such problems can cause severe bias in studies using diver surveys. To counter the biases introduced by changes in fish behaviour, remote (surface-based) observational methods such as baited remote underwater video (BRUV) can be useful. Two main types of remote video technique have been used to describe reef fish populations; both of these techniques can be left free standing on the seafloor without the need of an operator. The first system generally uses one downward looking camera (Willis et al. 2000; Ellis and Demartini 1995) and the other uses either one (Cappo et al. 2004) or two horizontally facing cameras (Harvey and Shortis 1996; Watson et al. 2005).

Our study investigated the suitability of baited remote underwater video (BRUV) techniques for describing the distribution of coral reef fish in highly-protected marine reserves in the lagoon of New Caledonia. We wanted to compare downward view baited underwater video (D-BRUV), horizontal view baited underwater video (H-BRUV) and underwater visual surveys (UVS) made by scuba divers. This was achieved by sampling along a suspected gradient in fish density and possible gradients in fish behaviour at sites across and outside a highly-protected marine reserve. It was expected that in the centre of the reserve, a greater number of fish would be observed compared with the outside of the reserve.

METHODS

New Caledonia is surrounded by a barrier reef, which borders one of the largest lagoons in the world (24 000 km^2). This lagoon supports diverse populations of fish associated with a variety of habitats, and subject to a wide variety of possible impacts, including fishing and terrestrial run-off. In May 2006, an in situ experiment was conducted on the southwest lagoon, in the highly-protected reserve at Ilot Signal (22º17.73'S, 166º17.41'E) and fished area of Récif Larégnère (22º19.71'S, 166º17.68'E). Surveys were conducted at three sites inside the reserve (A, B and C) and site D outside (Fig. 1). These sites were chosen to have comparable habitat of fringing coral reef with adjacent soft-sediment areas. At each site, replicate samples (n = 4) were collected using the three techniques to be compared. These were UVS, D-BRUV and H-BRUV.

For UVS, sampling was carried out along a 50 x 10 m belt transect (after Samoilys 1997). Commercial fish populations were recorded at species level, including abundance and size of each individual observed. For D-BRUV, we used a system that employs one camera pointed downward towards a bait pot centred on the base of a tripod (Willis et al. 2000, Fig. 2a). The base of the tripod forms a 1.6 m^2 quadrat and calibration marks can be used to measure fish seen within the quadrat. This system has been used successfully to monitor populations of commercially important fish inside and outside highly-protected marine reserves in warm and cool temperate areas of New Zealand (Willis and Millar 2005). For H-BRUV, Harvey and Shortis (1996) developed a stereo-video technique using two horizontally mounted video cameras (Fig. 2b) that uses a three dimensional calibration to estimate the size of fish. This system has been used successfully to study reef fish populations in temperate and tropical Western Australia (Watson et al. 2005). In this study,

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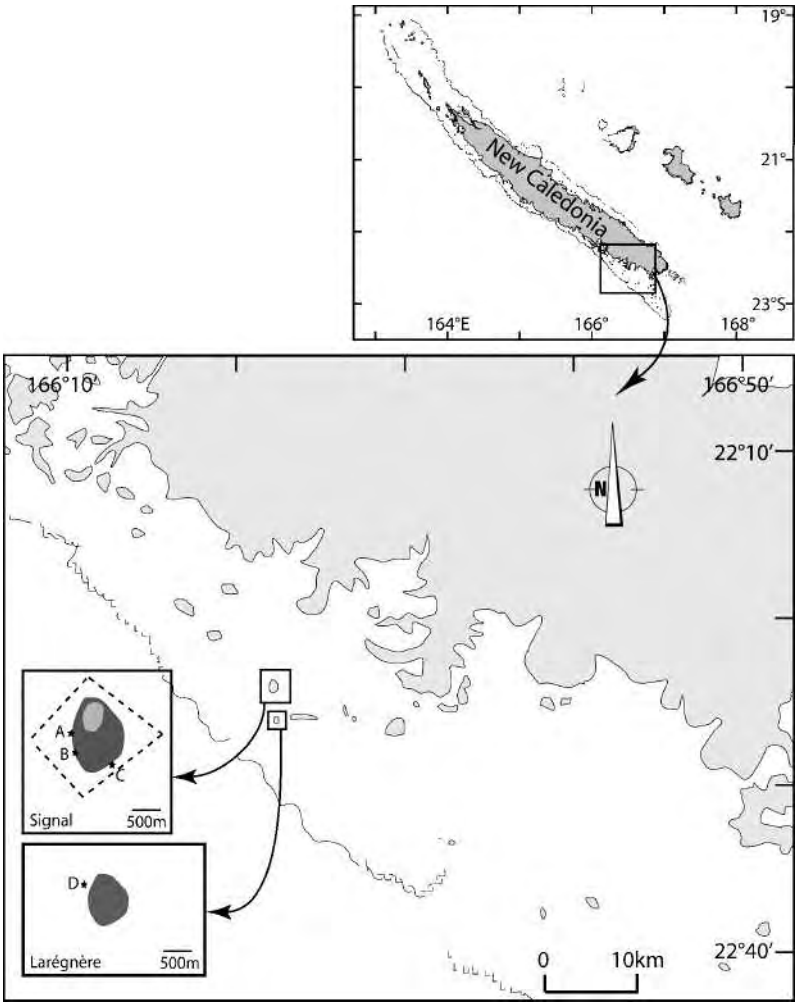

Figure 1: Map showing the location of Ilot Signal and Larégnère Reef, New Caledonia; and the position of the four sites. Three of these sites were inside the highly-protected marine reserve (A-B, in the centre; C, at the edge) and one outside (D).

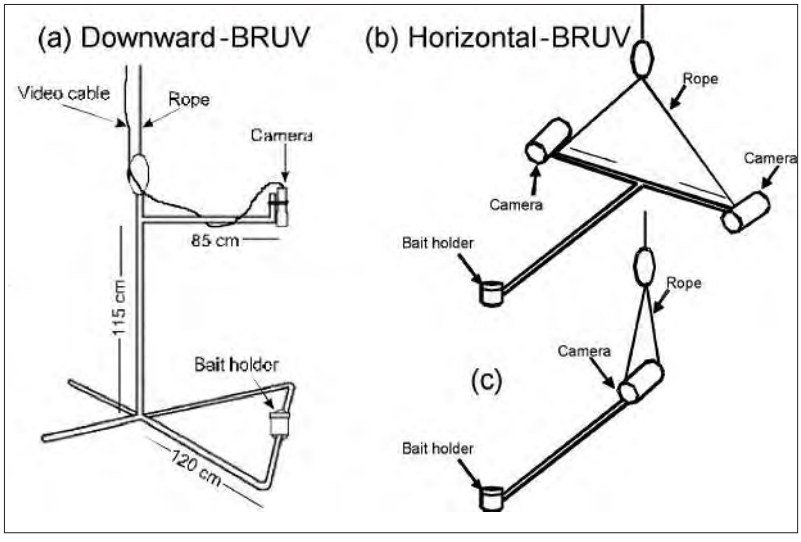

Figure 2: Different remote baited video system: (a) D-BRUV, H-BRUV using (b) two cameras in a stereo-video system or (c) one camera.

we used only one horizontal camera (Fig. 2c). This system simulates the field of view for the stereo-video system, but was not capable of estimating the size of fish. Each of the remote video techniques (D-BRUV and H-BRUV) was deployed for 30 minutes from a boat along the edge of the fringing reef, at the same sites where UVS transects were conducted. The remote video drops and UVS were not conducted at the same site

Baited stations contained 500 g of Sardinops sagax (sardines) in a plastic bait container. To avoid the repeated counting and measurement of fish attracted to a baited video, special care must be taken. Only the species present and the maximum number of individuals belonging to each species at one time are recorded, which gives a conservative estimate of relative density (MaxN, Willis et al. 2000). Only fish species considered to be targets of fisheries were recorded and their total number presented in the results. Density and biomass of fish populations recorded by UVS were used to compare with remote video techniques. Additional observations were made using different baits and bait holders.

Results

During the study, 132 species belonging to 16 families were recorded by UVS. Fourteen species belonging to four families were observed using H-BRUV. The fish belonged to Serranidae or groupers (*Plectropomus laevis*, *P. leopardus*, *Epinephelus merra*, *E. polyphekadion*, *Cephalopolis argus*), Lethrinidae or emperors (*Lethrinus atkinsoni*, *L. genivittatus*, *L. nebulosus*, *L. obsoletus*), Carcharhinidae or sharks (*Carcharhinus leucas*, *Triaenodon obesus*) and Acanthuridae or surgeonfishes (*Acanthurus xanthopterus*, *Ctenochaetus cyanocheilus*, *Naso unicornis*). The first three families recorded included carnivorous fish while the last one, the acanthurids, is mostly

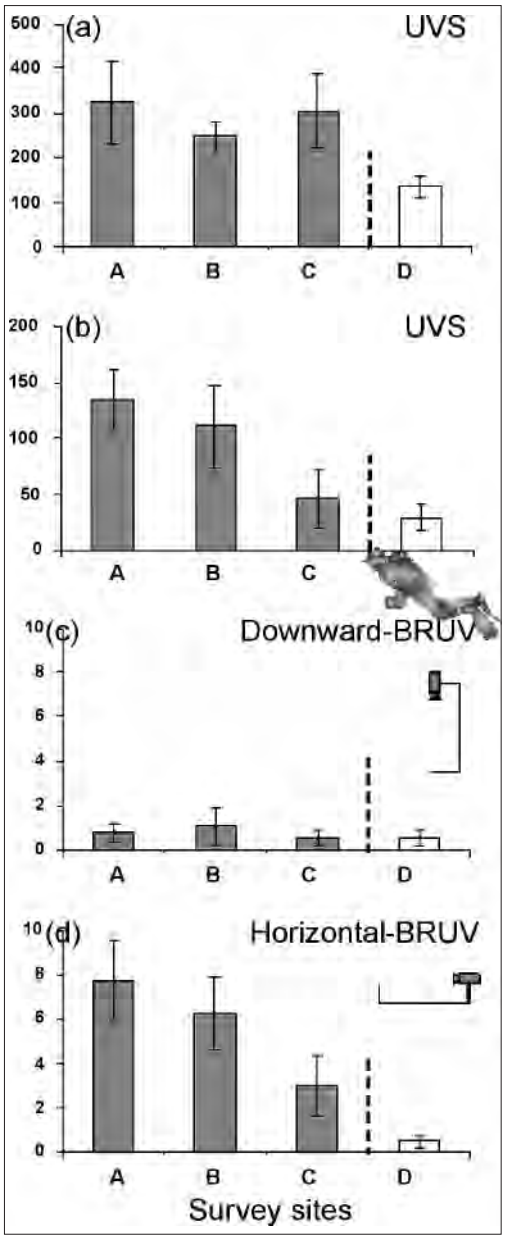

Figure 3: Commercial target fish recorded at sites at the centre (A-B), edge (C) and outside (D) the marine reserve at Ilot Signal. (a) Mean (±SE) abundance and (b) biomass recorded by underwater visual survey (UVS). Mean (±SE) abundance observed using (c) D-BRUV and H-BRUV. Closed bars are within the reserve and the open bar is the comparable fished area.

herbivorous. Only three species were recorded with the D-BRUV (*Plectropomus laevis*, *P. leopardus*, *Epinephelus polyphekadion*). Density and biomass observed by UVS was found to be highest in the reserve (sites A, B and C) compared with the fished area (site D) (density: 0.21±0.13 vs 0.06±0.05 ind./m^2, biomass: 575.6±0.30 vs 271.6±0.10 g/m^2). Inside the reserve, no gradient was observed in density between sites (Fig. 3a), however the biomass of all commercial species was found to decrease from sites A and B in the centre of the reserve to site C at the boundary and site D outside (Fig. 3b). D-BRUV found no difference between reserve and fished areas and observed far fewer fish than horizontally viewing video. The H-BRUV system found a distribution of abundance of commercial fish similar to the biomass recorded by the UVS, despite the fact that fewer fish were recorded by this video technique.

Concerning fish behaviour, additional observations suggested that certain species, such as the ones belonging to Lethrinidae and Serranidae, would rarely approach the remote video system with the camera positioned vertically above the bait (downward video system), but they would approach when the camera was positioned at the side (H-BRUV, Fig. 4a). Bait trials using sardine, mackerel, mullet and prawn suggested that sardine and mackerel were better baits to attract serranids and lethrinids. Bait holder trials suggested that heavy mesh bait bags were preferable to bait pots. The bait bags allowed small fish to feed and the activity of these fish appeared to attract larger target fish. The presence of sharks was also observed to increase the activity of target fish. However, sharks were responsible for the loss of two bait pots during these trials (Fig. 4b).

Discussion

Our investigation found underwater visual surveys (UVS) by divers to be the most comprehensive, non-destructive method to describe fish populations at our study sites. UVS recorded the greatest abundance and diversity of fish and found a gradient in their density and biomass from inside to outside the marine reserve. H-BRUV recorded a representative sample of the reef fish populations recorded by UVS, in particular groupers and emperors. H-BRUV recorded less than 10% of the species seen by UVS, but described a similar gradient in the density of these species inside and outside the reserve. D-BRUV did not perform well, which suggests differences in feeding behaviour between tropical and temperate reef fishes, particularly given the success of D-BRUV in temperate regions of New Zealand (Willis et al. 2000).

It is interesting to note that across the sites inside and outside the marine reserve, UVS found a strong gradient in fish biomass but not abundance, with greatest biomass in the centre of the reserve. H-BRUV also found a strong gradient in abundance, which was greatest in the centre of the reserve. This difference between the two methods suggests that UVS was better at detecting small fish than H-BRUV. It has been noted before that large fish can dominate the bait stations of BRUV systems resulting in reduced observation of smaller fish.

Our study found that H-BRUV was a useful method to describe populations of commonly fished predatory species living close to the benthos such as groupers (Serranidae) and emperors (Lethrinidae). This method was not useful for more pelagic preda-

tors such as jacks (Carangidae), barracudas (Sphyraenidae) and tunas (Scombridae), or herbivorous species that are also targeted by fishers such as parrotfish (Scaridae) or rabbitfish (Siganidae). The presence of sharks can be a problem as they can quickly remove the bait used to attract fish.

Watson et al. (2005) compared baited, unbaited and diver operated video methods. They recommended that for studies wishing to examine a particular impact (e.g. fishing) on fish assemblages, BRUV can be very useful. They also suggested that multiple BRUV systems can result in a vast reduction in field time and the number of staff required. This means that even with the costs of video equipment and time associated with analysing video images, use of BRUV techniques for repetitive studies of an area can be more efficient than methods involving divers such as UVS. Another benefit is that with remote systems survey depths are not limited by diver depth profiles.

This pilot study suggests that H-BRUV systems can be used to study reef fish populations in the lagoon and reef habitats of New Caledonia. The improvement of this system will require stereo-video techniques using two video cameras (Harvey and Shortis 1996, Fig. 2b) and three-dimensional calibration software to obtain accurate length estimates of fish (see www.gemsoft.com for information on the software). The cameras of these systems are inwardly converged to allow the length of oblique objects to be estimated (i.e. fish not swimming parallel to the cameras).

For future studies of marine reserves around New Caledonia, we recommend the use of H-BRUV's with stereo-video systems. We believe this will provide an efficient tool for gathering information on the density and biomass of fish populations, and to study their rates recovery from fishing. Furthermore, video surveys can be valuable where UVS surveys are limited by particular conditions (such as high sedimentation) and during regular monitoring for commercial species such as groupers and emperors. A combination of survey techniques, including remote baited video and UVS, would be advisable to include both behaviourally adaptable predatory species and fished species that do not respond to bait.

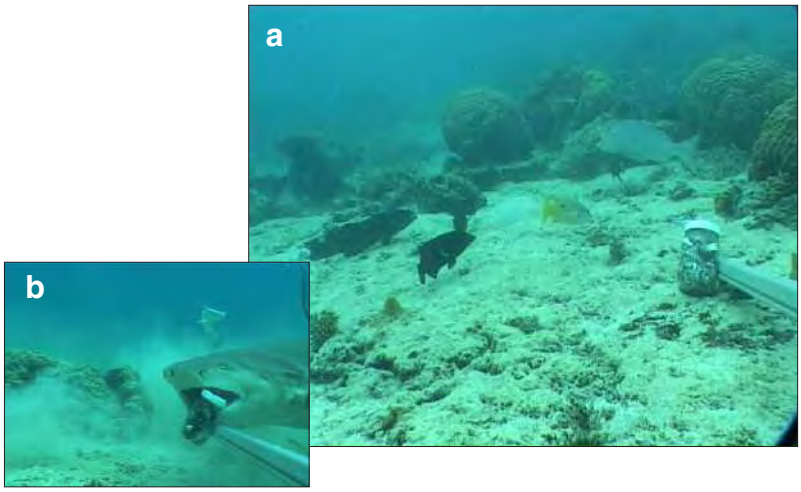

Figure 4: Images from the H-BRUV showing: (a) three *Plectropomus leopardus*, one *Lethrinus nebulosus* and one *Cephalopholis argus* approaching the bait pot; (b) one *Carcharhinus leucas* about to eat the bait pot.

Acknowledgements

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AQUACULTURE UPDATES IN THE NORTHERN PACIFIC: HAWAII, FEDERATED STATES OF MICRONESIA, PALAU, AND SAIPAN

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As the SPC Aquaculture Adviser, I recently visited areas of the northern Pacific region, as part of the Aquaculture Section's regular programming mission. One of the objectives of the visit was to assess mariculture activities in light of the planned recruitment of a mariculture specialist. There are some exiting developments taking place in this part of the Pacific and I identified a number of institutional partners for future collaboration.

Oahu, Honolulu

The Centre for Tropical and SubTropical Aquaculture (CTSA) is one of five regional centres established by US Congress to promote aquaculture and is funded by the US Department of Agriculture. Prof Chen-Shen Lee is the CTSA Director based at the Oceanic Institute in Oahu. The geographical focus for CTSA is the Sate of Hawaii and US affiliated islands. Projects include pearl development in the Marshall Islands and Micronesia, coral farming in Micronesia and a marine prawn farm in Northern Marianas.

The Oceanic Institute Research Facility at Waimanalo has a prawn research program headed by Dr Shaun Moss. The institute has been involved in the production of disease free Penaeus vannamei prawns. These are known in the trade as specific pathogen free (SPF) stocks. The institute is also at the fore in developing technology for intensive, high stocking density, prawn farming systems.

The University of Hawaii Sea Grant College Program is a part of a national network of universities established to promote better use of coastal resources. According to Dr Mary Donohue, Associate Director, the bulk of funds are directed towards aquaculture. Like CTSA, SeaGrant is mostly focussed on US interests, although there are mutual benefits for collaboration in joint programs at a regional level. For example, the indigenous aquaculture theme has a common link that overlaps Hawaii and other parts of the Pacific. The UH Sea Grant aquaculture extension agents are managed by Dr Darren Okimoto, who was previously based in American Samoa.

Dr Albert Tacon has been recently appointed to the vice-chancellor's office at the University of Hawaii, Manoa. As the aquaculture coordinator, his role is to interface between the UH system and various federal programs. For example, he has identified about 60 PhD students who are involved in projects that have implications for aquaculture.

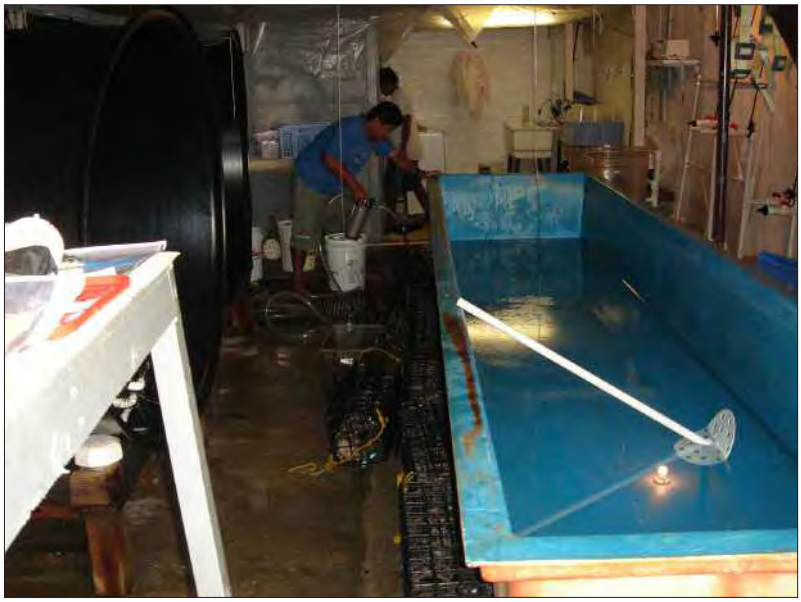
Within the state, the Hawaii Aquaculture Development Program is housed under the US Department of Agriculture. This unit is managed by John Corbin who helped developed the Hawaii aquaculture long-term strategy: The Blue Revolution. According to specialists Mr Dean Toda and Mr Leonard Young, the commercial environment for aquaculture is difficult, with overlapping jurisdictions although the expansion into offshore and deep sea cage culture offers prospects. There are few Pacific Islands with marketing outlets in Hawaii, although there may be some niche opportunities in fresh finfish and Japanese culinary dishes, such as seaweed.

Kona, Hawaii

The Natural Energy Laboratory of Hawaii Authority (NEHLA) site uses deep ocean waters rich in nutrients, which are brought to the surface enabling a unique environment for aquaculture culture. The location hosts about 30 aquaculture companies, which account for the bulk of Hawaii's production, generating about USD 40 million. Highly competitive about their trade secrets, the lineup of companies includes Cyanotech Cooperation (various algal such as Spirulina), Ocean Rider Inc (ornamental seahorses), Taylor Shellfish-Kona (edible oysters), and Uwajima Fisheries (fish flounder). One of the recent projects attracting attention is the Kona-Blue fish farm, which is successfully raising Hawaiian Yellow-tail (Kampachi) in offshore cages. The company is targeting the lucrative Japanese sushi market. This is the brainchild of Mr Neil Sims and Dr Dale Sarver whose past experience in the Pacific includes the pearl industries of the Cook Islands and Marshall Islands.

Hilo, Hawaii

Prof Kevin Hopkins (Head of Aquaculture School) along with Dr Sharon Ziegler-Chong (Associate Director, Coastal Management) and Dr Maria Haws (Associate Director, Aquaculture) have established the nearly completed Pacific Coastal Aquaculture Research Centre (PARC) at the University of Hawaii at Hilo (UHH). This project comes after years of dedicated effort, spurred on by a recent grant of USD 6



million. The facility houses a pearl/mollusc hatchery and a finfish hatchery. Raceways are already being utilised for student research projects. The PARC site also includes several large concrete tanks constructed by an electricity company. These are up to 20 meter diameter and 7 meters in depth, and could be used for pelagic (tuna) research or as holding tanks for other types of finfish. It is apparent that PARC is set to become an important centre in the northern Pacific for training and research programs.

UHH still retains some of its old aquaculture facilities, which are being used mostly for catfish and sturgeon fish aquaculture. Shipping containers have been modified into a modular design for a quarantine facility to treat the sturgeon fish embryos imported from Italy. There is still interest in rejuvenating the tilapia program, particularly focussing on the use of intensive culture using fertilization feed. Next to UHH, the Oceanic Institute has a feed formulation plant under construction.

Pohnpei State, Federated States of Micronesia

Masa Hiro is the leader of the pearl project based at the College of Micronesia (COM) under the stewardship of Dr Singeru Singeo (Executive Director). In the past few years, the project has been quite active: its first commercial pearl harvest was expected in July 2006 and the expansion to an additional four other islands is underway. Value adding opportunities are now being explored and the college is interested in a training workshop on pearl shell-craft and

Top: Pacific Coastal Aquaculture Research Centre

Middle: Shipping container

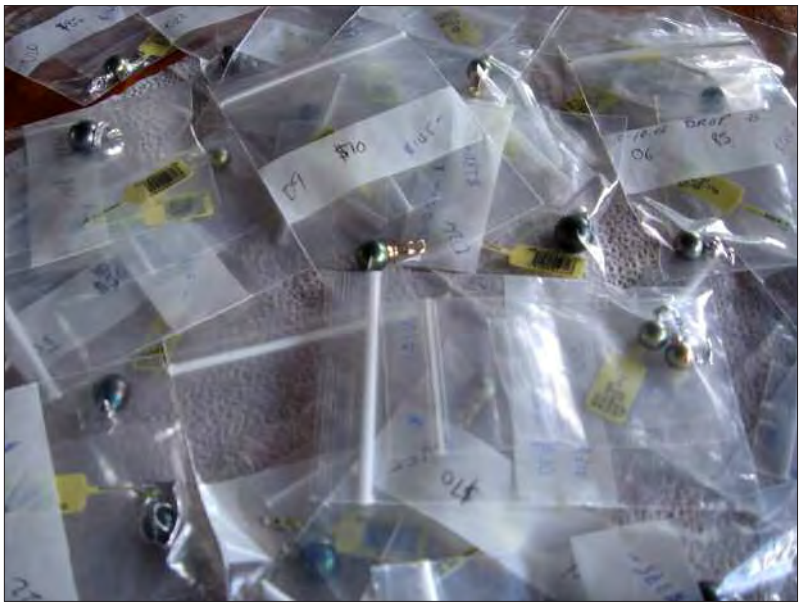
Bottom: Spawning at Nett Point, FSM

jewellery. The college also expressed interest in sea cucumber aquaculture and restocking, although they have limited technical expertise and will probably look to partners in the region for assistance.

The COM pearl hatchery at Nett Point has about 90,000 oysters, half of which are juveniles, and several thousand of which are seeded oysters. During my visit, the hatchery technicians successfully carried out the third spawning operation of the year. They work unsupervised, and according to Hiro are competent in all phases of hatchery production. The hatchery success at COM is critical to overcoming the lack of pearl stocks, which is preventing the expansion of the pearl industry in Micronesia.

Simon Ellis (Mid-Pacific consultants) and George Steven (President Nukuroa Pearls) presented a sample of pearls from the Nukuroa farm. The sample contained some good quality pearls with the distinctive green undertone colour, which is particular to Micronesian pearls. It appears that after a number of years since it began, the Nukuroa pearl farm has established a model for commercial production. The farm management system, involving ownership by the local community, could be a useful lesson for small, remote and rural islands.

The Assistant Secretary for Fisheries, Mr Marion Henry, expressed his desire for a stronger presence of regional expert agencies, such as SPC, in the northern Pacific. During a courtesy call on the SPC office in Ponhpei, we looked at and discussed the possibility of utilizing desk space or conference facilities. A South Korean aquaculture institute has expressed interest in aquaculture of a white-banded sea perch. Micronesia could also have potential for marine ornamental fish as well.



Top: Black pearls from Nukuroa Atoll
Bottom: Coral culture at Kosrae's National Aquaculture Center

Mr Yosvo Phillip, Director of Economic Development Assistance, is currently managing Japanese government aid funds for pearl farm development. Yosvo has been communicating with the Southeast Asian Fisheries Development Centre (SEAFDEC) in the Philippines on the possibility of assisting in trials for *Kappahycus* seaweed farming.

Kosrae, Federated States of Micronesia

Likiak Phillip is the manager of the National Aquaculture Center (NAC), where tens of thousands of juvenile giant clams (mainly *Tridacna derasa*, *T. maxima* and *T. squamosa*) are grown-out in concrete raceways. NAC has also

received *T. crocea* clams from Palau.

Also at NAC is Martin Selch (IMTRONA Ltd), a German business entrepreneur involved in the marine ornamental trade. Martin has been carrying out coral fragmentation trials for export, and hopes to establish a commercial relationship with NAC.

Next to NAC is the Kosrae Fisheries Department where the head, Robert Talung has been setting up a state-funded mud crab project. A Queensland, Australia company, which won the tender for the mud crab consultancy, has almost finished construction of a mud crab hatchery. Abraham Reedson, Director of Agriculture, Fisheries and Lands, participated in the SPC mud crab tour to SEAFDEC in December 2005, and is supportive of SPC continuing to strengthen linkages with Asian institutions.

The mud crab grow-out site comprises two large ponds earthen ponds on a 10 hectare site. Retaining walls are being built to reduce escapees. Anecdotal reports indicate that the surrounding mangroves now have greater numbers of mud crabs.

The crabs are fed trash tuna provided by transshipment boats in port. Exports of crabs to Guam have been taking place.

Saipan, Northern Mariana Islands

Aquaculture is a relatively new development in Saipan and there is yet to be established an institutional placement within the government system. In the interim, the Division of Wildlife and Fisheries is the main fisheries contact point, and Director, Sylvan Igisomar was able to organise an informative visit. Dr Bill De la Cruz is Secretary for Lands and Natural Resources office, which overseas the Division of Wildlife and Fisheries. Dr De la Cruz, previously Chief Veterinarian Officer, quickly grasped the potential for Saipan for providing disease-free prawn stocks to the Asia region, and the biosecurity issues that SPC has been attempting to address.

The Saipan Aquaculture Co. Ltd, managed by Micheal Ogo, recently (November 2005) began operations. The main species being farmed is *Penaeus vannamei* prawns and the bio-secure facility comprises a prawn hatchery and raceways setup to accommodate an intensive farming system. During my visit, three tonnes of prawns were being harvested for the local market, 45,000 post-larval juveniles had been sent to farms on Guam, and disease-free broodstock were being raised for export to Asia (the flight to the Philippines is just a three hours long). The original disease-free broodstock came from Kona, Hawaii. The facility has also integrated the production of Chitrilada strain of tilapia, sourced from Thailand.

Congressman Martin Borja has received *T. crocea* clams from

Top: Mud crab ponds

Bottom: Prawn farm Saipan

Palau as a show of goodwill by the President. We discussed some quarantine measures for future shipments. The Congressman is lobbying for an Aquaculture Bill to establish a government development body.

The Cooperative Research and Extension Services within the Northern Marianas College provide aquaculture extension and vocational training services. Ross Manglona, the Agricultural Extension agent, oversees this program. Two aquaculture specialists (Lee Bowen and Randy Tudela) introduced me to some of the farmers and projects they have been involved in recently.

- Anese Guerrouzo: Farms Nile tilapia and *P. vannamei* prawns. Is one of the main providers of tilapia fish locally, particularly to the Filipinos employed on Saipan.

- Peter Ariola: Raises Nile tilapia in a small backyard recirculating system designed by the college.

- Jeronomo Gulleon: Has about 20 x 10 tonne raceways. Used to farm tilapia but now is selling the farm.

- Matilda Feheran: Farms hybrid red tilapia. Has a well maintained facility. A family sized, hobby operation of about one dozen x 5 tonne tanks.

Palau

Accompanied by Theo Isumaru (Director Marine Bureau) and Roman Yano (Presidential Adviser), I visited the milkfish aquaculture project in Ngatpang State. The project is located several hours drive along the northeast coast and situated on the foreshore among the mangroves. The farm layout is designed to receive young juveniles that are raised in different ponds according to their grow-out stage so that the stocking density and feed can be changed. The total area of ponds is 14 hectares, and so far, 2 million embryos imported from Taiwan have been received. Harvesting of 20,000 fishes at five months of age and 5 inches in size was being carried out while I was there. The fish are sold as live bait to a local tuna fishing company. The onsite project manager is Mr Erik Basco who is on secondment from SEAFDEC. Erik has also set up other trials using *Crassostrea gigas* oysters, rabbitfish (Signadae) and mud crabs.

Obichang Orak, manager of the Palau Mariculture Demonstration Center (PMDC), estimates that they have about half a million juvenile Tridacnae clams and 200,000 larger clams stocked in the raceways. PMDC has set up 27 clam farms in Palau stocked with 1.3 million clams. The objective is to restock with 5 million clams per annum. The target species are *T. crocea* for the orna-

Top: Tilapia farm

Bottom: Milkfish ponds

mental trade, and to a lesser extent the larger *T. derasa* and *T. gigas* species for the ornamental and sushi markets.

I visited several giant clam farms in the lagoon around Babeldaob Island. According to Obichang, the general configuration is the same for most farms. This involves a fenced 50 x 100 foot enclosure with thigh-deep water. Each enclosure is normally stocked with up to 80,000 clams.

The Marine Bureau's fish hatchery is under the technical guidance of Sumito Akatsu, an OFCF aquaculture specialist from Japan. The main species of fish being raised are groupers for the live fish trade in Asia. Fingerlings of the grouper *E. fuscoguttatus* are successfully being reared routinely. Spawning trials for coral trout (*P. leopardus* and *P. areolatus*) are underway. There is a large broodstock of Napolean wrasse (*C. undulatus*) at the facility. Presently, the grouper fingerlings are supplied to Ngatapang where they are raised in net-cages in the lagoon. An alternative option would be the rabbitfish (*Siganus* spp.), because it does not require a carnivorous diet.

Palau's diverse marine fauna attracts a number of different marine organisations, some with undertones of aquaculture, including the Coral Savers Foundation, a Japanese NGO that cultures corals to rehabilitate degraded sites; and Belau Marine Ornamentals, which is the main exporter of marine ornamentals such as giant clams from PMDC and soft corals. Even the Palau Pacific Resort Hotel has a small land-based pond with giant clams where they hope guests will "adopt" a clam during their stay.

Palau Mariculture Demonstration Center (PMDC)

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