Fisheries Newsletter

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Editorial

Welcome to this last issue of the SPC *Fisheries Newsletter* for 2006. In this issue, an update of the Solomon Islands marine aquaculture is given. The Solomon Islands Aquaculture Division of the Department of Fisheries and Marine Resources will soon implement its Strategic Plan for 2007–2010 and this activity will be supported by an NZAID-funded institutional strengthening project.

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Cletus Oengpepa (WorldFish Center) holding a chaplet of blacklip pearl oyster (*Pinctada margaritifera*) at the Nusa Tupe field station, Western Province, Solomon Islands

in This Issue

SECRETARIAT OF THE PACIFIC COMMUNITY
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AQUACULTURE SECTION

2nd SPC Regional Aquaculture Meeting, New Caledonia
20-24th November 2006

In November 2006, the Secretariat of the Pacific Community hosted a regional meeting of aquaculturists from government, private sector and academia. The theme of the meeting — "Pacific aquaculture: Sustainability through diversity and cooperation" — reflects the challenges of building on the unique and diverse characteristics of the Pacific through regional collaboration. During the meeting, participants identified regional trends, priority commodities and a regional work plan, all of which will serve as the basis for a new Aquaculture Action Plan for the Pacific Islands region.

Background and introduction

The 1st SPC Regional Aquaculture Meeting, held in 2002 at the University of the South Pacific in Fiji, was an important milestone as it heralded the beginning of the first truly regional aquaculture programme within the Pacific. A major output of this meeting was the formulation of the SPC Aquaculture Action Plan 2002, which subsequently provided significant guidance to the region.

http://www.spc.int/aquaculture/site/publications/documents/spc-aqua-plan.pdf

Nearly five years after that inaugural meeting, the aquaculture sector has undergone significant changes. There are new developments to report on within the region, and there is a wider awareness of the role that aquaculture can play, particularly in terms of local food supply and trade. With aquaculture now firmly established as a primary development option for the Pacific, the task of this regional gathering was to review current and anticipated trends, and to take a forward thinking approach so that governments and the private sector are well placed to take advantage of their circumstances.

The 1st SPC Regional Aquaculture Meeting adopted the theme "Building Capacity for Aquaculture in the Pacific". The theme for the 2nd SPC Regional Aquaculture Meeting was "Pacific Aquaculture: Sustainability through diversity and cooperation", which reflects the challenges of building upon the unique and diverse characteristics of the Pacific through regional collaboration.

SPC provided funding for 20 country representatives (although some were unable to participate) and several international resource persons. A number of key institutions within the region were also present, such as the Australian Centre for International Agriculture Research (ACIAR), United Nations Food and Agriculture Organization (FAO) Sub-regional Office for the Pacific (SAPA) in Samoa, French Institute for Research and Exploitation of the Sea (IFREMER) in New Caledonia, Institute of Marine Resources in Fiji, Network of Aquaculture Centres (NACA) in Thailand, University of Guam, University of Hawaii, Sea Grant College Program, University of the South Pacific (USP) in Fiji, Queensland Department of Primary Industries and Fisheries in Australia, and the WorldFish Center in New Caledonia. A number of private sector representatives gave presentations to the plenary, including Justin Hunter (Hunter Pearls Ltd, Fiji) and Emmanuel Malpot (Tropical Fish, Tahiti).

Meeting objectives were to:

- review country reports;
- assess regional status and trends;
- present special presentations of emerging technology, commodities or development themes;

Left to Right - Dr Johann Bell (WorldFish Center), Theo Isamu (Palau Bureau of Marine Resources) and Maciu Lagibalavu (Fiji Fisheries Division) working on the formulation of a regional work programme

- formulate a regional work programme; and
- update the SPC Aquaculture Action Plan.

All documents and presentations are available on CD-ROM.

Country reports and statistics

Prior to the meeting, country pages on the SPC Aquaculture web-portal www.spc.int/aquaculture were updated with information from meeting representatives. Country reports at the meeting plenary were delivered from the web using the aquaculture portal as the backdrop.

The result of updating the aquaculture portal has been more comprehensive and accurate information on each member country page. From the country presentations, it was evident that several countries in the region have expanded and diversified their aquaculture sector, in particular French Polynesia and Fiji.

Several countries that previously did not have any aquaculture commodities reported on the aquaculture portal, have now been included: *Penaeus vannamei* prawn farming in the Northern Marianas, and freshwater shrimp (*Macrobrachium lar*) farming in Wallis and Futuna.

With an average of 110,000 hits and 2700 unique visitors per month, the aquaculture portal is becoming an important clearinghouse mechanism. During the meeting, there was a call for participants to use the portal more, and in particular, to contribute to the statistics and contacts database. SPC will soon release a CD-ROM of the entire aquaculture web-portal, which can be viewed from the computer with exactly the same features and information as the Internet-based version.

Status and trends

During the meeting, working groups were established to assess regional trends in aquaculture. Trends were grouped thematically, similar to the method used by the FAO State of the World Aquaculture Report 2006. The working groups made the following findings.

(1) ***Production: Environment, Species, Quantities and Values:*** There has been an increase in of volume production, particularly marine and freshwater shrimp, *kappaphycus* seaweed, and tilapia. There is also increase in value among some commodities, particularly ornamental species such as giant clam. There has also been improvement in price per gram of cultured pearls in recent years.

(2) ***Markets and Trade:*** A lack of quarantine and food safety standards was noted to be an impediment to trade.

(3) ***Contribution to Food Security and Access to Food:*** Aquaculture can provide subsistence food, backyard farming and cash opportunities to improve household buying power. It was noted that fresh reef fish is becoming scarce and expensive, and that aquaculture could be an important source of local produce in some places.

(4) ***Resource Use and the Environment:*** There is more diverse use of natural resources and the environment for aquaculture. This increases the need for biosecurity capacity and best-management practices.

(5) ***Legal, Institutional and Management Aspects:*** Legislation is lacking in many areas and incentives for investors need to be developed.

(6) ***Social Impacts, Employment and Poverty Reduction:*** There is a paucity of information to judge the impact of aquaculture. In order to get an objective analysis of the benefits of aquaculture, there needs to be a better system for measuring socioeconomic impacts (e.g. urban drift).

Dr Tim Pickering from the University of the South Pacific (left) talking to Australian and French colleagues

Regional work programme

Meeting participants developed a five-year work programme

that focused both on commodities and cross-sectoral linkages. The work programme activities will serve as a guide and will assist SPC and other regional and international agencies to coordinate their activities.

In the Aquaculture Action Plan formulated at the 1st SPC Aquaculture Meeting in 2002, the main work programme strategy was to focus resources on developing aquaculture commodities with the most potential to make a regional impact. Eight key commodities were identified as priorities for the region: coral, giant clam, *Macrobrachium* shrimp, milkfish, pearl, sea cucumber, seaweed and tilapia. At the 2006 regional meeting, four more commodities were added to the priority list: mud crab, penaeid prawn, marine finfish and trochus.

After identifying key commodities a development plan for each commodity was drafted. Each commodity has a log frame with a matrix of objectives, actions, and indicators for development.

After deliberating on commodity-specific issues, the working groups turned their attention to a broader perspective in order to identify cross-sectoral priorities for aquaculture development. The findings are summarized below.

- ***Information:*** Organisations need to determine their stakeholder requirements for information, and find ways to deliver information. One-stop shops such as the aquaculture portal are an example of the types of tools that can be developed. Information should also be sensitive to target groups (e.g. language used and media type).

- ***Training:*** Care must be taken in choosing the right person for training and, given the scarce resources available, the training must also have greatest impact. For each of the priority commodities the working group identified the list of skills lacking to develop the commodity, the level of training required, and the recipients for training.

- ***Research and development:*** Efforts to promote collaboration should continue and sub-networks established. Centralization of research would have benefits. Mechanisms for technology transfer are critical to bridge the gap between researchers and implementers.

- ***Biosecurity:*** Increased awareness of diseases is required. Countries must evaluate their policies and capacity for import or export of aquatic organisms and their products. Regional organisations such as SPC should be tasked with harmonizing standards and providing access to specialist services.

Special topics

Many interesting advancements in aquaculture have emerged recently. During the meeting, a series of special topic presentations were made. A summary of the list of presentations and the main content of each is described briefly below.

- ***Disease management and biosecurity measures for the* Litopenaeus stylirostris *prawn industry of New Caledonia.*** P. Primot, Les services vétérinaires de la Nouvelle-Calédonie. The prawn industry in New Caledonia is the largest agro-industry, with most of the 2000 tonnes exported to high quality markets. The country has invested in stringent quarantine and health management programmes.

- ***Successful* Macrobrachium rosenbergii *shrimp farming in Fiji.*** Lessons for the Pacific. A. Singh, and J. Terii, Institute of Marine Resources, Fiji. Through improved management practices, IMR has assisted the owners of the former government farm "Viticorp" to achieve a 20 t/year harvest and are aiming for 50 tonnes.

- **M. lar** ***farm trial in Wallis and Futuna and Vanuatu: A rural development option.*** S. Nandlal, SPC, Noumea. Recent work with indigenous freshwater shrimp has shown that this species has potential for integrated "dalo" farming or mono-culture in rural locations.

- ***Tilapia farming in Driti Village, Fiji: Opportunities for gender development.*** A. Vunisea and S. Nandlal. SPC, Noumea. In Driti village, a fish farming venture led by a women's group, generated quite significant cash, leading to an investment scheme to assist village projects such as purchasing gardening tools.

- ***Research and development efforts for aquaculture of sea cucumber in New Caledonia.*** N. Agudo, WorldFish Center, New Caledonia. Until recently, very little was known about the hatchery protocol and nursery of sea cucumbers, but significant progress has been made in New Caledonia. The sea cucumber fishery is an important livelihood option for Pacific Islanders, and aquaculture may have an important part to play in sustaining the industry.

- ***Pearl farming in Savusavu Bay, Fiji: Lessons for the Pacific.*** J. Hunter, Hunter Pearls Ltd., Fiji. Pearl farming has traditionally been the domain of eastern Polynesia where stocks are plentiful. However, through govern-

ment and community involvement and sound investment, the Hunter Pearls Ltd farm in Fiji has successfully carried out all phases of pearl farming: from hatchery seed supply to pearl culture and pearl marketing.

- ***Seaweed farming development in the Pacific: Opportunities and constraints.*** A. Meloty, Department of Fisheries and Marine Resources, Solomon Islands (delivered in absentia). Several years after the start of *Kappaphycus* seaweed farming in the Solomon Islands, there has been an exponential increase in exports to around 300 t/year. However, establishing a new rural industry is a challenging task that requires a balance between farmers' expectations and market demand.

- ***Successful application of the post larval settlement ranching system for aquaculture.*** E. Malpot, Tropical Fish Tahiti, Polynésie française. Capturing larvae from the wild before high levels of natural mortality can occur, provides an opportunity to benefit from the Pacific's biodiversity in a sustainable manner. Tropical Fish Tahiti focuses mostly on the marine aquarium trade, athough there is potential for food fish and coral ecotourism projects.

- ***Status and trends in aquaculture in Asia and linkages to the Pacific region.*** P. Bueno, Network of Aquaculture Centres in Asia-Pacific, Thailand. Asia is the powerhouse of aquaculture production, accounting for most of the world's supply. The region is also growing as an important market for importing aquaculture products such as marine finfish. The Pacific must carefully assess its niche opportunities and constraints within the Asia-Pacific sphere. The relationship between SPC and NACA provides and important cross-link between the Pacific and Asia regions.

- ***ACIAR-funded mini-projects, a programme for research and development.*** C. Hair, Queensland Department of Primary Industries and Fisheries, Australia. The mini-project concept makes available grants from a large pool of funds, which are intended to activate small and rapid response projects addressing aquaculture bottlenecks. In two years, 14 projects worth AUD 180,000 were successfully implemented under this scheme.

All presentations can be downloaded from a temporary link from main page of the SPC aquaculture portal:

www.spc.int/aquaculture

Field trip

A highlight of the meeting was a one-day excursion to several aquaculture sites in New Caledonia.

A stop was made near Boulouparis at a red claw crayfish (*Cherax quadricarinatus*) farm where the president of the Redclaw Farmers Association gave an impromptu presentation. The hardy red claw drew considerable attention from participants. Eels, tilapias and other freshwater species were also being cultured at this site.

The next site was in Tontouta at Aquamon prawn farm, which is a medium-sized farm by New Caledonia standards, producing about 150 tonnes of *Litopenaeus stylirostris* prawns per year. The farm has a hatchery (*Ecloserie de Montagnès*) that supplies other farms in New Caledonia with juvenile prawns. Participants noted the large size of the earthen ponds (between five and eight hectares each), which require small aluminum boats to evenly distribute the prawn feed, and the large level of investment required for the operation.

Lastly a stop was made in Dumbéa at an edible oyster (*Crassostrea gigas*) farm (*Les Huîtres de Dumbéa*). This farm produces 80 tonnes of live oysters per year, and more than half of all the oysters are consumed in New Caledonia. The triploid spat are air freighted in from a hatchery in France. The host of *Les Huîtres de Dumbéa* graciously supplied oysters accompa-

Field visit to Aquamon prawn farm at Boulaparis, New Caledonia

nied by French white wine for participants to savour.

SPC Aquaculture Action Plan

The regional meeting successfully provided the mandate and ingredients to formulate an update of the current SPC Aquaculture Action Plan, which itself was derived from the 1st SPC Aquaculture Meeting. The key components — including the regional trends, priority commodities and a work programme — were successfully extracted by the hard working efforts of the meeting participants. Some work still remains, such as validating, synthesizing and publishing the raw information generated. However, it is evident that the updated action plan will have a broader platform then the previous version.

In some respects, the burgeoning requirements of the draft plan reflect the maturing of the aquaculture industry. The 2nd SPC Regional Aquaculture meeting was a reflection of the expansion and diversity that is occurring. For example, in 2002 eight commodities were shortlisted for development, whereas in 2006, 12 priority commodities were prioritized. The meeting also captured the spectrum of increasing opportunities from subsistence to industrial scale production, seaweed to inland freshwater culture systems, and new techniques such as post-settlement larval ranching. Some of these opportunities will require cross-agency cooperation in order to be successfully implemented. Hopefully, this regional meeting has enabled the Pacific to plot its own path in determining the future shape of the aquaculture sector.

Regional workshop on genetic management and improvement in aquaculture

In September 2006, SPC Aquaculture Adviser, Ben Ponia, and Aquaculture Assistant, Marie Ange Hnaujie, organised this workshop. SPC Aquaculture Officer, Satya Nandlal, coordinated the workshop and compiled this report.

Aquaculture genetics is an emerging field. It promises significant benefits, similar to those experienced by the livestock sector, where, for example, the application of genetics in the poultry industry has largely been responsible for a three-fold increase in poultry meat and egg production. There is, however, a lack of knowledge of aquaculture genetics in the Pacific. Although there are a number of hatcheries that distribute tilapia and carp fingerlings, and post-larval freshwater prawns (*Macrobrachium rosenbergii*), the operators of these hatcheries are unsure whether the fingerlings or post-larvae being distributed are of high quality, and do not have long-term genetic management strategies to sustain genetic quality. In addition, there is a growing interest in the techniques to produce all male-only tilapia fingerlings to improve production as has been the practice in Asian countries.

Based on the above, and on specific requests for training in genetic management to maintain broodstock quality, a training workshop on Genetic Management and Improvement in Aquaculture was held at Peninsula Hotel, Suva, Fiji from 25–29 September 2006. The objectives of the workshop were to:

- provide participants with an overview of the fundamental principles involved in genetic management in aquaculture;
- outline practical methodology for maintaining hatchery broodstock to ensure maintenance of good genetic quality in hatchery stocks, particularly using the example of tilapia;
- describe and demonstrate technology in controlling breeding in aquaculture species, particularly covering the benefits of production of mono-sex tilapia; and
- identify pressing issues for genetics in the aquaculture sector and provide an opportunity to initiate collaborative projects in the Pacific.

The workshop began with a Fijian welcome ceremony (*sevusevu*) by staff of the Naduruloulou Aquaculture Station. This was followed by an opening speech made by Mr Saimone Tuilaucala, Director of Fisheries, Ministry of Fisheries and Forests, Fiji. Mr Tuilaucala expressed his interest in the workshop and made several remarks regarding broodstock management. He noted that broodstock management was an essential component of fish farming and that effective broodstock management depended on hatchery managers, technicians and fish farmers working at maintaining, selecting and reproducing the broodfish for fry production. But in order for this to occur he said that hatchery operators needed to have a solid understanding of species characteristics (such as size at maturity), broodstock holding facilities, number of broodstock needed (i.e. an effective population size), how to maintain broodstock (including knowledge of water characteristics, facility preparation, feeding and

fertilization), and care during spawning/breeding. Unfortunately this understanding has not occurred at all levels of broodstock management, resulting in the use of fish for hatchery breeding that are not in an appropriate condition for the production of good quality fry.

Mr Tuilaucala's opening statement was followed by presentations made by participants on issues in genetic management and improvement in their respective countries. These were followed by lectures, exercises and a practical over the course of the week. The following lecture topics were presented:

- Global status of tilapia and carp aquaculture
- Genetic improvement technologies in aquaculture
- Breeding systems for tilapia
- Genetic status of cultured *Macrobrachium*
- Sex control in aquaculture
- Genetic variability. Its value and management
- Effective population size and its application in genetic management of aquaculture stocks.

A classroom exercise on developing hatchery management plans for the long-term genetic management of cultured stock was carried out. Participants were split into four groups, with each group developing a genetic management plan based on a management scenario. The objective of the exercise was to develop a broodstock replacement strategy that maximizes the retention of genetic variation through the optimization of effective population size (Ne) from one generation to the next, and avoids the pitfalls of hybridization, genetic drift and unconscious selection. The exercise included the calculation, where possible, of what Ne will be per generation and an estimate of the rate of inbreeding that will occur per generation and per year. Group leaders presented their plans to the rest of the participants.

A practical session on breeding systems and collection of tilapia fry for sex reversal demonstration (hormone treatment) was held at Naduruloulou Aquaculture Station followed by practical sessions — at the University of the South Pacific laboratory — on diet preparation, tilapia sexing, and methods used for tagging. A DVD was also shown on tagging methods.

Feedback from participants based on the evaluation of the course indicated that most of them understood the course concepts and contents presented, and would be able to apply the knowledge and skills learned at the workshop to their own situations.

Drs Graham and Josephine Mair from Flinders University, Australia, were the main resources persons for the workshop. Associate Professor Peter Mather from Queensland University of Technology (QUT), Australia, gave a lecture on genetic status of cultured Macrobrachium. Satya Nandlal, SPC Aquaculture Officer, provided technical and organisational support for the workshop. At the closing ceremony, resource persons and some participants spoke about the application of the workshop's concepts and principles for their respective countries. Principal Fisheries Officer (Aquaculture), Mr Maciu Lagibalavu, Fiji Fisheries, issued Certificates of Attendance and closed the workshop with a speech.

Twenty-six participants attended the workshop, which was sponsored by SPC. SPC sponsorship was provided for one participant from each of the following countries: Papua New Guinea, Vanuatu, Samoa, Cook Islands, Nauru and Fiji. Three participants from PNG, one from Nauru and 16 from Fiji were sponsored by their respective employers.

Update on grouper aquaculture at the Queensland Department of Primary Industries and Fisheries Northern Fisheries Centre, Cairns, Australia

Where do we stand?

Excellent applied aquaculture research is being conducted in northern Queensland through the efforts of the Queensland Department of Primary Industries and Fisheries. Researchers at the Northern Fisheries Centre (NFC), in collaboration with regional partners (e.g. ACIAR), have developed protocols for rearing grouper species. Production has focused on the tiger grouper (*Epinephelus fuscoguttatus*) and gold spot grouper (*E. coioides*). These two species are high on the priority list for the Queensland aquaculture industry. Their spawning cycle, larval rearing and nursery phases are now well understood, and the culture techniques developed at NFC are currently being adopted by commercial aquaculture operators.

Both of these grouper species are tolerant of fluctuations in salinity, are relatively fast growing, and attract high market demand. This makes them perfect candidates for tropical pond aquaculture. In northern Queensland, prawn farmers who wish to diversify their production are currently carrying out trials in cages and earthen ponds to test the growth and survival rate of juveniles. On average, these grouper species take 9–12 months to reach a commercial size.

NFC's aquaculture system overview

At NFC, grouper broodstock are held in 30- and 60-tonne tanks. These recirculation systems are equipped with protein skimmers and biofilters, and have both photoperiod and thermal control to allow for the manipulation of the breeding season. All tanks have an overflow egg collection system. Approximately 10–20 fish are held in each tank and most of them spawn naturally without hormone induction. Experience has shown that spawning is influenced by both moon phases and social hierarchy within the tank population.

The larval rearing system is composed of two, 5 m^3 fiberglass tanks. Water is recirculated through biofilters, protein skimmers, filtration cartridges and UV for sterilisation. Metal

Top: Coral trout (*Plectropomus leopardus*) broodstock held in a 60-tonne tank

Middle: Fingerling gold spot groupers (*Epinephelus coioides*) ready for shipment to one of the commercial prawn farms

Bottom: Juvenile tiger groupers (*Epinephelus fuscoguttatus*) aggregating at the bottom of a nursery tank

halide lighting and a heater-chiller device allow full control over the temperature and photoperiod. Both tanks are yellow and rectangular with rounded corners, and have been tailor made for grouper larviculture.

There is a large live prey area at NFC. Zooplankton (rotifer, Artemia and copepods) is used for rearing grouper larvae. Several species of microalgae are mass cultured, including *Proteomonas sulcata*, a red cryptophyte algae especially cultivated to feed copepods. Other species of microalgae are cultured to rear the rotifers and to produce "green" water for the grouper larval rearing stages. Rotifers and Artemia are enriched using commercial enrichment products prior to feeding to larval fish.

After 40–50 days, larvae undergo transformation into juveniles and are transferred to the nursery system. This system is composed of nine two-tonne tanks operated as a flow-through system where water is pre-filtered by sand filtration units. Compressed oxygen is fed into the tanks to keep the dissolved oxygen at an optimum level. Juvenile fish are graded (at least once a week) to prevent cannibalism. Usually, the fingerlings are grown to 10–15 grams in the nursery. At this size the rate of cannibalism rapidly declines and the juvenile fish can be transferred to ponds, cages or raceways for experimental or commercial grow-out.

More research and prospects for the region

Currently, experiments are underway to evaluate the ability to transfer day-1 larvae over large distances, so that they can be cultured in earthen ponds, typical of those found at many aquaculture facilities. If these experiments demonstrate a high survival rate of larvae after transport and during pond-based larval rearing, the results could be greatly improved cost effectiveness of rearing grouper species, and this could be applicable to many areas in the Asia-Pacific region.

In recent years, aquaculture of barramundi cod (Cromileptes altivelis) has been developed by researchers and industry personnel in Southeast Asia and is now also being produced commercially in Australia. Coral trout (*Plectropomus leopardus*) broodstock are a recent addition to NFC, and spawning is forecasted for 2007. Successful rearing of this species will be another breakthrough for the grouper industry in Australia, because coral trout fetch very high prices on the live fish trade market in Southeast Asia and there is a large coral trout fishery of the Great Barrier Reef in northern Queensland. Another exciting area of research at NFC is the acquisition of giant grouper (*Epinephelus lanceolatus*) broodstock. This species has great potential for aquaculture given its extremely rapid growth rate and tolerance to salinity fluctuations and relatively poor water quality.

Beside the ongoing work carried out on the early larval stages and nursery culture, a research component on disease management is beginning in 2007. Specifically, the use of ozone, to eliminate nodavirus from larvae, which has negatively impacted the grouper aquaculture industry and more generally marine finfish culture in the Asia Pacific region.

Some countries in the Pacific region are looking to diversify their aquaculture industry, and therefore, grouper farming in ponds or in sea cages could be a viable option. It would be relevant for places such as New Caledonia where there are considerable coastal pond areas and a strong demand for fresh, high value fish. In French Polynesia and in Palau, where there is already substantial finfish work being carried out, cultured groupers could also help match the growing local demand as well the tourism industry's demand. Another benefit is that these products are ciguatera free!

Two-tonne nursery tanks at the NFC

Tropical crustacean aquaculture research at James Cook University

Research focus on mud crabs

Dr Chaoshu Zeng, leader of the Tropical Crustacean Aquaculture Research Group at James Cook University (JCU), Townsville, Australia, offered to host SPC's Aquaculture Officer on a tour of the aquaculture facilities where most of his work is based. Since early 2001, there has been a strong interest in studying crustaceans of commercial interest. The mud crab, *Scylla serrata*, has since then, been a major focal point of research interest, and a consistent amount of work has been done to break through the bottle neck of culturing this species.

Currently, some successful hatchery rearing of mud crabs is reported from several countries, mostly in Asia. However, low and inconsistent survival of larvae remains a major constraint for the industry and the supply of crablets to farmers. So far, mud crab farming relies mostly on the capture of juvenile crabs, but the availability of wild seed is decreasing. Hatchery techniques are a key to the sustainable development of commercial mud crab culture, and will greatly help reduce pressure on wild stock.

Larval rearing of mud crabs is complex as there are many stages before settlement (five zoeal stages and one megalopal stage). Dr Zeng and JCU students have been working on understanding larval develop-

Top: A JCU student from Japan cleaning broodstock tanks for ornamental shrimps

Middle: Broodstock blue swimmer crab (*Portunus pelagicus*)

Bottom: Experimental marine aquaculture set up at JCU's facilities

ment and the nutritional requirement of the different stages in order to formulate the optimum diet for mud crab larvae.

Research efforts have proven that microbound diets are readily accepted by mud crab larvae at various life stages. Several experiments were carried out and complete Artemia replacement was achieved for the megalopal stage.

Other research on mud crabs was or is being carried out on the following topics:

- improving survival of mud crab nursery culture, such as reducing cannibalism, improving culture units and toxicity of ammonia on the juveniles;
- effect of physical conditions — such as tank colour, temperature and salinity — on larval survival and development;
- diet particle size preference and optimal ration for various larval stages; and
- maturation and conditioning of broodstock.

The research carried out at JCU's aquaculture facilities is designed to have a direct benefit to the industry, and this programme continuously helps to improve hatchery production. The Tropical Crustacean Aquaculture Research Group believes that with the increasing demand for mud crabs and the scarcity of wild juveniles, commercial hatcheries are likely to take over the supply of mud crab juveniles in the Asia-Pacific region in the near future.

Diversifying research towards other commercially important crustaceans

Research is also being carried out on other crustacean species of commercial interest to the Asia-Pacific region. The blue swimmer crab (*Portunus pelagicus*) is a delicacy in Australia and in Southeast Asia. Research is currently being conducted to establish protocols for larval and juvenile culture, and to better understand their nutritional requirements. The results of this research could benefit the Pacific region, and particularly New Caledonia, where there is interest in culturing this species (blue swimmer crabs are found settling in prawn ponds).

Hatchery culture methods for an Australian strain of the giant freshwater prawn (*Macrobrachium rosenbergii*) are also being studied at JCU, including assessment of larval rearing with clear water and green water. Malwine Lober from Samoa is carrying out research for her Master's degree with this species, and results to date have suggested substantial differences in both general biology and culturing techniques between this strain and the commonly cultured strain that originated from Malaysia. This work will have direct repercussions for the growing freshwater prawn industry in the Pacific, as the native freshwater prawn from PNG is genetically closer to the Australian strain than the Malaysian strain.

Reproduction and larval rearing techniques for other species of crustaceans, such as ornamental shrimp (e.g. *Stenopus* spp., *Lysmata* spp.) are also being studied at JCU.

Towards regional collaboration?

Further aquacultural research is being conducted at JCU on other species and topics. However, the applied findings of the Tropical Crustacean Aquaculture Research Group are often readily applicable to the developing industry of many Pacific nations. The strengthening of links between SPC and JCU through ACIAR mini-projects funding will hopefully enhance linkages between the research group and the rest of the Pacific region.

Solomon Islands marine aquaculture update

In November 2006, SPC's Aquaculture Advisor and Aquaculture Officer (mariculture) visited the Solomon Islands. The main objective of the mission was to program joint activities (particularly mariculture based) with the new Aquaculture Division of the Department of Fisheries and Marine Resources (DFMR). Alex Meloty, the new Head of Aquaculture was recently appointed after Gideon Tiroba left the Department for the EU-funded seaweed project, as project manager.

Other objectives of this visit included scoping the ongoing aquaculture activities by industry, governments and NGOs, and to undertake a review of the EU-funded seaweed project that SPC has been following since its start in 2002.

Field visits by SPC staff, together with DFMR aquaculture staff, began in Honiara with the two marine ornamental livestock suppliers, Aquarium Arts and Solomon Island Marine Export. SPC staff and Alex Meloty then flew to the Western Province where they met the EU seaweed project staff and visited seaweed farming sites at Vaghena (south of Choiseul) and Rarumana as well as the sea-

weed project base in Gizo and their nursery sites around Mbabanga and Nusa Tupe. While in the Western Province, the team visited the WorldFish Center field station in Nusa Tupe and viewed the work with ornamentals (clams, lobsters and corals), sponges, and black-lip pearl oysters.

The marine ornamental trade in the Solomon Islands

Aquarium Arts is a Honiara-based company that exports marine ornamentals throughout the world, although its major clients are in the US and the EU and its parent company is based in the US.

The company operates two large systems, a fish system and an invertebrate system, in warehouses located between the town and the airport, near the seafront. In both systems, the water is re-circulated through home-made biofilters; foam separators are used for the fish system. UV is used for packing the animals before shipping. The survival rate in the warehouse is high and animals are shipped once they are acclimated, thereby reducing mortality on arrival at their destination

They have recently been marketing farmed ornamental corals and crustaceans produced by rural Solomon Island communities together with NGOs, such as the WorldFish Center and the Foundation for the Peoples of the South Pacific (FSP). Aquarium Arts has a good market for cultured corals, and a few hundred pieces are exported by airfreight every week. Small shipments of spiny lobster and cleaner shrimp reared in the Western Province are also exported.

Aquarium Arts used to export giant clams (several species) produced by rural communities with support from the WorldFish Center, but since the period of ethnic tension, no clams have been shipped from the Solomons until recently. However, several batches of *Tridacna derasa* are being grown out in the Western Province and will be sold to Aquarium Arts for export.

Traditionally, the company buys wild-caught products captured by Solomon Island divers, mostly around Guadalcanal, Ngella and the Western Province. Recently, the company has brought in professional divers from the Philippines in order to increase production, and to access deeper and rarer species that are valuable and much sought after.

Air-freight routes remain the main bottleneck of the operation. Shipments into the US have been recently reduced from three to two times a week because of the change in flight schedules. Furthermore, the company only has access to interesting prices if the volume shipped is large enough (2 tonnes of cargo per shipment). To achieve this, they work closely with Solomon Island Marine Export (SIME).

SIME specializes in exporting live invertebrates for the aquarium trade (anemones, sea stars, soft corals, small polyp hard corals, large polyp hard corals, fungids, and live sea shells). They have their own team of collectors and they harvest their products mainly from around Ngella. SIME divers have reported that some species were getting harder to find and were enthusiastic about accessing more farmed corals in the future.

Ornamental fish and invertebrates have proven to be valuable resources for the Solomon Islands. Farming and collecting activities provides rural communities with a cash income. Also, the WorldFish Center project on post larval fish and invertebrates capture and culture in the Western Province has proposed a new panel of products, most of which have benefited from successful marketing. At the top of the list are tiny spiny lobsters that are sold at seven Solomon dollars (farm gate price per piece) each. Some farmers earned over 200 Solomon Island dollars per month with these products, which is a good supplemental salary to traditional rural activities.

WorldFish Center aquaculture activities at Nusa Tupe Station

In the Western Province, the team visited communities using simple technology for capturing and culturing post larvae. Near the island of Naru and Rarumana village, crest nets are used for capturing reef fish and cleaner shrimp (*Stenopus hispidus*), and coconut log traps are used for catching lobsters. This fishery is well adapted to the rural Solomon Island lifestyle. The team had the chance to discuss the EU seaweed project and aquaculture issues with key community members in Rarumana and had good feedback from this project. Many people are currently expecting the giant clams from the WorldFish Center hatchery in Nusa Tupe, because they were a good source of cash income in the past. The growing worldwide demand for clams and the recent spawning of *Tridacna derasa* at the Nusa Tupe field station should soon create exports from the Solomon Islands.

Other commodities targeting the ornamental trade are being developed by the WorldFish Center and partners at Nusa Tupe, including hard corals from the genuses: *Porites*, *Montipora*, *Acropora*, *Seriatopora*, *Turbinaria* and soft corals from

the genuses *Sarcophyton*, *Cladiella* and *Sinularia*. A workshop on techniques for farming coral fragments was recently run, and involved villagers from surrounding communities.

Sponge farming trials with *Coscinoderma matthewsi* were also in progress, as well as with small colorful sponges that would be of interest to the ornamental trade. The work on *C. matthewsi* is a mini-project funded by ACIAR, and recovery and growth rates are studied under different conditions. There is a niche market for natural sponges (e.g. cosmetic, curios, and baby products), and the technique could be relatively well absorbed by a local rural industry as it is low tech and low capital input. The final product, which takes about a year to grow, is easy to process locally and export.

Several thousand adult blacklip pearl oysters cultured from wild spat are being held at the Nusa Tupe station in anticipation of a Japanese consortium that has shown an interest in conducting research leading to commercial development of pearl farming in the Solomon Islands. Subject to the signature of an appropriate agreement, the WorldFish Center will consider assisting the consortium with the research. The Solomon Island government is strongly interested in developing this commodity throughout the country and an EU-funded project to assess whitelip pearl resources, and the development of an investment plan for prospective entrepreneurs, is about to be undertaken.

Recent status of seaweed farming in the Solomon Islands

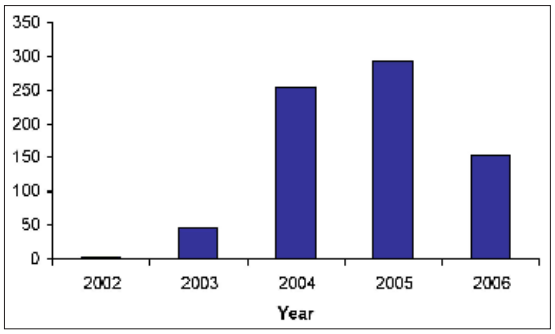
Vagehna Island, 120 km northeast of Gizo, is one of the main seaweed farming sites, inhabited by an I-Kiribati community. In 2005, Vaghena produced up to 40 t/month of dried seaweed, although since then, production has been at a steady decline to about 10 t/month. Several reasons for the decline include the drop in beach price, which has gone from SBD 2 to SBD 1.5.

During visits to seaweed farming areas, many abandoned plots were observed, and there were hundreds of unused stakes and little activity, except a few households that were still farming in the area. Vaghena inhabitants reported that with the downturn in seaweed prices and the moratorium on sea cucumber exports, they have turned their fishing skills to catching sharks and crayfish (tails).

Top left: Maintaining the coral farming trials

Top right: Offshore bottom seaweed farms in the Vaghena area

Bottom left: Seaweed farming camp in the Vaghena area, note the drying seaweed.



Seaweed production data from the Solomon Islands between 2002 and 2006

The team also visited Rarumana village, which achieved a peak seaweed production in excess of 20 t/month in 2004. There, we met with Maloe Daga, the village chief (80 years old), who was one of the most productive farmers with 3000 lines in the water. At present, there are only six seaweed farmers, compared with 146 farmers in 2004. It was reported that in the past two years, this site has experienced poor water and meteorological conditions for farming. Rarumana is a fertile island and female seaweed farmers have gone back to tending crops (Gizo market is a 40 minute boat ride away); men fish for shark fins and collect trochus, and are also involved in timber milling. We visited seaweed farming areas in the lagoon alongside reef crests. Rafts were used for initiating seaweed growth, and the plants were showing encouraging signs of growth.

The EU seaweed project is carrying out extension work in other Solomon Island provinces. The sites that have been identified for suitable farming include Ontong Java, the Reef Islands, and north Malaita. It is thought that the communities residing in the artificial islands of north Malaita will be highly productive farmers. Fisheries staff have also carried out trials in south Malaita, Marovo and Makira. While these sites have shown potential for good production, Vaghena remains one of the most suitable and sustainable sites in the Solomon Islands. Efforts will be made by the Department of Fisheries and Marine Resources (DFMR) and EU project staff to rejuvenate production at this island.

The major activities carried out by the project include:

- transfer of seedlings to potential farming sites;
- improvement of equipment in the farming areas: building of warehouses, implementing email equipment for communication, providing materials;
- appointment and the training of extension officers and buying agents;
- training of farmers; and
- implementation of a farmer database as part of the EU project.

A large effort has been made towards on-site quality control, targeting poor or unscrupulous post-harvesting practices by farmers A quality control manual is currently being published.

Future prospects for Solomon Island aquaculture industries

With the re-structuring of the DFMR aquaculture division, and the increase in capacity in terms of funds and staffing, the future looks promising for the Solomon Islands aquaculture industry. Furthermore, the NGOs are in a good position to continue to solidly contribute to the development of the industry by supplying training, extension and research and development services.

DFMR's aquaculture division will soon implement its strategic plan for 2007–2010. Part of this activity will be supported under an NZAID-funded institutional strengthening project. The government's aim is to expand the role of aquaculture, through creating livelihoods for coastal communities, and strengthening regulations. SPC will continue to advise and assist the DFMR by providing technical assistance and training.

Seaweed nursery raft at low tide

Crayfish farming in New Caledonia: A fast developing rural activity

How crayfish are farmed

The red claw crayfish, *Cherax quadricarinatus*, was introduced from Australia in 1992. In New Caledonia, it is farmed on the western coast of the Southern Province, mainly in the Boulouparis area.

The red claws are raised in small clay ponds (500–1000 m^2) fitted with covers made from building blocks, tarpaulins and tubes. The ideal water temperature for rearing and growth fluctuates between 27° C and 30° C, and the dissolved oxygen content between 1.5 mg/l and 3 mg/l. The ponds are aerated by a venturi system. The crayfish prefer a clean hard bottom and each pond is therefore completely emptied and cleaned once a year.

A hatchery is not necessarily needed to produce crayfish; they will reproduce naturally in ponds. To avoid risks of overpopulation and proliferation, male broodstock is kept in special ponds.

Females can begin breeding at the age of four months and lay 200–400 eggs per spawning period. As they hatch out, and when the juvenile crustaceans reach 2 cm in size, they are placed in pre-fattening ponds.

At the age of six months (7–10 cm), males are separated from females. They are then placed in the fattening ponds. They should be graded by size and sex to obtain good production results. A ten-month-old male crayfish can reach a weight of 120 g and female, 80g. The crabs are sent to market when they reach the minimum weight of 60 g.

Crayfish feed on phytoplankton and zooplankton in the ponds. They also receive a food supplement based on fish meal and fish oil, formulated by local

Top: Commercial sizes of Caledonian crayfish, ready for marketing. The large animal in the middle is a male

Bottom: Fishing device for crayfish. A small pump flows water through the gutter thus attracting crayfish inside the tank

suppliers (protein content 80%), and the formulation is in accordance with strict environmental specifications.

Ponds are harvested twice a year to permit good crayfish population management. To harvest the crayfish, a small box is placed alongside the pond, connected to it by a ramp down which water flows. The crayfish swim up the ramp against the flow and are then trapped in the box. Nearly the entire pond population can be harvested in two nights. Specimens weighing less than 60 g are released into another pond. The remaining crayfish are then graded into three sizes (60–80 g, 80-100g; 120g+ and placed in finishing tanks for 24 hours. The crayfish are not processed but are marketed live. They can be transported live out of the water for at least 72 hours.

The crayfish trade and the potential of the New Caledonian market

The crayfish industry at present involves some 30 producers operating 150 ponds and accounting for a total surface area of 11 ha. Production and sales are constantly increasing.

The producers have formed the association, Association Dulçaquicole Néo-Calédonienne' (ADNC: www.adnc.nc), which is responsible for technical supervision of

Top: Gravid female crayfish at different stages of maturation

Middle: Prior to commercialisation, crayfish are held in these tanks for purging

Bottom: This pond is getting drained, notice the shelter for the crayfish and the venturi aeration system

farms, marketing products, and developing freshwater aquaculture in New Caledonia.

The crayfish marketed by the association all come from farms using good farming practice guidelines, which make it possible to certify the quality of products sold to professionals in the restaurant and retail trades.

This guide takes into account the following technical parameters: design of farm ponds, crayfish shelters, feed, water quality, disinfection after harvesting, use of finishing ponds, effluent discharge, feeding and stocking density, crayfish handling and harvesting gear, farm inspection and monitoring.

The New Caledonian crayfish is not exported but many expressions of interest have been registered by ADNC. Exporting could be possible to small regional markets such as Tahiti, pending the development of this industry on a bigger scale. It should also be added that, so far, the introduction of crayfish has had no reported noticeable environmental impact in New Caledonia.

Year	Volume (t)	Value (M XPF)
2000	4	5
2001	6	10
2002	7	10
2003	9	15
2004	10	15
2005	9	15

(1 USD = XPF 95)

Oyster farming challenges in New Caledonia

The Dumbéa oyster farm and the local market

The Dumbéa oyster farm, *Huîtrière de la Dumbéa*, is a New Caledonian company that has been producing oysters (*Crassostrea gigas*) under the management of the Lavergne brothers since 2005. The objectives pursued since that date have been to increase production, improve product quality, gain a larger local market share for oysters, and diversify the shellfish production range.

The local market in New Caledonia is favourable for the development of oyster farming. Imports of live oysters represent 170 tonnes (t) per year on average, mainly from New Zealand but also from Australia and France. In 2000, total oyster consumption was 210 t.

In 2004, *Huîtrière de la Dumbéa* supplied 26% of the local market, with 80% of production being sold in the larger supermarkets. Since 2005, the company's strategy has been to target the restaurant market; new farming and finishing methods have made it possible to obtain larger, high-quality oysters. Also, the company's recent acquisition of an automatic grading machine brings its products into line with French standards.

- In 2005, *Huîtrière de la Dumbéa* accounted for 45.5% of the local market (73 t).
- In 2006, it covered 60% of the local market (90 t).
- A very high seeding rate in 2005 and 2006 should make it possible to produce between 100 t and 110 t and to supply 70% of the local market from 2007.

Spat imports and fattening methods

At *Huîtrière de la Dumbéa*, the oyster farming cycle takes place in the inshore zone, except for spat production. In New Caledonia there is no hatchery and the collection of wild local oyster species does not produce enough volume to be viable. For this reason *Huîtrière de la Dumbéa* brings in triploid spats, mostly from France (the île de Ré region in particular) and more recently from Australia.

Because of the very different environmental conditions (variation in water quality, temperature, turbidity, salinity, etc.), between spat exporting countries and New Caledonia, the spat mortality rate is high.

In 2006, 12 million spat were imported to satisfy increasing consumer demand, but also to offset losses, which could be as high as 80% during the farming cycle (three years). Alternative options are currently being considered.

On arrival at the farm, located just a few kilometres from Noumea, the spat are placed in raised beds in the sea in the Dumbéa River estuary. These beds extend over 50 ha and are accessible at low tide, meaning that the six staff at the oyster farm can walk out, clean the bags, and swirl the oysters around so that they do not stick to each other.

As in mainland France, the oyster farming company uses aluminium punts fitted with winches to bring the bags up onto the shore where the oysters are cleaned, sorted and graded. The largest ones are put on the market and the smallest are placed back into the finishing bags in the beds.

Huîtrière de la Dumbéa markets five oyster sizes: Nos 4, 3, 2, 1

and 0. Each size relates to the demand from a specific sector of the market: supermarkets, restaurants or retail to the public.

Research and development and diversification

In order to meet the growing demand, an increase in the size of the oyster farming area and the number of beds is under consideration.

The dependency of *Huîtrière de la Dumbéa* on imported spat remains a hindrance to production. Hatcheries in mainland France in particular are labouring under the demand that currently exceeds supply. It is therefore becoming increasingly difficult for this local business to obtain spat. Attempts to obtain supplies from Australia are in progress.

A hatchery is being constructed. A laboratory and algae room have been set up to conduct larvae production trials on *Crassostreas gigas* and local mangrove and rock oysters. The first batch of local spat is already in the grow-out phase, and spawning and larvae rearing trials will soon be further developed at *Huîtrière de la Dumbéa*.

The company is also considering moving into the harvesting and fattening of other shellfish that could be marketed in New Caledonia. For example, the palourde clam and especially mussel, for which import figures are currently high (approximately 100 t per year).

Also, many scallops (*Mimachlamys gloriosa*) recruit in the oyster enclosures. The company is interested in developing and intensifying this harvesting and fattening activity, which could also prove rewarding as an adjunct to the oyster farm.

***Huîtrière de la Dumbéa*'s automatic grading system**

NEARSHORE FISHERIES DEVELOPMENT AND TRAINING SECTION

Third *Sea Safety* bulletin published

The third edition of the SPC *Sea Safety* Special Interest Group bulletin was published and distributed in October 2006. This bulletin is prepared by the Nearshore Fisheries Development and Training Section and produced with financial assistance from France through the French Pacific Fund.

There is some excellent material in this bulletin, and we draw your attention to the lead article in the Safety Feature section regarding the ratification of the Torremolinos Protocol and the STCW-F Convention. As noted in the article, there is a real possibility for Pacific Island countries (PICs) to act collectively in the ratification and adoption of these important documents, in the interests of promoting common safety standards, saving lives and preventing accidents. This requires the development of political will to take responsible steps, within an international framework, with respect to safety issues: this is a task for all with an interest in preventing accidents and loss of life at sea.

Readers will also enjoy the contribution from Simon Reid on the New Zealand FishSAFE initiative, which has been a multi-agency commitment to addressing work safety issues at an individual boat level. This is an excellent initiative that is proving very successful and which could be applied more widely in the region. Thanks are due to John Swamy for his summary of the EU-funded sea safety programme for increasing safety awareness among artisanal fishermen in the tsunami-affected districts of Nagapattinam and Cuddalore, Tamil Nadu, India.

This edition of the bulletin also examines some important aspects of marine communications, with a summary of the new GPIRB and a discussion of the pros and cons of mobile phones.

The group coordinator and bulletin editor, Hugh Walton, encourages group members and readers to sharpen their pencils or sit down at their keyboard and send in safety-related stories and articles.

Third regional course for fishing vessel skippers held in Nelson

As part of SPC's efforts to promote economically viable Pacific Island fishing enterprises within a sustainable ecosystem context, the Nearshore Fisheries Development and Training Section has recently coordinated the third regional course for commercial fishing skippers in Nelson, New Zealand.

From 9–20 October 2006, 11 fishing vessel skippers were trained on vessel operation management and electronic aids at the New Zealand School of Fisheries of the Nelson Marlborough Institute of Technology (NMIT). The course was funded by SPC and the EU-DEVFISH Project (see section below "2006 Tuna Skippers Course in Nelson" for more detail).

During the first week of the course, SPC Fisheries Development Officer, William Sokimi, was in Nelson to act as a resource person, network with course participants, and provide input into course delivery. His extensive background in tuna longlining in the Pacific region significantly helped to enhance the group cohesion.

William was replaced by SPC Fisheries Training Adviser, Terii Luciani, for the second week of the course.

Course content and training methodology

The course programme was developed around two general themes, "Fishing Vessel Management" and "Electronic Aids for Fishing Operations".

Fishing Vessel Management covered four subject areas:

- Introduction to Computers (computer keyboard, getting started with Word for Windows, using email and the Internet),
- Vessel Economics (factors affecting vessel profitability),
- Organisation and Planning (vessel turn-around and in-port efficiencies, port infrastructure and vessel maintenance, crew management and training, seafood handling and quality, access to satellite information for fishing), and
- Compliance and Protocols (International maritime law, MARPOL and SOLAS, vessel insurance, skipper's responsibilities, introduction to HACCP principles, vessel safety management systems).

Top: Tour of the F/V *Daniel Solander*

Bottom: Geared up for the factory tour

Under the theme Electronic Aids for Fishing, a range of equipment was introduced and practical training was given in their use, based on participants' needs and the time available (ARPA Radar, GPS/Plotter, weather fax and Sea Surface Temperatures, Inmarsat C, EPIRBs, Vessel Monitoring Systems, echo sounders, sonar, etc.).

The course was designed to build on participants' existing skills and assist with areas where individual participants lack expertise. Because participants were from differing backgrounds and had different levels of knowledge and experiences, the course was operated in a participatory manner and formal lecturing was kept to a minimum. Where appropriate, learning was achieved by sharing experiences and small-group discussions. Some sessions were also conducted by carefully selected guest speakers.

On the last day of the course, trainees were asked to undertake a formal evaluation of the course. Overall, the third regional course was a success. In addition to developing useful professional networks in the New Zealand fishing industry, participants gained many new ideas and knowledge that will help them better manage their fishing vessels and, hopefully, improve their financial profitability.

2006 tuna skippers course in Nelson, New Zealand

The third regional course on Vessel Operation Management and Electronic Aids for Commercial Fishing Skippers began with a *powhiri*, or welcome, at Wakatu *marae*. The day continued with an orientation tour and an introduction to the computers in the seminar room. William Sokimi (SPC) and Mike Wells, a New Zealand longline skipper with considerable fishing experience in the Pacific, were introduced to the group, comprising ten skippers from eight Pacific Island countries. Luckily the weather held out for the evening welcome barbeque where skippers met the staff from the School of Fisheries.

It was immediately apparent that there was a wide variation in people's familiarity with computers. So, for the remainder of the course, and where applicable, considerable emphasis was placed on the benefits of using this technology to improve fishing performance. Initially this revolved around exercises using the Fishing Profitability software developed by SPC. Tuesday finished with an afternoon discussion led by William and Mike on "Fishing Technology: Challenges and Perspectives", where the experience of these two presenters quickly sharpened people's minds regarding the real issues facing Pacific Island tuna fishermen. Cutting costs through efficiencies and improving quality were established as key goals.

John Cleal, Managing Director of Fishing Vessel Management Services led the Wednesday morning discussion on vessel management. William and Mike later expanded on this, leading the group in a workshop on "What makes a good skipper?". The afternoon saw a complete change of pace and it was down to the fire station and the Breathing Apparatus Training building for an afternoon refresher on fire prevention and control with Mike Evans. Here the emphasis was on crew familiarity and drills, and the role of the skipper in ensuring crew are ready and capable should a fire break out on board.

No matter how good a fisherman is at catching fish, the job isn't over until the fish is sold for the best price possible on that day. In terms of quality, it's all down hill after the fish comes on board unless everyone involved understands the importance of personal and vessel hygiene, and correct fish handling, processing and care of the catch. Cushla Hogarth took the group through HACCP procedures and the need for documented quality systems. William discussed tuna loining and the challenges involved, and Grant MacDonald talked about freezing and refrigeration. Once again, MacCure Seafoods welcomed the group to their plant where the group was able to see how this company puts into practice the points that had been covered by Cushla earlier in the day.

John Cleal has had a close involvement with getting the NZ fishing industry owner-operators to adopt FishSafe so he was chosen to lead Friday's discussion on vessel safety management systems. In the following workshop, the skippers that were present were led through the process of putting a hazard identification plan into action on their own vessels. Friday came to a very pleasant close at Solander Fisheries where Paul and James Hufflett hosted lunch. The group then inspected a shipment of chilled mahimahi which had arrived from Fiji earlier that day, before going to the wharf and closely inspecting the longline vessel F/V *Daniel Solander*.

After such a busy week it was time to get on the water and relax with Martin Holmes on his charter vessel *Marie Antoinetta*. Unfortunately, the scallops were few and far between so after getting enough for a taste, we returned to Nelson where Viliami Langi and the local Pacific Island community had organised a barbeque.

The final week concentrated on vessel electronics, and participants started off with a look at Sky Eye, a satellite-based weather information system. Tutors Phil Pinniger and Roger Wincer led several familiarisation sessions on standard wheelhouse electronics, with a special emphasis on troubleshooting. On Tuesday morning, we met John Cleal at the port for a practical session on implementing a hazard identification programme. Three local fishermen had made their longline vessels available so that the group was able to look over these boats and put their knowledge into practice.

The next day, Mike Wells and Paul Hufflett introduced the Orb Image software and Paul explained how Solander uses it to manage their fleet of longliners based in Suva. Mike pointed out some of the finer points — from the fisherman's point of view — and by the end of the session, all had learned a little more about how satellite-based information systems could help improve fishing efficiency and reduce fuel costs.

With the week drawing to a close it was time to head to Motueka to visit Talley's fisheries processing facility. After the return to Nelson and lunch, tutor Joost Besier talked to the group about Bridge Resource Management from a fishing skipper's point of view. The day was rounded off with the

evening farewell function and presentation of certificates by Paul Hufflett.

On Friday morning, Brian Fossett took the group for a sea safety and survival session that included a flare demonstration and discussion on the importance of crew drills before the course wrapup in the afternoon. All the participants felt that the course had been worthwhile, with something for everyone and a good mix of refresher training and new material. It provided an excellent opportunity for companies to showcase some new products and it gave tutors at the School of Fisheries a greater appreciation of some of the issues currently facing fishermen in the Pacific.

DEVFISH project activity

Development of Tuna Fisheries in the Pacific-ACP States Project (DEVFISH), which is jointly implemented by the Forum Fisheries Agency and SPC, continued to undertake activities in its second-year work programme. The period October–December 2006 accounts for the second quarter of the second-year work programme.

3rd sub-regional industry workshop, Majuro, Marshall Islands

One regionally focused activity of the project was facilitating private sector exchanges and interactions. The approach convened countries in sub-regional groupings that reflected their locations and similarities in scopes and types of tuna industry operation in countries.

The first sub-regional workshop was for the Polynesian countries and was held in Apia, Samoa in April 2006. The second workshop was for the Melanesian countries, and was held in Suva, Fiji in September 2006.

The last sub-regional meeting was held in Majuro, Republic of Marshall Islands from 7–9 November 2006. The meeting brought together representatives of the fishing industry, fishermen's associations, managers of leading tuna fishing companies, as well as government officials involved in tuna fisheries management and development from the Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Palau and Tuvalu. The focus of this meeting was on the tuna fisheries of the Micronesian countries and Tuvalu.

Participants discussed a range of issues relating to the management of the region's tuna stocks, and development issues affecting domestic tuna fishing industries in their countries.

Participants expressed concern over the status of the region's tuna stocks, noting that bigeye and yellowfin tuna are at risk of becoming overfished in the region, mainly due to large-scale foreign fishing efforts. They further stressed the need for the fishery to be managed so as to maximize economic benefits to Pacific Island countries, while ensuring long-term sustainability of the resource. The need for up-to-date national stock assessments to complement the region-wide picture was emphasised, and participants also noted the need for a clearer understanding of the stock assessment models used and the limitations of data.

Participants discussed a range of policy issues affecting the tuna industry and highlighted the need to address issues such as fuel costs, airfreight, investment policies, and tax, reform noting that some of these could be handled on a sub-regional basis. The importance of full consultation with all stakeholders was emphasised and it was noted that there may be a need

Visit to the Marshall Islands Fishing Venture (MIFV)

to restructure government fisheries administrations to be more responsive to development needs. Participants also noted the need for short-term measures to assist the industry to overcome difficulties associated with low fish prices and increased operating costs, particularly costs arising from increasing fuel prices.

Participants noted the importance of market access and requested that more detailed information on specific market opportunities be gathered and disseminated by the Forum Fisheries Agency (FFA). It was agreed that a study on recent developments in the Japanese tuna food products market would be of benefit.

The meeting emphasised the key role for FFA in helping member countries to meet obligations under the Western and Central Pacific Fisheries Convention, and stressed the need for industry participation in meetings and discussions of national positions. The importance of forthcoming discussions on allocation was highlighted and the need for Pacific Island countries to be prepared to defend the interests of local and locally based fisheries was emphasised.

Participants discussed the proposed Fisheries Partnership Agreement with the European Union and, while acknowledging its potential to assist industry development, noted the need for greater consultation with local industry personnel.

Participants identified a number of priorities for action by regional organisations to facilitate the development of domestic fishing industries. DEVFISH will take the lead in following up and implementing some of the meeting recommendations.

Detailed updates and reports of all project activities can be viewed at:

www.ffa.int/DEVFISH

Fisheries Development Officer, Steve Beverly, visits Port Moresby, Papua New Guinea to deploy FADs

Fisheries Development Officer (FDO), Steve Beverly, spent October to December 2006 in PNG, providing technical assistance to the domestic tuna longline industry and coordinating the rigging and deployment of six FADs for local artisanal and sports fishermen.

The FAD project

The FAD project in Papua New Guinea's (PNG's) Central Province came about as a result of talks between SPC, World Bank, PNG National Fisheries Authority (NFA), the European Union Rural Coastal Fisheries Development Project (RCFDP), PNG Central Provincial Fisheries, and the Port Moresby Game Fishing Club (PMGFC). SPC had previously deployed a FAD at one of the sites used during the current project[1]. The FAD had been deployed southwest of Daugo Island for the artisanal fishermen living on the island. The FAD proved to be very successful, having stayed on station for three years. The same site was re-surveyed during the current project, as it proved to be a popular site for both artisanal and sport fishermen. Steve Beverly worked with Peter Cusack, a Fisheries Development Adviser at SPC during the 1992 FAD project. Mr Cusack initiated talks between all interested parties and SPC to organise the current project.

FAD materials were provided by the Port Moresby Game Fishing Club and the European Union. Some of the materials (ropes) were on hand from a previous FAD project carried out by the PMGFC. Floats for the Indian Ocean rafts were ordered from New Zealand and Taiwan, while some of the other material was sourced in Port Moresby, including stainless steel cable, cable grips, ferrules for crimping cables, plastic sheathing for the cables, and the forklift counter weights. Wooden boxes were fabricated in Port Moresby for storage and deployment of the FAD mooring ropes.

FAD site surveys

After discussions with PMGFC, RCFDP, and Central Provincial Fisheries, it was decided that six FADs would be deployed at different sites. The sites to be surveyed — going from southeast of Port Moresby to northwest — included Round Hill Passage, Gabagaba (aka Kapakapa), Pyramid Point Passage, south of Daugo Island (Daugo B), southwest of Daugo Island (Daugo A), and Idihi Light. The chart used for reference was Aus 505 Port Moresby to Hood Point.

[1] Beverly S. and Cusack P. 1993. Report of a pilot fish aggregation device (FAD) deployment off Port Moresby, Papua New Guinea, 27 June–8 August 1992. Secretariat of the Pacific Community.

The FAD survey boats were all sports fishing boats belonging to PMGFC members. The time on the boats was donated, one captain (PMGFC member) came along on most surveys, and fuel was provided by PMGFC. SPC provided a Furuno GP-1610CF GPS with plotter and a Furuno FCV-1100L colour echo sounder for the surveys. The echo sounder transducer was mounted in a portable aluminium housing that was bolted to a piece of re-enforcing timber (Fig. 1) that was in turn lashed to the vessel's starboard side. The monitors for the GPS and echo sounder were mounted on a piece of plywood that was then mounted in the boat's cabin. The echo sounder had a 28 kHz transducer and 3 kilowatts of power, enabling it to reach depths in excess of 3000 m, far below the depths sought during the surveys. Surveys were carried out following guidelines in SPC's FAD manual[2]. On all of the surveys, National Fisheries College (NFC) Master Fisherman, Samol Kaniwa, steered the boat, following lines of latitude and travelling either east or west at 0.25-nm intervals, while the SPC Fisheries Development Officer observed the lines of longitude on the GPS and recorded depths from the echo sounder at 0.25-nm intervals. Surveys were conducted in roughly 2 x 3 nm rectangular areas. Afterwards, the data were plotted on plotting sheets, contour lines were drawn at 100-m intervals, and the best FAD sites were selected.

FAD rigging

After the surveys were completed, six FADs were rigged. All of the FAD rafts were rigged as Indian Ocean FADs following the most current design, and consisted of strings of alternating hard plastic and soft foam floats (Fig. 2). The upper mooring consisted of 250 m of 8 mm 7 x 19 stainless steel flex wire (following the design used in New Caledonia by Marine Marchande – Philippe Simoni pers. comm.). The wire was closed at either end by a Flemish eye sealed with two ferrules and three stainless steel cable grips. The portion of cable threaded through the floats was sheathed in PVC tubing.

The moorings were rigged so that the entire length — cable, rope, and chain — would be approximately 120% of the site depth. Four of the sites were in the 1000 to 1100 m range so these moorings were made with five coils of polypropylene (1100 m), 250 m of cable, and 10 m of chain. Total length was 1360 m, or about 123% of the site depths of 1100 m. Two of the sites were 750 m deep. The moorings for

Figure 1 (top): Echo sounder transducer in portable housing

Figure 2 (bottom): Six Indian Ocean FAD rafts rigged and ready to deploy

[2] Chapman L.B., Bertram I., Beverly S. and Sokimi W. 2005. Manual on fish aggregating devices (FADs): Lower-cost moorings and programme management. Secretariat of the Pacific Community.

these sites were made with three coils of polypropylene (660 m), 250 m of cable, and 10 m of chain. Total length was 920 m, or 122% of the site depth.

The coils of rope were uncoiled using a turntable made from an old office chair (Fig. 3). They were flaked out directly into wooden boxes made especially for the moorings. After the coils were spliced together using double splices, eyes were spliced into each end. The eye splices were whipped using 3 mm three-strand nylon. Nylite rope connectors were attached to the two ends of each rope for connections to swivels. All hardware at the top end was stainless steel while all hardware at the bottom end was galvanised low carbon steel.

The anchors for the six FADs all consisted of discarded counterweights from forklifts (Fig. 4). This is the same type of anchor that was used in the 1992 FAD deployment off Daugo Island and might have had something to do with the longevity of that particular FAD. Forklift counterweights are virtually indestructible and they weigh in excess of 1.5 t. The anchor chains were threaded through holes in the counter weights and shackled back onto themselves.

Figure 3 (top): Samol's rope turntable made from an old office chair

Figure 4 (bottom): Forklift counterweights used for FAD anchors

In lieu of flagpoles, old discarded longline radio buoys were used as markers. These were attached directly to the cables via a Flemish eye. The radios were removed and the compartments and the antennas were sealed and glued in place to avoid pilferage. Flags were fabricated from orange plastic sheets and attached to the radio buoy antennas with plastic cable ties. All shackles and cable grips on the upper mooring were tack-welded with stainless steel rod. To avoid chaffing of the rope portion of the mooring on the bottom, two pressure floats were spliced onto the rope several hundred metres above the anchor chain. This gave the floating rope enough additional floatation to lift several metres of chain off the bottom and to prevent the rope from touching the bottom. Figure 5 shows the basic configuration of the six FADs.

Deployments

The vessel used for deploying the six FADs was the coastal cargo barge, M/V *Agutoi Chief* (Fig. 6). Prior to departure, all materials were loaded in a partially assembled state. For safety, final connections were made after the materials were loaded onto the vessel. The FAD rafts were connected to the upper ends of the mooring ropes with stainless steel shackles and swivels, the galvanised anchor chains were connected to the forklift counterweights with

galvanised shackles, and the anchor chains were connected to the lower ends of the FAD mooring ropes with galvanised shackles and swivels. All shackles were safety wired with stainless steel wire. All shackles and cable grips on the upper ends of the moorings were tack welded. The FADs were laid out in order of deployment, with the anchors sitting just behind the boxes containing the FAD mooring ropes, and the upper FAD moorings sitting just in front of the rope boxes (Fig. 7)

All six FADs were deployed using the raft method as outlined in the SPC FAD manual[3]. Plots were drawn with waypoints east and west of the intended sites and on the intended sites. As the vessel approached the FAD survey area it slowed to about 3 kt. The vessel then steamed in an easterly direction going into the wind and current on the west side of the intended FAD site. The FAD raft was then deployed at a distance equal to two-thirds of the total length of the FAD mooring away from the intended FAD site. This was the first waypoint. The second waypoint was the intended site. The third waypoint was at a distance equal to one-third the length of the mooring away from the intended site. This is where the FAD anchor was to be deployed. For each FAD site these waypoints were entered into the plotter as marks. The vessel captain was directed to steer along a west-east line along these marks on the GPS plotter. As the first waypoint was reached the Fisheries Development Officer instructed the deck crew to deploy the raft. The vessel continued steaming and the upper cable and mooring rope were paid out. When all of the mooring was paid out the vessel had crossed over the second waypoint and was approaching the third. The FAD

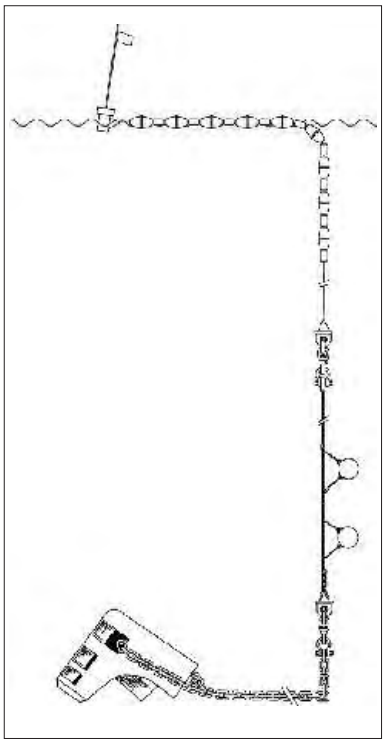


Figure 5 (top right): Basic configuration of the six FADs

Figure 6 (middle left): M/V *Agutoi Chief* just after deploying a FAD

Figure 7 (bottom right): All six FAD moorings laid out on deck ready to be deployed

[3] Chapman L., Pasisi B., Bertram I., Beverly S. and Sokimi W. 2005. Manual on fish aggregating devices (FADs): lower-cost moorings and programme management. Secretariat of the Pacific Community.

anchor was deployed close to the third waypoint. The vessel stopped for the anchor deployment. The anchor was lifted using the ship's boom, and swung out over the rail. A crewman armed with a machete then cut a sacrificial rope allowing the anchor to fall freely (Fig. 8). With a bit of luck the anchors should have landed near the intended sites. Position checks just after deployments indicated that all six FADs were on the mark.

Positions of the six FADs were:

Round Hill FAD: 09º58.75'S and 147º27.00'E in 750 m;

Gabagaba FAD: 09º49.75'S and 147º22.00'E in 750 m;

Pyramid FAD: 09º37.00'S and 147º13.00'E in 1100 m;

Daugo B FAD: 09º34.25'S and 147º01.00'E in 1100 m;

Daugo A FAD: 09º32.50'S and 146º57.75'E in 1100 m; and

Idihi Light FAD: 09º29.75'S and 146º46.00'E in 1100 m.

Figure 9 shows one of the six FADs just after deployment.

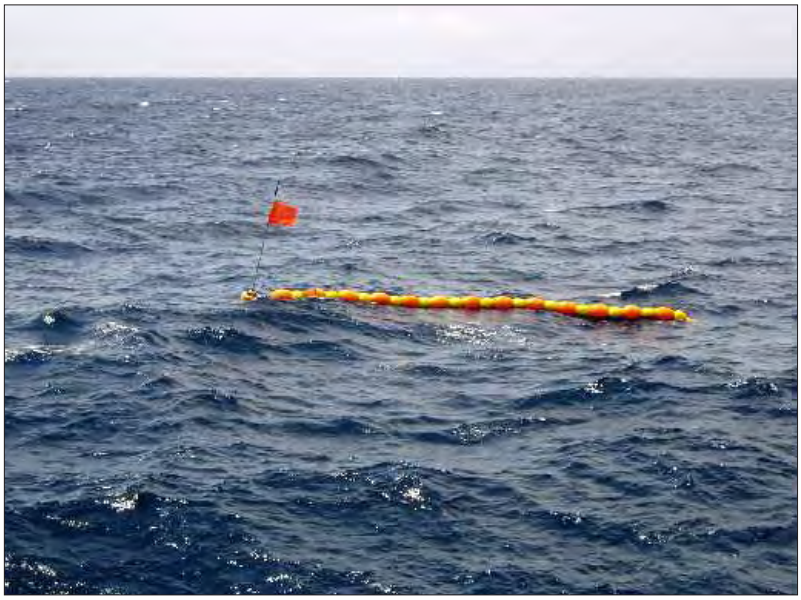


Figure 8 (top): Cutting the anchor free

Figure 9 (bottom): One of the PNG FADs just after deployment

This FAD project was not a simple SPC field project. It was a cooperative endeavour that could not have happened without the contributions of various people and organisations. The World Bank provided expertise. PMGFC and the EU's RCFDP provided funding for all FAD materials and assistance during the deployments. NFA provided accommodation for the Fisheries Development Officer for his entire stay in Port Moresby. PMGFC provided a vehicle and fuel to the Fisheries Development Officer for his entire time in Port Moresby. PMGFC also provided the use of the three FAD survey vessels, fuel for the surveys, meals for the surveys and deployments and many man hours of help during the surveys and deployments. SBS Electrical provided materials and logistical support. Moore Printing provided a warehouse for rigging and storing the FAD moorings. The Bump Shop fabricated the six wood boxes used for storing and deploying the FAD ropes, and they fabricated Samol's rope turntable. The Bump Shop also recovered and delivered all of the forklift counter-weights. Steamship's Shipping provided the use of the deployment vessel, M/V *Agutoi Chief*. And finally, NFC provided the services of Samol Kaniwa, and Kaius Mai, who both worked hard during the project and helped to make it a success.

All six FAD deployments were successful and without mishap. The deployments were carried out on 13 and 14 December 2006. Unfortunately, it was reported by members of the

PMGFC that some of the FADs had been vandalised soon after deployment. This sad note spoiled what was otherwise a model FAD project. This happened in spite of a public awareness programme that was carried out by the RCFDP that included a live radio broadcast the day after the last three deployments. For any future FAD deployments in the Central Province it may be better to rig and deploy a FAD similar to the FAD deployed in 1992. This FAD was a spar buoy FAD with a heavy duty chain for the upper mooring and heavy duty double sheathed 32 mm rope (Samson Braid) for the rope portion of the mooring. This may have accounted for the longevity of this FAD. It stayed on station three years and produced noticeable benefits for the fishing community, including artisanal fishermen and sports fisherman alike. Another option to consider in the future would be the deployment of sub-surface FADs.

In Brief

- As part of a two-month assignment in Papua New Guinea (PNG), Fisheries Development Officer (FDO), Steve Beverly, looked at the domestic longline fishery in order to advise on improvements to increase profitability and sustainability. Three longline companies were examined, Sanko Bussan PNG, Fare well Investments, and Latitude 8. Between them they operate a fleet of around 30 tuna longliners. These three companies had been experiencing losses and were having difficulties operating profitably due to a number of factors, including rising fuel and airfreight costs, decreasing market value for export fish, and decreasing catch rates. Several boats were looked at in this brief study, including boats from each company. Off-loading and processing was also viewed from all three companies. The Fisheries Development Officer, however, only went on one fishing trip. A number of problems were identified with the vessel and this information has been passed on to the National Fisheries Authority in a formal report. Airfreight availability and cost have always been a problem for PNG longline fisheries. The cost of air freighting fresh tuna to foreign markets is often equal to half the total revenue from fish sales, and cargo space is often hard to find. One way to avoid the dependency on airfreight is to produce frozen value-added products that can be exported by sea freight. One option to be considered is producing value-added products on board vessels. In order to do this, however, new vessels would be needed for the fishery.

- In November 2006, Fisheries Development and Training Adviser, Michel Blanc, took part in a joint mission to Tokelau with representatives of SPC and other Council of Regional Organisations in the Pacific (CROP) and UN agencies. The purpose of that visit — a first in the region — was to receive first-hand exposure to the challenges faced by Tokelauan communities. Visits were made to the three atolls of Atafu, Nukunonu and Fakaofo, and to prepare the development of a CROP/UN Joint Strategy of Support for Tokelau for the period 2007–2009. In the area of marine resources, such integrated assistance may cover a number of areas including the management of inshore resources (stock assessments and management advice to follow up on the study undertaken by the Pacific Regional Environment Programme SPREP in 2003), the provision of alternatives to reduce the fishing pressure on inshore resources and the development of a small-scale commercial tuna fisheries sector (establishment of FAD programme, sea safety training and local value-adding). As another follow up to the November mission, it is expected that SPC and the Forum Fisheries Agency (FFA) will jointly undertake in March 2007 a feasibility study of commercial tuna longlining. The Joint Strategy of Support for Tokelau should be presented to the Tokelauan government by April 2007.

- In keeping with the spirit of the Ecosystem Approach to Fisheries, several sections within SPC's Coastal Fisheries Programme are implementing, in close collaboration with the Nauru Fisheries and Marine Resources Authority, an interesting project that may improve the well-being of communities in Nauru. Starting in March 2007 with a four-week canoe building workshop for the Nauru Fisheries and Marine Resources Authority (NFMRA) staff and prospective boat builders, the project will deploy a number of inshore fish aggregating devices (FADs) — several innovative designs will be experimented with — and a series of

workshops on safe canoe handling and FAD-associated fishing methods. A professional boat builder will supervise the canoe building workshop (four one-man KIR-7 canoes will be constructed), while SPC Fisheries Development Officer, William Sokimi, will assist NFMRA staff with FAD deployments and follow up FAD fishing skills workshops. Two communities have been identified by NFMRA and the SPC Coastal Fisheries Management Section will be involved in the project as part of their community-based fisheries management plan. NFMRA will monitor the use of the project canoes and inshore-FADs in collaboration with the concerned communities. If successful, the canoe/inshore FAD concept will be exported to other coastal communities in Nauru. This project is funded by the government of Taiwan/ROC, the DEVFISH project, and the Nearshore Fisheries Development and Training Section.

- The Nearshore Fisheries Development and Training Section, the Service de la Marine Marchande et des Pêches Maritimes of New Caledonia and turtle expert Mike McCoy will soon be implementing a turtle bycatch mitigation project in New Caledonia. The objectives of the project are to 1) heighten awareness of sea turtle interactions with fishing gear by familiarizing commercial fishing operators in New Caledonia and fishery observers and staff of the government Service de la Marine Marchande et des Pêches Maritimes with techniques of handling sea turtles caught incidentally to fishing operations, 2) provide appropriate equipment and instructions to the fishing industry on how to address specific sea turtle interactions with commercial fishing gear, 3) collect baseline data on interactions between sea turtles and tuna fishing vessels in New Caledonia, 4) integrate appropriate topics in sea turtle interaction with commercial fishing into the ongoing work programmes of Marine Marchande, the École des Métiers de la Mer (local fisheries training institution) and SPC, and 5) enhance cooperation among the different government and non-governmental organisations involved in fisheries management and turtle conservation, locally and regionally. The project will consist of a series of training workshops and meetings in the two ports from which the tuna longline industry operates in New Caledonia: Noumea, in the Southern Province, and Koumac, in the Northern Province. Each workshop will be conducted by the outside consultant, with assistance from SPC personnel. Presentations on the importance of reducing sea turtle interactions and mortality from the standpoint of the commercial fishing industry will be made, and mortality mitigation practices and devices explained. Individual informational meetings will also be held with the staff of Marine Marchande and senior management at the various firms engaged in tuna longline fishing in New Caledonia. A separate workshop will be held for Marine Marchande staff and onboard fishery observers. Observers will be trained in mortality mitigation techniques, record-keeping, and aspects of fishery management and sea turtle conservation relevant to the topic of sea turtle bycatch. A training syllabus to be used in this and future training in New Caledonia will be produced with assistance from the outside consultant. The project, which is funded by the US National Oceanic and Atmospheric Administration Fisheries' Pacific Islands Regional Office (PIRO), will run from March to April 2007.

- In addition to the above project on turtle bycatch mitigation, the Section's inputs into the New Caledonian fisheries sector also include technical assistance to the domestic tuna longline industry. Early in 2007, Fisheries Development Officer Steve Beverly will make a trip on each vessel owned by Navimon to observe fishing and fish handling practices, provide on-the-job training to vessel skippers, and advise on ways to improve the profitability of the vessel. It is envisaged that the Fisheries Development Officer will undertake a total of five to six two-week-long fishing trips from February to May 2007. Vessel-specific

findings will be presented to Navimon's senior management staff immediately after each trip, while the more general recommendations will be included in the end-of-project report. The government of New Caledonia has requested the Nearshore Fisheries Development and Training Section to conduct a training workshop on mid-water fishing methods around FADs for staff of local fisheries institutions. The workshop will be held in Lifou (Loyalty Islands) and is tentatively scheduled in October 2007. Meanwhile, Section staff will assist local authorities with the ordering of fishing gear and bait for the fishing workshop and trials. It is expected that, after the initial workshop, a number of commercial fishermen will continue using the FAD fishing methods (mainly vertical longlining), with their fishing activities and catches monitored by the provincial fisheries administration.

FISHERIES MANAGEMENT SECTION

National workshop on the Community-based Fisheries Management Programme

A five-day workshop was conducted 26–30 June 2006 in Nauru. The aim of the workshop was to train participants in facilitating community meetings regarding the development of community fisheries management plans, and to raise awareness among district representatives on coastal fisheries management initiatives.

The workshop was opened by the Acting Chairman of the NFMRA, Mr Cyril Buramen. In his opening remarks, Mr Buramen highlighted the importance of inshore fisheries resources for food security, and he appealled to communities to become involved in management and conservation. In conclusion, Mr Buramen highlighted the need for Nauruans to increase their use of marine resources, especially inshore resources, for food security and family incomes.

The workshop attracted 41 participants, of which, 29 were representatives from the 14 districts in Nauru, and 12 from NFMRA.

Developing Meneng's coastal fisheries management plan

Nauru's Meneng community — through their representative at the national workshop — requested NFMRA to establish a community-based fisheries management programme in their district. Consultations with the district executive committees and the district communities began in August 2006. In September, the first draft of the Fisheries Management Plan was produced.

Fisheries legislation review

In addition to establishing a coastal fisheries management programme that involves local communities, the Coastal Fisheries Management Section was also requested by NFMRA to assist with the review of the fisheries legislation. The call for a review was viewed by NFMRA as an essential component of its efforts to manage the country's coastal fisheries resources.

In September 2006, the Coastal Fisheries Management Adviser and a Nauruan legal consultant began initial consultations to review and develop Nauru's fisheries legislation. The decision to select a local lawyer was so that the team had someone onboard who was familiar with the issues and local situation. Mr Leo Keke was selected as part of the SPC team to develop Nauru's coastal fisheries legislation.

Extensive consultations with stakeholders, including government departments, corporations, NGOs and local communities were carried out by the team in order to gather information and gain wider perception in developing a legal framework for coastal fisheries management. A meeting with representatives from the 14 districts was also called to advise them of the coastal fishery legislation and to seek their advice. Quite a number of the community representatives that had attended the national workshop also attended the meeting. Several few questions were asked about empowering local communities with manageing their respective fishing areas.

The draft coastal fisheries management bill

The assignment concluded with the team producing a draft bill with provisions, including proposed regulations and fisheries by-laws that are now going through more reviews and refinements before submission to NFMRA for consideration and presentation to the necessary authorities for approval.

Coastal Fisheries Management Programme in the Solomon Islands

Through the Strategic Plan for Fisheries Management and Sustainable Coastal Fisheries in the Pacific Islands, the Solomon Islands Department of Fisheries and Marine Resources (DFMR) requested assistance from SPC's Coastal Fisheries Management Section in establishing a national community-based fisheries management programme (CBFMP) for the Solomon Islands. The programme recognises DFMR's legal obligations to lead the management and conservation of inshore fishery resources in the country.

Preliminary study

From 20 July–5 August 2006, the Coastal Fisheries Management Adviser (CFMA) undertook a preliminary study to find out how the national CBFMP for Solomon Islands may be developed, taking into account the availability of fisheries personnel, finance, the support of other interested government departments, NGOs, and the reactions of local communities. The study also identified the respective responsibilities of the DFMR and SPC for the initial development of the national CBFMP. Recommendations from the study led to the implementation of the following activities by DFMR and SPC's Coastal Fisheries Management Section.

National workshop

Following on from the preliminary study, a national workshop

Top: Fisheries Extension Officers at the national CBFMP workshop

Middle: DFMR Extension Officers during one of the practical exercises

Bottom: Chief Fisheries Officer for Extension and Development Mr Alex Carlos offering an explanation

on CBFMP was conducted in the first week of October 2006. The workshop aimed at training Fisheries Extension personnel to become community facilitators and understand the basic principles of CBFMP.

Workshop activities were mainly presentations on aspects of community-based resource management and the roles of community facilitators, experience-sharing — not only from existing programmes from other countries, but also from work already carried out by the NGOs in the Solomon Islands — and, practical exercises where participants were given the chance to put into practice what they learned during the workshop.

Participants were also given the opportunity to discuss and analyse some of the projects implemented in their respective provinces, the successes and failures of those projects, and lessons learned for positive progress under the scope of coastal resources management involving local communities. Participants included fisheries extension officers from the provinces, senior officers from DFMR headquarters, staff from various NGOs in the Solomon Islands, and community representatives.

Awareness programmes

The successful implementation of the CBFMP depends on the level of awareness among local communities about marine resources and ecosystems, problems associated with these, possible solutions, and actions that minimize its effects on the communities that depend on these resources on a daily basis.

Taking this into account, 12 information sheets were produced. These contained simple and basic information written in everyday language, and targeting students of all levels, decision-makers, and the community at large. Topics included fisheries management at the community level, how CBFMP works, marine pollution, mangroves, coral reefs, marine protected areas/fish reserves, ciguatera fish poisoning, coral reef management and aquaculture.

These will be translated into the local language (Solomon Islands Pidgin) and distributed to all provinces by the Fisheries Extension Officers. DFMR will also run radio campaigns and advertisements using the local media.

Staff attachment

In October 2006, the Chief Fisheries Officer (for Extension and Development) and Acting Chief Fisheries Officer (Research) undertook a two-week attachment with the Coastal Fisheries Management Section at SPC in Noumea. The main purpose of the attachment was to develop a model for the Solomon Islands CBFMP, taking into consideration the complexity of the Solomon Islands' tenure system. The approach should be culturally acceptable and the design should involve local communities in the decision-making process. The attachment concluded with a presentation by DFMR staff of the so-called Wantok Model for CBFMP in the Solomon Islands in which all SPC fisheries staff were invited.

Future activities

- Continue with nation-wide awareness programmes and media campaigns. Fisheries Extension Officers should carry out awareness programmes and distribute information sheets in their respective provinces.
- Work closely with interest communities in developing their respective fisheries management plans.
- Review existing legislation to provide for empowerment of local communities to take responsibilities with the management of inshore fishery resources.
- Conduct a review of the programme on a six-monthly basis.

First phase of fisheries statistics and stock assessment training successfully completed

A two-week training programme (conducted 27 November–8 December) in fisheries statistics and stock assessment has been successfully completed at the University of the South Pacific (USP) in Suva, Fiji, by participants from 16 Pacific Island countries.

"In 2004, the Icelandic government and the Commonwealth Secretariat (ComSec) decided to support SPC and USP in providing training for government fisheries officials from Pacific Island countries," says Dr Tumi Tomasson, Director of the Fisheries Training Programme at Iceland's United National University (UNU). Dr Tomasson represented the Government of Iceland in the joint effort.

"Under the ComSec and Government of Iceland three-year development assistance programme in fisheries for

Pacific Island countries (2005/06–2007/08), funds were provided to meet the cost of a regional training course in fish stock assessment and statistics," explains Semisi Fakahau, Adviser from ComSec. "Two fisheries scientists from the UNU Fisheries Training Programme and USP experts delivered the course to 25 participants from 16 countries."

The programme is designed to fulfil the needs of national fisheries agencies for training in the use of basic fisheries data to assess the status of fish stocks. Assisting fisheries agency staff in their efforts to collect, store, retrieve and analyse basic fisheries data and indicators to monitor the status of fish stocks is a need identified in the SPC-produced Strategic Plan for Fisheries Management and Sustainable Coastal Fisheries in Pacific Islands. Addressing this goal includes the provision of short courses on the "collection of fisheries data from subsistence fisheries" and the "use of basic fisheries data in assessing the status of fish stocks" for staff of fisheries agencies in Pacific Island countries.

Tongan participant Tu'ikolongahau Halafihi recognised that, "We do fisheries management in the Pacific but we manage our resources without knowing the stock. After the course, the stock assessment principles became clear to us. It is my hope that it will help us to protect our resources from overfishing and extinction and also conserve and further develop our resources."

Joyce Samuelu, from Samoa, said, "I would like to thank the lecturers for the very valuable training they provided. It was eye-opening for me and certainly made a huge change. Data sampling will never be the same for me again."

Participants are now working on national assignments of which many will be using the national data collected from the PROCFish surveys to assess the level of important inshore fishery resources in their respective countries. The final phase of the training is scheduled to be held in Samoa towards the end of the year.

REEF FISHERIES OBSERVATORY

Staff of the coastal component of the Pacific Regional Oceanic and Coastal Fisheries Development Programme (PROCFish/C) and the Coastal Fisheries Development Programme (CoFish) concluded all fieldwork in both the Solomon Islands and Papua New Guinea (PNG) in the fourth quarter. This included invertebrate, finfish and socioeconomic surveys at two sites in PNG's Milne Bay Province (Sideia and Panaete–Panapompom; see Fig. 1), and the final finfish and socioeconomic survey at Marovo Lagoon in the Solomon Islands.

Survey work in Papua New Guinea

Survey work was conducted in Sideia and Panaete–Panapompom in October and November 2006 (split schedules for different disciplines). The PROCFish/C survey team consisted of 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, who conducted all socioeconomic surveys at these two sites; Noel Wangunu, Conservation International (CI); Jimmie Muraga, CI; and Jeff Kinch, private fisheries consultant; and the elders, community members and people from the two sites surveyed. The use of Conservation International equipment, such as dive tanks and a dive compressor, greatly contributed to the success of this PNG mission.

Sideia

Sideia is a mountainous island with no distinct intermediate reef system. Eighteen dive stations were sampled (Fig. 2), and these covered the outer reef, back reef and coastal reef. The coastal sites showed a moderate density of fish of average sizes, and a relatively high biodiversity. Fish were sometimes nervous from the diver's presence and their reaction was attributed to the effects of spearfishing. The outer reefs consisted of very steep walls topped by shallow flat reefs with higher densities, sizes and biodiversity of fish compared with coastal reefs. The back reefs also showed rather high values of density, average sizes and biodiversity of fish.

The team encountered a few schools of *Bolbometopon muricatum* (bumphead parrotfish), on the outer reef and back reef sys-

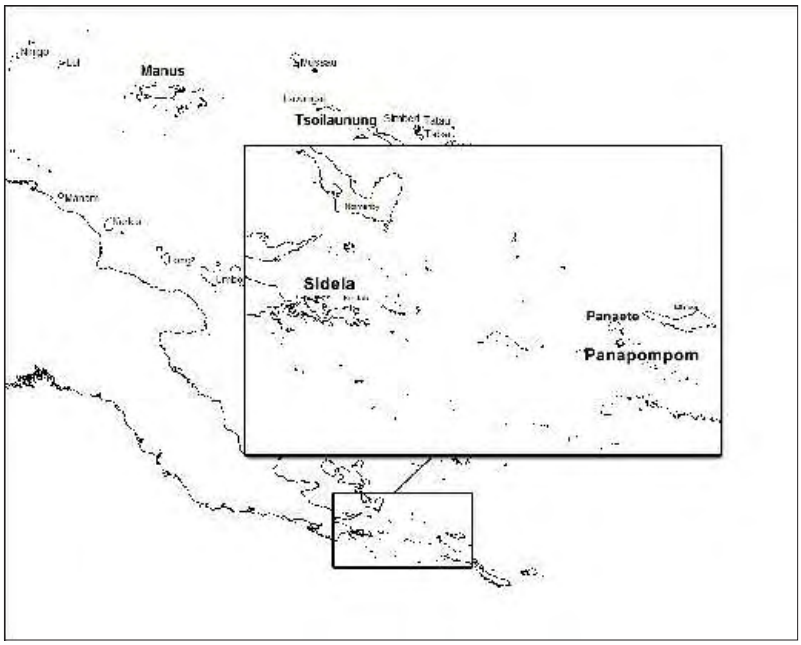


Figure 1 (top): Survey sites in Papua New Guinea
Figure 2 (middle): Sampling sites at the Sideia Island fishing area
Figure 3 (bottom): Local fisherman in Sideia

tem, and *Cheilinus undulatus* (Maori wrasse) — a CITIES listed endangered species — was rather common across the three habitats. Other herbivorous fish such as parrotfish and surgeonfish were quite abundant and often sighted in large schools in the three habitats. Jacks, trevallies and schools of rainbow runners and fusiliers were also sighted in several sites. Top predators such as sharks, groupers, coral trout (Fig. 3), snappers, sweetlips and emperors were a rather common sight across the three habitats. Spearfishing is not common on the island, while handlining on the outer reef slope and the adjacent lagoon area used for subsistence is relatively widespread, and is mainly done from traditional dugout outrigger canoes. From discussions with fishermen, most handline fishing is done over depths of 60–100 m off the outer reef.

Thirty households were surveyed at Sideia, randomly selected from the major hamlets along the coast. In addition, 30 finfish fishers and 30 invertebrate fishers were interviewed. The people are heavily dependent on fisheries resources for their diet and income generation, although they had alternative sources of nutrition and income with crops and livestock (pigs and chickens). Per capita fresh fish consumption in Sideia was 23.9 kg/year with 43% of households quoting fisheries as a first source of income. On average, three people per household were involved in fishing, with 90% of Sideia households owning a canoe (Fig. 4).

Finfish fishers target the sheltered coastal reef, lagoon and outer reef areas, with handlining being the main fishing method. Men target the outer reef, while women and children stay closer to shore and fish the more protected sites. The average annual reported catches of Sideia fish-

ers range between 311 kg/fisher for the sheltered coastal reef and 351 kg/fisher for the outer reef, with CPUE ranging between 0.5 to 1.2 kg/hour fished. The average catch per trip is low: 3–4 kg at the sheltered coastal reef and 5–19 kg at the outer reef. Invertebrate collection is much less important than finfish fishing, and mainly done by women and children for subsistence purposes, although the collection and processing of sea cucumbers during the season has been a major source of income.

The invertebrate surveys revealed an almost complete absence of sea cucumbers in the Sideia fishing area. This was true for even the low value species. Algal blooms (blue green) were common on both reefs and sandy areas, and the surfaces were predominantly silted, which may be partially a result of the absence of these "system sweepers". Relatively moderate densities of white teatfish (*Holothuria fuscogilva*) were recorded on deep dives, but these were in deeper water (greater than 25 m, which provides a surrogate protected area for this stock) and difficult for free divers to access. Trochus similarly has been removed, with low numbers recorded. Trochus fishing is a daily activity during the beche-de-mer closed season.

Relatively moderate densities of giant clams were recorded, especially *Tridacna maxima* and *Hippopus hippopus*. A few *Tridacna derasa* specimens were also recorded. There was also a moderate presence of the painted spiny lobster (*Panulirus versicolor*).

Panaete–Panapompom

Panaete–Panapompom is an atoll formation about two hours by dinghy from Misima Island. Both islands are high volcanic islands; Panapompom is in the centre of the lagoon system, while Panaete lies on the northern border (Fig. 5). The fishing area of Panapompom is shared with the northern island of Panaete. Fishermen from Panapompom travel exclusively by sailing or paddling canoes (Fig. 6). This creates a tension with motorboat users from Panaete Island. Four habitats (outer reef, back reef, coastal reef and intermediate or lagoon reef) as well as the whole fishing area near the Panapompom community were sampled, with 24 dive stations surveyed (Fig. 5).

Overall, the site has a very high density of fish of average sizes, and high biodiversity. The barrier reef to the west of Panapompom appeared to be impacted by fishing pressure, probably due to the fishers from the larger island of Panaete targeting this area. Surveys at Panapompom found a larger size of coral trout and groupers, along with larger herbivorous

Figure 4 (top): Traditional sailing canoe in Sideia

Figure 5 (bottom): Sampling sites in Panapompom fishing area

fish such as Maori wrasse, bump head parrotfish, surgeonfish, and unicornfish, compared with Sideia. However, there was a lack of sharks, probably because fishers harvest them for the Asian sharkfin market. Stock abundance was almost the same across the four reef habitats, which is quite unusual given the proximity of the coastal reef area to the fishing community. The unusually high density and biomass of fish in the coastal reef area of Panapompom might be attributed to the community's effort in creating a 100 m closed area around the coast of the island where fishing activity of any sort was banned. This restriction was still in place when the survey team was on the island. Moreover, after the decommissioning of the gold mine on Misima, the main trading centre for the area, fishing for commercial purposes declined (this has been the case for almost three years). This long break in commercial fishing might have contributed to the recovery of most commercially sought-after fish stocks, which were observed in great abundance in many of the surveyed stations.

Thirty households were surveyed in this area, consisting of 20 households from the Panapompom settlement (Fig. 7) and 10 from Panaete. In addition, 30 finfish fishers and 30 invertebrate fishers were interviewed. The people were found to be heavily dependent on fisheries resources for their diet and income generation, although they had alternative sources of nutrition and income such as agriculture, handicrafts and livestock (pigs and chickens). Per capita fresh fish consumption in Panapompom and Panaete was 36.2 kg/year, with 70% of households quoting fisheries as a first source of income. On average, three people per household were involved in fishing, with 73% of Panapompom and Panaete households owning a canoe or motorised boat.

Finfish fishers target the sheltered coastal reef, lagoon and outer reef areas, using a combination of handlines, deep bottom lines and trolling. Men target the outer reef, while women and children stay closer to shore and fish the more protected sites. The average annual reported catches of Panapompom and Panaete fishers range between 311 kg/fisher for the sheltered coastal reef, and 534 kg/fisher for the outer reef, with CPUE ranging between 0.7 kg/hour and 3.5 kg/hour. Invertebrate collection is much less important than finfish fishing, although the collection and processing of sea cucumbers during the season was a major source of income.

Figure 6 (top): Traditional sailing canoe (the only means of transport in the village) in Panapompom

Figure 7 (bottom): Community meeting in Panapompom

Like Sedeia, despite good habitats (shallow sandy lagoons, sea grass beds, rubble bottoms along the inner barriers), there was an almost complete absence of sea cucumbers at Panapompom. Even the lowest value species (e.g. lollyfish, *Holothuria atra*) were absent. Algal blooms (blue-green) were noted on reefs, sand and even down to 35 m depth, where drifts of blue-green algae in the current were swamping the surfaces of black coral stands and killing them. Deepwater assessments were more promising, with some relatively good densities of white teatfish (*H. fuscogilva*) at around 25 m. One unidentified species of sea cucumber was also recorded (Fig. 8).

The conditions at Panapompom, despite the lack of shoals, were better for trochus (*Trochus niloticus*), but stocks were depleted. Reefs known for trochus held the bare remnants of what was once an excellent resource (judging by habitat, and the presence of dead shells and index top shells).

Giant clam stocks were very promising for larger specimens of *Tridacna maxima* and *Hippopus hippopus*. Other species were rarer, although two large *Tridacna gigas* and a few *Tridacna derasa* were seen. There were more specimens of dead shells of larger species present than living specimens. Lobsters were in moderate numbers, represented primarily by the painted spiny lobster, *Panulirus versicolor.*

Figure 8: Unidentified sea cucumber specimen from Panaete–Panapompom

Solomon Islands: Marovo-Chubikopi village

Conducting the finfish and socioeconomic surveys in the Chubikopi village area (Fig. 9) in December completed all PROCFish/C fieldwork in the Solomon Islands. The PROCFish/C finfish team consisted of Silvia Pinca and Pierre Boblin, with programme attachment, Rosalie Masu conducting the socioeconomic surveys. The team acknowledges and thanks the following people who assisted or worked with the team: Ms Ethel Sigimanu, Permanent Secretary at the Department of Fisheries and Marine Resources, and Patrick Mesia, Rosalie Masu, the boat skipper Bradley, and the fishers and community in Chubikopi for helping to make the trip successful.

The team sampled the four habitats found in the area. Six transects were surveyed on each of the following habitats: the coastal and intermediate reefs, the back barrier reefs, and the outer slopes of the barrier reefs. Marovo Lagoon does not appear to be naturally rich in coral; the bottom is sandy and often covered in silt or mud. The inner reef (both coastal, back and intermediate) coral assemblage is very poor (Fig. 10), with very few coral patches

in the middle of the lagoon, and very shallow coastal reefs around the main island of Marovo, often covered by large macroalgae. The coral motus that make up most of the barrier reef hinder water exchange with the open ocean. In addition, this sector is subject to the effects of logging and deforestation and consequent erosion that impacts the lagoon during every rainy season. The outer reef in contrast is quite rich and diverse in corals (Fig. 11).

Fish abundance and diversity were generally very poor. The fish fled immediately when they detected divers and returned much later, or not at all. The marine reserve visited on the barrier reef in the middle of the motu chain in the north has a very small surface area, and it would have very little impact in regard to replenishing finfish stocks in the lagoon. The fishing area in front of Chubikopi should be classified as impacted.

Motorboat fishers practice hook-and-line fishing, night-time spear-fishing with flashlights, and net fishing in a very sporadic manner. Local fishermen from Chubikopi and other villages around Marovo Island are at present fishing beyond their customary local borders due to poor catches in front of their villages.

Figure 9 (top): Sampling stations in Marovo Lagoon, in front of the island of Chubikopi

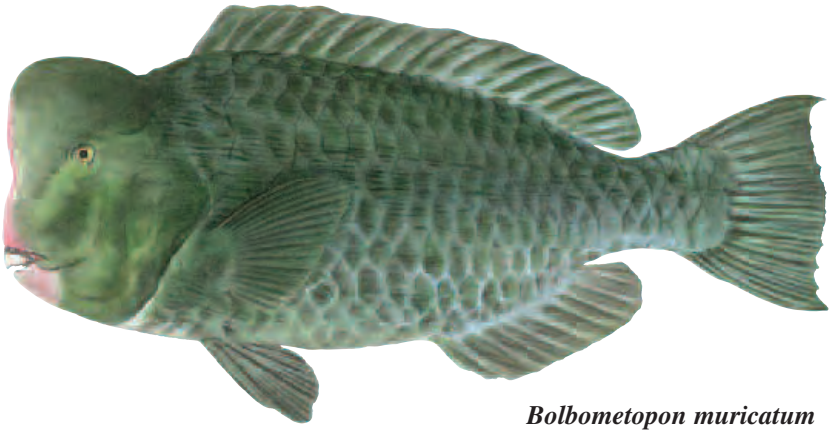
Figure 10 (right): Poor coral assemblage in lagoon site

Figure 11: Rich coral coverage on the outer reef

Activities back in Noumea

With the winding down of fieldwork for the year in the fourth quarter, staff focused on data entry and checking, data analysis, and writing country site reports for each of the three disciplines (finfish, invertebrates and socioeconomics). Once these reports are completed for each discipline, they are placed on the PROCFish/C website in the restricted area, and the country or territory concerned is notified that the draft site report is available. This process will continue between fieldwork activities to make the data available to countries and territories as soon as possible after completion of fieldwork.

Additional paperwork for the two-year, no-cost extension for the PROCFish programme, including specific information requested by the European Commission, was provided in December 2006. It is anticipated that the final decision will be made in early 2007, before the current completion date for the coastal programme of 28 February 2007.



Bolbometopon muricatum

BABY FISH "SMELL THEIR WAY HOME"

Marine scientists working on Australia's Great Barrier Reef have uncovered evidence that baby fish, only millimetres long, manage to find their way to their home coral reef across miles of open sea by using their sense of smell.

Remarkable in itself, the discovery by a team including Professor Mike Kingsford of the ARC Centre of Excellence for Coral Reef Studies and James Cook University and colleagues from Woods Hole, USA, also shines a new light on how the breathtaking diversity of fish on coral reefs has arisen. This has major implications for how reefs are managed.

"The babies of many coral fish species are swept off their home reef by ocean currents within days of hatching. Ordinarily you'd expect them to be thoroughly mixed up and this would mean the population of one reef would be pretty much the same, genetically, as another," he says.

"But that is not the case. There are major genetic differences between fish of the same species on reefs only a few kilometres or even hundreds of metres apart."

This diversity between populations of the same fish species is what drives evolution on the Reef and underpins the spectacular richness of its sea life, Prof Kingsford says. "This genetic separation between reefs may be what gives rise to so many different species in coral reef systems."

The researchers were intrigued how tiny damsel and cardinal fish, born on one reef, managed to find their way back home to preserve such remarkable population differences, braving strong currents and ferocious predators in their 20 days at sea — all when only a centimetre or so in size. "We tested several ideas, but the most attractive seemed to be that they could smell the unique trace of their home reef, rather like salmon can smell the home river.

"We know these late stage fish larvae, generally between about 9 and 14 mm long, already have developed noses, but the question was whether they could use them to recognise what the home reef smelt like, when they left it only a day or so after hatching."

The team exposed tiny fish larvae in a tank to pure streams of water from four different reefs. To their amazement, within minutes a surprisingly high percentage of baby fish had congregated in the water flow from their home reef.

"It was a lot more than you'd expect to happen by pure chance, and it applied, in differing degrees, across several species of fish," Kingford says.

The fish could also be responding to other stimuli, including distant noise off a reef and the behaviour of other fish, but the team concluded that smell was probably the dominant factor leading the babies home.

"Every reef gives off its own unique chemical signature, a rich mixture of the proteins and amino acids emitted by corals, all the plankton and mucus from its life. We think baby fish can pick this up and distinguish it from other reefs.

"We think some fish then choose currents that smell like 'home' and swim up them. The ones that cannot do this perish. The ones that get home preserve the unique 'ethnic' make-up of their tribe, and so continue the process of evolving into separate new species."

How the fish learn the unique smell of home is a mystery still. The researchers theorise that it is imprinted on them either when they are an egg inside their mothers, a fertilised egg swept around on the bottom, or new-hatched fry loose in the stream or brooded in their parents' mouths.

"An egg, even a fry, hasn't a fully developed sense of smell, but it may have a way of absorbing the local molecules and then recognizing their signature as "home" when it grows up a bit and is ready to settle," Kingford says.

"This evidence that individual coral reefs play such a key role in the emergence of new species is a fresh reason to take even greater care in how we look after them."

The research has been published in the Proceedings of the US National Academy of Sciences on January 16, 2007, 104/3.

(Source: http://www.coralcoe.org.au/news_stories/olfactory.html 22 January 2007)

AQUACULTURE DEVELOPMENT ADVANCES IN AMERICAN SAMOA

It's been an encouraging year for American Samoa's nascent aquaculture industry. A long-awaited giant clam hatchery is nearly complete, and a leading producer of the US territory's top aquaculture crop, tilapia, began extensive expansions to his operation.

And that's not all. John Gonzales, the Sea Grant extension agent in American Samoa, sounds the most excited when he talks about helping tilapia farmers convert their farms to integrated aquaculture–agriculture systems through either aquaponics — which combines aquaculture with hydroponics, or the growing of plants without soil — or the use of fish waste as a fertilizer in traditional agriculture practices. Gonzales, six months into his role as the junior aquaculture extension agent for the University of Hawaii Sea Grant College Program, is also teaching his students at the American Samoa Community College (ASCC) about aquaponics as part of a general focus on sustainable aquaculture.

"Since agriculture is a socially and economically important component to the Samoan lifestyle, they can see the conversion from fish waste to plant growth," Gonzales says. "Sustainability is very important to them."

Producers are also introducing better management practices, such as techniques that control breeding. Yet Gonzales is most proud of the few farmers who are already adopting integrated techniques. Troy Fiaui of Auto village, for example, is retrofitting his two cement raceways with pumps, and plans to use fish effluence to irrigate taro, bananas, and other fruit and vegetable crops.

Another producer, Alailepa Fiti from Western Samoa, has a farm down a long bumpy road on land in American Samoa granted to him by a high chief. "He's implementing net cage technology even though others scoff at him," says Gonzales. "To see someone work hard and be productive with little resources is inspiring."

Change is never easy. And a switch to aquaponics for two farmers accentuates the greatest challenge faced by aquafarmers in American Samoa: nutrition, including a lack of access to low-cost feeds. Even so, aquaponics culture systems should eventually result in production that is not only greater but also more reliable than production experienced with traditional green water systems, Gonzales says.

Local tilapia production has yet to fill consumer demand, but the industry grows. The man who some credit with jump-starting the tilapia industry in American Samoa by providing other farmers with fingerlings is expanding his operation. President of the Samoan Family Sunfish Cooperative, Alosina To'omalatai is adding six cement tanks to his farm, which already has two raceways and about eight tanks. He's receiving up to USD 25,000 in materials to complete construction of the new tanks from the Vocational Rehabilitation and Employment Service of the Department of Veterans Affairs, says Selina Higa, of the Veterans Affairs Regional Office in Honolulu. The program helps veterans with service- connected disabilities pursue education or self-employment.

"We can't buy fish or shrimp for him, but we can buy — directly from vendors — food, supplies, or more tanks for growing the fish," Higa says. In most cases, the agency hires contractors, but To'omalatai opted for materials in order to maximize funding. The VA is helping a few other veterans with aquaculture ventures in American Samoa, Higa says.

To'omalatai also hopes to make his operation more integrated, adds Gonzales. Plans include making his own feed and adding a house on site. He wants to start selling fish and other crops directly to end customers and is looking for an outlet akin to a roadside stand.

What about the giant clam hatchery? It is nearly operational and almost ready to start spawning trials. Years in the making, the hatchery in Aloa village will provide clam seed for growout by villages on the islands of Tutuila and Manu'a.

Giant clams are a delicacy in American Samoa. Some of the cultured clams will be raised as food or used for stock enhancement near depleted coral reefs, but most clams will be sold to the aquarium trade.

Owned by nonprofit Native Resources Developer Inc., the hatchery also will provide education and training for local people. "Creating more opportunities and increasing the capacity of people on the islands is critical to the future of aquaculture here," Gonzales says.

In another step toward that end, Kevin Hopkins, Ph.D., professor of aquaculture at the University of Hawaii at Hilo, and Gonzales have developed an aquaculture certificate program at ASCC that will enable students to continue on to the aquaculture program at UH Hilo and/or to start their own business or take over another business in American Samoa, says the extension agent.

Gonzales is optimistic about aquaculture development in the territory. He points to the strong support from Congressman Eni Hunkin Faleomavaega, ASCC President Adele Satele Galea'i, PhD, and the matai or chiefs — some of whom are farmers themselves. "Villagers look up to their chiefs and follow their example," Gonzales says

Source: Center for Tropical and Subtropical Aquaculture Regional Notes vol. 17, n. 4, December 2006. www.ctsa.org

SANDFISH HATCHERY TECHNIQUES MANUAL

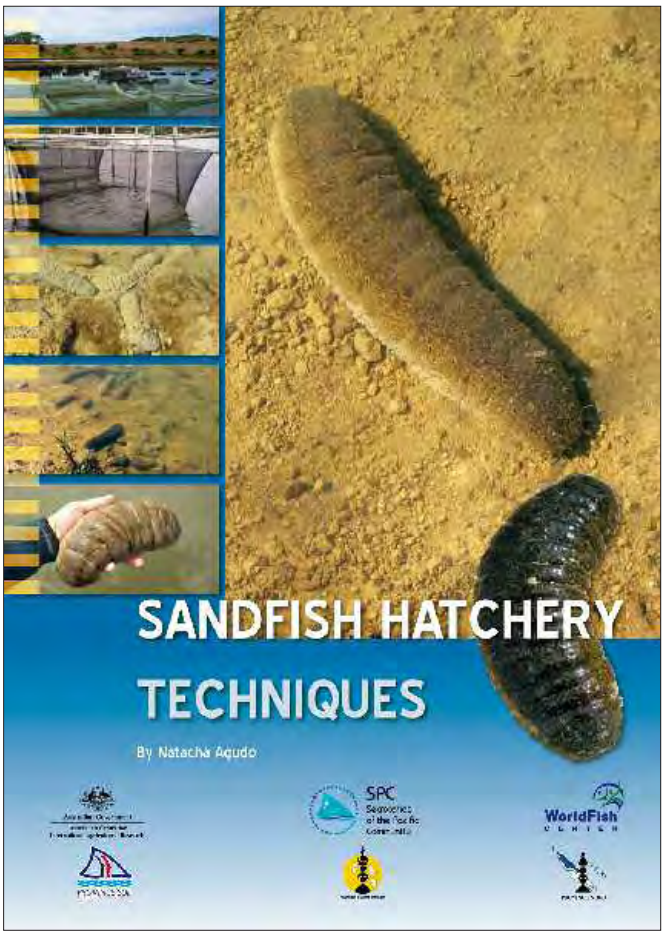
Given the overexploitation of sandfish, programmes to release juveniles into the wild, "put and take" sea ranching operations, and tank or sea pen hatcheries for juveniles could all help restore populations of this sea cucumber, which has a very high market value. A manual has been developed to help government agencies and members of the private sector interested in implementing any of the methods mentioned above.

The manual outlines basic methods for spawning and rearing juvenile sandfish. It builds on the pioneering work done in 1988 at the Tuticorin Research Centre of the Central Marine Fisheries Research Institute (CMFRI), in India and is based largely on methods developed and applied by the WorldFish Center (formerly ICLARM) in the Solomon Islands, Vietnam and New Caledonia.

The information in the manual will enable hatcheries to produce sandfish suitable for release to the wild in relatively large numbers (tens of thousands) on a regular basis. However, it does not pretend to be fully comprehensive, but is rather a reflection of current knowledge.

The manual is available (in English and French) from the Australian Centre for International Agricultural Research (ACIAR) (www.aciar.gov.au/web.nsf/publicationlatest), the Secretariat of the Pacific Community (SPC) (www.spc.int/coastfish/), and the WorldFish Center (www.worldfishcenter.org).

Source: Natacha Agudo,WorldFish Center, c/o Secretariat of the Pacific Community, BP D5, 98848 Noumea cedex, New Caledonia



SUVA HARBOUR FOUNDATION

Suva Harbour forms a beautiful ocean backdrop for Fiji's capital city. The harbour, however, is becoming increasingly polluted by sewage, solid waste, oil spills, and abandoned ships. The Suva Harbour Foundation (SHF) was founded in 2004 to improve the environment of the harbour. SHF attempts to highlight harbour environmental issues and focus public attention on ways to make improvements.

The current president of the foundation is Colin Philp who is supported by a board of directors who come from backgrounds in awareness campaigns, scientific studies, water sports, fisheries, and the Fiji Navy.

A grant from the Wildlife Conservation Society enabled SHF to begin activities. This has been followed up by generous assistance from Colonial Bank and a grant from the International Waters Project through the Environment Department is pending. Presently, all activities of the foundation are on a voluntary basis.

The work of the SHF has been modest to date. The foundation has:

- made an up-to-date compilation of all laws and regulations relevant to Suva Harbour. About 30 legal instruments have been collected, including the Sea

Top: Suva Harbour from the air

Middle: Derelict vessels that could potentially sink are a major problem in Suva Harbour

Bottom: Fishing vessels in Suva Harbour, some of which may end up on the bottom where they pollute and are expensive to remove

Ports Management Act, Fisheries Act, Wreck and Salvage Act, and the Drainage Act;

- organized community clean-up campaigns for Mosquito Island and the Suva foreshore;
- promoted the use of re-useable canvas shopping bags, rather than plastic bags;
- advised Suva city on the management of Mosquito Island;
- drawn attention to the issue of derelict vessels sinking in Suva Harbour;
- notified authorities of oil pollution events;
- provided input into the debate on new wharf construction in the Lami area; and
- encouraged the formation of foreshore recreation areas.

In the medium term future, SHF will focus on rapid responses to urgent issues such as oil spills, imminent sinking of vessels, and acute sources of pollution, while also carrying out ongoing public awareness programmes.

(Source: Bob Gillett)

Suva Harbour: Did you know?

Thousands of disposed plastic bags are a major problem in the harbour, and the number of such bags floating in the harbour, washing up on the beaches, fouling outboard engines, and snagging on coral and trees is increasing. In the recent past, the Cook Islands government has banned the use of such plastic bags. Regulations doing the same in Samoa will soon become effective.

Fuel spills from vessels have been a chronic problem for Suva Harbour, and have especially affected fishers and recreational users. Pago Pago harbour in American Samoa is the home to two of the largest tuna canneries in the world, and tuna vessels from a wide area of the Pacific unload there. Pago Pago has regulations against oil spills and other forms of vessel-related pollution. These are strictly enforced and penalties are immediate and severe. Many vessels, especially older Asian fishing vessels, are chronic polluters, and unable to comply with Pago Pago's strict anti-pollution measures. Those vessels go to other harbours in the region where regulations and/or enforcement are more lax, and many of them choose Suva Harbour.

Sunken vessels are a hazard in the harbour, a source of pollution, and very expensive to remove after they are on the bottom. Presently there are a large number of derelict fishing boats in the harbour and a few have sunk recently (two sank just off Mosquito Island last year). In June 2005 a new legal tool became available. The Sea Ports Management Act became effective and now derelict/dangerous vessels may be removed by port authorities before they sink.

Tuna vessels in Suva Harbour. Many older Asian vessels are unable to comply with the strict pollution regulations in Pago Pago and may choose alternate ports such as Suva.

FISH AGGREGATING DEVICES: THE OKINAWAN/PACIFIC EXPERIENCE

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Background

In the Pacific region, fishers from most coastal communities predominantly engage in gleaning for sea shells and crustaceans on the dry reef flats and in shallow water pools formed at low tide. Fishers also engage in line fishing, netting and diving activities along the reef dropoffs, bays, coves, inlets, and lagoons, while those with sailing canoes and powered punts frequently undertake offshore trolling for pelagic species. The spread of urbanisation into once rural areas and the increasing reliance on cash to cope with urban demands has turned many subsistence fishing activities into semi-commercial or fully commercial activities that equate earning capacity with quantity harvests. This puts considerable pressure on reef stocks, and the result is that some areas face reef damage or deterioration of fisheries resources, which can take years to recover. Encroachment of urban fishermen into rural fishing areas also increases the rate of fisheries resource extraction in these fishing grounds and leads to larger areas of declining reef stocks.

Regional fisheries organisations, country fisheries departments, fisheries-affiliated NGOs, and environmental groups are actively trying to curtail unsustainable and destructive fisheries practices. Fisheries management systems are continually being reassessed to enforce efficient and effective measures that relieve pressure on reef stocks. These systems focus on sustainable harvesting methods conducive to ecosystem development and attuned to progressive environmental maintenance, while at the same time encouraging sufficient yields to appease fishermen's livelihood requirements within reasonable means. However, to successfully get fishing communities to cooperate with fisheries management policies, alternate or substitute fishing activities needed to be identified to encourage fishers to move away from over-fished reef areas (Fig. 1).

Many options have been recommended to communities. High among these are the closure of demarcated fishing areas, which proved successful in several cases and had impacting results in the recovery of reef stocks. In some islands, however, this was constrained to small fishing ground owners whose options were either to fish their limited reef area or abstain from fishing entirely. The other viable prospect was to shift the focus from quantity harvest to the production of "value-added" quality products using minimum resources.

The introduction of fish aggregating devices (FADs) to the Pacific region gradually became popular among offshore fishermen targeting pelagic species, especially tuna. As fishermen became familiar with FADs, their popularity increased and more fishermen participated in FAD fishing, which turned fishermen's attention away from nearshore reef resources. FADs provide fishermen the alternative to fish for pelagic species while the reef stocks are given time to recover.

FADs in the Pacific region

FADs were first introduced to the Pacific region in the late 1970s from the Philippines. Since then, many designs were experimented with producing

Figure 1: Nauruan fishermen and fisheries officers at a FAD fishing methods workshop discuss methods of relieving pressure on reef resources

mixed results. The Secretariat of the Pacific Community (SPC) plays a major role in the promotion of FADs in the region and backs this with technical support to island countries interested in implementing FAD programmes[1].

The principal criteria for Pacific Island FAD designs are that they be cost effective to construct and deploy, and durable enough to withstand adverse sea conditions, especially strong westerly winds and cyclones that pass through the region.

SPC has experimented with several designs in the region with some degrees of success as well as noticeable failures. These designs include a modified version of the Indian Ocean FAD (Fig. 2) and the spar buoy FAD (Fig. 3).

Although these designs did not remain in place as long as desired, the fish aggregating results were impressive enough to encourage further exploration in this area and also induced canoe fishermen to request simple designs to be moored closer to reefs. An inshore FAD programme was implemented by the Asian Development Bank-funded Community Fisheries Management and Development Project in Kavieng, Papua New Guinea in late 2005 to deploy inexpensive but durable bamboo FADs (Fig. 4) for several rural coastal communities[2].

Two main factors were initially identified as the cause of FAD failures: vandalism and the inadequacy of the designs to withstand the region's rough sea and weather conditions (especially designs that had large surface areas resistant to weather action and thereby creating more strain on the mooring section).

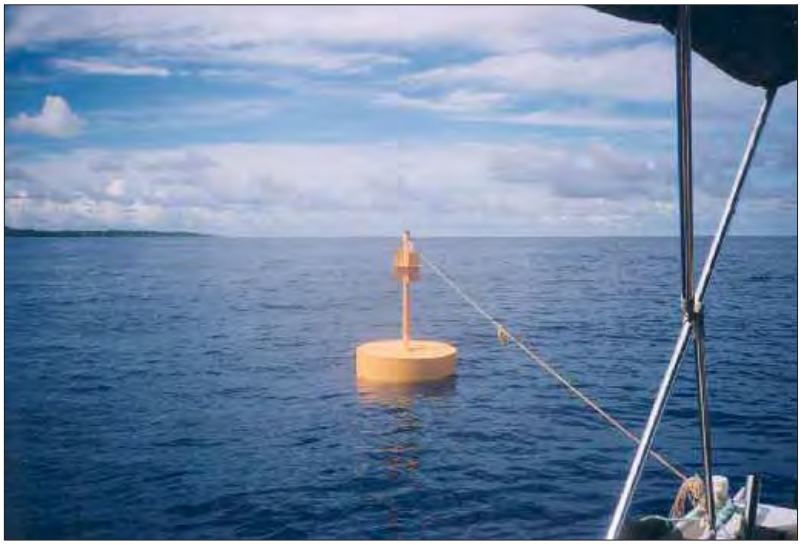


Figure 2 (top): Indian Ocean FAD in Kavieng, PNG

Figure 3 (bottom): Spar buoy FAD in Nauru shortly after deployment

Later findings revealed that the Indian Ocean type FADs were susceptible to collapse as a result of the foam purse-seine floats being "squeezed out" when subjected to depths beyond its pressure rating. This occurs when the FADs are forced underwater after reaching their extreme surface stretch point due to strong currents and stormy conditions.

Widespread interest in FAD programmes throughout the region invited considerable

[1] Four FAD manuals were produced by SPC to complement work carried out in the Pacific region and to facilitate fisheries departments or interested parties to conduct FAD projects

[2] Sokimi W. 2005. Field Report No 29 Technical assistance on small-scale baitfishing trials and course presentation to the national Fisheries College, and FAD experiments to the Community Fisheries Management Development Project assisting in Kavieng, Papua New Guinea. 38 p.

debate and literature on the impact of FADs on ecosystems, fisheries development, and community welfare. The main apprehension is the use of FADs as tools to supplement industrial-scale commercial fishing activities participated in by large tuna purse-seine vessels and pole-and-line vessels. The companies that operate these vessels deploy their own FADs to supplement the vessels' search for tuna (Fig. 5). FADs aggregate juvenile yellowfin and bigeye tuna alongside huge schools of skipjack tuna targeted by these vessels. While pole-and-line vessels are generally selective of skipjack target species, purse-seine vessels do not discriminate the catch entrapped in their nets so many juvenile yellowfin and bigeye tuna end up as bycatch or are dumped overboard as rejects. The concern is the overall impact that large-scale extraction of juvenile yellowfin and bigeye tuna will have on the region's tuna stocks.

Figure 4 (top): Inshore bamboo FAD in Kavieng, PNG

Figure 5 (bottom): Torpedo-shaped steel FAD currently used by PNG-based purse-seine vessels.

However, when comparing industrial FAD catch rates to small craft FAD catch rates, the impacts from small craft fishing around FADs are negligible. The Okinawan FAD fishery in Japan is one of the most active FAD fisheries in the Pacific, and keeps good records of catches. Since 1989, the Okinawa FAD fishery has produced yellowfin catches that fluctuate from 600–1300 mt/year[3] compared with 312,000–460,000 t/year from purse seine and longline catches in the western and central Pacific Ocean[4]. Although these are 1999 figures, the catch ratio has not changed much since then.

The FAD fishing experiences of the Okinawan fisherman's associations is a good example of how FADs can benefit coastal fishing communities and contribute to sustainable fishing practises and recovery of reef stocks.

Fish aggregating devices (FADs) in Okinawa's Itoman District

Although FADs have been trialled and used in Okinawa for 30 years, projects for offshore FADs deployed in depths greater than 1000 m began in 1982 through experimental work carried out by the Okinawa Experimental Station and two fisheries cooperatives in Miyako. By 1984, Okinawa had an established commercial FAD fishery. Initially FADs were designed to be as inexpensive and simple as possible but the quest to have longer-lasting

[3] Kakuma S. 1999. Synthesis on Moored FADs in the North West Pacific Region. 16 p.
[4] Lawson T.A. (ed). 1999. Secretariat of the Pacific Community Tuna Fishery Yearbook 1998. Oceanic Fisheries programme, SPC, Noumea, New Caledonia. 155 p

FADs saw meant that FAD designs became more complicated and expensive to produce. Fourteen experimental FADs were trialled, producing exceptional results that contributed to the escalation of FAD development throughout Japan. Since then, expensive commercially manufactured FADs have been popular in Okinawa (Fig. 6). In recent years though, with the shifting of FAD responsibilities to fishermen's associations, inexpensive but durable designs are again being considered in order to cut back on costs.

The Itoman fisheries association is now looking at adopting a similar outlook to SPC in order to implement cost effective FADs, although not necessarily as inexpensive as the ones SPC deploys. Currently, SPC's FADs are far less expensive than those deployed in Okinawa, although they are not as durable. However, the latest SPC-modified Indian Ocean design, using pressure floats, has the potential to outlast the previous designs and several of the latest deployments of this modified design have already been in the water for over a year now, showing good signs of remaining in place for even longer.

During earlier FAD programmes Okinawa fisheries associations faced the same predicaments that other Pacific Island countries faced when deploying FADs: the FADs did not remain in place long enough to justify the cost and effort of installing them. FAD losses, due to typhoons and stormy weather, were a serious problem and remains the main cause of FAD losses today (although not as much as in earlier years). In the early stages of FAD deployments, most Okinawa FADs lasted only between 1 and 1.5 years and some less than a year; the same dilemma that currently occurs in the Pacific. Nevertheless, the returns from FAD fishing were enough to warrant persistent new deployments while FAD experts tried to produce more durable designs.

FAD designs from Okinawa and the rest of Japan are now much improved, although very expensive for Pacific Islands to adopt for sustainable FAD programmes. The mooring sections of new designs were improved by replacing the single anchor system with two anchors, the upper mooring rope was replaced with stronger rope, and shackles are now seldom used because they were found to be a common breaking point. Shackles are now replaced by splices or joining knots. Where applicable, especially for smaller FADs, regular maintenance works are carried out to continuously change defective materials whenever they are spotted. For the larger and more costly surface FADs, expensive systems are used for construction, deployment and maintenance. For example, the Nirai FAD (Fig. 7) that was funded by national and prefectural government subsidies is made of durable steel and designed to last at least 10 years. It was moored with huge chains and reinforced wires, and was deployed using a large vessel with proper winches to carry out precise mooring work. The FAD raft is 7 m deep and 13 m at the base, and constructed according to a precision shipwright design.

The Itoman fishermen's association currently has 12 assorted types of FADs moored in depths of 1000–2000 m up to 20 nm offshore along the coastline under its jurisdiction.

Much more can be written about the Itoman and Okinawa FAD experiences, including costs, restrictions, advantages, disadvantages, and successes and failures, but one of the latest FAD innovations that must be mentioned is the "submersible" or "subsurface" FAD concept, which was implemented 15 years ago although a more serious approach was carried out 10 years ago. This FAD design is now proving to be a success story in terms of aggregation and durability.

Okinawa Subsurface FADs

Fifty-six subsurface FADs were deployed throughout the coastal waters of the Okinawa and Amami districts since 1996 by the Japan Marine Fishery Resource Research Centre (JAMARC), and to date, records

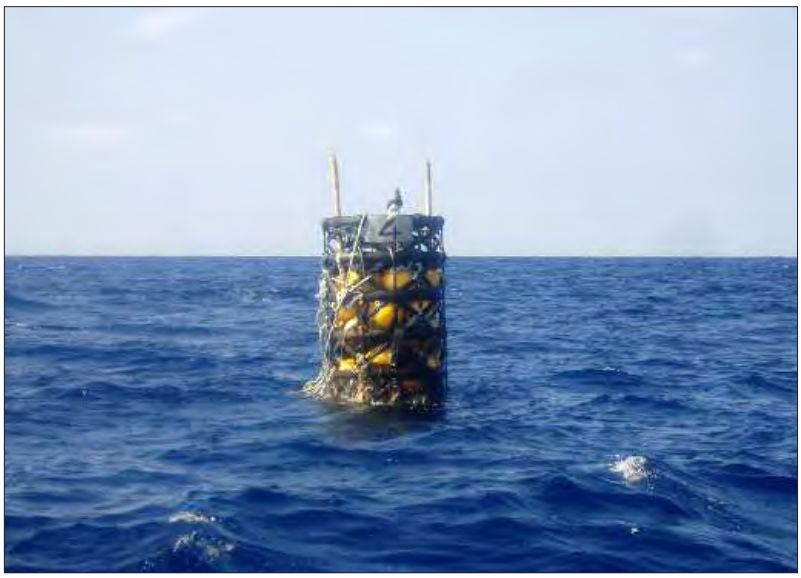
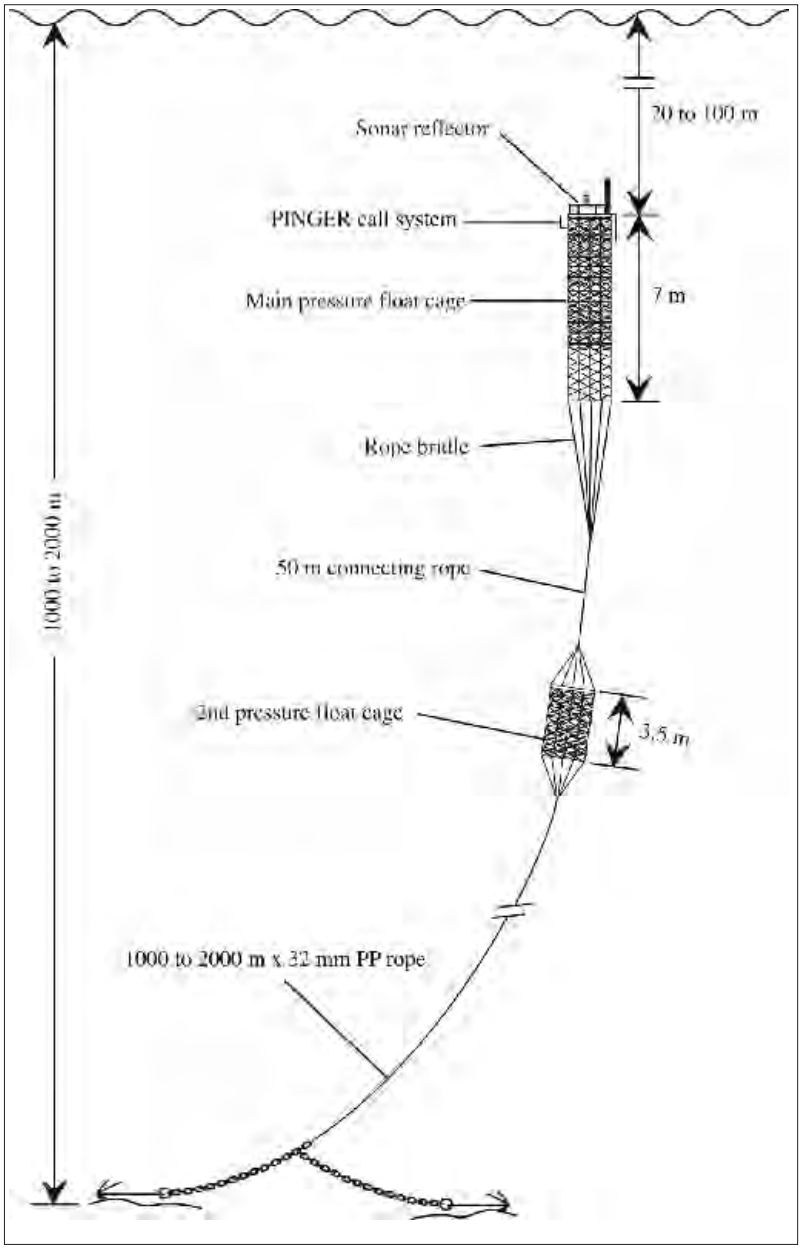


Figure 6: Current Okinawa surface FAD design



indicate that only one has disappeared. The rest are still intact and producing abundant fish stocks for fishermen; some FADs are more successful than others though, probably due to the locality of the FAD. Catch details, which are updated daily or whenever a fishing vessel fishes one of the FADs, can be obtained from JAMARC.

Several observations indicate that subsurface FADs provide good aggregating capabilities and also give fishermen good returns. Some fishermen believe that the subsurface FADs aggregate more fish faster than surface FADs.

The three main advantages of subsurface FADs (Fig. 8) are that they last much longer, aggregate fish faster, and give fishermen good returns because larger fish schools aggregate around these FADs. However, there are several disadvantages, especially for Pacific Islands. These FADs are huge and costly to produce and to deploy. The mooring systems are constructed from bigger and more expensive rope types and deploying the FAD requires a small cargo vessel with several adaptations for deployment.

The fibre reinforced plastic (FRP) cages are specially manufactured in a factory to calculated specificatins in order to withstand stresses that may be encountered. A second vessel would also be required to simultaneously deploy a second anchor at an angle of 45° to 90° from the main vessel.

Because they are submerged, the FADs are harder to find, so fishing vessels will need a GPS and sonar onboard to locate the

Figure 7 (top): The famous USD 1 million Nirai FAD

Figure 8 (bottom): Submersible FAD design

submerged FAD easily. An echo sounder/fish finder can do the job in place of sonar, but fisherman will need to make several runs directly over the FAD before an image is registered on the echo sounder. This will require excellent judgement to pass over the exact location on the first run since the FAD will shift slightly from the GPS deployment mark according to the daily direction and strength of currents in the area. Pinpointing the exact location of the FAD is important in order to identify the direction in which the fish schools will generally aggregate and to avoid getting lines caught on the mooring.

When a subsurface FAD is deployed, the deployment method needs to be carried out with precision so that the FAD settles in depths of 50–100 m (preferably 50 m). At 50 m it is expected that surface action due to wind and swells will not be experienced. The turbulence caused by swells in the roughest of conditions will rarely be experienced at this depth and recent data show that in the vicinity of subsurface FADs, pelagic species aggregate and spend most of their daylight hours around this depth. These species are mainly seen at the surface at night, very early in the morning, or when they gather to run in schools to pursue baitfish during the day.

The final problem that must be highlighted is the means of carrying out maintenance work on the FADs once they are settled at the submerged depth. A dilemma that the Okinawan fishermen now face is the abundance of growth on the FAD floatation section itself. One of their long lasting subsurface FADs from the experimental days, which has now been in the water for over 10 years, is becoming burdened with heavy underwater growth that eventually may cause its collapse due to excessive weight. On the bright side, this FAD has given more than its share of returns on its cost in the 10 years it has been in the water.

The Itoman fishermen's association are currently constructing half-size subsurface FADs for deployment (Fig. 9). The design is basically the same as the current large sizes; only the cages and number of floats are downsized to be the same as those deployed for surface FADs. The concept of the subsurface FAD is useful for the Pacific region and although the chances are slim that the region will deploy expensive FADs such as those used in Okinawa, there are still very options for deploying inexpensive modified designs of the Okinawa subsurface FADs that are just as effective and durable.

Even the idea of visually pinpointing FADs location can be easily achieved without having to resort to sonar or echo sounder; however, a GPS is very handy for directing fishers to FAD mooring sites.

The Japanese International Cooperation Agency (JICA) has already worked with the Fiji Fisheries Department and the Fiji School of Maritime Studies to deploy two inexpensive subsurface FADs in Fiji in early 2006. One of the FADs was successfully submerged but the second one missed the mark by a large margin and settled in shallower waters resulting in the FAD now being a surface one. Hopefully, the opportunity will arise to experiment with designs to produce a FAD that is more affordable for the Pacific region and just as long lasting and effective as those used in Japan.

Conclusion

Fish aggregating devices may well be the partial solution to relieve pressure on coastal reef resources in the Pacific Islands. Proper implementation of FADs with appropriate management plans can contribute tremendously to the Pacific Islands' coastal fisheries development as experienced in Okinawa, Japan.

Perhaps the next step in FAD programmes for the region should be in trialling subsurface FADs, based on the same criteria for surface FADs ensuring that

Figure 9: The half size FRP cage component of a subsurface FAD

they are inexpensive and durable. This should not be difficult to implement and improvisations such as a location marker can be adopted to make the FAD position known to local fishermen without the use of echo sounders or sonar. However, this will require the full cooperation of the community to ensure that the location marker remains in place. The main objective is to establish an alternative fisheries concept that not only provides fishermen with an additional choice for supplementing their income or subsistence requirements, but also assist in diverting fishing activities from the coastal and inshore reefs. FADs are far ahead as one of the methods for achieving this.

Small craft safety procedures and basic small craft commercial fishing economics are constantly promoted in most SPC FAD fishing method programmes as part of small craft operations management strategies to minimise loss of life at sea and encourage sustainable fishing operations.

DEEP-SETTING LONGLINE TECHNIQUE FOR BYCATCH MITIGATION TESTED IN HAWAII

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I spent several weeks in Hawaii (June through August), fishing with one of the highliner boats that fishes in the Hawaii-based tuna longline fishery. I accompanied the boat, F/V *Caroleigh*, and crew on two of seven planned trips that collected data on the deep setting technique (see *Fisheries Newsletter # 109*). The project was funded by the Joint Institute for Marine and Atmospheric Research (JIMAR), which is a part of the National Oceanographic and Atmospheric Administration (NOAA) that operates out of the University of Hawaii in Honolulu, Hawaii. Scientists from JIMAR's Pelagic Fisheries Research Program (PRFP) at the Pacific Island Fisheries Science Center (PIFSC) worked with SPC to design a project to collect more data on the deep setting technique that was first developed by SPC and tested in Mooloolaba, Australia (Beverly and Robinson 2004). The technique uses a new gear design for longline fishing for tuna that sets all baited hooks below 100 metres, out of range of most sea turtles and other bycatch species such as billfish, but within the best range of the main target species, particularly bigeye tuna, using lead weights and paired floats and the mainline as long floatline (*Fisheries Newsletter #114*)

When the technique was first tested in Mooloolaba, it worked fine and the results were promising. Sets on one fishing trip in 2004, using the deep setting technique, caught 42% more bigeye tuna than sets using the boat's normal configuration. However, because of the small amount of data (only 6000 hooks were fished in all) and the fact that bycatch was not monitored, the results of these trials were considered to be anecdotal and not significant. One of the recommendations coming from the project in Australia was that more testing was needed to get a more robust data set. In 2005, SPC began communicating with fisheries scientists, Chris Boggs and Mike Musyl, at JIMAR about the possibility of a collaborative project. The result was that SPC was invited to further test the deep setting technique using a tuna longline boat chartered especially for the experiments. Hawaii is an ideal place for testing bycatch mitigation methods because there is a well developed longline fishery there and because they have several issues regarding bycatch in their longline fisheries (see *Fisheries Newsletter #93*, Dalzell 2000).

Tuna longline boats target tuna but catch other species as well, which are often called bycatch. Target species include bigeye tuna (*Thunnus obesus*), yellowfin tuna (*T. albacares*), and albacore tuna (*T. alulunga*). Bycatch can include striped marlin (*Tetrapterus audax*) — which is marketed is some areas — and fish that are discarded such as lancetfish (*Alepisaurus* spp.), snake mackerel (*Gempylus serpens*), and some sharks. Some bycatch species are discarded because they are endangered and are protected by law, including sea turtles, sea birds, and marine mammals. Research has shown that sea turtles spend most of their time in the upper 100 m of water (Polovina et al. 2003). Ten times more turtle encounters occur in the top 100 m of water than in deeper water (SPC 2001). Many billfish species are also usually encountered in the top 100 m of the water column. By contrast, two of the main target species of longline fishing — bigeye tuna and albacore tuna — spend most of the daylight hours (when most tuna longline boats are fishing) at depths greater than 100 m. Fishermen targeting these species usually fish deep. However, because of the way longlines are usually set, some hooks still fish in shallow depths even on a deep set.

The experiment conducted in Hawaii used two different setting techniques — control sets and deep sets. The experiment attempted to eliminate shallow hooks on deep sets to maximize catch of deep dwelling species such as bigeye tuna while reducing catch of other species. In the experiment, the boat was allowed to keep and sell all of the catch and choose the fishing areas, setting and hauling times, and number of hooks per basket. Deep sets were achieved by attaching paired 3 kg (6.5 lb) lead weights directly below paired floats on 75 m long portions of the mainline. Since the floatlines were 25 m long, the actual depth of the shallowest hooks was around 100 m. The rest of the fishing portion of the line was well below 100 m, often getting as deep as 300 m. The range of depths fished was from about 100 m to 250–300 m. The control sets, by contrast, fished a range of depths from about 25–50 m to 200–250 m. Depths were verified by the use of Star-Oddi temperature depth recorders (TDRs).

In order to compare catch rates on control sets (fishermen set the longline gear as they normally would) versus catch rates

on deep sets, paired sets targeting bigeye tuna were made. In other words, if the first set was a control set, then it had to be followed by a deep set in the same general vicinity and so on. Seven paired sets were made on each fishing trip. The only parameter that was changed between control sets and deep sets was the line configuration. Everything else, including the bait, time of set, time of haul, etc., remained the same. The experiment involved a total of 45 paired sets (45 control sets and 45 deep sets) or 90 sets total. Each set had 2000 experimental hooks so the total number of hooks fished in the experiment was 180,000. This should provide enough data to determine if the technique is viable. To be viable the mitigation technique must reduce bycatch and either increase or not change target species catch. From the fishermen's point of view the technique must either not change revenue or it must increase revenue to be viable. One goal of the project, therefore, was to increase the bigeye tuna catch on the deep sets enough to offset any losses in revenue from a decrease in marketable bycatch (often called byproduct) such as striped marlin. At the fishermen's and boat owners' request the project will use fish auction data from all fishing trips to compare the economics of the two set types.

I made two trips, one in June and the second one in July. Each trip lasted about three weeks. All fishing was done in Hawaii's EEZ or in surrounding international waters. Data were taken on two forms: the South Pacific

Top: F/V *Caroleigh*

Middle: Lead weight with snap

Bottom: Icing the fish

Regional Longline Logbook and the SPC/FFA Regional Longline Observer Catch Monitoring Form LL-4. On the first trip I measured all fish and recorded all data. On the second trip, JIMAR Fisheries Biologist, Dan Curran went along with me to learn the deep setting technique and to record data. Dan then trained observers from the NOAA's Pacific Islands Regional Office (PIRO) Observer Program for all subsequent trips. This included going on the third trip and seventh trip. All data were recorded by NOAA observers on trips three through six.

Before I left Hawaii, Dan had a brief look at the data from the first two trips and found some interesting preliminary results. Of all fish caught during the first two trips on a total of 56,000 hooks, the deep sets caught 59% of the main target species, bigeye tuna, while the control sets caught 41%. For one of the principle bycatch species in question, striped marlin, the deep sets caught just 12% while the control sets caught 88%. The figure below shows the relative percentages of most of the species caught during those trips. It should be kept in mind that these results, although very promising, are only from 56,000 hooks of a total 180,000 hooks that will be fished, and are therefore very preliminary. Results of the total experiment will eventually be published as a manuscript after all data are analysed.

The materials needed for this project were all purchased by JIMAR in Hawaii and included the following:

- 160 three kg (6.5 lb) lead weights with bails for line attachment;
- Six coils of 6.4 mm tarred polyester floatline;
- 60 x 360 mm hard plastic longline floats;
- 400 longline snaps;
- Two pairs of cutters;
- Two small Swedish fids; and
- One set of Star-Oddi TDRs (15 units, connector box, software).

Prior to leaving on the first trip the crew assisted Steve and Dan in splicing all of the lines on the lead weights and floats. This extra gear was needed to supplement the boat's normal compliment of floats and floatlines.

F/V *Caroleigh* is the newest boat in the fleet owned and operated by Pacific Ocean Producers in Hawaii (dba Vessel Management Associates). The specifications of F/V *Caroleigh* are as follows (Anon 2004):

Vessel type: Tuna longliner

Owner: Vessel Management Associates

Designer: Hal Hockema & Associates

Builder: Fred Wahl Marine Construction

Construction: Steel with aluminum pilothouse

Launched: 2003

Cruising range: 10,000 nm (16,200 km)

Length: 24 m

Beam: 6 m

Depth: 2.75 m

Accommodations: 6 berths plus Captain's stateroom

Fish hold: 73 m^3

Bait freezer: 9 m^3

Fuel: 36,824 liters

Fresh water: 8236 liters

Main power: TAMD 165C Volvo 382 kW

Reduction gear: Twin Disc MG516 5.05:1

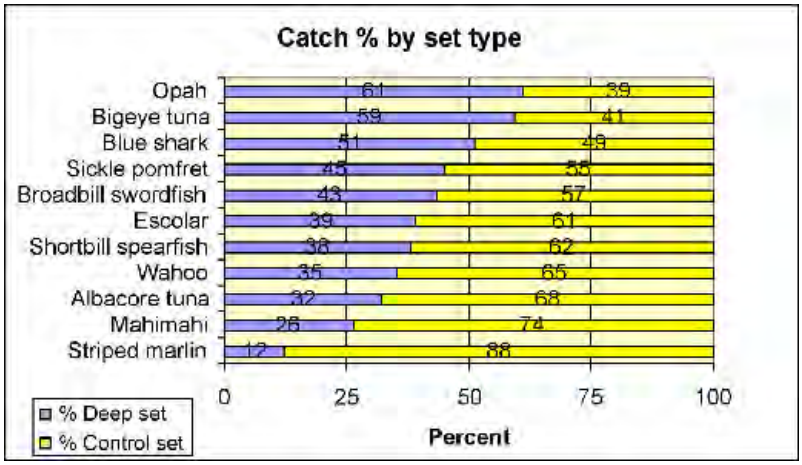
Shafting: Aquamet 11.43 cm diameter

Propellor: 160 cm x 125 cm four blade bronze Rice Propeller

Propulsion controls: Mathers Micro Commander

Steering system: FWMC

Gensets: 2 Northern Lights MP445T-55kW



A comparison of percentages of fish caught on deep sets and control sets from two trips (56,000 hooks).

Hydraulics: FWMC

Longline reel: Lindgren-Pitman Superspool III (50 nm)

Longline setter: Lindgren Pitman LS-3

Fishing gear: 2500 monofilament branchlines, 100 floats and floatlines

Each fishing day the line was set starting at about 08:00. The bait was a mix of 50% sanma (*Cololabis sairi*) and 50% California sardine (*Sardinops sagax*). Setting generally took about four hours for control sets and a little longer for deep sets. As an aside, F/V *Caroleigh* is set up to do side setting (Brothers and Gilman 2006). In other words, the line setter is on the starboard rail, forward of the wheelhouse and baited branchlines are thrown over the side and not the stern. This is the best method found so far to mitigate bycatch of seabirds. The bait sinks out of reach of the birds before reaching the stern of the boat. Hauling usually started about 18:00 and continued until 02:00 or 04:00 the next day. All fish were iced in the single large fish hold after being spiked, bled, and gilled and gutted. All fish were eventually sold at the auction block in Honolulu (United Fishing Agency).

The Captain of F/V *Caroleigh*, George Ching, has been fishing in the Hawaii longline fishery for several years. He started on Japanese basket gear boats as a deckhand and later switched to monofilament, eventually working his way up to captain. George is part Hawaiian (Hawaiian-Chinese on his father's side) but has but also has other Pacific Island Origins. His mother is from Pohnpei. This is probably why F/V Caroleigh has an all Pohnpeien crew (George has had the same crew for over two years). The three crew members – Allen Lenzy, Otto Dannis, and Mac Malakai – are all from Pohnpei. The hard work and professionalism of the captain and crew made the experimental fishing go very smoothly.

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THE LIVE REEF FISH TRADE IN THE PACIFIC: A LOOK AT RECENT TRENDS AND DEVELOPMENTS

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Introduction

The SPC Regional Live Reef Fish Trade Initiative is in its sixth year of operation. The Initiative addresses issues and concerns of SPC Pacific Island member countries and territories regarding their live reef fish trade (LRFT). Reports and overviews of the Initiative's activities and achievements have been presented during previous Heads of Fisheries meetings and at sub-regional fisheries meetings. It is felt, however, that it is worthwhile to provide a short account of what the LRFT Initiative has done to date — with regards to trends and development in the trade — as an information update and a re-introduction of the SPC Regional LRFT Initiative to the growing number of new fisheries staff in SPC member countries and territories.

Background

The LRFT includes two totally different commercial fisheries: the live reef food fish trade (with Hong Kong and China as the main markets) and the marine aquarium fish trade (with the main markets in the USA, Europe and Japan). The LRFT continues to exhibit great potential as an income earning opportunity for coastal fishing communities, especially small Pacific Island countries with limited agricultural and mineral resources. This, together with the sustained high demand from international markets for products from these fisheries, has maintained interests for active operations, including new interests by investors (both local and foreign), especially in Pacific Island countries where operations did not exist in the past.

The SPC LRFT Initiative was established in 1998 — through the endorsement of SPC member countries and territories — to assist members in addressing issues relating to the trade of marine resources for the live reef food fish and marine aquarium trades. Over the last nine years, the Initiative has kept up with the ever-changing dynamics and trends in these two fisheries and has provided timely and practical assistance to member countries and territories in developing sustainable live reef fish operations.

This short review of the LRFT Initiative gives a general account of the changing problems and issues of the LRFT in the Pacific and the efforts taken to address these issues. It is not meant to be a full report of the project, but rather aims at highlighting the significant characteristics of the trade, main issues, trends and developments that have evolved since the start of the Initiative. Much of the focus of this short review will, however, be on the more recent and current activities and achievements of the Initiative in relation to the existing management challenges of the LRFT today.

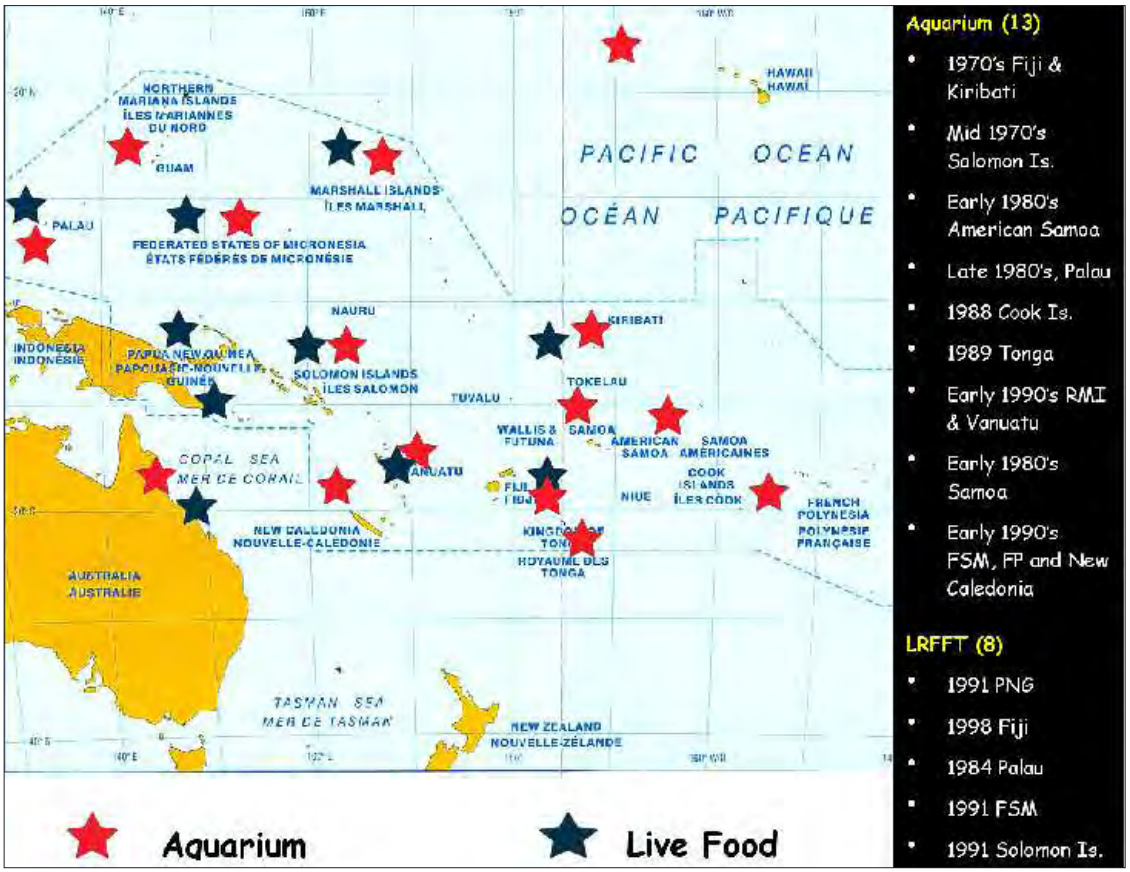
A quick look at the past

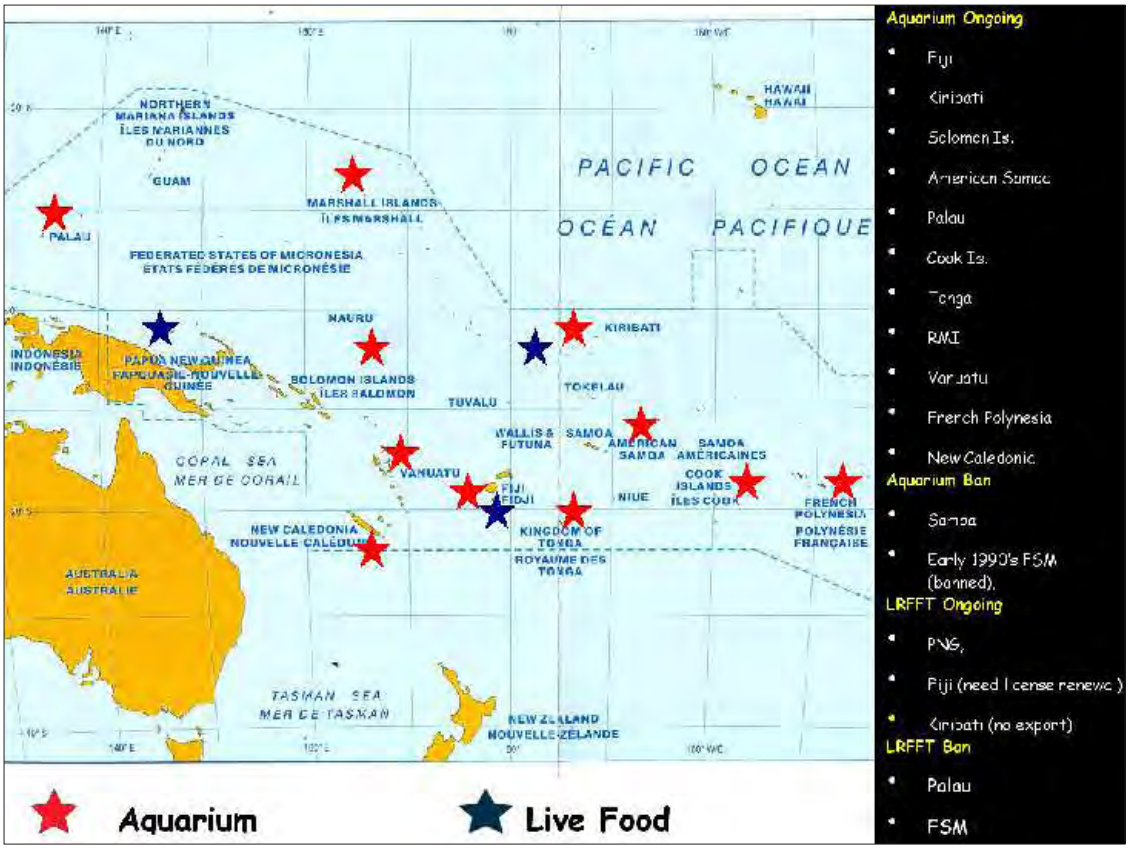
Of the two live reef fish trades, the marine aquarium trade was the first to begin in the Pacific, with the first operations occurring in Fiji and Kiribati in the early 1970s. The marine aquarium trade further expanded to other Pacific islands, with the Federated States of Micronesia, French Polynesia, and New Caledonia being the latest additions to this trade in the early 1990s. To date, 13 Pacific Island countries participate in the marine aquarium trade. Throughout the years of operation, there has been very little concern about the trade, especially from local communities.

This is probably due to the fact that the marine aquarium trade was not competing with food fish fisheries — an important part of the subsistence livelihood of most Pacific Island communities. Also, the marine aquarium trade was also seen as making use of a resource that would otherwise be left unutilized. The collection of marine aquarium species and the establishment and operation of land-based marine aquarium facilities requires considerable technical knowledge, as well as substantial capital investment. For these reasons, most operations have been foreign-owned.

The live reef food fish trade (LRFFT) took hold in the Pacific much later, in 1984, with the first operations in Palau. This was not surprising given Palau's proximity to the demand centre for live reef food fish — Hong Kong.

Because the trade was new to the Pacific, there was generally a lack of understanding of the trade and its dynamics. The target species for this trade, groupers and humphead wrasse — which had not been previously commercially harvested in most Pacific countries — were present in abundance. The





Top: The distribution and starting dates of live reef fish trade operations in Pacific countries and territories
Bottom: The current status of live reef fish trade operations in the Pacific

income from this trade to local fishers was instant and quite attractive, compared with the traditional "fresh dead" fishery, especially in remote islands where ice plants are not available for preserving catches. Along with the desperate need of fishing communities to find income earning opportunities, the LRFT trade quickly developed its reputation as an attractive fishery for local fishers in remote island areas.

This resulted in a big boom and expansion of the LRFFT trade into the insular Pacific in the 1990s, and by the late 1990s, 10 Pacific Island countries were involved in the trade. The spread of the LRFFT in the Pacific was so fast that most government fisheries departments did not have time to consider or put into place any management controls on the fishery.

Typically, foreign operators come in as foreign investors on a joint venture business with a local partner. The foreign partner (usually with nearly total ownership of the operation) runs the entire operation, with the local partner playing a role only in negotiating with local communities to gain access to fishing grounds.

Once the agreement has been sealed, the foreign operator works directly with local fishing communities, and provides all the necessary cage facilities to hold and keep fish alive, as well as boats, engines, fuel and fishing gear (lines and hooks) to fishers. This is usually done in the form of a loan to fishers.

This loan is repaid back to the company through fish catches. For the foreign operator, this ensures that fishers fish only for them. Some loans, however, have been too much for fishers to pay back, and even after several shipments to Hong Kong, most fishers with a loan still owe the company. Foreign companies often require a 15 tonne minimum of fish per shipment from the Pacific to Hong Kong in order to make it economical. The minimum requirement, however, is a problem for most fishing communities to meet and, as operations stay longer in one fishing area, the harder it becomes for fishers to supply the required catch.

Spawning aggregations have been hit hard and as catches drop, operations are forced to move to new locations. In such cases, facilities are abandoned and unpaid loans are written off. This makes no business sense unless of course, the companies have made profits great enough to have already paid off their investment in facilities.

Unlike the marine aquarium trade, soon after the start of LRFFT operations in the Pacific, problems and conflicts between communities and operators — and even within communities — began developing. With the perceived potential of the LRFFT as a value-adding fisheries, and as a good income earning opportunity for rural fishing communities, Pacific Island countries requested that SPC take a look at the trade in order to address issues and concerns, and to set up sustainable LRFFT operations in the region.

At the 2001 Heads of Fisheries meeting, member countries and territories endorsed SPC in developing the capacity to address these concerns. Following this, the SPC Regional Live Reef Fisheries Trade Initiative was developed.

Recent trends and developments

Both the marine aquarium trade and the live reef food fish trade have experienced changes over the last 20 years.

The number of countries participating in the marine aquarium trade has remained nearly constant. Eleven countries are actively involved; two countries that had previously imposed bans were now reconsidering reopening the trade; and new interests are being expressed by three countries that have never had operations.

One of the main changes has been the opening of new markets in Europe and Asia (Hong Kong, Singapore and mainland China) in addition to traditional markets in the US and Japan. The species being traded have not changed, except that there has been an increasing interest in the trade of live rock, with some operators totally switching their operations to live rock

Centropyge loriculus

from marine aquarium fish (e.g. in Fiji and Tonga). Market demand has nevertheless been increasing steadily with the new markets. This is expected to increase rapidly with China's economic growth. Fish prices have generally increased slightly except for some species such as *Centropyge loriculus*, which at one time were collected excessively from Christmas Island. The resulting flooded market meant a drastic drop in price given to Christmas Island exporters from USD 20 a piece to USD 1 a piece. (The value has improved subsequently over the last few years and is now about USD 5–10 a piece.)

One of the main issues now is the number of increasing conflicts between tour and dive operators and marine aquarium operators. This has occurred in several Pacific Island countries, indicating an urgent need to establish management guidelines that include the allocation and mapping of resources for different users.

Because live corals are listed under CITES, their export is limited and only allowed with a CITES permit. Coral farming, which allows only second generation corals to be exported, gets around this restriction.

Although the definition of "second generation" corals is spelled out by CITES, there are disagreements about the interpretation. It is therefore important that such definitions are clearly described and clarified in order to avoid misunderstandings and future conflicts. The supply of cultured giant clams from hatcheries has remained quite successful and seems to be stable.

Also, there is now a growing interest in the rearing of post-larval reef fish for the marine aquarium trade with successful commercial trials in French Polynesia and the Philippines.

The LRFFT in comparison has shown considerable changes. Of the eight countries participating in the trade at the end of 1990s, only three remain with an interest, and only one of these (Papua New Guinea) is actively exporting fish. The decrease in the number of interested countries is due to improved awareness by the public and fisheries departments on the implications and consequences of the trade, especially in attempting to meet the minimum shipping tonnage. For fish transported by sea, exporting companies are now requesting 20–30 tonnes of fish per shipment (compared with 10–15 tonnes 10 years ago).

As a result, several Pacific countries are pushing their exporting companies to consider air freighting, which is highly recommended over sea freighting as smaller amounts of fish are required (500 kg of fish per fish bin) and less pressure is placed on resources.

Hong Kong remains the major market, but the mainland China market is expanding very quickly, and as it improves its trade links internationally, suppliers will be able to deal directly with mainland China buyers, rather than going through Hong Kong as is currently the case. There is a small market on the US west coast that a Fijian company exported to for awhile. The US provides a good market option for most Pacific countries, given that it is closer than Hong Kong and the Hong Kong market is already dominated by Asian suppliers (Indonesia and Philippines) that Pacific Island suppliers cannot compete with.

The species composition of exports from the Pacific has

Top: Fish carrier vessel collecting fish in the Pacific

Bottom: Fish bin used in air transportation of live reef food fish

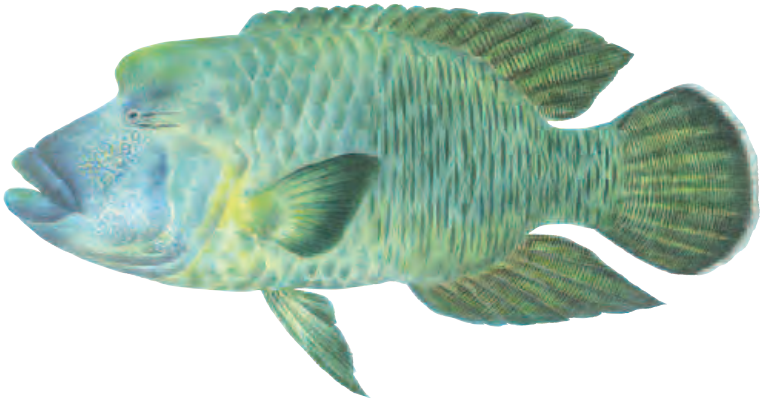
remained the same but with a slight increased acceptance of low value species by operators and exporters. The humphead wrasse is still in great demand, but supply is likely to become limited in the near future with the recent "red listing" of the species under CITES II, and with Hong Kong's strong intentions to enforce its CITES obligation.

The mariculture of groupers has had success with full cycle commercial rearing of two important species, *Cromileptes altivelis* and *Epinephelus fuscoguttatus* for a number of years now. It was expected, therefore, that these two species would flood the market, causing significant drops in the prices of even wild-caught supplies. But this has not happened, and there is still quite a high demand of these species from the wild.

The SPC Live Reef Fish Trade Initiative

In consideration of the needs and requests of member countries and territories for assistance with their live reef fish trades, a project was established to develop a common framework of standards for licensing live reef fish enterprises, and for monitoring and regulating these fisheries. The project was also to provide a common standard of training for fishing communities in order to ensure that sustainable practices were established from the beginning, and to provide overviews and reports on the status of the trade for the benefit of decision-makers at all levels. In addition the project would continuously respond to requests from member countries for information and advice, establish databases of information, and produce and distribute newsletters.

Faced with a paucity of data and information about reef fisheries in general in the Pacific, especially those pertaining to the LRFT, it became apparent that in-country assessments of the fishery, including resource surveys, should be the first step in getting baseline information on the fishery and the resources being targeted, before giving any advice. Covering the different operation sites, including proposed potential sites in the 10 countries with LRFFT operations, was too expensive a task. SPC had very limited funds to organise and support a full-scale team of fisheries scientist to visit each of the 10 countries and conduct assessments and resource surveys. A fisheries scientist (official title now known as the Live Reef Fisheries Specialist) was nevertheless recruited in 1998 to set up the



Humphead wrasse, *Cheilinus undulatus* a fish species that is often targeted for the live reef food fish trade which is now under CITES Appendix II listing

Two important LRFFT species that have had success in full cycle culture: *Cromileptes altivelis* (top) and *Epinephelus fuscoguttatus* (bottom)

capacity within SPC as required by member countries. The fisheries scientist was required to provide advice and to address issues and problems where possible. But with only one staff member for the SPC LRFT Initiative, in-country field resource surveys could not be done without field assistance from elsewhere. SPC, therefore, decided to collaborate with other organisations as partners in order to provide the required capacity to assist member countries and territories.

A formal partnership was developed with three non-governmental organisations in 1999: The Nature Conservancy (TNC), International Marine Life Alliance (IMA) and World Resource Institute (WRI). With funding support from an Asian Development Bank (ADB) grant under its Technical Assistance, SPC and its partners were able to conduct some LRFT resource surveys in selected countries where there were significant problems and concerns.

The working partnerships initially worked out well until much later during the project when one of the partners felt split off from the project. The duration of the project and the extent of funding were not enough to address the needs of all SPC member countries who had requested assistance, and unfortunately, the extension of funding from ADB could not be considered given the failure of the partnership.

In 2002, when ADB funding ended, there was still a strong need for assistance on LRFT issues. There was also an increase in concern about the marine aquarium trade and the need to look at setting up management plans and monitoring programmes. It was therefore necessary for SPC to look elsewhere for funding to support the LRFT Initiative. At a regional meeting held in Honolulu in 2002, a presentation was made by SPC on the LRFT Initiative. A representative from the MacArthur Foundation indicated the foundation's interest in providing a grant. Since then, they have been the sole provider of funding support for the LRFT Initiative.

The grant however was just enough to support the capacity within SPC and maintain the LRFT Initiative, but was not enough to cover in-country field assistance. To keep the Initiative's active practical role of responding to member countries' requests, it was necessary to look for other sources of funding. Some funds have been obtained through the SPC Minor Fisheries Projects, Taiwan Funding, and more recently from AusAID. The needs of countries, however, at the moment still far outweigh the available funds to address them and therefore the search for more funding is a continuous task.

Activities of the LRFT Initiative

The long-term goal of the Initiative is to have locally supported and administered effective management and monitoring arrangements for the LRFT in Pacific Island countries to ensure and support sustainable live reef fish operations. Several areas of focus for assistance to Pacific Island countries were identified, including:

a. Baseline information about the resource, information about the existing fishery, or relevant information required to measure the potential of the fisheries (for new interests);

b. Capacity building of fisheries officers and relevant local trade personnel to monitor (conduct resource surveys, analyze and interpret data), and manage the fisheries effectively;

c. Developing management plans and regulations, and monitoring programmes;

d. Developing the supporting framework for management (management committee, management funds) and for monitoring (regional database to support monitoring and data collection); and

e. Assistance in implementing management plans and monitoring programmes.

Considering the number of countries requiring assistance in all of the above areas, the amount of work and funds required is quite considerable. To make the most of the limited funds, it was decided to focus on capacity building, but taking the capacity building process one step further by utilising it to address the needs of each country.

The SPC Live Reef Fisheries Trade Specialist makes a trip to a country with LRFT concerns, and conducts field training for local fisheries staff (a team of four surveyors minimum) on survey methods. The first week of training includes in-water sessions using the UVC survey method, fish species and habitat identification, and size estimation. Once the fisheries officers have mastered the survey method, they, together with the LRFT Specialist, conduct a full survey in one of the areas of interest for live reef fish operations.

The data collected from the survey is taken to SPC and one of the fisheries officers is invited to take up a one to two-month attachment training there. At SPC, the attachment officer learns how to clean and enter the data on the database, how to make queries, and conduct analyses and interpretation of the data. And, together with the LRFT Specialist, the attachment drafts the survey results into a technical report that provides

Hands-on UVC field training for Pacific Island fisheries officers

information to support management decisions.

Also during the attachment, the fisheries officer with the LRFT Specialist, develops a LRFT Management Plan with regulations as required, and using the survey report as much as possible. A monitoring programme is developed for the trainee's country as well as an implementation plan. At the end of the attachment, the trainee is expected to go back to his country with a:

1) survey report that interprets survey results and findings,

2) draft LRFT management plan and regulations (as needed),

3) draft monitoring programme, and

4) implementation plan (action plan).

Through the attachment training the needs of the country listed are addressed. The monitoring programme includes regular UVC surveys that can now be done by local fisheries officers and with further analysis and interpretation of results by the attachment trainee. The management plan and regulations, and the monitoring programme, are distributed for review by relevant stakeholders and in stakeholder consultation workshops before it is finalized and submitted for endorsement by the government.

The regional database is developed at SPC and training on its use is provided through a regional workshop and later through hands-on training in the initial implementation of the management plan and work.

Future surveys and monitoring can be easily done by the competent officers without assistance from the SPC LRFT Specialist.

This approach has been taken and applied to several countries with great success. More importantly it provides a way of addressing countries needs with limited resources.

Achievements

Some of the more interesting and relevant achievements of the Initiative are listed below.

- LRFFT public awareness information package;
- Surveys in Kiribati (LRFFT and marine aquarium trade), Vanuatu (LRFFT and marine aquarium trade), Fiji (LRFFT in two areas), Tonga (marine aquarium trade) and Tuvalu (marine aquarium trade);
- Training in UVC methods for Kiribati (five officers), Fiji (four officers), Vanuatu (four officers), Tonga (five officers), Marshall Islands (two officers, two locals) and Tuvalu (four officers);

- Attachment training at SPC: Kiribati (one officer), Marshall Islands (one officer), Vanuatu (one officer), Fiji (one officer) and Tonga (two officers); and

- Draft management plans and monitoring programmes have been developed for Kiribati (Abaiang LRFFT), Fiji (Bua), Vanuatu (marine aquarium trade), Marshall Islands (marine aquarium trade) and Tonga (marine aquarium trade)

Future LRFT related activities

- Attachment training for Tuvalu;

- Implementation follow-up for Vanuatu, Tonga and Kiribati;

- UVC training and resource survey for Nauru (marine aquarium trade) and the Federated States of Micronesia (marine aquarium trade) and Samoa (marine aquarium trade);

- Attachment training for Nauru, FSM and Samoa;

- Development of a regional database;

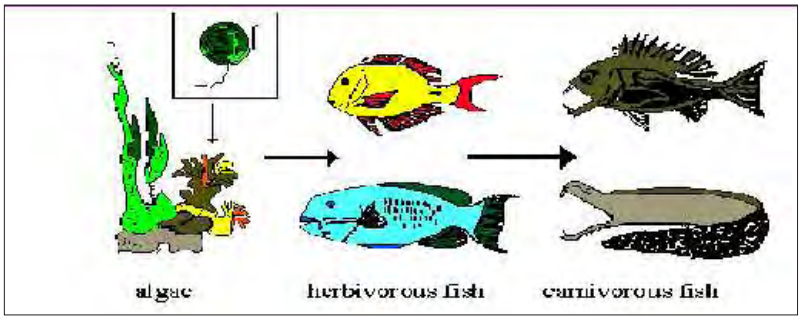
- Regional workshop on the use of regional database;

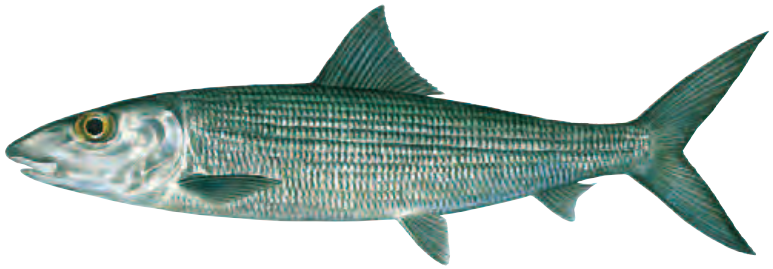
- Development of marine aquarium trade awareness information package; and

- Integration of ecosystem approach to fisheries management into the management of the two LRFT industries.

The capacity building component of the activities are aligned in a progressive way to address the country's needs and to slow-

The cause of ciguatera fish poisoning (*Gambierdiscus toxicus*) and how it is passed up the food chain





The bonefish tourist based fishery brings USD2.5 million annually to Christmas Island in Kiribati (Pacific). The bonefish *Albula glossodonta* (top); An angler using light tackle to catch bonefish – a popular tourist sport (bottom)

ly build the required capacity within the country in order to implement the management plan and monitoring programme for the LRFT effectively without depending on outside assistance.

Other activities and responsibilities

The involvement of the Initiative in other related issues includes working on:

- Ciguatera fish poisoning issues, given its importance and implication to LRFT;
- Assisting in management of bonefish tourist catch release fishery, which is basically a live reef fishery;
- CITES and IUCN red listing, especially for the humphead wrasse. (Please note an overview report on the implications of CITES on the export of humphead wrasse for the LRFFT will be circulated soon.); and
- Work on the conservation of spawning aggregations is one of the main issues of concern in the LRFFT. A memorandum of understanding was recently signed between SPC and the Society of Conservation of Reef Fish Aggregations (SCRFA). This will provide a stronger basis for working closely together to address spawning aggregations issues.

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