Fisheries Newsletter

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Editorial

Too often we read about Pacific Island fishermen being lost at sea. Like road safety programmes, there are no quick solutions to reducing the loss of life at sea. It is also difficult to estimate the extent of the problem as most countries in the region don't keep statistics of small boat accidents. SPC and the Food and Agricultural Organization of the United Nations have been working closely together to improve the safety of small boats. One way is to increase awareness of sea safety through training programmes. Political will is essential for developing long-term national strategies to enhance sea safety for small vessels.

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Safety at sea is a major issue in the region (see article by Mark Smaalders in this issue). SPC is committed to assisting its member countries and territories on this issue and has produced a series of awareness materials in different local languages

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

REEF FISHERIES OBSERVATORY

Preliminary findings: A snapshot of the condition of coral reefs in Fiji Islands, French Polynesia, Kiribati, New Caledonia, Tonga and Vanuatu from 2002–2004

The coastal component of the European Union-funded Pacific Regional Oceanic and Coastal Fisheries (PROCFish) project is conducting the first regional comparative assessment of coastal and reef fisheries undertaken in the Pacific. The five–year interdisciplinary project is working at a range of sites in 17 countries and territories[1] across the Pacific region. PROCFish researchers are assessing the status of finfish and invertebrate resources and associated coral reefs, while also examining socioeconomic factors related to marine resource use. This article presents a preliminary review of the condition of coral reefs at sites in six countries where studies have been completed.

Coral reef condition was assessed in 27 villages in the six South Pacific countries using a live coral index (ratio of live coral to total coral cover). Researchers compared the extent of live hard coral cover at a given site relative to the total amount of hard coral cover present (i.e. live coral as a percentage of total cover, the latter including both live and dead coral). At least 24 transects were surveyed in each fishing ground, giving 675 transects in total.

Calculation of a live coral index allowed classification of sites within a scale that might represent reef conditions at the regional level. Most sites were found to fall between 40 and 60% on the live coral index, with a few sites at the upper (>70%) and lower (<30%) ends of the scale (Fig. 1). These preliminary results, when compared with global figures, indicate a lower live coral cover on coral reefs in the South Pacific region and highlight the need for monitoring the condition of Pacific reefs.

Our snapshot study has revealed two factors that need to be examined. First, the low absolute proportion of the total substrate surveyed that was

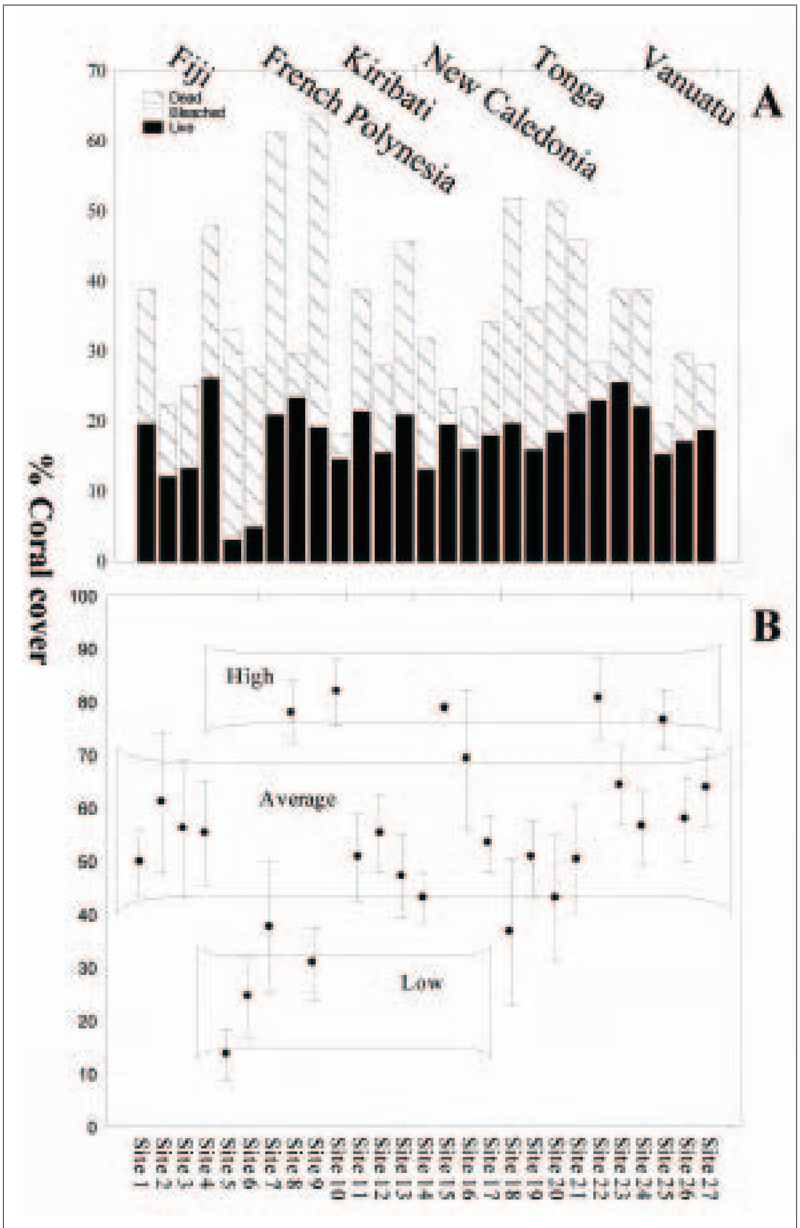

Figure 1. Average per cent coral cover (A) and (B) live coral index for 27 sites in six countries and territories of the South Pacific. Error bars are 95% confidence intervals.

[1] Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Republic of the Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu, and EU French Territories (OCTs: French Polynesia, Wallis and Futuna, and New Caledonia)

supporting live coral cover on reefs at the regional scale and, more importantly, the generally low live coral index.

We estimated a live coral cover of only 17% of total substrate cover on average (Fig. 1). This result was consistent across reef types (Fig. 2), although live coral cover was higher on average on the outer slope reefs (25%). The average figure of 17% for live coral cover was significantly lower than the global average estimate

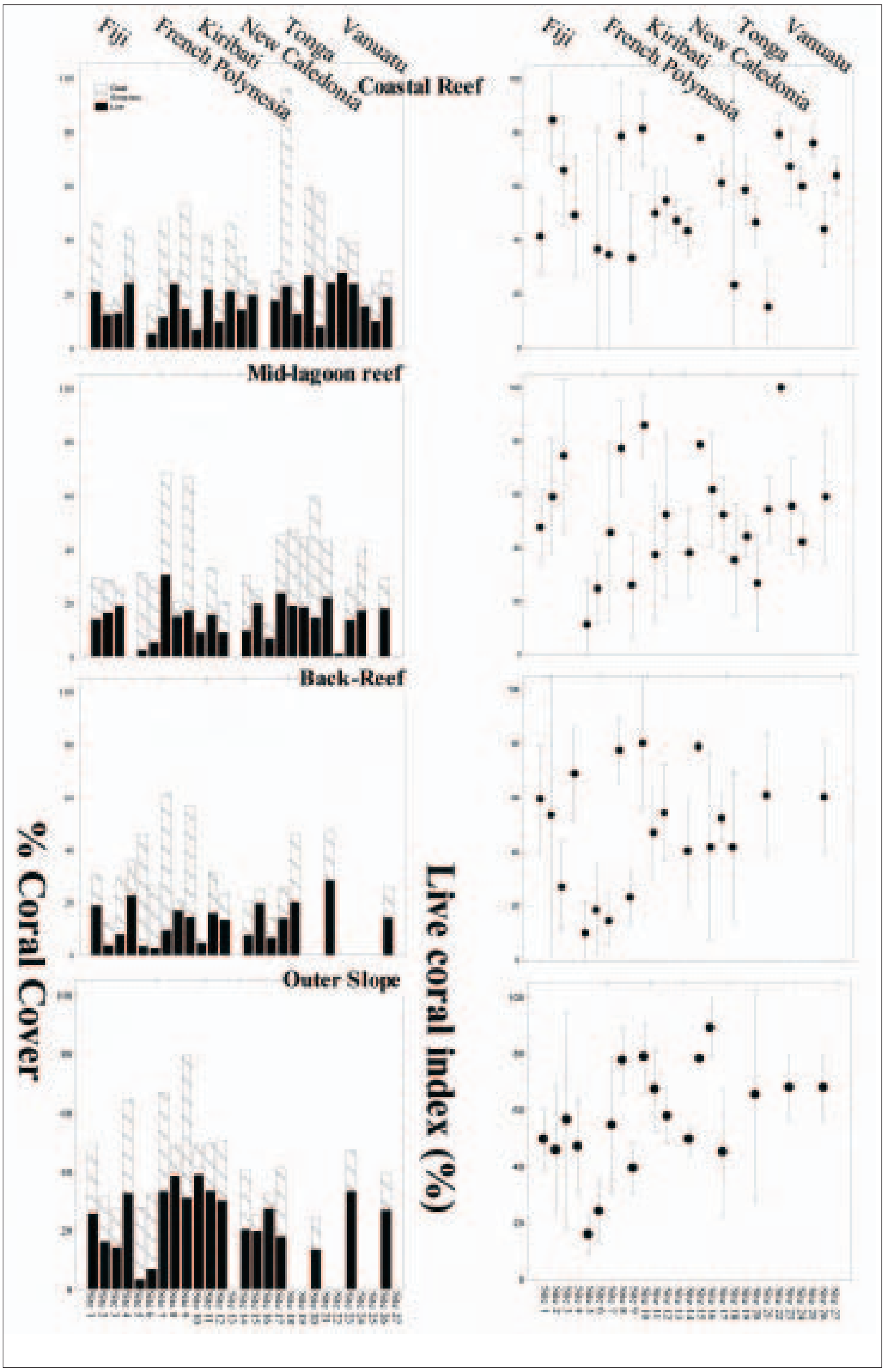

Figure 2. Average per cent coral cover (left column) and live coral index (right column) for the coastal, mid-lagoon, back reef, and outer slope reefs for 27 villages in six South Pacific countries and territories. Error bars are 95% confidence intervals.

of 32% live hard coral cover reported by Wilkinson (2002).

The second characteristic revealed by the study was the low amount of live coral cover present relative to total coral cover (including live, recently bleached and dead coral) as indicated by the calculation of the live coral index. This is a more telling indicator than the absolute values for "live coral cover" as it illustrates the extent of coral mortality. Our preliminary results suggest that live coral index values of 40%–60% may represent typical lower and upper figures that could be expected to be found in the region, with values lower than 30% possibly indicating severely stressed reef systems and values higher than 70% indicative of unimpacted reefs.

When interpreted using this scale (Fig. 1), results from two study sites located on the same island in Fiji suggest that those reefs were exceptionally stressed. At the time of the assessment (November 2002), people of the villages told us that coral had died after a combination of bleaching and crown of thorns starfish (COTS) events about four years previously (1998). Fiji reported mass bleaching in 2000 (40% mortality), variable bleaching in 2001 and 2002, and annual COTS events since 1996 (Wilkinson 2002).

The widespread 1997–1998 bleaching event resulted in a global decrease in live coral cover of approximately 10% (Wilkinson 2002). The live coral cover in the countries studied to date by PROCFish averages 15% lower than the global average. Taken together, these observations suggest that coral mortality may partly be the cause of a lower live coral cover on coral reefs in the South Pacific region.

During PROCFish surveys in Tuvalu (Nukufetau Atoll) in October 2004, an early stage coral bleaching event was observed. Recent bleaching was not detected on all islands in the group and was only present in parts of Nukufetau Atoll, affecting 10–30% of live corals in the lagoon and passes.

A field assessment undertaken in Kiribati in November revealed a recent, extensive and significant bleaching incident in Abaiang Atoll; 40–80% coral mortality was observed in shallow water areas, but bleaching was also found to be extensive up to depths of 35 m. Coral was also bleached in the main atoll of Tarawa, and recent bleaching was noted in the south of the Gilbert Group on Tabiteuea Island.

These bleaching occurrences are significant, as corals along the equator were thought to be more tolerant to heat stress, and bleaching had not been previously reported from Kiribati, at least not since it is being monitored by modern technology. This situation is now changing, with records from both the Gilbert and Phoenix Islands groups in Kiribati showing recent and extensive bleaching of corals.

Our study highlights the relatively large proportion of dead coral cover on coral reefs at the study sites, which could be indicative of the situation in the South Pacific region generally. This study cannot reveal the cause(s) of this mortality. Observed patterns may be typical of reef ecosystems in the region. Alternatively, the large proportion of dead coral relative to total coral cover at the regional scale may be the end result of past mass-mortality events, due either to coral bleaching or COTS events. The

Top: Live coral
Right: Dead coral

global frequency of coral mass-mortality has increased, with large bleaching events now occurring every few years. Taken into consideration the length of time needed for recovery (a decade in the most pristine outer slope areas), and the presence of other anthropogenic stresses (Wilkinson 2002), the situation suggests that there is cause for concern.

Major efforts are now underway to consistently monitor coral reef health globally. Our study presents an assessment of coral reefs at a regional scale in the South Pacific, using standardized in-water survey methods, as part of a generalised reef fishery monitoring programme. PROCFish research results will be used as a benchmark by SPC and participating governments to determine whether the live coral index of reefs in the Pacific is changing in the future.

Acknowledgements

The PROCFish Project team thank the Fisheries Departments and local communities involved in the study across Fiji, French Polynesia, Kiribati, Tuvalu, New Caledonia, Tonga and Vanuatu for their help and collaborative support in implementing this study. The study was funded mainly by the European Union under the Pacific Regional Indicative Programme of the 8th EDF.

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FISHERIES DEVELOPMENT SECTION

Finalising field reports for Tuvalu and Papua New Guinea

Fisheries Development Officer, William Sokimi, and Fisheries Development Adviser, Lindsay Chapman, finalised field reports for work done in Tuvalu and in Papua New Guinea. These reports are available upon request from the Section.

Manual and booklet being drafted

Section staff members are working on several technical manuals. The results of the FAD research project are forming the basis for a revised technical manual on FAD mooring designs. This manual is an output of the project and is nearly complete. The manual covers the new Indian Ocean FAD design (now recommended by SPC), which is explained on page 25. This manual should be completed in June or July 2005.

Two marine species identification manuals are being developed. The aim of these manuals is to improve both the quality and quantity of data being provided by domestic fishermen, so that this data can be used by scientists for stock assessment purposes. This is a collaborative project with several sections within the Coastal and Oceanic Fisheries Programmes providing input.

The first marine species identification manual is for domestic tuna longline fishermen in the region, and covers the main species likely to be caught, plus some uncommon species. The final section of this manual covers species of special interest, including sea turtles, toothed whales and dolphins, and

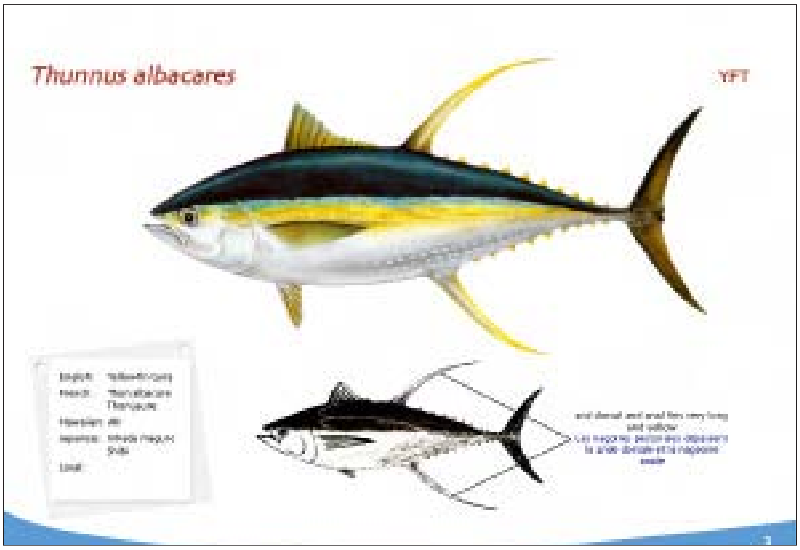


Figure 1: Sample page from the tuna longline marine species identification manual

seabirds. For the main species, there will be a colour picture of the fish, plus a line diagram with common identifying features indicated. Each fish will have the scientific name, FAO species identification code, and the common name in English, French, Japanese and Hawaiian, for marketing purposes (Fig. 1).

This manual should be finished by the third quarter of 2005. The second manual will have the same format as the first, but it will cover deep-water snappers and associated species found at depths of 100 to 400 m. This manual is in its early stages and will be completed in early 2006.

The final manual underway is on the basics of handling and chilling fish, and is targeted at small-scale fishermen in the region. Text has been drafted and the manual should be completed and distributed in the third quarter of 2005.

The section is also looking at developing a booklet that outlines the deep-setting tuna longline work conducted by Fisheries Development Officer, Steve Beverly, to reduce interactions with bycatch species, such as sea turtles. The aim of this booklet will be to present the fishing technique in its basics, so that tuna longline operators in the region can adapt this technique into their current fishing activities.

Technical assistance to Nauru

Fish aggregating device (FAD) materials and a deep-water echo sounder were ordered for Nauru. William Sokimi went to Nauru in early March for two weeks to assist in rigging and deploying two FADs, while also training staff of the Nauru Fisheries and Marine Resources Authority (NFMRA) in these procedures.

The FAD design used was the new Indian Ocean-type now recommended by SPC as a result of the recently concluded FAD research project (see article on page 25 of this newsletter). The design (Fig. 2) incorporates a buoy system using 15 x 20 kg hard plastic pressure floats (rated to 200 m) and 14 x 7 kg foam purse seine floats alternately threaded onto an 18-m length of 28 mm nylon three-strand twisted rope with an eye splice in each end. Three-strand twisted nylon and polypropylene rope were used for the mooring line, with Nylite rope connectors used to protect the eye splices. A 22 mm galvanised swivel was placed between the buoy system and upper mooring line, and the lower mooring line and the anchor chain. Galvanised safety shackles were used for all connections. One FAD was rigged for deployment in 1500 m, and the other for 2500 m.

While the FAD mooring systems were being rigged (Fig. 3), William also worked with NFMRA staff to design and construct flagpole arrangements that could also hold a "screw-on" light indicator for the FADs.

NFMRA's new Furuno FCV 1200L echo sounder consists of three separate units: a colour LCD sounder display unit, a 3 kW transducer unit, and a processor unit. These units came completely unconnected with the wiring provided, but without the plug-in sockets hooked up. In order to get the system working, the display unit had to be connected to the processor unit and the processor unit to the transducer.

A holder unit was constructed to secure the transducer, so that it could be mounted on the side of one of the NMFRA vessels (Fig. 4). The transducer casing base was 54 x 25 x 27 cm, and the post height was 185 cm. A plywood carry box was also constructed for the echo sounder display and processor units (Fig. 5).

When the echo sounder was tested the system worked perfectly. The seabed reading came out clearly with the vessel running at 6 knots. As the soundings got deeper, 2500 m plus, the vessel speed had to be reduced to get a clearer picture.

The FADs were ready for deployment well before Williams departure, although, they could not be deployed because the Nauru Phosphate Company's barge, which was to be used to transport the FADs to the deployment sites, needed repairs that could not be made before William's departure. Therefore, William spent some time working with the National Fisheries Corporation (NFC), which is the commercial fishing arm of NFMRA. The company has two tuna longline vessels, the NF5 (F/V *Victor Eoaeo*) and the NF6 (F/V *Austin Bernicke*). The NF5 was on the wharf at Anibare (Fig. 6) having a major overhaul, while the NF6 (Fig. 6) had just completed major repair work and was fishing again, with four trips completed.

Since commencing operations, NFC has experienced continuous problems in trying to get the two longliners operating efficiently. After William was briefed on the fishing operations system used, it was determined that the shore-side and ship operations management teams needed to be coached in several strategic areas. A briefing was carried out with all members of NFC to train them in as much of tuna longline operations as possible.

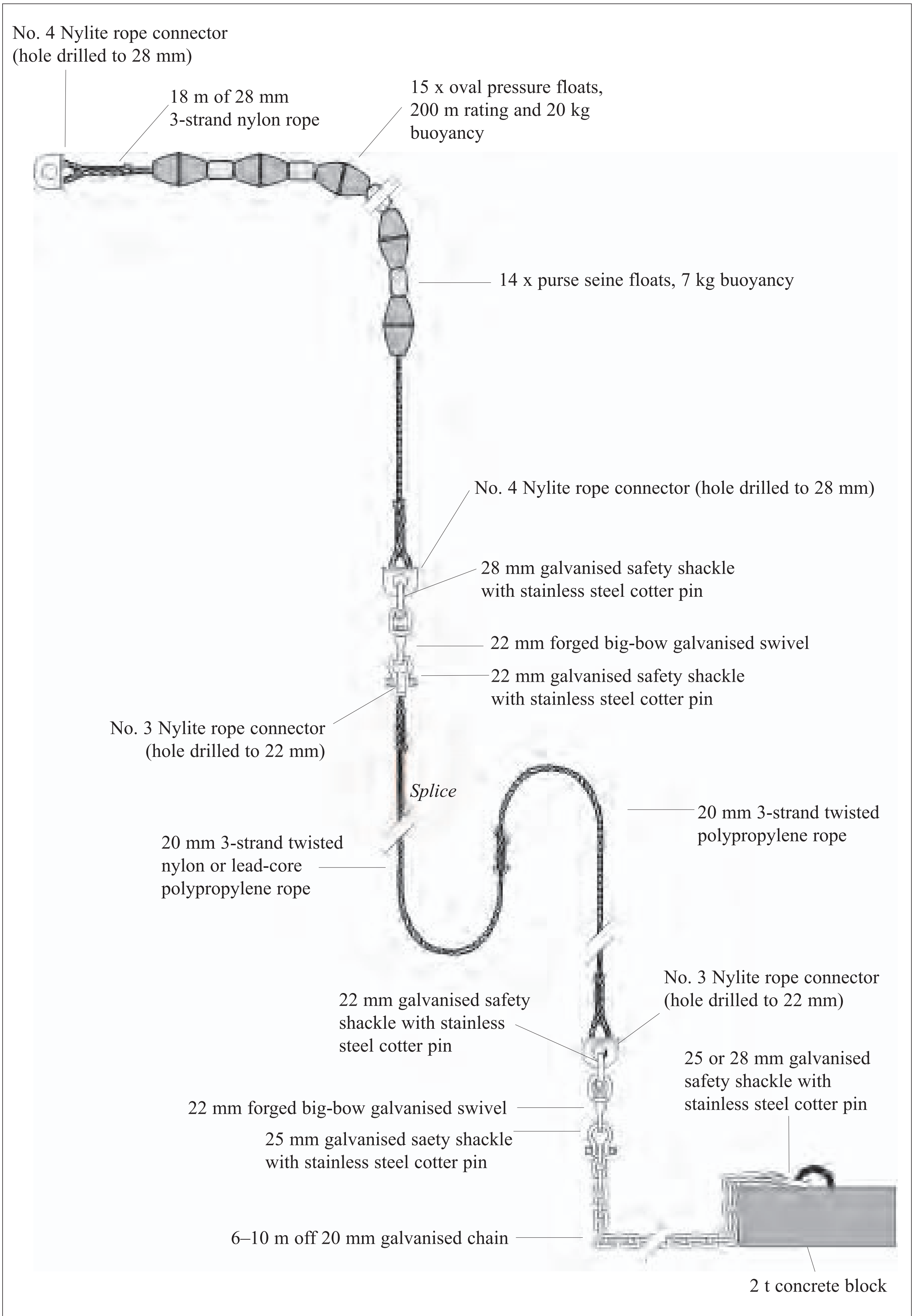


Figure 2: FADs rigged in Nauru

Figure 3 (top left): Making an eye splice in the upper mooring rope
Figure 4 (top right): Mounting for transducer on vessel side
Figure 5 (bottom left): Plywood box with the echo sounder display and processor units mounted
Figure 6 (bottom right): NF5 on the wharf being overhauled and NF6 at the wharf

The following points were stressed during the briefing:

- timing of fishing trips and vessel turnaround times;
- crew commitments to fishing and the need for them to give advanced warning if they can not make a trip;
- length of fishing trips, with at least five sets being made, and the need to stay out until the fish hold was full, or the vessel was low on fuel, bait or ice;
- timing for vessel departures and returning to port based on flight schedules for exporting the catch;
- crew desire to fish and earn more income if they have better catches;
- fish quality and the need for the crew to work together to insure fish are handled, processed and chilled correctly;
- maintaining the fishing gear and personal items assigned to them, such as wet weather gear, to cut overall operating costs for the vessels;
- the need for crew to be shown the actual figures for fish sales, deductions, and shown how their percentage is derived; and
- the need for stocks of fishing gear and other consumables to be kept on hand at NFC, based on what the skippers are using or requesting.

William also discussed the fishing operation of NF6 with the vessel's skipper. Discussions revealed that the mainline reel and line shooter were not being used to their full capacities. The current practice was to "free-spool" the mainline reel and run the line straight off the stern through a guide block, not using the line shooter at all.

In order for this system to perform correctly, the coordination between the reel and shooter needed to be established by tuning two valves on the shooter. The two NFC skippers, crew, and shore maintenance personnel were shown how to carry out this adjustment and the crew were enthusiastic about using the shooter system on their next fishing trip. The crew were advised that they may have to perform one more adjustment to the tension, on the in-board valve, once the mainline on the reel had passed the half-way mark.

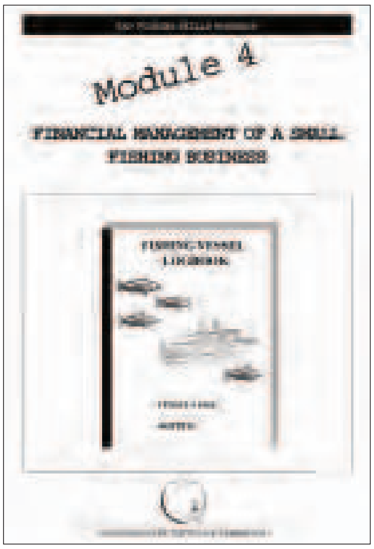
TRAINING SECTION

Small fishing business management course offered at Vanuatu Maritime College

With funding from the Commonwealth Secretariat, the SPC Fisheries Training Section is responding to a need for small business management training as identified in 2004, in the small-scale fisheries sectors of Vanuatu and the Solomon Islands.

The two-stage training project includes a joint Vanuatu-Solomon Islands "Training of Trainers (TOT)" course; participants will afterwards return to their regular posts and implement the follow-up, in-country programmes. The project is based on a collaboration between SPC and training institutions in Papua New Guinea, where "Start Your own Fishing Business (SYFB)" courses were successfully introduced in 2003. The SYFB course content has been tailor-made to suit the specific needs of the PNG artisanal fisheries sector. The present project intends to export the PNG programme to neighbouring countries with similar socioeconomic and cultural situations.

The TOT course will be hosted in June 2005 by the Vanuatu Maritime College in Santo. Participants will be selected from institutions active or with a potential role in small business management training (e.g. fisheries departments and colleges of both Vanuatu and the Solomon Islands, the Vanuatu Chamber of Commerce and Industries, and the Solomon Islands Small Business Enterprise Centre). The course will be delivered by trainers from the PNG National Fisheries College in Kavieng and the Small Business Development Centre in Port Moresby. Its content will include the standard SYFB "Training of Trainers" course (two weeks) and a component to assist the local trainers with the planning of achievable in-country programmes to deliver SYFB training to fishing communities. Based on the training needs identified in Vanuatu and the Solomon Islands, it is expected that the primary targets will be the rural fishing centres (Solomon Islands), a number of newly established fishing cooperatives (Vanuatu), as well as women's groups.

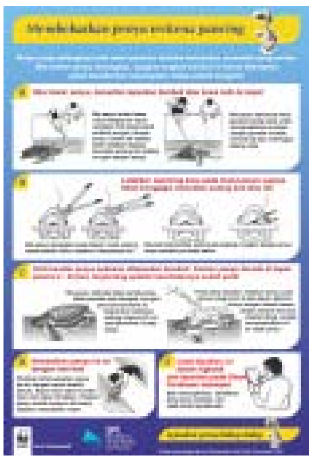


SPC bycatch materials reach Indonesian fishermen

The SPC awareness campaign on the bycatch of turtles during tuna longlining is taking a new turn with the translation of the "Guidelines for Safely Releasing Hooked Turtles" in Bahasa. This work is part of a project coordinated by the World Wildlife Fund's Indonesia office, and is aimed at enhancing the collection of bycatch information (mainly on turtles) from tuna fisheries in the West Papua area.

This Indonesian version of the SPC guidelines (initially produced in English and French) will be printed on laminated cards, for use onboard fishing vessels. SPC's Fisheries Training Section will receive 200 copies of the cards for distribution to Indonesian longline vessels, operating in SPC's region (principally in Micronesian countries and Papua New Guinea).

The SPC manual "Protected marine species and the tuna



longline fishery in the Pacific" also positively impressed the staff of WWF Indonesia for its completeness and applicability to their upcomig training activities and educational use with the local fishing industry. The manual may soon be translated in Bahasa and used under the same project.

Following the success of the "Marine Turtle Identification Cards", the Training Section is completing a similar identification tool for shark species that interact with the region's offshore tuna fisheries. The cards should be completed by June. Distribution will be done via national observer programmes, fisheries associations, as well as regional Fisheries Departments.

For further information on bycatch awareness materials, contact the Fisheries Training Section.

Fisheries HRD planning in Nauru

The financial crisis currently facing the Nauru government has resulted in a major reduction in the standard of living for all Nauruans. Although the country's food security continues to rely heavily on food imports, there is a much stronger focus now on gardening (despite limited and fragmented land suitable for agricultural purposes) and subsistence fishing.

At present, most of this fishing effort is concentrated on the island's limited fringing reef and outer slopes. Reef gleaning, spearfishing, gillnetting and handlining are the most commonly used fishing techniques by Nauruans, while fishing from canoes outside the reef remains an activity practised mainly by expatriate workers (I-Kiribati and Tuvaluans). Only a limited number of Nauruans have an outboard-powered vessel (estimated to be 50 total on the island), and in the absence of FADs, chasing offshore pelagic species is too costly for most boat owners. It is within this context that most sections of SPC's Coastal Fisheries Programme are, or will be, engaged in projects in Nauru this year. Interventions will include the deployment of FADs and associated training for small-scale fishermen, training in commercial tuna longlining, the development of a strategic plan for the aquaculture sector, assistance in tilapia and milkfish farming, as well as field work conducted by SPC's Pacific Regional Oceanic and Coastal Fisheries (PROCFish) project team members and staff from SPC's Community Fisheries Management Section.

Following a request from the Nauru Fisheries and Marine Resources Authority (NFMRA), SPC's Fisheries Training Adviser visited Nauru in January to assist with a fisheries training planning exercise, undertaken by the NFMRA. The purpose of the visit was to develop, through a consultative process, a human resources development (HRD) plan to guide NFMRA's fisheries training and awareness-raising activities over the next five years.

After some consultations with several fishing business owners, including one fishing charter operator, a two-day workshop with key personnel from NFMRA and its commercial arm, the Nauru Fishing Corporation (NFC), was held at NFMRA's new offices at Anibare Bay. Workshop participants considered seven training areas in relation to the "National Fisheries Objectives and Strategies 2003–2010", and for each area, several activities were discussed. Details such as target audience, training strategy, cost and performance indicators were entered into a matrix. The resulting document makes an HRD plan consisting of:

- A long-term educational campaign targeting school children through the development of fisheries educational packages (for kindergarten and primary schools). The campaign also includes training local teachers in the use of these educational materials as well as ongoing inputs from NFMRA staff (in secondary schools);
- An apprenticeship scheme for youth workers that includes fisheries lectures and presentations by NFMRA staff as well as practical work attachments;
- A promotional and awareness-raising campaign on fisheries and marine environmental issues targeting communities through media use;
- A series of in-country workshops in fisheries-related skills targeting subsistence and small-scale commercial fishermen. The training will have a strong focus on sea safety and fishing activities outside of the reef areas;
- A series of in-country workshops on seafood value-adding and community-based resource management that target communities, particularly women;
- A series of short, technical courses on operating longline fishing vessels profitably. All managers, engineers and skippers of the Nauru

Fishing Corporation will be required to take the courses;

- A series of statutory certificate courses on safely operating longline fishing vessels. All NFC skippers, engineers and crews will be required to take the course;

- A comprehensive training package for NFMRA staff consisting of in-country courses, work attachments and selected overseas courses. The initial focus of the training will be on NFMRA senior officers (organisational management training) and trainers (extension skills training).

While some training programmes will require overseas trainers (mainly for short, technical training courses and work attachments), efforts will be made to use local training institutions, such as the University of the South Pacific's Extension Centre (distance learning courses).

While several components of the HRD plan will be implemented with SPC's assistance and NFMRA's existing human and financial resources, other parts of this ambitious and long-term plan will require additional support. It is envisaged that NFMRA will present a funding proposal to that effect, at a forthcoming donor meeting in Nauru.

AQUACULTURE SECTION

Sustainable aquaculture in Pacific Islands region and northern Australia

An update on the February 2004 ACIAR Project Leaders Meeting in Cairns, Australia

Introduction

The ACIAR-funded Sustainable Aquaculture Project is intended to support responsible aquaculture in the Pacific region and northern Australia, particularly among the indigenous populations. The inception of this project was reported in the February 2004 issue of the SPC *Fisheries Newsletter* (#108). The project comprises three core components:

1) mini-projects that will address development bottlenecks through research and capacity building;

2) extension of post settlement capture and culture techniques; and

3) technology to develop sea cucumber aquaculture and reseeding efforts.

The main organisations and their representatives in this project include Mike Rimmer and Cathy Hair from the Queensland Department of Primary Industries and Fisheries (QDPI&F), Ben Ponia from SPC, and Warwick Nash from the WorldFish Center. Tim Pickering from the Institute of Marine Resources (IMR) at the University of the South Pacific also participated, as IMR has proven to be an active participant in project activities.

This article reports on the major outputs since the project began, provides an update of upcoming activities, and reviews other project developments.

Sea cucumber reseeding/aquaculture

Cathy Hair gave an update on sea cucumber broodstock acquisition and maintenance, and hatchery production in Queensland up to February 2005. Cathy will pursue options for obtaining new broodstock for the Torres Strait 2005–2006 spawning season.

Warwick Nash provided an update on ACIAR project FIS/99/25 — "Optimal release strategies for restocking and stock enhancement of the tropical sea cucumber, sandfish". This study, which is being carried out by the WorldFish Center New Caledonia office, has been extended to June 2006. The most recent hatchery runs produced large numbers of juveniles for the grow-out and release experiments, although problems with larval survival remain. A number of promising experiments have been undertaken involving grow-out of juveniles in ponds, using hapas and bag nets under different conditions (e.g. shaded vs unshaded, fed and unfed, artificial substrata vs no substrata). A paper is in preparation that examines the relationship between movement rates and no-take zones, while further workshops are planned to determine the location and techniques to be used for future large-scale reseeding experiments.

The choice of a second Pacific Island country for transfer of sea cucumber production technology was discussed, with Kiribati a possibility because it has an established pearl oyster hatchery with algal culture facilities, and an active sea cucumber (white teatfish) hatchery. Fiji also has a hatchery and algal culture facilities.

Presettlement fish capture and culture (PCC) fishery

Cathy Hair gave an update on this project's progress in Solomon Islands, and will explore the possibility of doing some simple modelling (with Dr Neil Gribble of QDPI&F) to support the claim that controlled crest netting will not lead to overfishing of presettling larvae.

Dr Tim Pickering mentioned the possibility of Fiji receiving training in PCC methods. Fiji has a well established aquarium fish export industry, and excellent air links to the US and Europe. Exporters are supportive of a sustainable industry and will actively support attempts to introduce PCC techniques. Many rural Fijian communities are experienced in this industry. In addition to involving the Fiji Ministry of Fisheries, there are also valuable links with USP and industry. Two trips were originally planned to assess possible sites for transferring technology to a single community. These trips could instead be used to:

1) establish two monitoring sites to assess the suitability of selected reefs over several months; and

2) run a training workshop for community members, Fiji Fisheries and industry representatives.

The WorldFish Center–NZ-aid funded Rural Livelihoods Project has begun. This project is expected to enhance the transfer of PCC technology in Solomon Islands through the hiring of four more technicians and funding to cover additional sites.

The inception workshop of the Agence Française pour le Développement (AFD)-funded Coral Reef Initiative for the South Pacific (CRISP) will include extension of pre-settlement fish capture/culture methods from French Polynesia to other Pacific islands, probably including Fiji.

PNG freshwater aquaculture

Brett Herbert from QDPI&F Walkaman Station presented an overview of an ACIAR project proposal — "Development of capacity for aquaculture of indigenous fish species in Papua New Guinea". The project is focused on native fish species (e.g. catfish) that are popular with locals, as there are no introduced species in Papua New Guinea's upper Fly River. He also discussed linkages with another large ACIAR project (led by Paul Smith from the University of Western Sydney), and potential contributions from QDPI&F to address training needs at Aiyura Highlands Aquaculture Station.

Yonki Lake in the Eastern Highlands Province of PNG was discussed as a potential mini-project site to examine cage culture of GIFT tilapia. Currently, there are 50 commercial cage farms with GIFT tilapia set up, using government-subsidised cage materials and fish. There is concern about the potential for overcrowding and a lack of sustainability with the current rate of increase in cage farming. Another constraint is the lack of feed, as the nearest mill in Lae is not producing any. This study would monitor water quality to determine impacts on growth, and conduct fish cage density trials. Another mini-project on feed formulation is already underway, and will benefit the cage fishery when it is complete. There are also linkages to other current and proposed ACIAR projects (e.g. an Indonesian study on the impacts of cage aquaculture (Australian Institute of Marine Science), and a study on cage tilapia farming in the Philippines).

Indigenous aquaculture

Chris Robertson of QDPI&F outlined results from the "Scoping Study for Opportunities for Indigenous Aquaculture in North Queensland". The focus of the study was to reduce the failure rate of indigenous aquaculture ventures, and to that end, a project assessment tool has been developed. A large project under development for Torres Strait involves sponge farming at York Island in collaboration with the Australian Institute of Marine Science. An Indigenous Aquaculture Extension Officer has been recruited to assist with the development of indigenous aquaculture ventures in Queensland.

The need for a definition of indigenous aquaculture was discussed, but no accurate and succinct definition was developed at the meeting. An indigenous aquaculture logo has been designed by SPC for the indigenous aquaculture webpage.

Aquaculture economics and marketing

Ben Ponia, Tim Pickering and Bill Johnston (an economist with QDPI&F) reported on their discussions regarding a training programme for aquaculture economics and marketing. The three organisations jointly produced an Aquaculture Economics CD. SPC will hold two subregional workshops targeting economic and marketing aspects of aquaculture, supported by training funds from Taiwan/ROC. The workshops will also teach participants how to use the Aquaculture Economics CD. The first workshop will be held at the University of the South Pacific in Fiji, and the second at

Bribie Island Aquaculture Research Centre in Queensland, Australia.

Mini-projects

Ben Ponia summarised progress to date on mini-projects. He emphasised that it took some time to build momentum, but that a number of mini-projects have come on line fairly quickly; SPC's preference is for mini-projects to focus on research. Ben highlighted the importance of projects supporting ongoing government research and development activities in PICs, rather than simply being of academic interest. It is important that proposals be well defined at the outset, before resources are committed. Ben also emphasised the importance of engaging stakeholders early in the process, and securing agreement in principle before getting caught up in project technicalities.

Discussion points relating to funded mini-projects were:

- *The hiring of a consultant for the Aquaculture Assessment of Motupore Island Research Centre at the University of Papua New Guinea. The preference is to identify a consultant that is able to establish linkages with an Australian research institution, leading to potential collaboration.*
- *The feeds formulation project involving Fiji and Papua New Guinea is progressing well. Personnel from SPC, Queensland University of Technology, and ACIAR have conducted field visits to PNG and Fiji. The project has the potential to develop linkages with French expertise through institutions such as IFREMER, which has a station in New Caledonia. There may be an opportunity for PIC postgraduate attachments at IFREMER; development of* Macrobrachium *feeds was one potential area identified. The SPC consultant nutritionist (Carmen Gonzales) is acting as an external supervisor for two USP students; Ben Sagata (Fiji Ministry of Fisheries) is the local counterpart for the miniproject and currently enrolled in a master's degree programme at USP doing feed research. The other student, James Teri from Solomon Islands, is carrying out a master's degree project to monitor farm performance (including feeds) as part of a GIS study of ponds in Fiji.*
- *The Fiji shrimp disease status mini-project is nearly complete. The main researcher (Salote Waqairatu) is due to finish her master's research at USP after having completing her viral and DNA analysis at CSIRO in Brisbane. The impacts of this project and the potential to develop specific pathogen-free brood stock were discussed. Now that the disease status is known, the next step is to assess the availability of broodstock.*
- *A mini-project to conduct basic trials for farming of wild freshwater shrimp (*Macrobrachium lar*) is underway in Vanuatu and Wallis and Futuna. Very little is known about* M. lar*, including basic information such as growth rates. In Wallis and Futuna the shrimp will be stocked into ponds that are integrated with taro swamp plantations. Vanuatu will trial monoculture using high quality formulated diets. The project to due to be completed by mid-2005.*

Potential new mini-projects

Ben Ponia presented some mini-project concepts targeting Nauru, which emerged from a recent visit. The country is currently facing a financial crisis, and food security is becoming a concern as household cash diminishes. In the past, milkfish aquaculture was widely practiced and of great importance to the local culture, but this tradition has waned and most ponds are now in a dilapidated condition and infested with Mozambique tilapia. In order to use the ponds, methods to control or integrate the Mozambique tilapia must be developed, and the mini-project mechanism may assist in this. The culture of GIFT tilapia, which is a much superior strain of tilapia as compared with the Mozambique variety, is an option with regards to providing a source of fish protein. There is popular support for rejuvenating milkfish aquaculture, although such an effort is likely to be a long-term project. It could benefit from the application of the "backyard" hatchery model developed in Indonesia.

Mud crab aquaculture is generating general interest in the Pacific region. There have been recent grow-out trials in Kosrae and an attempt at grow-out in Samoa some years ago. Some interest in assessing the potential for a mini-project in this area was expressed.

USP reported low survival of *M. rosenbergii* (~20–30%) through the hatchery phase. It is suggested that the genetics of local stocks need to be evaluated to determine if this is due to inbreeding depression or poor husbandry. *M. rosenbergii* from Fiji has been distributed to other Pacific countries and it is important to ensure that the best genetic stocks, which do not jeopardise future efforts at genetic improvement, are being sent out.

Algal training is a critical area lacking well-trained technicians. Samoa and Tonga have both applied for training support; the CSIRO laboratory in Tasmania has been identified as a potential location for providing training.

Mabe pearl is a niche product that Kiribati could produce from its fledgling pearl industry. This product would tie in well with plans (by the ACIAR Black Pearl Project at James Cook University–JCU) to run a pearl-coconut jewellery workshop in the near future. Ben presented a mini-project (with the Kiribati Ministry of Fisheries and JCU) to trial mabe pearl production at the government pearl farm on Abaiang Atoll.

16th NACA Governing Council Meeting

SPC's Aquaculture Adviser, Ben Ponia, participated in the 16th Network of Aquaculture Centres in Asia-Pacific (NACA) governing council meeting held in the Philippines in March. SPC is an associate member of NACA and assists this dynamic network in representing the interests of the Pacific region. The meeting was hosted by the Philippines Bureau of Fisheries and Aquatic Resources and the Bureau Director served as the chairperson.

The governing council meeting was preceded by the two-day workshop for the Support to Regional Aquatic Resources Management (STREAM) Project based at NACA

www.streaminitiative.org

The aim of STREAM is to empower poor farmers and improve their livelihoods; the workshop was the final output. Most of the STREAM activities have been carried out with impoverished communities in countries such as India or those that share the Mekong River (Vietnam, Cambodia, Thailand). The workshop was able to determine a broad set of parameters that define the livelihoods approach, and it was recognised that the livelihoods analysis can help build bridges between communities and policy makers. At the same time, national governments must make poverty alleviation and providing assistance to poor communities a priority, and this needs to be reflected in both policy and planning activities.

The Asian tsunami was a special topic of the governing council. Many of the affected areas supported a sizable aquaculture industry. For example, prior to the tsunami Indonesia's Aceh Province produced over 10,000 t of shrimp and 6000 t fish from 45,000 ha of ponds that directly employed 50,000 people. Many of the key aquaculture facilities in Aceh were wiped out, with a number of key staff killed. Many meeting participants (from NACA, FAO and country representatives of Indonesia, Sri Lanka, Thailand and Australia) are currently involved in the front line of the relief effort. The Pacific extends its sympathies to its neighbours in light of this immense tragedy.

An initiative suggested by the NACA Director General was for a conference with ministerial level participation from the Asia and Pacific region. This conference would be a timely event to raise the profile of the aquaculture sector, its development agencies and global policies. Bearing in mind the demands for time on ministers, it was felt that the conference should target issues of critical importance to countries, in particular trade relationships. NACA and other agencies, including SPC, will collaborate further on this concept.

NACA continues to strengthen its work programme. While relatively small in size compared to the breath of its country membership and scale of aquaculture production, the organisation is an effective advocate for the industry. Networks continue to be established; links have been established with an Eastern European network, and there is interest in building a network from Arabian Gulf states. Iran was formally accepted as a member during the 16th governing council meeting.

Synergies between the SPC animal health program and activities within SPC were noted. During a side meeting, a concept for an aquatic biosecurity project was raised by Ben Ponia and a schedule for developing this project was outlined. The NACA secretariat has also offered its assistance to facilitate training. One area of particular interest is for study tours to the Asia region and Ben was able to get a tentative agreement for one such tour to be scheduled in the near future.

FROM LOBSTER FLOCK TO LOBSTER FEAST?

New source of larvae could make large-scale lobster farms feasible

Harbor Branch Oceanographic Institution has begun a new program scientists hope will make large-scale culturing of spiny lobster economically feasible. The project is based on the serendipitous discovery that lobster larvae are settling on open water fish cages in Puerto Rico by the thousands.

"Spiny lobsters are one of the most highly-prized fisheries species in the world, and especially in Florida waters," says Megan Davis, director of Harbor Branch's aquaculture program. "This research is very exciting because we expect to make breakthroughs that will help to make the culture of this species a reality," she says.

Spiny lobster is an ideal target for commercial culture due to its high value and limited availability from wild capture, mostly using traps. Each year, 3 to 4 million pounds of Florida spiny lobsters valued at about USD 17 million are harvested and account for 11% of the spiny lobsters on the U.S. market. Overfishing of lobster has also led to ecological problems in some areas that might be relieved through successful culture and release to the wild.

The main barrier to successful commercial spiny lobster culture, which has been explored through pilot programs in various countries, has been the need to collect larvae from the wild and the difficulty in doing so. The lobster larval growth cycle is extremely complicated and as yet reproduction and growth to adulthood has not been accomplished in captivity in reliable numbers.

Development of collection methods to get enough larvae to support large-scale commercial culture has so far not been possible, but in 2003 technicians with Puerto Rico-based Snapperfarm, Inc., discovered that lobster larvae by the thousands happened to be settling on large submerged cages the company uses to raise fish. The cages, anchored in 100 feet of water, are about 50 feet high by 80 feet in diameter, making for a total of 12,000 square feet of lobster larvae-snagging surface area.

In 2004, with USD 50,000 in funding from the National Oceanic and Atmospheric Administration's Small Business Innovation Research program, the company began working with Harbor Branch's aquaculture program and other groups to determine if commercial-scale quantities of larvae could be collected from the cages.

The team found initially that up to 400 larvae per month could be collected — enough for testing commercial feasibility of raising the lobsters to market size. They have now received Phase II funding from NOAA for two years totalling USD 200,000 to explore techniques for gathering even more larvae, to study open water and land-based methods for raising the larvae to adulthood, and to begin developing possible feeds for the lobster. Small-scale lobster culturing has been possible using cast off parts of conch and other species from seafood processing plants and elsewhere, but this is not an economic option at larger scales. A final goal of the new project will be to determine if increased availability of lobster might make higher-value options, such as selling live or whole spiny lobster, possible.

Over the next six months, scientists from Harbor Branch, Snapperfarm, the U.S. National Marine Fisheries Service in Puerto Rico, the Florida Sea Grant Program in Ft. Pierce, and the University of Miami will be working in Puerto Rico to construct lobster larvae collectors and determine the best design and placement locations on the cages; to set up submerged lobster enclosures and refuges referred to as casitas for raising juveniles; and to begin raising lobster in troughs on land. Work to develop a lobster feed that could ultimately be marketed to a lobster aquaculture industry is running concurrently at Harbor Branch.

(Source: Harbor Branch Oceanographic press release, 7 March 2005)

http://www.hboi.edu/news/press_releases.html#press

1 pound = 0.434 kg
1 foot = 0.304 m
1 square foot = 0.092 m²

SCIENTISTS DISCOVER HOW FISH EVOLVED TO FLOAT AT DIFFERENT SEA DEPTHS

Scientists at the University of Liverpool have discovered how fish have evolved over the last 400 million years to stay motionless at different water depths. A research team led by Dr Michael Berenbrink, a Comparative Physiologist at the School of Biological Sciences, has revealed how modern fish, such as pike and cod, have developed a way of floating at certain water levels using a gas-filled swim bladder.

Dr Berenbrink investigated the mechanism that allows fishes to keep the swim bladder inflated with gas even at great water pressure in the depths of the sea. The mechanism comprises of a complex system of arteries and veins, called the *rete mirabile*, and special blood proteins, which can release oxygen even at high oxygen concentrations.

These systems drive oxygen from the blood into the swim bladder allowing the fish to float at different levels in the sea without coming to the surface of the water for air. A similar system is also present in the eye of the fish, which provides oxygen to the retina.

Dr Berenbrink explains: "I am interested in how the mechanisms in the swim bladder and eye could have evolved. Some fish have no swim bladder and others fill it by swallowing air at the surface of the water. Another group of fishes has a closed swim bladder that is inflated through gas secretion even when they are in high water pressures. My aim was to find out how these systems came into place and how this allowed for the great variety of fishes we have in our oceans today."

The study revealed that the special blood proteins, which are essential for oxygen secretion, were present in the eye system 250 million years ago. This predated the swim bladder system by 100 million years. The special blood proteins induced development of the swim bladder system.

Dr Berenbrink continued: "Many researchers believe that the swim bladder evolved from a primitive lung, which can be traced back 400 million years. These findings will help us to understand the diversity and success of modern fishes in their environment."

Dr Berenbrink's research has been published in Science Magazine *on Friday, 18 March 2005.*

(Source: University of Liverpool, 18 March 2005)

A GREAT LEAP UPSTREAM FOR FISH FARMERS

The Japan Science and Technology Agency has become the world's first to successfully transplant cells between two different fish species, using the primordial germ cells found in all animals in early stages of development. Primordial germ cells are cells that have not yet undergone sexual differentiation to develop into sperm or egg cells.

This success will become the basis for surrogate reproduction and preservation of genetic resources for fish. The research was conducted by a team headed by Tokyo University of Marine Science and Technology Associate Professor Yosliizaki Goro. It marks the first time that cross-species transplantation of germ cells in any animal has resulted in the birth of offspring of the donor species.

After establishing technology to discriminate between primordial germ cells and other cells, the second step in the research was to establish the technology to implant the primordial germ cells in the host species, the masu salmon *Oncorhynchus masou*. After extracting live primordial germ cells from rainbow trout, 10–20 were inserted into the peritoneal cavity of the host salmon using a tiny glass pipette. The transplanted primordial germ cells eventually made their way to the salmon's gonads. Inside the gonads, the primordial germ cells multiplied and differentiated, and those in male salmon eventually developed into mature sperm. When these sperm were used to fertilise normal rainbow trout eggs, 0.4 per cent of the offspring were rainbow trout. The rest of the offspring were trout-salmon hybrids.

Over-fishing of wild tuna is a worldwide problem and this research may greatly benefit the farm-raised tuna industry. In specific terms, the germ cells that become the cells that produce eggs and sperm could be extracted from living tuna and transplanted into smaller fish such as mackerel. It takes huge sea pens to house the adult tuna needed for reproduction, but if large numbers of mackerel could be made to spawn tuna eggs instead, the large pens would no longer be needed. After the tuna hatched and grew to a certain size, they would be released into the open sea.

A final important use for this research is in the preservation of species threatened with extinction. The primordial germ cells of endangered species could be stored indefinitely using freeze-preservation technology. If a species faced imminent extinction, these primordial germ cells could be thawed out and transplanted into a related species using cross-species transplantation technology developed by Yoshizaki's team. This research was published in the August 5, 2004 issue of the journal *Nature*.

(Source: Fishing Boat World, March 2005 - Baird Publications (www.baird.com.au))

REEF AND SHORE FISHES OF THE SOUTH PACIFIC

The South Pacific has long been in need of a comprehensive guide to reef and shore fishes. Reef and Shore Fishes of the South Pacific, by John E. Randall covers the inshore fish fauna of New Caledonia, the Loyalty Islands, the southern Gilbert Islands (Kiribati), Tuvalu, Fiji Islands, the Wallis Islands, Tonga, Samoa, American Samoa, the Tokelau Islands, the Phoenix Islands, the Cook Islands, the Austral Islands, Rapa, the Society Islands, the Tuamoto Archipelago, the Marquesas Islands, and the Pitcairn Islands.

It contains accounts of nearly 1,500 species of fishes, illustrated with more than 2,000 color photographs, taken mostly underwater.

Species accounts are headed by the English common name, the scientific name, the author or authors who described the fish, and the date of the description. This is followed by a concise list of the characteristics needed to identify the species, the total length it attains, its distribution, habitat, and in summary form what may be known of its biology. More than 600 references are given, for those seeking more information on individual species. The introduction contains a two-page color spread of the main external features of fishes. An extensive glossary of scientific terms precedes the index.

The author, John E. Randall, is one of the world's foremost authorities on tropical marine fishes; he has described 555 new coral-reef fishes. He has authored 635 publications in marine biology, including regional guides to the fishes of the Caribbean Sea, Hawaiian Islands, Red Sea, Oman, and Great Barrier Reef of Australia. Since 1970 he has been senior ichthyologist at the Bishop Museum in Honolulu.

The guide will be released in May 2005. For more information, please contact the University of Hawai'i at

uhpbooks@.hawaii.edu

or visit the following website:

www.uhpress.hawaii.edu

(Source: University of Hawai'i Press)

FADBASE AND FUTURE DIRECTIONS FOR ECOLOGICAL STUDIES OF FAD-ASSOCIATED FISH

Tim Dempster[1] & Marc Taquet[2]

Fish aggregating devices, or FADs, are used throughout the tropics by recreational, artisanal and commercial fishers to concentrate pelagic fish for capture. Currently, approximately 1.2 million tonnes of yellowfin, skipjack and bigeye tuna and over 100,000 tons of bycatch are caught around drifting FADs in the Atlantic, Indian and Pacific oceans, which is approximately 1.5% by weight of the world's capture fishery each year. The global extent of catches around moored FADs is unknown, but they are an important component of fisheries strategies in many areas.

Given the increasingly widespread use of FADs over the past 20 to 30 years, a review of what was known about how they affect the fish they attract seemed timely. We traced the literature on FADs from the earliest observations, such as those made by Thor Heyerdahl of dolphinfish and tuna aggregating under his Kontiki expedition rafts, to modern research on both moored and drifting FADs. The result was "FADbase", a database of more than 400 references relating to FADs. Using FADbase we looked for trends in publication number and type over time, study topics, approaches and techniques, where FAD research had been done, what fish species it has focussed upon, and whether research effort has been biased towards moored or drifting FADs.

Publications before 1980 were predominantly peer reviewed, although non-peer reviewed literature has dominated since 1980, due to the numerous technical reports produced as FADs became more widely used in artisanal and large-scale industrial fisheries in the 1980s. Most studies of the ecology of FAD-associated fish were descriptive, with few mensurative experimental studies and even fewer manipulative experimental studies that tested specific hypotheses, due to inherent difficulties in working in the open ocean on objects that are temporary in space and time. Research on the ecology of FAD-associated fish has focused on moored FADs, despite the major FAD-based fisheries being around drifting FADs. Publications presenting information on moored FADs outnumbered papers on drifting FADs by a ratio of 3.5:1.

While the eternal question of "why are fish attracted to FADs?" will continue to fascinate many, there are pressing research needs concerning the current widespread use of FADs and their effects on fish stocks. Our review revealed large gaps in our knowledge of the ecology of fish associated with FADs. We suggest that FAD research should focus on:

1) describing how fish interact with FADs (spatial and temporal patterns of association with FADs by fish);

2) determining how fish locate and remain associated with FADs (sensory processes) and;

Mooring the deadweight (2 t concrete block)

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3) establishing the consequences of association with FADs for both individual fish stocks and the wider pelagic ecosystem.

We make several key recommendations for future research. Most of the research so far has been descriptive. To generate a better understanding of the mechanisms of attraction and aggregation at FADs, manipulative experimental approaches must replace the dominance of observational and descriptive studies. Because we know comparatively little about how fish interact with drifting FADs, far greater emphasis should be placed by fisheries scientists and funding agencies on researching them to provide better information for management of large-scale FAD-based industrial fisheries. Detailed information of the sensory capabilities of pelagic fish, and more specifically information that relates to their ability to sense FADs, is almost completely lacking. Physiological studies to develop such information are a vital first step in researching how fish locate and remain associated with FADs.

Finally, our analysis of FADbase highlights the enormous mismatch between the amount and value of tuna caught around FADs and the amount of research conducted on the use and effects of FADs. We call for a "paradigm shift" in the focus of pelagic fisheries scientists, managers and funding agencies to re-direct both human and monetary resources towards research of the use and effects of drifting FADs.

FADbase is freely available at www.ifremer.fr/dcp/ and the full review is available from Reviews in Fish Biology and Fisheries through:

www.springerlink.com

or by contacting Tim Dempster for a pdf file at tim.dempster@sintef.no

We intend FADbase to be a living information resource for those who use and research FADs and we will update it regularly. If you have published an article/report regarding FADs or the aggregative behaviour of fish around floating structures and you want it to be included in FADbase, please send an email to Marc Taquet at Marc.Taquet@ifremer.fr, with a copy as a pdf or txt file.

Reference

Dempster T, and Taquet M. 2004. Fish aggregation device research: Gaps in current knowledge and future directions for ecological studies. Reviews in Fish Biology and Fisheries 14(1):21–42.

The Indian Ocean-type FAD has been completely deployed

WHAT DO TUNA EAT? A TUNA DIET STUDY

Valérie Allain,
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SPC, Noumea
New Caledonia

Tuna live in different ecosystems throughout the Pacific Ocean and they adapt their feeding habits to what is available in their environment. To acquire better knowledge of their diet as well as understand how species interact (i.e. who eats who and in what quantity), the stomachs of tuna caught by fisheries are collected by scientific observers in several countries in the region. These are then examined at SPC to establish the species and the quantities of prey consumed.

Yellowfin tuna
Thunnus albacares

Tuna have a high metabolic rate and digest their food quickly. Although their daily ration is estimated to be 5 to 15% of their weight, according to their age, the average stomach content is low, at around 0.3% of the body weight; that is, for a 1-m-long yellowfin tuna, which weighs about 17 kg, the stomach contents will be about 50 g, the equivalent of a hen's egg.

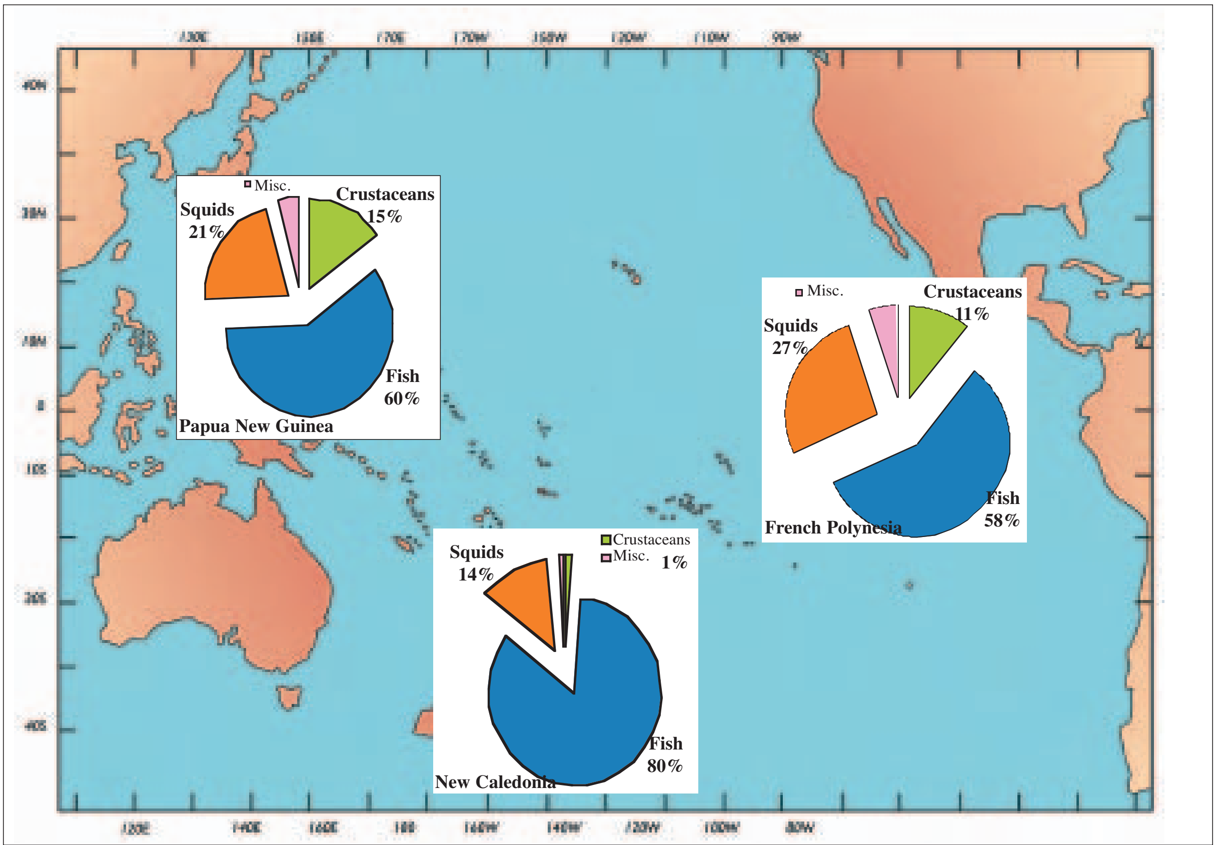
In general, prey items measure less than 15 cm and their average length varies between 4 and 7 cm according to certain areas.

Fish are the main prey of yellowfin tuna, followed by squid. Crustaceans are negligible in the diet of New Caledonia yellowfin tuna, whereas they represent a large proportion of the diet of tuna in Papua New Guinea and Polynesia.

The main squid identified in the three areas is *Stenoteuthis oualaniensis*, which is characterised by the presence of a large photophore on its back.

In New Caledonia, yellowfin tuna prey on surface fish such as flying fish or skipjack, and also deep-sea fish such as lancetfish and other fish of the tuna family.

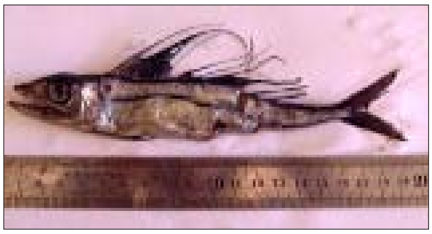
In Papua New Guinea, prey consist mainly of surface organisms such as flying fish, pufferfish, crab larvae and a large portion of juvenile reef fish, such as surgeonfish or triggerfish.

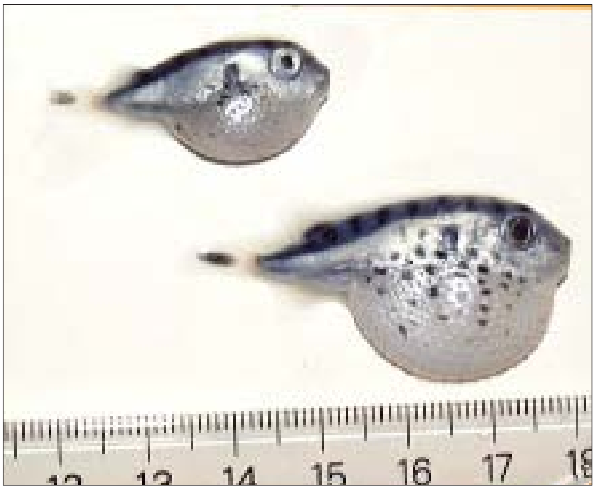


The three areas considered in the study: Papua New Guinea, New Caledonia and French Polynesia

Left: Stomach contents
Right: The squid *Stenoteuthis oualaniensis*

Some species found in tuna diet in New Caledonia: Juvenile skipjack (top right), flying fish (top left), and lancetfish (bottom right)





Some species found in tuna diet in Papua New Guinea: Juvenile pufferfish (left), and triggerfish (right)

In French Polynesia, the yellowfin tuna diet is a mixture of surface prey with numerous juvenile reef fish, such as surgeonfish and rabbitfish, but also deep-sea fish such as barracudinas.

The knowledge acquired in studying the diet of tuna and other top predators such as sharks, marlins, and dolphinfish will be used to assess the impact of fisheries and also climatic phenomena such as El Niño on tuna and the ecosystem they belong to.

Some species found in tuna diet in French Polynesia: Juvenile surgeonfish, and filefish

SMALL BOAT SEA SAFETY IN THE PACIFIC

Mark Smaalders

The Pacific Islands region is composed almost entirely (98%) of ocean, and most of that is unprotected, open water. The majority of Pacific Island countries and territories include many — in some cases hundreds — of inhabited islands. Small boats (less than 12 m long) remain the primary means of transport between islands, and are also used extensively by Pacific Islanders for fishing. Such craft number in the thousands, with an estimated 4500 skiffs and canoes in just one country (Kiribati), and perhaps ten times that number in the region as a whole. Many of these boats are used in offshore waters, and often make lengthy journeys, yet crews are rarely trained in how to avoid or cope with accidents, breakdowns and sinking, and most carry little if any safety equipment. While no accurate count exists of the number of emergencies that occur, there are hundreds every year; the cost of search and rescue activities in the region is estimated at between USD 5 and 8 million. Some of the most dramatic incidents — involving drift voyages of thousands of kilometres — do make headlines, but mishaps are sufficiently common that most create barely a ripple in the public consciousness.

What steps need to be taken to change this situation and improve sea safety in the Pacific?

Although there are many aspects to the issue, in the Pacific sea safety remains very basic: the ability of a vessel to safely complete a trip and return to its home village, island or port. Over the last four decades UN agencies, regional organisations, donors and others have focussed on various aspects of this issue, at different times addressing boat design, boat construction, fisheries training and safety equipment.

A regional study of sea safety conducted by the FAO in 2003, concluded that most maritime casualties in the Pacific Islands region are associated with small fishing vessels; typically these boats are also used for inter-island transport. These craft are generally not covered by legislation, construction standards, and enforcement strategies, and their owners typically receive no training on their proper use. The study identified five areas that should receive priority attention in future efforts to address sea safety:

- building awareness among fishery managers that sea safety is a legitimate and important objective of fisheries management;
- focusing more attention on small fishing vessel safety;
- improving systems for recording and analysing sea accident data and making use of the results;
- public awareness programmes on sea safety; and
- a regional sea safety workshop.

The last recommendation was realised through the joint FAO/SPC Regional Expert Consultation on Sea Safety in Small Fishing Vessels, held in Suva, Fiji, in February 2004. Participants included artisanal fishers, a legal specialist, boat builders, and personnel from government fisheries and maritime agencies. The experts addressed the issue of sea safety regulations, sea safety awareness programmes, how to improve the safety of the small fibreglass skiffs commonly used in the region, and how to enhance data collection of accidents at sea. They concluded that improved small boat safety would best be achieved by carrying out coordinated national strategies. Important elements of such strategies include generating political will at the national level, identifying individuals at the national level committed to sea safety, and increasing awareness of sea safety through training programmes and incorporation of sea safety issues into fisheries management. To help build a continuing dialogue on these and other sea safety issues, the experts recommended that SPC establish a sea safety special interest group, and publish an associated newslet-

Risks and dangers at sea

Typical problems faced by Pacific Islanders when fishing or travelling in small boats include bad weather (the danger is heightened when radio warnings about bad weather aren't available), a loss of power (most boats are outboard powered, and carry no spare engine or emergency sails), fires, poor boat construction or design, overloading of boats (and taking small boats offshore or on prolonged trips), a lack of communication or other safety equipment, and an absence of navigation skills and equipment (many boats lack even a compass).

ter. The experts' recommendations were endorsed by PICTs through the 2004 Heads of Fisheries meeting, as well as through the 2004 meeting of the Pacific Community's Committee of Representatives of Governments and Administrations.

The results of the Expert Consultation reinforced the outcomes of an earlier (1991) FAO study of sea safety in the Pacific, which found that professional mariners were almost unanimous in recommending increased public awareness through educational programmes and publicity as being the one means most likely to improve sea safety in the region. That finding has helped guide the work of SPC's Marine Resources Division in the area of sea safety since then, and the training and awareness materials produced by SPC over the past decade are believed to have been instrumental in building awareness of sea safety in the region. The 2004 FAO study recommended continuation of the current awareness programmes, but with a change in emphasis: more effort should be made to build awareness in remote areas (where this may be the only practical mechanism for improving safety). In addition, SPC safety awareness tools should be viewed as a complement to national awareness efforts, not as a replacement.

Materials produced by SPC to date include posters, stickers, laminated check list cards, leaflets, videos, radio programmes, TV clips, workshop and course curricula, model sea safety management systems for boat operators, and (beginning in February 2005) a Sea Safety Special Interest Group Bulletin (SIG). More information on materials available from SPC, and an online version of the Sea Safety SIG, is available at:

www.spc.int/coastfish/sections/training/index.html

Much remains to be done to enhance sea safety for small boats in the Pacific Islands. Political will to improve small-vessel safety is important, and requires that committed people are identified who can help develop long-term national strategies. Well-targeted assistance from international organisations will also be needed. In this context, SPC remains committed to assisting its members on the issue of sea safety.

International and regional regulations

While an extensive body of regulations have been developed to address safety issues aboard large ships, there are no international agreements or conventions that address boat construction, training and certification of crew, or required safety equipment for small (under 12 m) fishing vessels. Some voluntary guidelines exist for craft 12–24 m, but these are not applicable to the small scale or artisanal boats common in the Pacific.

Sea safety training programmes are one way to increase awareness of this issue

FAD RESEARCH PROJECT: FINAL RESULTS ON MOORING DESIGNS, AGGREGATORS AND COSTS

Lindsay Chapman[1], Ian Bertram[2], and Brendon Pasisi[3]

Introduction

The three-year SPC FAD research project ran from mid 2001 to mid 2004, with a six month extension until the end of 2004 to allow the completion of fieldwork, data analysis and report preparation. This project was funded through the New Zealand Government's Pacific Initiative for the Environment (PIE) fund. The project was implemented in three locations: Niue, and Rarotonga and Aitutaki in the Cook Islands. The objectives or outputs of this project were to:

1. Develop a more cost-effective FAD mooring design, with an average lifespan of at least two years, while reducing costs to a target unit level of NZD 4500 for deep-water FADs (1000 m depth) and NZD 3000 for shallow-water FADs (300 m depth);

2. Conduct studies with selected coastal communities to measure the FAD-related benefits accruing to the communities and the usefulness of FADs as a management tool; these issues were of special interest in areas where reef and/or lagoon marine protected areas (MPAs) have been declared and FADs deployed.

3. Collect catch and effort data from fishermen involved in FAD fishing, disaggregated according to the fishing technique used, and conduct a cost–benefit analysis of the use of FADs; and

4. Produce a technical manual and other literature, reports and articles to document the findings of the project, with the technical manual covering the new and recommended design for FADs based on the project results.

This is the first of two articles to summarise the final results and outputs of the project. This article covers the results in relation to the first objective (FAD designs and costs). The next issue of the *Fisheries Newsletter* will cover the final results in relation to objectives 2, 3, and 4 above.

Activities undertaken in the first two years of the project

A progress report on the FAD mooring designs initially trialled during this project and the activities undertaken in the first two years were reported in Fisheries Newsletter #105. A brief summary of those early results are provided here.

FAD materials were ordered for the three project locations in late 2001; materials arrived in early 2002. Site surveys (Fig. 1) were conducted in late 2001, with 15 FADs deployed from February to April 2002 (eight off Niue, four off Rarotonga and three off Aitutaki, all in depths from 400–1150 m).

Three FAD buoy designs (Fig. 2) were trialled during the early stages. The first design, used for offshore FADs, had 15 pressure floats and 14 purse seine floats threaded alternately onto an 18 m length of 32 mm diameter nylon rope with an eye spice and galvanised thimble at each end. The second design, used for inshore FADs, had five pressure and four purse seine floats threaded alternately onto eight metres of 32 mm diameter nylon rope, with an eye splice formed around a galvanised thimble in one end of the rope, while the other end was spliced directly onto a mussel float. The third design, also for inshore FADs, was very similar to the second, but the 32 mm rope was replaced with 20 mm nylon rope, which was sheathed with black PVC tubing to protect the smaller diameter rope.

Several types of mooring line were used in the new designs. These included 9 mm galvanised wire cable with a tube thimble hand spliced into each end to form an eye, 18 mm and 20 mm nylon three-strand rope, 20 mm three-strand polypropylene rope, and 20 mm three-strand lead-core polypropylene rope.

Replacement FAD designs

In May and June 2003, after the loss of five project FADs (2 off Niue, 1 off Rarotonga and 2 off Aitutaki), it was decided to deploy one replacement FAD at each location. In reviewing the design, the wire cable upper mooring (4 losses) and the polypropylene rope upper mooring with chain counterweight (1 loss) were considered not the best designs to pursue. Therefore, all replacement FADs used either the 20 mm, three strand nylon rope or 20 mm,

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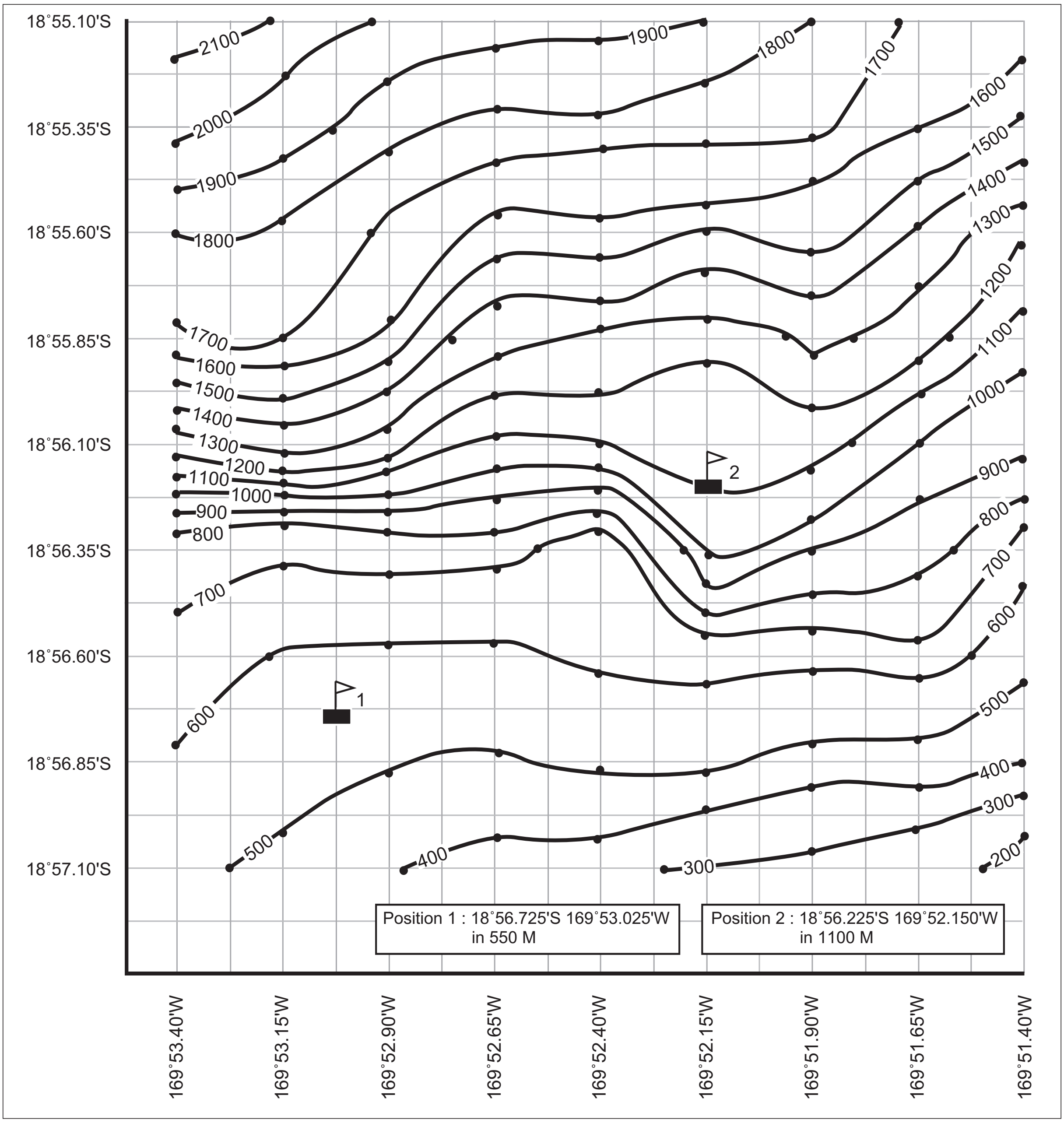


Figure 1: Sample site survey — Toi area off Niue with sites for two FAD deployments

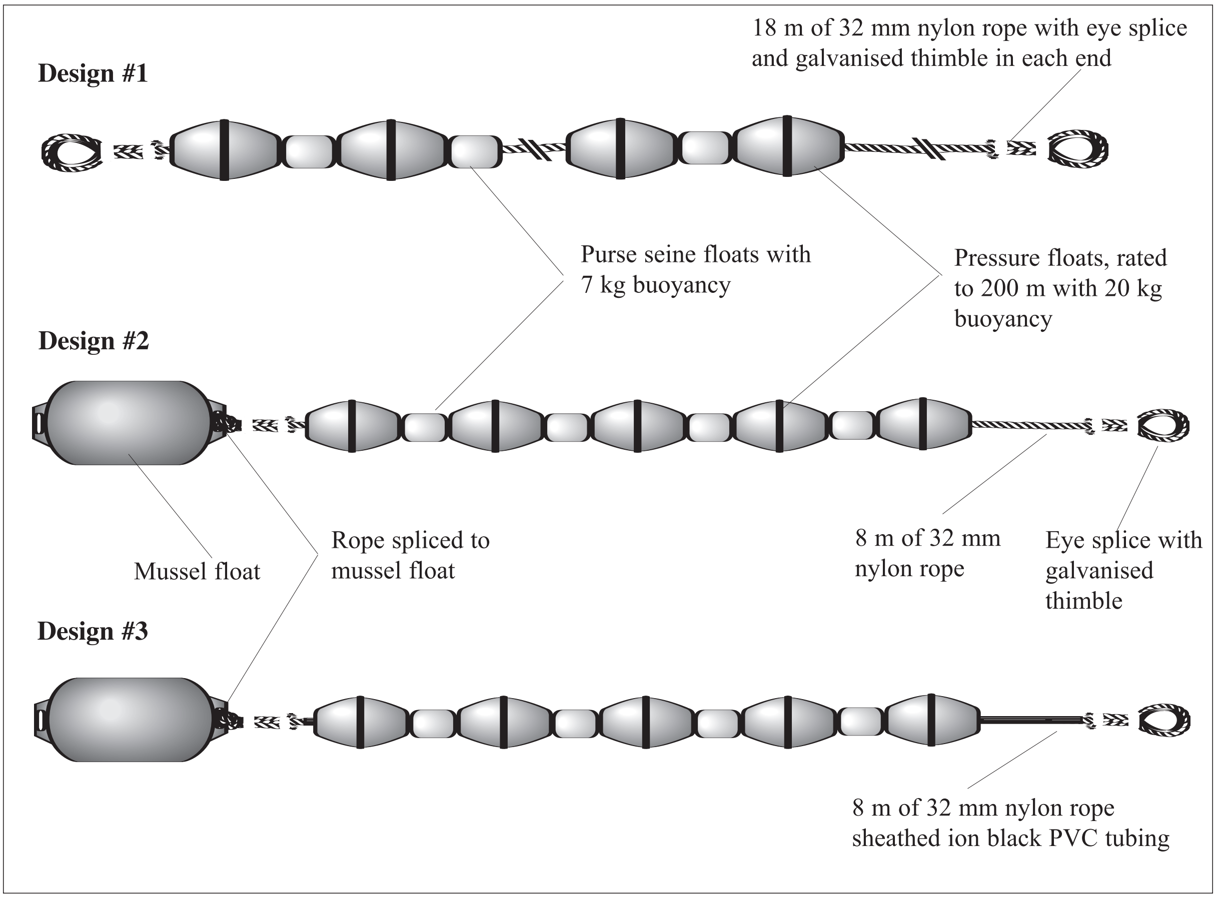
three strand lead-core polypropylene rope for the upper mooring.

The buoy system was also changed slightly, using 28 mm nylon rope and No. 4 Nylite rope connectors (Fig. 3). This replaced the galvanised thimbles in the eye splices of the 32 mm nylon rope, which rusted and turned in the splice causing some abrasion to the rope. The same arrangement of alternate pressure floats and purse seine floats was used, with the mussel float retained for inshore FADs only.

Cyclone Heta devastated Niue in early January 2004, which resulted in the loss of four FADs, with some damage to the buoy system of others. As a result, two additional replacement FADs were deployed off Niue in June and July 2004. Figure 4 shows the design and lists the materials recommended for the new Indian Ocean type mooring system.

FADs deployed, their status and cause of loss

Table 1 summarises the deployment date, location, the depth at which each of the original FADs was deployed, and the status of each FAD as of 31 July 2004. Twelve of the original FADs deployed have been lost, between 249 to 693 days (8 to 23 months) after deployment. Six of the lost FADs were of the same design, using 9 mm galvanised wire rope on the upper



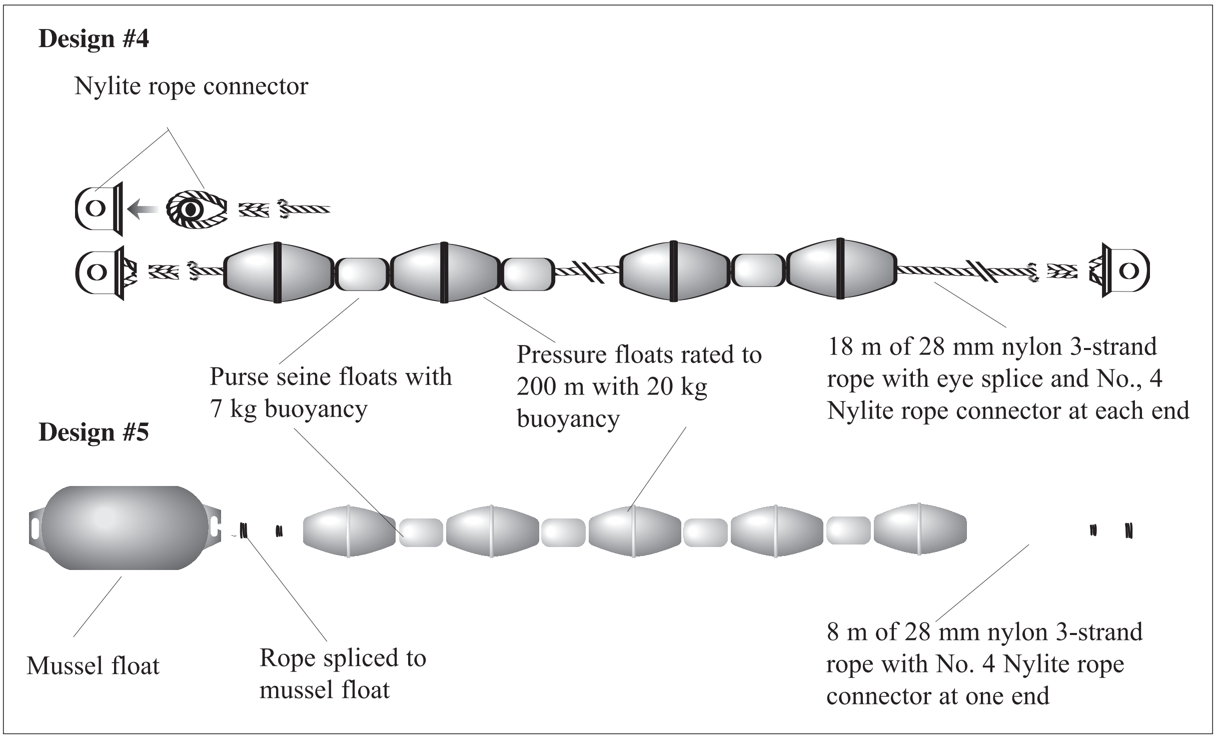


Figure 2 (top): The three designs of FAD buoy systems used by the project
Figure 3 (bottom): Final design buoy systems used on replacement FADs

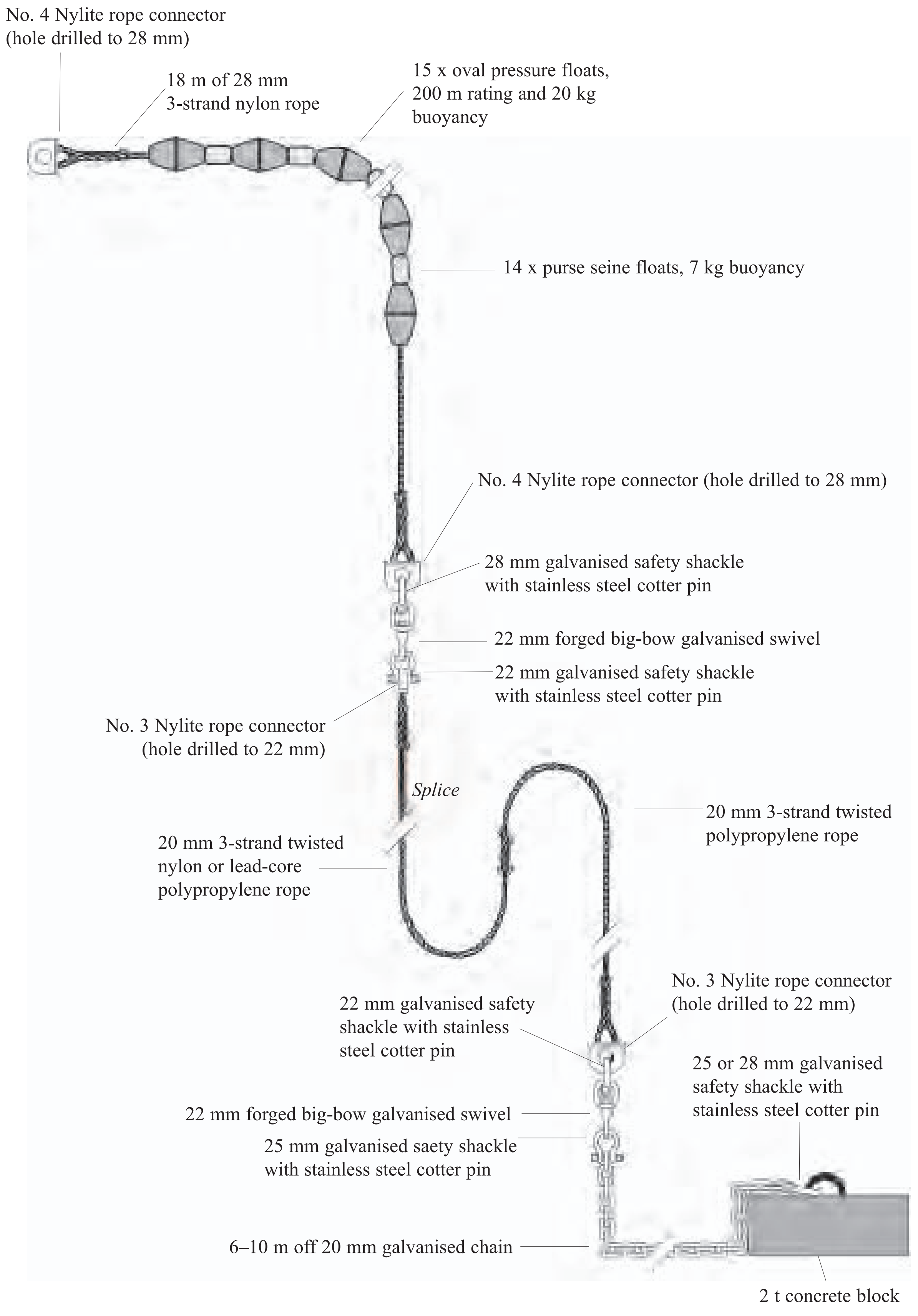


Figure 4: Design and materials recommended for the new Indian Ocean-type mooring system

Table 1: Summary of the original FAD deployments undertaken in Niue and the Cook Islands from February to April 2002 and the status of the FADs as of 31 July 2004

Area	Latitude (S)	Longitude (W)	Deployment depth (m)	Status of FAD
Niue:				
Lakepa	19º 00.000'	169º 47.375'	400 m	Lost 18/12/02 – 313 days on station
Avatele	19º 07.125'	169º 56.750'	900 m	31/07/04 – 904 days on station
Limufuafua	19º 11.125'	169º 51.875'	900 m	Lost 01/03/03 – 382 days on station
Vaiea	19º 08.875'	169º 54.125'	400 m	Lost 19/07/03 – 523 days on station
Halagigie	19º 04.000'	169º 59.500'	800 m	Lost 05/01/04 – 693 days on station
Toi 1	18º 56.725'	169º 53.025'	550 m	Lost 05/01/04 – 691 days on station
Toi 2	18º 56.225'	169º 52.150'	1100 m	Lost 05/01/04 – 691 days on station
Hikutavake	18º 57.250'	169º 55.375'	650 m	Lost 29/07/03 – 530 days on station
Rarotonga:				
Matavera	21º 13.000'	159º 43.000'	650 m	Lost 20/03/03 – 358 days on station
SE Titikaveka	21º 18.125'	159º 43.750'	1150 m	Lost 15/01/04 – 659 days on station
Rarotongan Hotel	21º 17.500'	159º 50.250'	1150 m	Lost 03/07/03 – 463 days on station
N of Black Rock	21º 10.875'	159º 48.250'	550 m	31/07/04 – 857 days on station
Aitutaki:				
W of Maina	18º 56.000'	159º 52.625'	950 m	31/07/04 – 848 days on station
SE of Motukitiu	18º 59.500'	159º 42.000'	1030 m	Lost 25/05/03 – 415 days on station
N of Arutanga	18º 48.500'	159º 47.500'	960 m	Lost 10/12/02 – 249 days on station

mooring. This design lasted from 313 to 530 days (10 to 18 months) on station before loss. One of the buoy systems with cable was recovered; the bottom eye splice broke (Fig. 5) and caused the loss. It is assumed that similar problems were encountered with the other five wire cable design FADs that were lost.

Three of the remaining six FAD losses were a result of cyclone Heta. It is not known if the extreme weather conditions caused the mooring line to part, if the buoy system was pulled

Figure 5: Rusted and broken eye splice in wire cable upper mooring design

under to a depth where the floats imploded or were crushed by the pressure, or if the hard plastic pressure floats were smashed together, causing them to crack or break and loose their buoyancy, with the buoy system then sinking. The latter was observed on one of the inshore FADs, where the hard plastic pressure floats were smashed (Fig. 6) as a result of cyclone Heta.

Of the three other FAD losses, one was attributed to hockling of the three-strand nylon rope at a depth of around 90 m (Fig. 7); the other two losses are thought to be due to the buoy system having been pulled under by strong currents in the area of deployment, which led to implosion of the buoys. A fisherman reported that the FAD buoy system on one unit was underwater one day when he was fishing. The next day the FAD could not be located. It is assumed that the mussel float used in that buoy design imploded when the buoy system was pulled under (it is not a pressure float), and that the other floats had insufficient buoyancy to support the FAD in strong currents.

Table 2 summarises the deployment date, location, the depth each of the replacement FADs were deployed in, and the status of each FAD as of 31 July 2004. One of the replacement FADs was also lost off Niue, soon after cyclone Heta, and it was thought that the mooring line might have been damaged by the cyclone.

Figure 6 (left): Buoy system retrieved after cyclone Heta with hard plastic pressure floats smashed
Figure 7 (right): Hockling in the nylon rope of one FAD, which lead to the rope breaking

Table 2: Summary of the replacement FAD deployments undertaken in Niue and the Cook Islands with their status as of 31 July 2004

Deployment date	Area	Latitude (S)	Longitude (W)	Deployment depth (m)	Status of FAD
	Niue:				
29-May-03	Limufuafua	19° 11.000'	169° 51.600'	900 m	Lost 15/03/04 – 288 days on
9-Jun-04	Halagigie	19° 01.750'	169° 55.225'	720 m	31/07/04 – 52 days on station
22-Jul-04	Hikutavake	18° 57.660'	169° 55.060'	625 m	31/07/04 – 9 days on station
	Rarotonga:				
13-Jun-03	Matavera	21° 12.925'	159° 42.950'	650 m	31/07/04 – 414 days on station
	Aitutaki:				
18-Jun-03	Arutanga/Amuri	18° 48.750'	159° 48.000'	1000 m	31/07/04 – 409 days on station

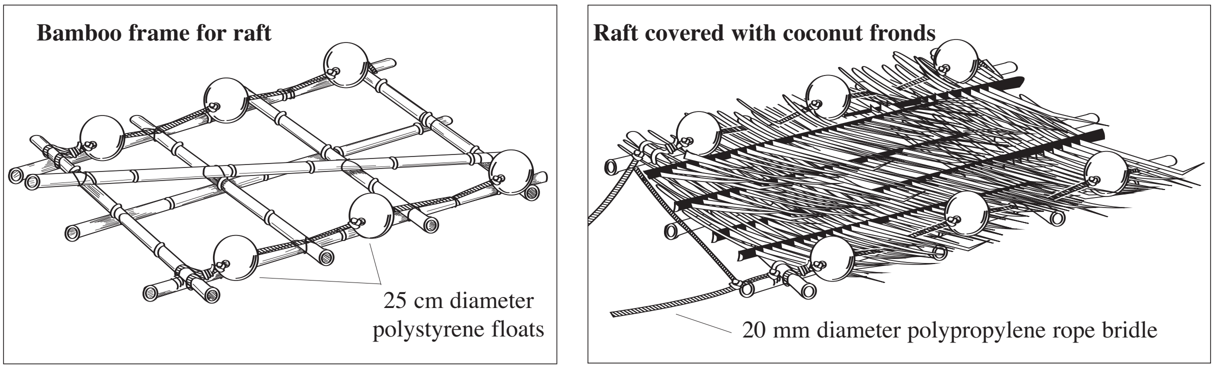
As of December 2004, three of the original and four of the replacement FADs were still on station. Five of these FADs have 20 mm three-strand nylon rope for the upper mooring and two have the 20 mm three-strand lead-core polypropylene rope for the upper mooring. The three original FADs have now been in the water for 32–34 months, while two of the replacement FADs have been on station for almost 18 months. These two designs appear to be reaching the two-year average lifespan as set out as one of the objectives of this project. In fact, if cyclone Heta had not occurred, there would have been another four FADs off Niue. Three of the lost FADs had been on station for 23 months when the cyclone hit.

Aggregator types and effectiveness

All project FADs had aggregators placed on them, although how long these lasted varied, based on weather conditions and design. A data sheet was completed during each FAD maintenance trip, and when trips were made specifically to work on the aggregators. The aggregators trialled were:

Bamboo raft aggregator arrangement. This is a Niuean design covered with coconut fronds and has been used for many years (Fig. 8). The raft is approximately three metres by four metres and is lashed together with purse seine twine; six polystyrene floats provide additional buoyancy. The raft is attached to the very end of the FAD buoy system by a 20 mm diameter polypropylene rope bridle, so it streams behind in the current. The local fishermen in Niue like this type of aggregator, and they feel it is effective in holding fish around the FAD.

String of five polystyrene floats. These are threaded on 10 metres of 18 mm nylon rope, some with PVC sheathing (Fig. 9). The floats were spaced about two metres apart, and the rope was tied in an overhand knot on each side of each float to stop it from moving on the rope. The PVC sheathing covered the rope between floats. Coconut fronds and strapping materials were secured to short lengths of 10 mm diameter polypropylene rope, which were attached to the aggregator next to a float.



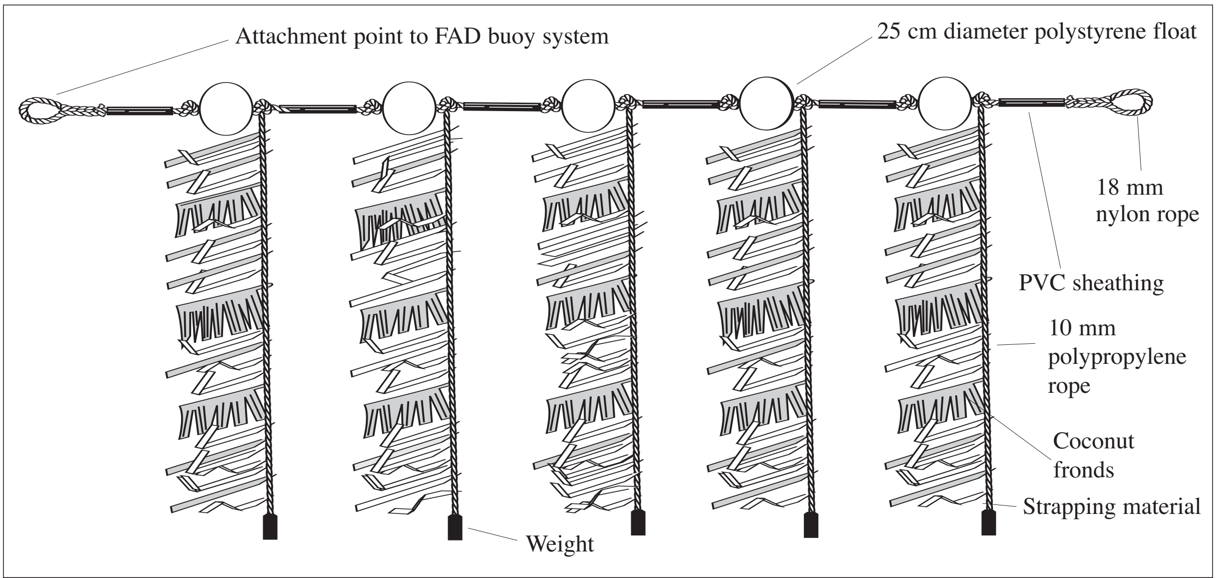
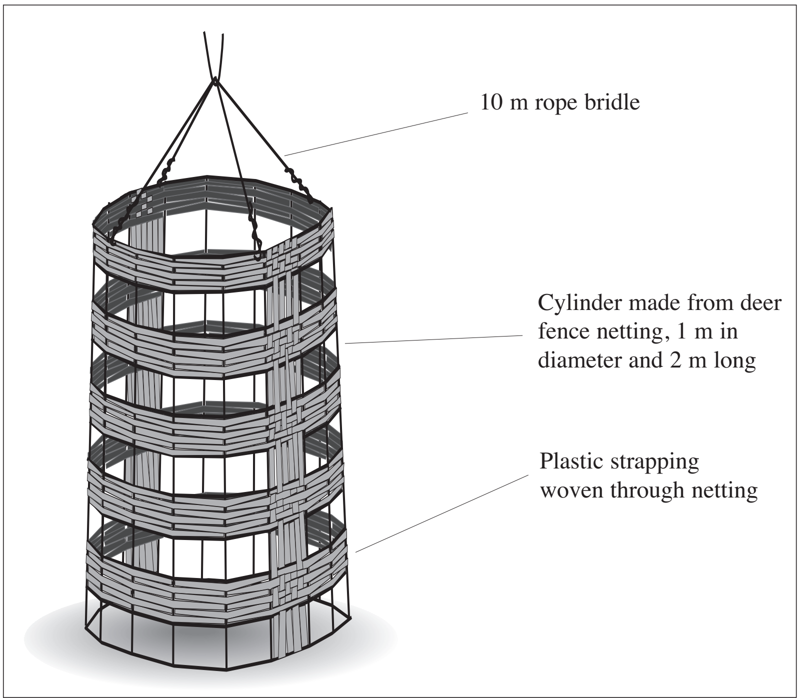


Figure 8 (top): Bamboo raft aggregator design used in Niue
Figure 9 (bottom): Rope and polystyrene float design aggregator being trialled by the project



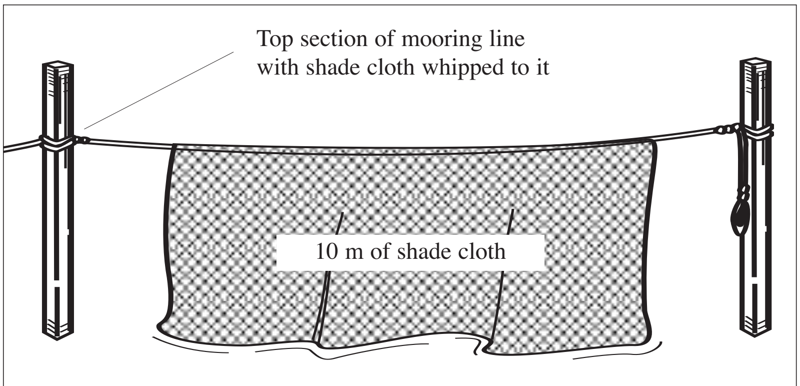


Figure 10: Aggregator made from deer wire fencing materials and used in both Niue and Rarotonga
Figure 11: Shade cloth aggregator whipped to upper mooring line before the FAD was deployed

Problems occurred with this aggregator system tangling and bunching up, and fishermen in Niue do not think these are as effective as the bamboo rafts.

Cylinder type. This was constructed from two-metre-wide deer fencing wire, which was formed into a cylinder (Fig. 10). Plastic strapping material was woven through the wire mesh to provide areas where baitfish could congregate. An attachment bridle made of 10 mm polypropylene rope was attached to the top of the cylinder (Fig. 10), with the other end of the bridle attached to the FAD buoy system. This allowed the aggregator to hang under the buoy system. This system did not appear to work very well and they had a much shorter lifespan compared to other aggregator designs.

Shade cloth. This incorporated 10 m of shade cloth two metres wide, which was whipped to the upper portion of the nylon mooring line (Fig. 11). Heavy twine was used for the whipping. The only problem with this design was in maintaining it, as it was attached to the mooring line prior to a new FAD being deployed. The shade cloth worked well and hung in the current, but could not be replaced without the use of divers, or if the upper mooring line was hauled aboard the servicing vessel.

Wire mesh and tyre type. This type of aggregator was trialled off Niue and used 6 x 2 m of deer fence wire mesh, six old car tyres and four styrofoam floats (Fig. 12). The wire mesh was rolled around four of the car tyres and secured. The remaining wire mesh (around 4 m long) was left out straight, with two old car tyres attached as shown in Figure 12. The four styrofoam floats were attached to the "top" end to provide buoyancy; the rope was also used as the attachment point to the FAD buoy system. Coconut fronds were then whipped onto the wire mesh using heavy twine. This provided a large shade area when it hung vertically in the water, and it provided shelter for small baitfish. The Niueans liked this design and thought it worked as well as the bamboo raft design. This design should only be used in areas of low current.

Overall the aggregator trials are inconclusive in regard to which design is best. The bamboo raft design and the fencing wire and car tyre designs appear to be working well and also have the longest lifespan, lasting several months in reasonable weather conditions. The other designs trialled were also effective; several did not last long before they were lost, however, which did not allow a good trial period for assessment. Fisheries Departments experienced problems in being able to get to the FADs regularly to check on and maintain the aggregators. The only definite statement that can be made is that FADs work better when deployed with some form of aggregator.

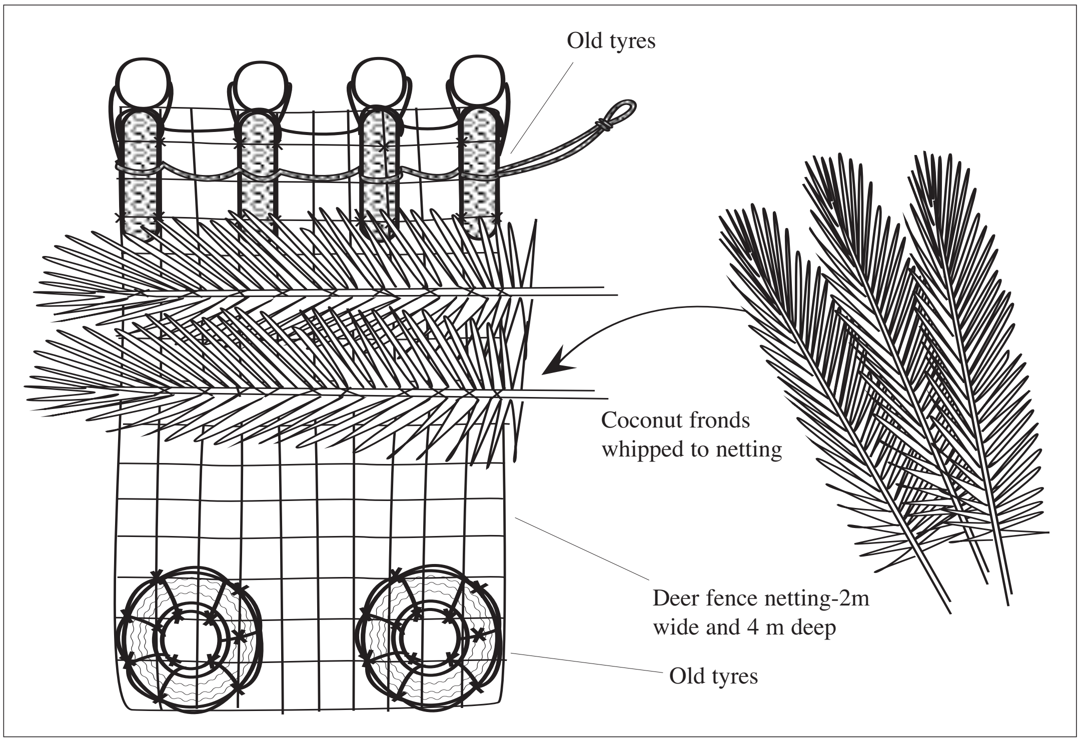


Figure 12: Deer wire fence netting and old car tyre design trialled off Niue

FAD maintenance

A data sheet was used for recording maintenance activities and repairs to the FADs. With this system, the wear of upper hardware components and the buoy system could be monitored, and repairs undertaken at the appropriate time.

FAD maintenance was conducted in two ways. Off Niue, the Public Works workboat was used for maintenance runs. This vessel was fitted with a powerful capstan winch on the transom. The workboat was manoeuvred alongside the buoy system, and the latter hauled aboard by hand. Once the top connection of the upper mooring to the buoy system was on board (Fig. 13), the mooring line was wrapped around the capstan and the upper mooring hauled slowly (Fig. 14) until the rope became taught. The mooring line was cleared of growth and fishing line as it was hauled (Fig. 14). Once the rope was checked and any repairs made to the mooring line or the upper hardware, the rope was slowly let out and the buoy system placed back in the water.

A totally different approach was used in the Cook Islands, where the Fisheries Department used

Figure 13 (top): Buoy system pulled on board ready to haul the upper mooring line

Figure 14 (bottom): Hauling the upper mooring line and removing marine growth and fishing line

their skiff or workboat, SCUBA gear and air-filled lifting bags to bring the upper mooring line to the surface. The skiff was tied to the buoy system. Two divers with SCUBA gear (Fig. 15) would then go down taking empty air-lift bags. When they reached 30 m depth, a lift bag was attached to the mooring line and air from the diver's regulator put into the bag, causing it to rise and take the mooring line to the surface. The divers would wait at this depth until the air bag reached the surface.

When the first air-lift bag reached the surface, the divers would attach a second bag in the same manner, and fill it with air (Fig. 16). Additional air-lift bags could be attached. The divers then returned to the skiff while the last 30 m section of mooring line was being raised to the surface. With the mooring line on the surface, supported by the air-lift bag, it could easily be hauled onto the skiff, cleaned and checked. Repairs were then undertaken, and afterwards the mooring line let out.

Overall, the two methods of conducting maintenance on the upper mooring and hardware worked well. However, in Niue, it was not easy to access the workboat in good weather in order to do the work. In addition, after cyclone Heta it was almost impossible to get access to the workboat. Nevertheless, the maintenance programme worked well, and the repairs that were undertaken definitely added to the lifespan of the FADs. Regular ongoing maintenance is essential to the overall success of a FAD programme.

FAD costs

One of project objectives was to develop a more cost-effective FAD mooring design. The aim was to achieve an average lifespan of at least two years, while reducing costs to NZD 4500 for

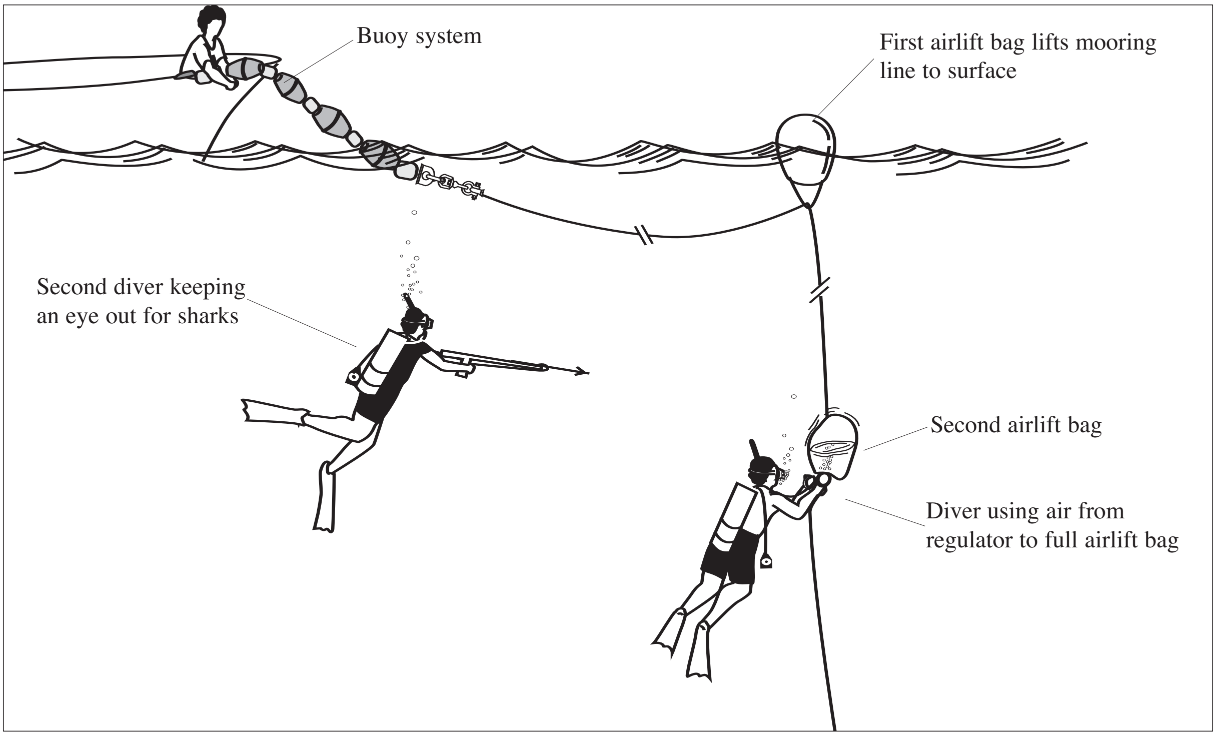


Figure 15 (top): Divers preparing to enter the water with empty air-lift bags
Figure 16 (bottom): Attaching air-lift bags to the upper mooring line

deep-water FADs (1000 m depth) and NZD 3000 for shallow-water FADs (300 m depth).

To determine the overall costs, the actual FAD costs need to be defined. Tables 3 and 4 split up the component costs to give a better understanding of where the costs were incurred. For this project the FAD costs were considered to include all but the deployment cost. The latter was excluded as the cost varied so significantly between locations (from NZD 0 to 800 per deployment). Maintenance costs have also been included in Tables 3 and 4, although these are ongoing costs in addition to the initial FAD costs.

For the initial 15 FADs deployed, the average cost of a shallow-water FAD excluding deployment cost was NZD 3093 (15,462 ÷ 5 = 3093). This meets the requirements of the objective on reducing costs of FADs to around NZD 3000 per unit, especially given that most FADs were deployed in water deeper than 300 m. The cost of the deep-water FADs excluding deployment costs averaged NZD 4472 (44,716 ÷ 10), also meeting the target cost of NZD 4500.

All replacement FADs were rigged using the more expensive deep-water buoy system design. The FAD deployed off Aitutaki used 12-strand ropes (nylon upper and polypropylene lower), which added another NZD 1300 to the cost of this FAD. The other four FADs cost NZD 4183 on average, which is well within the target figure, although three of these were set in depths from 625 to 720 m.

Overall the objective of designing FADs whose component costs do not exceed the set maximums has been met, with the FADs that remain approaching, or having passed, the 2-year average lifespan objective.

Summary

Fifteen FADs were initially deployed in early 2002, eight off Niue, four off Rarotonga and three off Aitutaki, using different buoy and mooring systems. Early losses ruled out the continued use of wire cable and polypropylene rope with counterweights. Three replacement FADs were deployed in mid-2003, one at each location, with another two deployed off Niue in mid 2004 following the loss of four FADs as a result of cyclone Heta.

Overall, two FAD designs are proving to meet the target two-year average lifespan, with

Table 3: Summary of costs for each of the initial project FADs

	Cost of components in New Zealand dollars (NZD)								Aggregators and ongoing maintenance costs *
FAD (depth in metres)	Buoy system	Mooring system	Anchor block	Sub-total	Freight costs	Sub-total	Deployment costs	Total cost	
Niue – shallow									
Lakepa (400)	742.87	1386.08	400	2528.95	520	3048.95	350	3398.95	319.09
Vaiea (400)	707.15	1357	400	2464.15	520	2984.15	350	3334.15	1005.39
Toi No. 1 (550)	742.87	1469.1	400	2611.97	520	3131.97	350	3481.97	644.6
Sub-total	2192.89	4212.18	1200	7605.07	1560	9165.07	1050	10,215.07	1969.08
Cooks – shallow									
Black Rock (Rar –550)	707.15	1614.61	400	2721.76	430	3151.76	800	3951.76	1301.44
Matavera (Rar – 650)	692.07	1624.06	400	2716.13	430	3146.13	800	3946.13	218.64
Sub-total	1399.22	3238.67	800	5437.89	860	6297.89	1600	7897.89	1520.08
Total – shallow FADs	**3592.11**	**7450.85**	**2000**	**13,042.96**	**2420**	**15,462.96**	**2650**	**18,112.96**	**3489.16**
Niue – deep									
Avatele (900)	1376.82	2105.08	400	3881.9	520	4401.9	350	4751.9	1071.59
Limufuafua (900)	1376.82	2254.83	400	4031.65	520	4551.65	350	4901.65	384.89
Halagigie (800)	1376.82	1967	400	3743.82	520	4263.82	350	4613.82	681.9
Toi No. 2 (1100)	1376.82	2388.8	400	4165.62	520	4685.62	350	5035.62	868.04
Hikutavake (650)	1376.82	1888.83	400	3665.65	520	4185.65	350	4535.65	700.09
Sub-total	6884.1	10,604.54	2000	19,488.64	2600	22,088.64	1750	23,838.64	3706.51
Cooks – deep									
Raro. Hotel (Rar – 1150)	1376.82	2571.98	400	4348.8	430	4778.8	800	5578.8	820.09
Titikaveka (Rar – 1150)	1376.82	2413.15	400	4189.97	430	4619.97	800	5419.97	958.89
Maina (Aitu – 950)	1376.82	2199.35	400	3976.17	650	4626.17	150	4776.17	1203.84
Motukitiu (Aitu – 1030)	1326.02	2309.76	400	4035.78	650	4685.78	150	4835.78	644.84
Arutanga (Aitu – 960)	717.05	2149.85	400	3266.9	650	3916.9	150	4066.9	218.64
Sub-total	6173.53	11,649.09	2000	19,817.62	2810	22,627.62	2050	24,677.62	3846.3
Total – deep FADs	**13,057.63**	**22,248.63**	**4000**	**39,306.26**	**5410**	**44,716.26**	**3800**	**48,516.26**	**7552.81**
Total FAD costs	**16,649.74**	**29,699.48**	**6000**	**52,349.22**	**7830**	**60,179.22**	**6450**	**66,629.22**	**11,041.97**

* Cost of aggregators and ongoing maintenance costs (materials and fuel) for the FADs after deployment (no staff costs)

three original FADs having been in the water from 32 to 34 months; as of December 2004, two of the replacement FADs having been on station for almost 18 months. One of these designs uses 20 mm three-strand twisted nylon rope in the upper mooring, and the other uses 20 mm three-strand twisted lead-core polypropylene rope. The use of alternating purse seine floats and 20 kg lift pressure floats on 28 mm nylon rope and Nylite rope correctors is proving to be the most effective buoy system.

The costs of the project FADs have met the target limits of NZD 4500 for deep-water FADs (1000 m depth) and NZD 3000 for shallow-water FADs (300 m depth). The costing of project FADs included materials, freight to get the materials to the project locations and the cost of the mooring block (2 t concrete block). Deployment costs were not included as these varied greatly from one location to another. Overall, the project shallow-water FADs averaged NZD 3093 each, while the deeper-water FADs averaged NZD 4472 for the initial units, and NZD 4183 for the replacement FADs.

Table 4: Summary of costs for each of the replacement project FADs

	Cost of components in New Zealand dollars (NZD)								Aggregators and ongoing maintenance costs *
FAD (depth in metres)	Buoy system	Mooring system	Anchor block	Sub-total	Freight costs	Sub-total	Deployment costs	Total cost	
Niue									
Limufuafua (900)	1224.2	2331.35	400	3955.55	520	4475.55	350	4825.55	514.59
Halagigie (720)	1384.1	2122.2	400	3906.3	520	4426.3	350	4776.3	113.05
Hikutavake (625)	1453.7	1614.15	400	3467.85	520	3987.85	350	4337.85	121.04
Sub-total	4062	6067.7	1200	11,329.70	1560	12,889.70	1050	13,939.70	748.68
Cook Islands (Raro)									
Matavera (650)	1246.8	1765.9	400	3412.7	430	3842.7	150	3992.7	795.84
Sub-total (Niue / Raro)	**5308.8**	**7833.6**	**1600**	**14,742.40**	**1990**	**16,732.40**	**1200**	**17,932.40**	**1544.52**
Cook Islands (Aitu)**									
North Arutanga (1000)	1218.62	3546.8	400	5165.42	650	5815.42	150	5965.42	689.88
Total FAD costs	**6527.42**	**11,380.40**	**2000**	**19,907.82**	**2640**	**22,547.82**	**1350**	**23,897.82**	**2234.4**

* Cost of aggregators and ongoing maintenance costs (materials and fuel) for the FADs after deployment (no staff costs)

** More expensive 12-strand ropes used as no other materials available on Aitutaki at the time.

FINAL STAGES OF WORLDFISH–SPC SEA CUCUMBER PROJECT

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The WorldFish Center
Noumea, New Caledonia

Why is there so much interest in sea cucumbers? The answer is simple: prices for sea cucumbers have increased over the past decade, while export prices of some other island commodities have fallen. Top grade beche-de-mer, the name for the dried product, now sells for USD 100–300 per kilo at distributional markets in Singapore and Hong Kong.

Lucrative returns to fishers have motivated heavy fishing pressure on sea cucumber stocks and depleted numerous areas of viable breeding populations (Uthicke and Conand 2005). Sea cucumbers can have complex life histories with long life spans, and annual recruitment is often sporadic. Recent research provides empirical confirmation of the notion that sea cucumber populations are often fragile (Lovatelli et al. 2004, Uthicke et al. 2004). A frequent lesson is that sustainable yields will only be maintained at low fishing pressure, for example less than 5% of the standing biomass per year. But amidst the pandemia of over-exploitation, many Pacific nations are taking encouraging actions to bolster their management of sea cucumbers.

How can breeding populations of sea cucumbers be restored to productive levels? One potential approach is to release hatchery-produced juveniles into the natural habitats, and when these reach sexual maturity they can then become breeding populations that then "kick start" the recovery of a depleted fishery (Purcell 2004a). This idea is at the heart of a WorldFish–SPC research project now in its fourth year in New Caledonia, funded by ACIAR, the three provinces of New Caledonia, the government of France and the ATSE Crawford Fund.

The focal species of the project, the sandfish *Holothuria scabra* (Fig. 1), fetches the highest price of any tropical sea cucumber on the Asian dried food market. The project's main aim is to develop optimal methods of releasing hatchery-produced sandfish into the wild; how, when, where and at what size and in what density. Originally planned for Solomon Islands, the WorldFish Center project was relocated to New Caledonia and has been hosted and partnered by SPC.

Since an earlier article on the project (SPC F*isheries Newsletter* # 103, Oct–Dec 2002), the hatchery team produced thousands of juvenile sandfish in three consecutive summer seasons. Recent experiments at the hatchery north of Noumea have refined new methods, pioneered by the WorldFish Center in Vietnam, to grow the juveniles in net enclosures within earthen shrimp ponds up to larger sizes for release (Figs. 2 and 3). The sea cucumbers can grow rapidly in earthen ponds, eating only the organic waste matter in sediments, and have a further function of bioturbating pond sediments (Purcell 2004b).

Hatchery production of sandfish has been kept to an experimental scale, this year totalling 20,000 juveniles. This has allowed resources to be spread to the field research and stock assessment surveys. An initial study showed that sandfish can have limited gene flow among neighbouring populations, giving evidence that sandfish should not be translocated to distant sites, in order to preserve genetic diversity of wild stocks (Uthicke and Purcell 2004). Further work showed that the putative sub-species *Holothuria scabra* var. *versicolor* (golden sandfish) is actually a separate species, but can naturally hybridise with *Holothuria scabra* (sandfish) (Uthicke et al. in press).

Figure 1: The sandfish, *Holothuria scabra*, the most valuable of tropical sea cucumber species in a seagrass bed near Noumea. (Photo: Steve Purcell)

Figure 2: "Bag net" enclosures within an earthen shrimp pond.
Figure 3: Hatchery-produced sandfish juveniles, around 1 g in weight, grown in the bag nets.

Other completed studies in the project include the following:

- Methods for broodstock maturation and spawning
- Optimal methods for transportation of juveniles for restocking
- Optimal habitats for release
- Best times of the day for release
- Methods for tagging juveniles
- Diurnal burrowing cycle of wild sandfish in New Caledonia
- Co-culture of juvenile sandfish with juvenile shrimp
- Broad-scale stock assessments of sea cucumbers in the three provinces of New Caledonia
- Modelled dispersal of sandfish from release sites for the sizing of no-take zones

A current large-scale experiment, launched in April 2005, involves an initial 9000 hatchery-produced sandfish juveniles (Fig. 4). At each of four sites along the main island of New Caledonia, "La Grande Terre", juveniles were released into replicate sea pens (500 m^2 each) at three different densities. The sea pens are simply a short plastic mesh fence, without cover, to limit the emigration (escape from sites) of the juveniles from the natural habitat but allow predators to reduce numbers as they would in a normal restocking situation without sea pens. Survival and growth of the juveniles will be monitored for 12 months.

We hope this final experiment will provide a "proof of concept" that sufficient numbers of sandfish can survive to maturity to make restocking a viable option. The costs, and likely benefits, of restocking can only then be weighed against other forms of management (Bell and Nash 2004). The project is due to finish in June 2006, after which the WorldFish Center hopes to embark on the final (Phase 3) project of the programme. That project will seek to apply the hatchery methods from Solomon Islands and the release methods from New Caledonia to carry out broad-scale restocking of sandfish in several Pacific Island countries.

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Figure 4. Southern Province fisheries technician, Marc Homou, with a bag of juveniles prior to release into the sea pens.

MONOCULTURE OF THE NATIVE FRESHWATER PRAWN *MACROBRACHIUM LAR* IN VANUATU, AND INTEGRATED WITH TARO IN WALLIS AND FUTUNA

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Introduction

For a number of years SPC has promoted aquaculture as a means of contributing to rural food supplies, income generation and foreign exchange. One of SPC's objectives has been to promote extension and research on the sustainable multiple utilisation of inland waters, including integrated aquaculture-agriculture, marshlands and small water bodies.

The integration of aquaculture with agriculture and inland fisheries, and its use in marginal aquatic habitats is a sustainable practice that offers potential for increasing the supply of fish protein as well as income, particularly in rural areas of Pacific Island countries (PIC). Integrated fish farming embraces a diverse set of technologies, which link fish culture to terrestrial farming systems. It is recognized as a sustainable form of aquaculture-agriculture, and as a major contributor to the world's production of farmed fish. Its importance lies in its ability to provide fish protein at a relatively low price to rural communities, and it is therefore considered to be significant in contributing to PICs' food security.

It is common knowledge that integrated fish farming makes a major contribution to world aquaculture and that inland aquaculture is the fastest growing sector of aquatic animal production. Integrated fish farming systems, especially in Asia, have proven highly productive, economically viable and environmentally stable over a long time. However, it has not always been possible to transfer these systems to PICs, which have little tradition of fish farming. It is SPC's belief that there is considerable potential for extension of integrated fish farming, in the broadest sense, to many rural areas in PICs. There is also an interest in developing cottage industries.

The goal of an SPC project will be to investigate the potential of growing *Macrobrachium lar*, a native prawn, in monoculture (Vanuatu) and integrated systems as well as determining the feasibility of integrating *M. lar* with taro farming systems (Wallis and Futuna).

Background to *Macrobrachium lar* culture

The number of species in the genus *Macrobrachium* is approximately 125 worldwide, and these are widely distributed in fresh and brackish waters, mainly in subtropical and tropical areas. Several species are known to occur in Vanuatu, and Wallis and Futuna, one of which, *Macrobrachium lar* has been harvested for commercial sales.

In Vanuatu, *M. lar* that are caught in remote rural areas are an important source of cash income, but because catches have greatly declined recently, this resource is gradually being lost. *M. lar* is believed to make up the bulk of the freshwater catch, and is the most important species caught from freshwater systems. The various methods used for harvesting are by hand, push nets, woven traps or even fine spears. Most species survive for some time out of the water and are often sold alive, wrapped in taro and banana leaves. Vanuatu Fisheries staff has indicated that local commercial sales at roadside stalls, supermarkets and restaurants have increased recently. In urban areas *M. lar* is a priced food item, affordable by high-income earners only. The average price has gradually increased from 800 vatu per kg in 2000, to 1200–1500 vatu per kg in 2003.

Background to taro-prawn culture

Swamp-based taro plantations are common throughout the Pacific and are found in both Vanuatu and Wallis and Futuna. In rain-fed areas, taro is grown during the wet season and ponds remain fallow during the rest of the year. In irrigated conditions, taro growing continues throughout the year.

Taro is a common staple food in the diet of Pacific Islanders. Its cultivation is etched into the social fabric of the subsistence lifestyle, particularly in the rural areas where the custom of feastings is an important part of life and ceremonies. Growing taro is demanding work and farmers often spend many hours working their plantations. Plantations have normally been tended for generations and there is a keen awareness of the tenure system.

One of the main attributes for integrating freshwater shrimp farming with taro farming is that it could possibly create added benefits to existing practices with minimal impact. At its most basic approach this project will test whether, for example, prawns could be stocked directly into taro plantations under normal farming techniques and planting routines. Since wild prawns occur naturally in the taro beds of Wallis and Futuna and Vanuatu it is hypothesized that the farmed prawns could derive most of their dietary needs from the organic micro-fauna already present. This basic system could be modified to fit more productive and commercially oriented systems whereby fallow ponds could be used for monoculture prawn farming with feed inputs to supplement dietary needs. Adopting semi-intensive systems is likely to be relatively easy to establish and this will enable production to grow in accordance to market demand.

In modern times, natural stocks of *M. lar* have declined in many places due to over-exploitation, illegal fishing and habitat modification as a result of an increase in sediment load, pesticides, fertilizers or introduced exotic fish species. Also, some varieties of taro available today are very different from those produced in the past. Many of the ancient varieties of taro have disappeared through lack of cultivation and commercial cultivators consequently have brought in new varieties.

Many island nations are looking to develop integrated aquaculture-agriculture to supplement their food requirements. While exotic species have been trialed in culture in some nations (e.g. tilapia in Samoa and Fiji), indigenous species present less of a threat to natural ecosystems. *M. lar* has been suggested as a potential candidate for culture in taro-prawn culture systems, but some preliminary work undertaken on this prawn species has suggested that it is not an easy species to culture in artificial pond conditions.

Therefore, before any serious attempt is made to evaluate *M. lar* as a culture species, it is necessary to develop appropriate technologies for grow-out of juveniles in culture environments.

The development of these technologies can provide two important outcomes:

1. Provide farmers in PICs with the technology to culture this species in integration with taro, rice, or other food crops.

2. Permit trials to be undertaken to evaluate *M. lar* as a culture species and thus improve our knowledge on the ecology of this species.

The objective of the SPC study is to undertake rigorous trials of integrated taro-prawn culture systems in various combinations to determine the specific environmental conditions that need to be satisfied in order to allow successful juvenile growth to adult prawn. Thus, the study will concentrate on the optimization of parameters that affect the growth of juvenile prawns to adult stage in taro fields. Major parameters will include monitoring and, where applicable, measuring water exchange, stocking density, feeding rate, nutrition, temperature, dissolved oxygen (DO), salinity and general maintenance of the culture ponds.

Wild *M. lar* juveniles from discrete water bodies on Efate Island (Vanuatu) and Futuna, where they are native, will be collected and conditioned in tanks. These juveniles will be identified, weighed and stocked into taro plots.

Activities carried out before stocking of juveniles (preconditions)

Site selection in Vanuatu was carried out in 2004 and the following factors were considered:

- The field must hold water continuously for several months, and in fact, the longer, the better. The field must have an abundant and dependable water supply. Irrigation water, ground water, diverted streams, spring and other water sources (tap) to be used should not be contaminated by pesticides. Good results can be expected if the taro field is covered to a depth of about 30 cm. It is not a serious problem if some areas are shallower or deeper than this, as long as the taro is not affected adversely. However, dikes

Macrobrachium lar
(Source: www.hawaii.edu/hsrc/photos/img001.jpg)

and field boundaries must be above maximum flood level. Sites should be chosen with good drainage in mind, and should be free from flooding.

- Clay holds water better (prevents seepage) and may also be good for taro farming. It should be ensured that water is retained and that the soil or area is suitable for taro farming, or is an existing taro-farming site.

- The site must be close to the farmer's house or station. This makes checking the farm and feeding the prawns less time-consuming. It will also help discourage theft.

- Farmers should be aware that preparing the prawn-taro field for prawn culture entails work. Farmers and staff need to take advantage of existing conditions on the land to save costs. Some examples are:
  - If the land is sloping, a high dike on the uphill side of the field is usually not needed. The layout of the land will help confine the prawns.
  - Existing sites that have ponds or canals within the taro field will be best. If a pond can be included in the system, there may no longer be a need to dig a trench or pond.
  - If the taro field is basin-shaped or oval-shaped, this will save considerable work. For example, in a basin-shaped taro field, the middle of the field is the deepest point and little effort will be needed to raise dikes, and trenches can be dug around the taro field.

Design and size of field

- Independent filling and draining of each taro-prawn pond compartment is considered appropriate.

- Ease of prawn movement into the taro field is considered and prawns should be free to move quickly into canals or pond refuges when water level is very low.

- Size of taro-prawn plot considers the existing natural partitions of the field and recommended size is 100 m^2 of surface area for taro planting and 50 m^3 of water for *M. lar* rearing.

- Dikes are made strong and big enough to withstand the pressure of the water level at all times.

- Appropriate fencing structures using plastic lining to be constructed around the periphery of the ponds to avoid prawns escaping.

- Prawn refuge to be placed in the ponds.

- Designs with pond refuge, which hold more water and is less risky, are preferred over trench refuge. Refuge size proposed is 20–50% of taro field area. A bigger refuge or a pond adjacent to the taro field may also be connected to it through a canal (depending on the site availability).

- For construction of a refuge, the pond/canal is excavated manually around the field and connected to the field so that the prawns can have excess to the area planted with taro.

- Inlets and outlets to be screened.

- Inlets and outlets to be made of PVC pipes or existing materials or other low-cost materials. Screens prevent the escape of stocked prawns or entry of unwanted fish into the field.

- Follow standard procedures for pond preparation, ensuring all unwanted fish are removed from the pond site.

Stocking of juveniles

- Timing: Prawns should be stocked after the taro is planted and is well established.

- Stocking rates: No references are available and may not be appropriate in any case. For this trial, five juveniles per cubic meter of water volume will be stocked in all the ponds.

Feeding

Macrobrachium prawns will eat most potential feed material. In the wild, this species consumes worms, snails, clams, fish, rice, wheat, beans, nuts, aquatic plants and some fruits. *Macrobrachium* favor fish/prawn pellets, pieces of fish and clams. Feeding should commence a day after stocking.

- Feed: Monodon starter pellets will be used, starting at 15% of the total body weight and reducing gradually by 5% every month (i.e. after every sampling to four months of culture cycle).

- Sampling of juveniles should occur once every month (10% of the population stocked) using standard procedures.

Routine maintenance

- Measurement of water temperature, dissolved oxygen (DO), pH, water depth, turbidity, flow rate, monitoring and recording the progress of juvenile growth.

- Daily feeding.

- Maintain weeds and other activities (clean screens).

Harvesting

- Harvest prawns by draining the water very slowly one week before taro harvest to avoid trapping the prawns in the middle of the field.
- Measure individual weight and length.
- Select large prawns for consumption and confine the smaller prawns for further culture.

Taro agronomy

1 Taro varieties: use existing high-yielding varieties, maturity period of 120–130 days, tolerant to 30–40 cm of water, resistant to diseases.

2 Seedbed preparation and planting space: follow as per guidance provided by staff and farmers in country.

3 Land preparation: after clearing and removing all rubbish, level the field evenly so that every part of it will be evenly irrigated.

4. Taro transplanting:
   - Age of tubers: 25–40 days (obtain young tubers where possible).
   - Cut old leaves but retain young leaves and shoot.
   - Cut tuber in half.
   - Planting distance: use existing practice or 50–70 cm intervals.
   - Water depth: 10 cm below the water surface
   - Begin harvesting the prawns after 4–5 months.

Weed control: prawns stocked in taro fields may help to control certain weeds. Weeds to be controlled through:

- thorough land preparation;
- flooding the field at an effective water depth for 1–2 weeks immediately after transplanting; and
- manual weeding.

Water management: water depth in the field when taro is newly transplanted is 3–5 cm. This is then gradually increased to 10–30 cm to provide better living space for the prawns as they grow bigger.

Other controls: ensure farm is secure from theft from humans and other pests such as pigs, cattle and eels.

Progress to date

Wild stocks of juveniles were collected using various methods from streams and creeks in Vanuatu and Wallis and Futuna, and stocked in holding tanks. Prawns were conditioned and thereafter identified. Individual weight and length were recorded and individuals stocked into ponds at 5 prawns m^{-2}. Two ponds at Sarete village in Santo, Vanuatu and a pond each at Tuatafa and Fiua villages in Wallis and Futuna have been stocked. The stockings in Sarete were carried out from 14–18 February, and in Wallis and Futuna from 22–28 February 2005.

Anticipated benefits of the study

Results from the growth studies will be used to prepare a report that tabulates basic growth and survival data for *M. lar*. Results will also provide baseline data on the performance of *M. lar* in aquaculture, and indicate directions for future research into the development of husbandry techniques.

Results will not only help to optimize grow-out procedures for *M. lar*, but may also be applied to developing techniques for other indigenous freshwater and brackishwater species for which grow-out rearing conditions are unknown (e.g. there are a number of other *Macrobrachium* and *Palaemon* species with culture potential). This study could therefore be used as a model when attempting to define the grow-out requirements for other species in the future. Also, data obtained from this study on the optimal conditions for survival and growth of *M. lar* will add to our knowledge of the general ecology of this species, wild caught or hatchery reared. This work has never been carried out successfully in the past.

A national and Indo-Pacific fishery essentially already exists for *M. lar*, but our present knowledge of hatchery technology of this species is limited. The optimisation of pond grow-out environments forms the basis for development of an economically viable production system for most aquatic species. Successful grow-out of *M. lar* would facilitate further culture trials of this species as wild stocks have declined in some places and attempts will be made to culture it. Supplementing wild stocks of various species of prawns and fish with hatchery-reared ones has already been attempted in the Indo-Pacific region. Numerous reports have indicated that stock enhancement needs to be continued and expanded as human impacts on inland environments increase.

Compared with many technologies, taro-prawn culture or other integrated systems are a relatively low-risk technology. Financial inputs are low and technologies are not demanding for farmers so few conflicts are likely with other farm activities in PICs.

Income from prawn sales can provide additional financial benefits to small-scale poor farmers. And since this is a subsistence activity, to a large extent there is little competition in the market among current producers.

Hundreds of individual taro farms that engage thousands of farmers are impacted by low returns from mono-crop taro farms in the Pacific. Many of these farms, their owners or clan members could benefit if we can demonstrate, document and extend information relating to a more sustainable farming system, compared with the existing model of taro-prawn farming. The results will be documented and the findings will be shared through this publication and meetings presented by SPC.

Experiments will be conducted in collaboration with the Department of Fisheries staff in respective countries. Integrated taro-prawn farming is commonly practiced in the Pacific. Improvements in this system will provide an appropriate strategy for small-scale rural farmers in terms of technical, environmental and economic aspects. It will be of interest to all NGOs involved in rural development and specifically on aquaculture extension and outreach activities.

The project involves collaboration with Vanuatu and Futuna Fisheries departments, the Australian Centre for International Agricultural Research (ACIAR), Queensland University of Technology (Brisbane), University of the South Pacific and various Fisheries Departments of Pacific Island countries.

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