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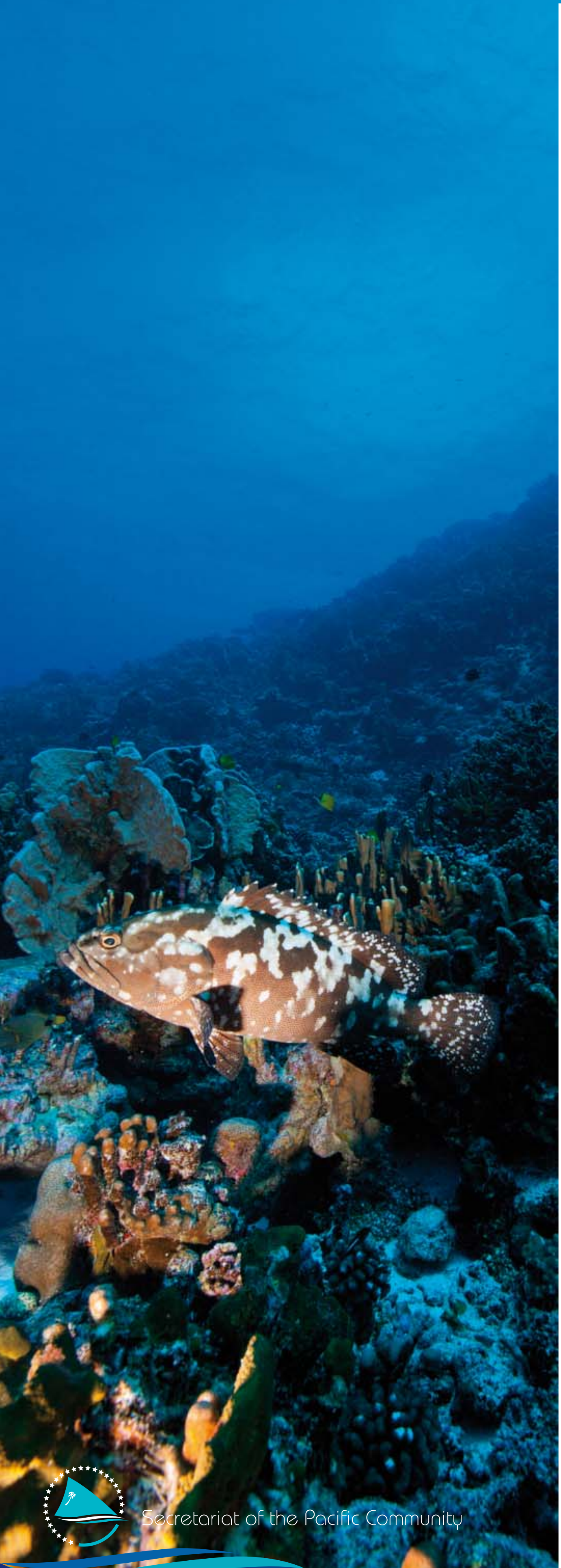

Editorial

In countries such as Kiribati, where the fisheries sector is the main player in local and national economies — as well as the main source of food and protein — impacts on marine resources may have dramatic consequences for the local population. In her article on page 21, Vina Ram-Bidesi assesses the potential impact of a destructive fishing method called *te ororo* on coastal fisheries and community livelihoods in Kiribati. *Te ororo* is a method that involves gill nets in combination with sticks, metal rods and crow bars to scare or drive fish into nets — a small-scale fishing method that is, unfortunately, widely used in tropical reef fisheries. According to Vina: "The economic costs of destruction from *te ororo* fishing is estimated to be 5.0% of government revenue annually and approximately 3.5% of gross domestic product. The cumulative effects of this loss over time on the economy and people of Kiribati should be underscored for immediate action."

In the second feature article (p. 28), Michel Sharp presents a cost-benefit analysis of fish aggregating devices (FADs). Using data from Niue, he shows that FADs provide benefits to fishermen in the form of increased catch rates and reduced fuel consumption; but, more importantly, he concludes that the Niue government-led FAD programme is financially and economically profitable. Much has been written on FADs but very little on their financial and economic benefits to fishing communities and PICT economies. Michael's report is a welcome addition to this series.

The magnificent picture of a camouflage grouper on this cover was taken by Éric Clua a month before a massive spawning event that involved tens of thousands of fish of the same species. In their article (p. 20), Yvonne Sadovy de Mitcheson and Éric explain that these spawning aggregations are "highly susceptible to overfishing if unmanaged, and can disappear within just a couple of years if overfished." The importance of protecting spawning aggregations is now widely recognised, but it proves to be a very challenging task.

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SPC activities

News from in and around the region

Feature articles

Secretariat of the Pacific Community

Prepared by the Information Unit, Division of Fisheries, Aquaculture and Marine Ecosystems

Oceanic Fisheries Programme embarks on a new adventure

The Ecosystem Management and Analysis Section of SPC's Oceanic Fisheries Programme and the French Research Institute for Development (IRD) are studying mid-trophic level pelagic zooplankton and micronekton. The project's name, NECTALIS, comes from "nekton", the aquatic organisms that actively swim in the water column (in contrast to plankton that passively drift), and "Alis", the name of IRD's research boat based in Noumea, New Caledonia.

Project goal

Outcomes of this research cruise will be particularly important for Pacific Island countries and territories (which exploit tuna resources), by bringing more confidence to model-derived predictions of tuna movements and fishing and environmental impacts on pelagic ecosystems. Models are important in providing information to fisheries managers. Our goal is to improve our understanding of spatio-temporal distribution and behaviour of tuna prey species (zooplankton and micronekton) to better understand the relationships among tuna, environment and fishing.

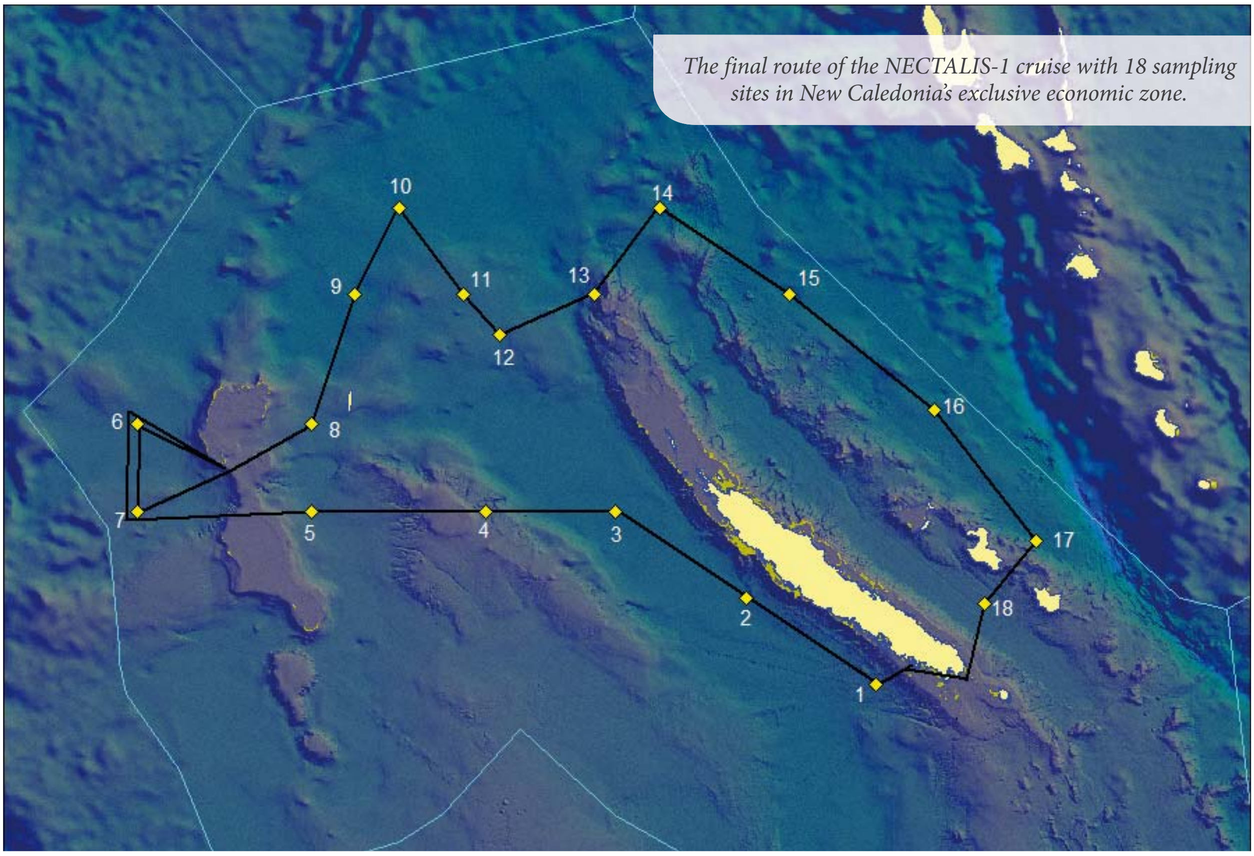
Zooplankton and micronekton are the link between the physical and chemical factors of seawater (which influences their distribution and abundance) and tuna (which prey on them). Zooplankton and micronekton components of ecosystem models are particularly uncertain, mainly because very little direct observations exist to validate the models. During the NECTALIS cruises, we hope to fill this gap in observation to help validate ecosystem models.

The cruises

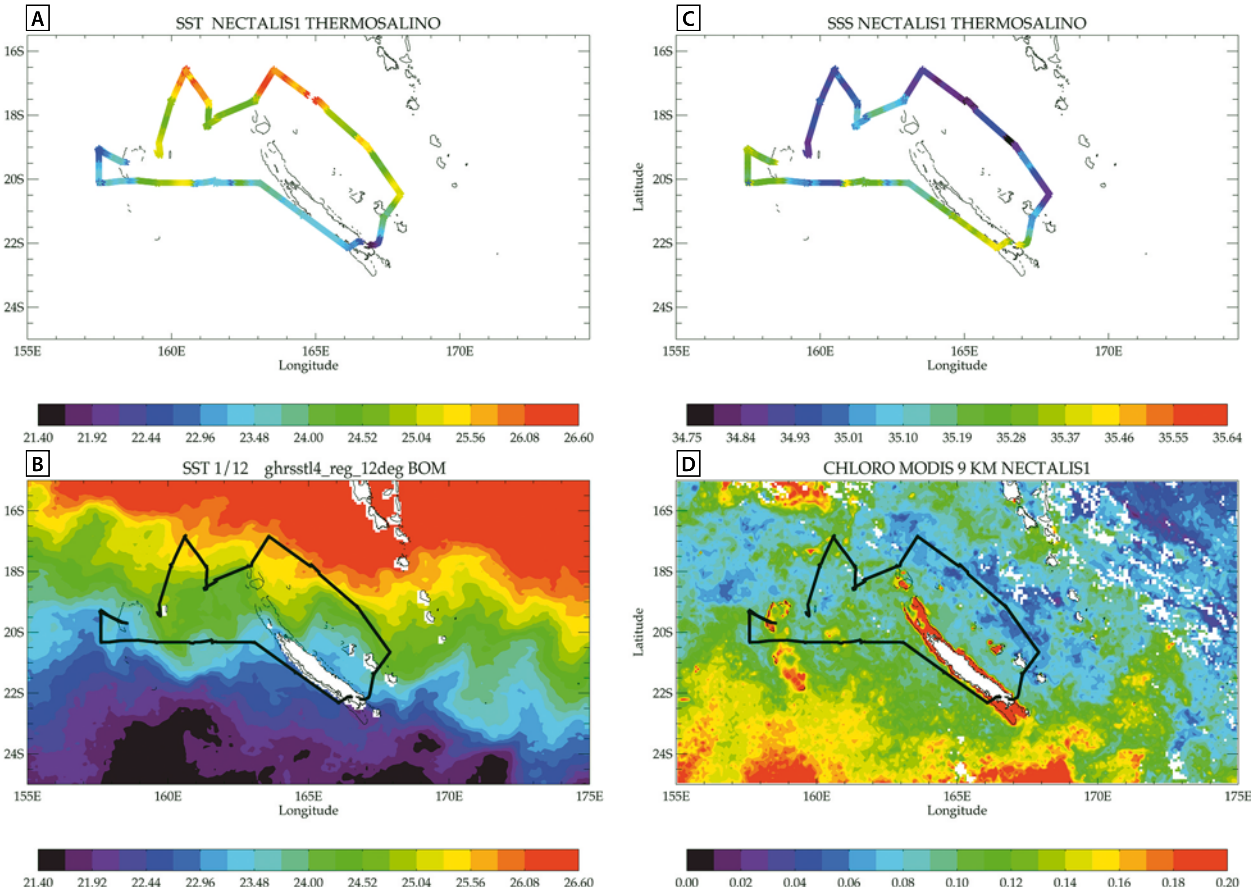
We will be conducting two multidisciplinary cruises to collect physical and chemical seawater data as well as data on zooplankton and micronekton. The two cruises will occur during the Southern Hemisphere's cooler months (July to August), and warmer months (November to December) when environmental conditions are different.

To characterise physical and chemical conditions and primary production, we will measure temperature, salinity, oxygen, fluorescence, light, currents, nutrients, photosynthetic pigments, phytoplankton abundance, primary production and phytoplanktonic communities. Secondary production (zooplankton and micronekton) will be measured with acoustic and net sampling of zooplankton and micronekton.

The first cruise, NECTALIS-1, departed on 30 July from Noumea, New Caledonia onboard the research vessel *Alis* for a three-week campaign in New Caledonia's EEZ with 29 sampling sites scheduled.



The final route of the NECTALIS-1 cruise with 18 sampling sites in New Caledonia's exclusive economic zone.



Data recorded during the ship's cruise:

A: Sea surface temperature (SST) in °C (recorded from the ship);
B: Sea surface temperature (SST) in °C (satellite image);
C: Sea surface salinity (SSS) in ‰ (recorded form the ship);
D: Chlorophyll in mg m^{-3} (satellite image).

The team

The research team consists of specialists (from different research institutions) in acoustics, biogeochemistry, oceanography, biology and fisheries who will collect, analyse and model observations on mid-trophic level zooplankton and micronekton.

Dr Valerie Allain, fisheries research scientist (ecosystem analyses) with the Ecosystem Monitoring and Analyses section of SPC's Oceanic Fisheries Programme and Dr Christophe Menkes from IRD were the cruise leaders.

Scientist	Working area	Institution
Valerie Allain	Micronekton	SPC
Christophe Menkes	Physical oceanography	IRD
Martine Rodier	Chemistry and phytoplankton	IRD
Houssem Smeti	Zooplankton	IRD
Erwan Josse	Acoustics	IRD
Francis Gallois	Electronic equipment	IRD

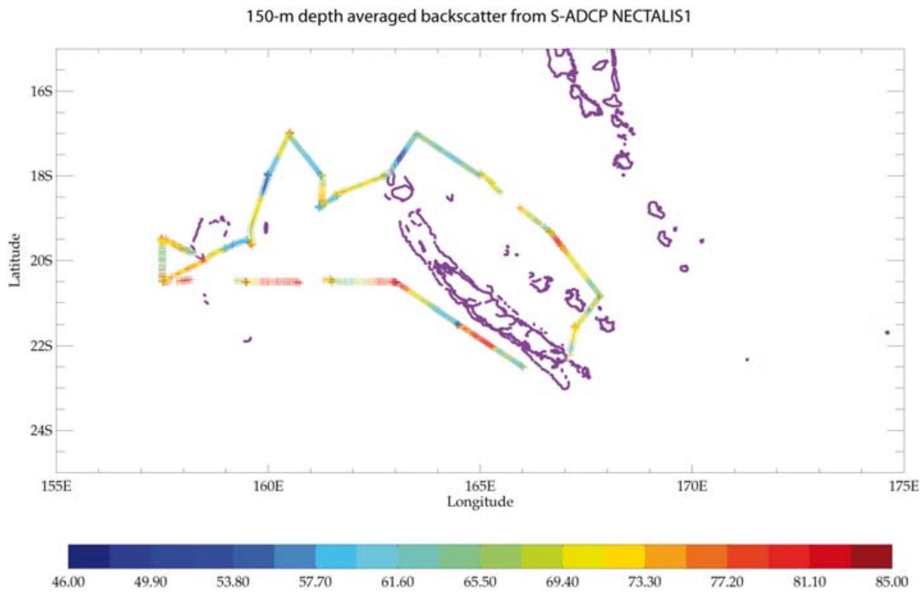
Beyond the cruises

The cruises will be complemented by physical, chemical and biogeochemical modelling; tuna diet studies; and modelling of pelagic ecosystems, including several sub-models that involve a large team of scientists from SPC and IRD.

Initial results

The first cruise finished in mid-August and scientists returned with considerable data and samples for analyses. The original cruise plan was modified due to rough weather and various logistical problems, and the number of sampling stations visited had to be reduced to 18. Most of the data collected will need to be processed and analysed thoroughly before providing results, but some interesting information has already been identified, as detailed below.

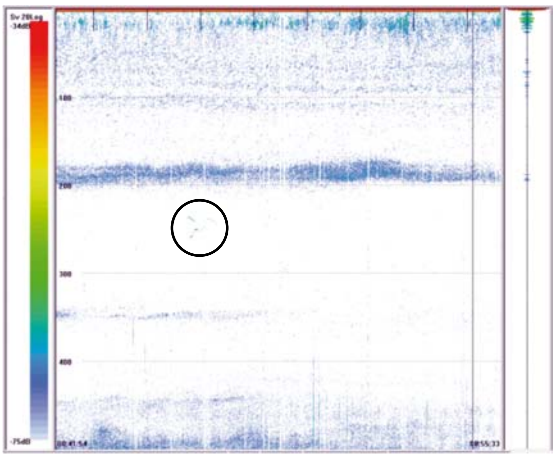
Examining temperature and salinity recordings taken at the surface (0–3 m depth) during our cruise, we found that there was a warmer and fresher (i.e. lower salinity) water mass in the north, while in the south, the water mass was colder and saltier (i.e. higher salinity). A warmer and fresher water mass is



Acoustic backscatter anomalies (daytime data minus daytime mean; night-time data minus night-time mean to remove the daily cycle) averaged over 0–150 metres depth.

characteristic of tropical waters, while a colder and saltier water mass reflects the northward seasonal migration of subtropical waters. A clear front exists between these water masses. In the two regions, the backscatter from one of our acoustic gear — which can be interpreted as a relative biomass of mesozooplankton and micronekton — shows that, at 0–150 m depth, there are fewer organisms in northern waters than there are in southern area waters.

The echosounder is a very important tool on the cruise as it makes it possible to establish the vertical distribution of micronekton and to estimate its relative biomass. It can also detect large animals. On the EK60 echogram image below, we can see a layer of micronekton between 180 m and 200 m depth. Just below this deep layer, at around 250 m depth, an isolated signal (see black circle in figure below) was interpreted as a group of at least two tunas, about 100 cm long, based on the signal's strength.



Screen shot from the EK60 echogram

Micronekton comprises organisms (e.g. lanternfish, hatchetfish, deep shrimps, small squids, and gelatinous animals) that live at different depths and which migrate vertically in the water column. Some of these animals move from great depths toward the surface at dusk, and will stay there all night before diving down to deeper depths at dawn. During our cruise, we collected micronekton samples with a large pelagic net, targeting layers observed on the echosounder.

Micronekton specimens: a mix of small fish, squids and crustaceans. These constitute the daily meal of tunas and other large pelagic predators.

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Satellite tag remains on fish for 351 days — but on what fish?

As part of a project to monitor albacore tuna movements in New Caledonia's exclusive economic zone, 10 fish were fitted with satellite tags.

Recent progress in technology has made it possible to reduce the size of "pop-up" satellite tags, so named because they detach themselves from fish after a pre-set time, and rise to the surface and transmit recorded data (e.g. depth, water temperature, ambient light) via the Argos system. Unfortunately, albacore (*Thunnus alalunga*) are a fragile tuna species, and the stress of capture compounded with the stress of tagging (due to what is a fairly bulky tag for a 20 kg fish), led to the death of 8 of the 10 albacore tunas (after between 6 and 20 days). The last hope of retrieving any data disappeared when the date set for data transmission (350 days after tagging) from the tags on the last 2 fish went by with no data being received.

It was, therefore, a big surprise when one such tag began transmitting some 40 days later. Why the delay, especially given the accuracy and reliability of the tag system? The battery's performance was outstanding because it enabled transmission to continue for more than 14 days after the set date for final transmission, thereby sending the vast majority of data recorded the previous year. An assessment of the data, however, revealed that either the tag sensors were faulty, or something happened to the fish about three days after its release. After the first three days of recording, when the animal's daily vertical movements seemed normal, the tag recorded a deep dive to a depth of 800 m, followed by resumption of normal daily movements at depths located between 400 m and 800 m, and that trend continued for a total of 351 days after tagging. One possible explanation could be that the tuna died after three days, and then sank and was later eaten (along with the tag) by a predator at a depth of about 800 m. But what predator remains in this bathypelagic zone without ever swimming back up to shallower layers, and how could it be possible for a tag to remain for so long in the stomach of such a predator without being regurgitated or damaged?

The data collected were sent to the tag manufacturer for a possible answer to this mystery.

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A satellite tag has been inserted close to the dorsal fin of an albacore tuna, which is then immediately released. The whole operation lasts 1–2 minutes maximum.

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The views expressed in this publication do not necessarily reflect the views of the European Commission.

6th annual tuna stock assessment workshops

A record number of participants attended this year's annual tuna stock assessment workshops hosted by SPC's Oceanic Fisheries Programme (OFP). In total, 30 participants from 23 Pacific Island countries attended the workshops, which are recognised as being an important programme in capacity building for fisheries officers and managers in the region. This year, for the first time, participants were introduced to the tuna management simulator (TUMAS), a new software tool developed by OFP that allows fishery managers and advisors to evaluate the performance of different management options.

OFP produces regular assessments of tuna stocks in the western and central Pacific Ocean. These assessments provide information regarding the health of the region's tuna stocks and the potential impact of different management measures on these stocks and the fisheries that target them. These are technically complex assessments that incorporate the very latest scientific developments and innovations. Thus, it is important that fisheries managers from Pacific Island countries and territories have the capacity to interpret the outputs from these assessments, and understand the implications for domestic and regional tuna fisheries management. To assist in building such capacity, OFP has been hosting a series of annual stock assessment workshops since 2006. These workshops are targeted at Pacific Island senior fishery officers who generally play a major role in providing advice to their fisheries managers and who attend the annual Scientific Committee meetings of the Western and Central Pacific Fisheries Commission (WCPFC).

This year, two stock assessment workshops were held at SPC's headquarters in Noumea from 20–25 June and from 28 June–4 July 2011. The first workshop was designed for fisheries officers and managers who have not received significant exposure to stock assessment concepts and principles, while the second workshop was for participants who have attended stock assessment workshops in previous years.

The first workshop focussed on providing participants with an understanding of fish population dynamics, the interaction between fisheries and fish populations, and the fundamental concepts and basic stock assessment principles. The workshop also included a session that introduced participants to the key biological reference points used by WCPFC to determine the status of tuna stocks in the region. Presentations, informal group discussions, and practical computer-based exercises were used to deliver the material during the workshop to ensure that participants received sufficient opportunities to learn and ask questions. The workshop ended with discussions about the key information that can be drawn from stock assessments to inform management decisions at the national and regional level.

To refresh the memories of returning participants, the second workshop started with a revision of fish population dynamics and stock assessment principles. Participants were then introduced to the concepts of uncertainty and sensitivity analyses, which are key concepts to understand when assessing the assumptions typically made in regional tuna stock assessments.

The major focus of this workshop, however, centred on management option analyses, in particular, the use of TUMAS. Participants were given several days to become familiar with using TUMAS. At the end, each participant developed and reported on their own management options analysis. In this exercise, participants were asked to develop their own management objectives and then explore the performance of a range of management options in meeting these objectives. Responses from participants about TUMAS were overwhelmingly positive, with participants eager to use TUMAS in their countries as a tool to allow stakeholders to visualise how

Donald Bromhead (SPC consultant) providing advice to Efoti Ala (Fisheries Department, Ministry of Natural Resources, Tuvalu) during a stock assessment practical class.

changes in policy within a region could potentially affect tuna stocks and the fisheries that exploit them.

Invitations to the workshops were sent to all SPC member countries, as well as the Philippines, Indonesia and Vietnam. To maintain participants' comprehension of stock assessment concepts and principles, previous and current workshop material is made available on SPC's website at www.spc.int/oceanfish/en/meetingsworkshops/saw, and online revision exercises are distributed to returning participants during the year.

Funding for participants to attend the workshops was provided by the WCPFC-administered Japanese Trust Fund and West Pacific East Asia Oceanic Fisheries Management Project, the Western Pacific Fisheries Management Council, and the EU-funded SciFish project.

Valerie Chan (Pacific Islands Regional Office NOAA Fisheries Service, Hawaii) and Bruno Muneret (Service de la Pêche Service Territorial des Affaires Rurales et de la Pêche, Wallis and Futuna), listen and take notes during a stock assessment presentation.

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Elaine Garvilles (National Fisheries Research and Development, Philippines), Lilis Sadiyah (Research Centre for Fishery Management and Conservation of Fishery Resources, Indonesia) and Aketa Taanga (Ministry of Fisheries and Marine Resources Development, Kiribati) work on developing management options using TUMAS.

What is TUMAS?

Better-informed fishery managers make better management decisions. This is the idea behind the new software TUMAS (TUna MAnagement Simulator), designed by SPC to support the management of the world's largest tuna fisheries.

Using the same science and models used by SPC, this user-friendly simulator allows the user to evaluate the potential effects of different management options on the region's tuna stocks and the fisheries that exploit them. After the user has defined a fishery management plan, the software predicts how this management option will affect the health of the resources, as well as the performance of the fisheries both in terms of catches and catch rates. For example, the user can choose to change future catch or effort levels for individual fisheries in the western and central Pacific Ocean, and examine the effects of these on bigeye, yellowfin and skipjack tuna stocks, or on catches in their own domestic fishery.

TUMAS also allows members of the Western and Central Pacific Fisheries Commission to gain a better understanding of the consequences of different management options that are discussed and negotiated at regional fisheries meetings.

TUMAS was funded through a grant from the Pelagic Fisheries Research Program in Hawaii.

For more information, check http://www.tumas-project.org or contact: Simon Hoyle, Senior Fisheries Scientist, Stock Assessment Section, SPC Oceanic Fisheries Programme, SimonH@spc.int

Vanuatu communities mobilise for sea cucumber management

Harvesting sea cucumbers is an important income-generating activity for coastal communities in the Pacific Islands region. In the Maskelyne Archipelago south of Malekula Island in Vanuatu, sea cucumbers are an important source of income, although heavy fishing pressure coupled with a lack of effective management measures have led to overexploitation of this resource. Fishers can still recall a time when sandfish were plentiful in front of their villages prior to the fishing "boom" of the 1990s. The situation is different today because sea cucumbers are continuously harvested to supply the lucrative beche-de-mer trade.

Maskelyne communities have been managing their marine resources through the customary practice of a *tabu*, but in 2007 they were led to believe that the reseeding of sea cucumbers would help restore sandfish populations. Juvenile sea cucumbers imported from outside were reseeded on Maskelyne reefs in exchange for harvesting wild stocks for the beche-de-mer trade. Several months later, the community discovered that their wild sandfish stock had been fished out. Such pressures are a challenge to the effectiveness of local management. On the other hand, commercial fishing activities are beyond the capacity of local management, an area best left to national and provincial fisheries authorities. However, the sea cucumber fishery has not been well regulated, leaving communities exposed to external market pressures. Maskelyne communities are relieved that the government has stepped in to enforce the 2008 ban on the sea cucumber fishery as they have little power to control buyers.

As the end of the five-year ban approaches, Maskelyne communities are wondering whether their sea cucumber resources have recovered from the previous harvest and are ready to be fished again. The Vanuatu Fisheries Department will need to decide before January 2013 whether to lift the ban or extend it, and this decision will be based on information from resource assessments. SPC is assisting the Vanuatu Fisheries Department with training and development of a resource monitoring system.

Resources assessment surveys and training

The first training provided by SPC was completed in June 2011. Five participants from Vanuatu's Fisheries and Environment departments, two members of the Maskelyne community, and one officer from the Solomon Islands Ministry of Fisheries and Marine Resources applied their newly acquired knowledge and skills to complete a comprehensive sea cucumber resource survey in the Maskelyne area. Although only two community participants were invited to join the team, many more community members, including chiefs, were keen to follow the team each day and provide valuable information on habitats, species aggregation and fishing grounds.

Preliminary results of the resource surveys

Preliminary survey results were then presented to the leaders and community members of Peskarus, Lutes, Bellonk and Avok islands. Presentations were given on the number of sea cucumber species present, their distribution, abundance (in terms of numbers recorded) and sizes, and comparative results of a protected area versus a recently fished area. The highlight of the presentation was the status of sandfish stocks. Community leaders were happy to learn of the recovering population of golden sandfish (*Holothuria lessoni*), a species that has not been seen for many years. A small population that was recorded at Avok Island is only beginning to recruit to other areas in the archipelago. Avok community leaders were particularly happy to learn of the healthy status of their *Holothuria scabra* stocks, which have not been fished for nearly 10 years as a result of a land ownership dispute that also involves the reef area.

The community leaders of Peskarus, Bellonk and Lutes on Uliveo Island, however, were not encouraged by the low number and relatively young

*Jayven Ham holds a golden sandfish (*Holothuria lessoni*) specimen.*

Trainees (from left to right) Jason Raubani, Jayven Ham, Kassy Nagof, Paul Tua, John Laggette, Vatu Molisa and George Amos.

sandfish populations, which are the result of heavy fishing four years ago. Despite this, communities were happy overall to learn that their sea cucumber resources are recovering well, which is promising if the current management system is maintained into the future.

Community support

In response to the presentation, the chiefs of the four communities thanked the Vanuatu Government and SPC for enabling them to better understand their resources. They also thanked the government for enforcing the ban to save their resources from further depletion, and proposed that the current moratorium be extended. When the fishery is finally opened, they asked that the Fisheries Department maintain stronger control of the fishery in order to ensure that the harvest is never again depleted. The leaders also want the activities of beche-de-mer traders to be controlled in order to protect their communities from pressure from buyers. There was discussion about community members being given opportunities to participate in the beche-de-mer trade, rather than the trade being run exclusively by foreigners as it currently is. For other resources, the leaders expressed concern on the declining status of the trochus fishery, and asked that the Fisheries Department close the fishery as it is no longer a profitable activity. They said that closing the trochus fishery would not affect their income opportunities because their main income now comes from copra, kava, finfish, root crops and handicrafts, which are exported to Port Vila markets. These demands were presented to the Director of Fisheries and will be considered when developing the sea cucumber fishery management plan for Vanuatu.

This work was made possible with SciCOFish[1] funding.

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[1] SciCOFish (Scientific Support for the Management of Coastal and Oceanic Fisheries in the Pacific Islands Region) is a project designed to provide a reliable and improved scientific basis for management and decision-making in oceanic and coastal fisheries.

Pacific women's participation in fisheries science and management

Patricia Tuara and Kelvin Passfield worked on the gender objective of the SciCOFish project,[1] which is to increase the benefits to women from the fisheries sector by increasing women's participation in oceanic and coastal fisheries science and management. The report of their study is now available,[2] as well as a brochure presenting the main outcomes and proposals to make fisheries careers more accessible to women.

Case studies were undertaken in Solomon Islands, Marshall Islands and Tonga. In each country, a gender analysis was completed for a range of fisheries-related positions (aquaculture officers, fisheries economists, fisheries management officers, policy and legal officers, post-harvest specialists, marine conservationists and fisheries research officers) involved in inshore and offshore fisheries.

Women comprise 18% of fisheries staff

The fisheries science and management sector employs more men than women. The case studies show that women comprise only 18% of staff working in this sector (including government fisheries, environmental institutions and environmental nongovernment organisations), or 25% if fishing vessel observers are not included (most are men). In contrast, the percentage of women employed in administrative and clerical roles in government fisheries divisions exceeds 60%.

No physical barriers

Developments over the last two decades in the fisheries science and management sector have resulted in more choices and opportunities for women. Those women who have entered the sector have demonstrated that there are no physical barriers that prevent women from doing the same work as men. Examples include women working as researchers, as observers on fishing boats, and as fieldworkers conducting stock assessments.

Gender stereotypes

Each of the three countries studied has specific constraints that affect the participation of women in fisheries science and management, but there are some common factors, mostly based around societal perceptions.

- The traditional role of women is to be homemakers and caregivers (this results in extra obligations for women who also pursue a career).
- Fisheries in general — and science and management in particular — are technological fields best suited to men; women are more suited to employment in teaching, health, or other fields generally dominated by women.

Breaking down the barriers

There are several ways to increase women's participation in fisheries:

- raise the profile of fisheries as a potential career, and give examples of women already working in the sector;
- provide a support network; and
- strengthen the institutional level (work environment) and improve working conditions.

With the help of fisheries departments, non-governmental organisations, the private sector, development organisations and donor agencies, women are being provided with more opportunities that facilitate choice. Institutions should put more effort in raising awareness about the need to reduce gender barriers and stereotypes throughout the fisheries sector

About gender and equality, not about women

There is a need to inform the public that a fisheries career is open to both women and men. The approach should not be solely to increase women's participation, but to also raise the status of fisheries as a career for young people with an interest in science. At the same time, the fact that women are just as able to participate in the fisheries sector as men needs to be reinforced.

While this study has shown that there is a gender imbalance in the fisheries sector, women should not be pushed into fisheries science and management if a country does not need more fisheries scientists and managers, and if women are not interested in pursuing such careers. However, where there is a need and an interest, women should clearly understand their options, opportunities should be made available, and the choice left to individuals. Women who have an aptitude and desire for a career in fisheries science and management need to know that this is an option, and equal opportunities need to be available to enable them to exercise such an option.

For more information:

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1 SciCOFish: Scientific Support for the Management of Coastal and Oceanic Fisheries in the Pacific Islands Region
2 http://www.spc.int/DigitalLibrary/Doc/FAME/Reports/Tuara_11_GenderOceania.pdf

New information sheets on marine species

SPC has been working with the Locally Managed Marine Area (LMMA) Network to produce a series of information sheets on marine species used for food and livelihoods in the Pacific Islands region.

Sixteen information sheets are in the process of being designed and printed. The sheets cover eight fish groups and eight invertebrates. Fish include groupers, rabbitfish, emperorfish, parrotfish, reef snappers, trevallies, mullets and surgeonfish. Invertebrates include sea cucumbers, giant clams, trochus, mangrove crabs, lobsters, coconut crabs octopus and green snails. These sheets are expected to be available in October 2011 and information sheets on other species may be prepared, depending on demand.

The information sheets will be available individually or as a kit that consists of all sheets with a guide to using the sheets. Each sheet provides information on the species' distribution, habitat(s) and feeding, lifecycle and reproduction, fishing methods and fisheries management options.

The purpose of the information sheets is to assist fishing communities, and people working with them, by providing information on species of interest and advice on appropriate fisheries management options.

Community-based fisheries management involves fishing communities taking a key role in managing the fisheries resources on which they rely for both food security and livelihoods. To do this, communities require technical information and advice on the resource species involved. The information sheets provide this basic information and the guide to the sheets discusses many topics of interest to fishing communities.

Are time-consuming and often expensive scientific surveys always needed? The guide to the information sheets provides advice on how an assessment on the "health" of community fisheries can be based on information from local fishers.

What does fisheries management mean in fishing communities? The main aim of fisheries management, whether by communities or national fisheries authorities, is to ensure that fishing is sustainable. If management is successful, seafood will continue to be available for local fishers, both now and in the future. In all cases, this means allowing adult fish to live long enough to breed and produce small fish, many of which will grow and be available for capture in future years. The guide and information sheets discuss how this can be done.

What fisheries management measures are appropriate in community fisheries? Many methods or "tools" are available to manage fisheries and the guide to the information sheets summarises these. Many of these have been applied by Pacific Island fishing communities for hundreds of years. Not all management measures work equally well with all species, and each information sheet discusses the measures that are most appropriate.

Will a fish reserve or no-take area really work? Establishing a fish reserve is just one of the tools available to manage fisheries. Local people who require a daily supply of seafood are most interested in whether or not a fish reserve will result in increased catches in nearby local fishing areas. But not all species will increase in numbers because a fish reserve has been established. The information sheets discuss this problem for each of the species groups.

How can we tell if management is working? Whatever management tools are used, it is necessary to determine whether they are achieving what they are meant to. From a community's viewpoint, the most appropriate indication of this is whether management measures are improving or sustaining catches in the managed area. The information sheets provide the optimum management measures for each species group.

What needs to be discussed in fishing communities? The guide to the information sheets offers some valuable suggestions on discussion topics that can help communities decide which management option(s) will be the most beneficial. Such discussions are essential in all community-based resource management approaches to ensure that the best use is made of local and traditional knowledge.

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A new web-based shark tagging information system

A shark tagging information system (STAGIS) has been launched on SPC's Oceanic Fisheries Programme website and can be accessed (for free) at http://www.spc.int/ofp/shark/index.php.

This database was populated by contributions from numerous shark researchers (who generously gave information and time to support this effort) and by a literature review conducted by SPC's Oceanic Fisheries Programme.

STAGIS contains meta-data (i.e. data about data) for approximately 200 shark-tagging studies (more than 80,700 tags deployed on over 60 shark species in the Pacific). It is hoped that this information will help shark researchers to better understand the current status of shark tagging research in the Pacific. In addition to supporting the Western and Central Pacific Fisheries Commission stock assessments of key shark species (to be conducted by SPC in late 2011), STAGIS can assist in highlighting issues for further research, facilitating research collaboration, and identifying critical habitats.

To familiarise themselves with the database, users may wish to read and follow the text on the "What's in STAGIS?" webpage, which describes how to search the database in four different ways. This will lead users through the main features of STAGIS and allow them to then explore other areas and features of interest.

Despite attempts to develop an information system that is as complete as possible, there may be omissions, inaccuracies or mistakes that have inadvertently been included in STAGIS. Users are encouraged to provide feedback on the system as well as the data, and to contribute new information to ensure that STAGIS is a vibrant and useful tool.

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or

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Aquaculture Section bids farewell to Antoine Teitelbaum

SPC's Coastal Fisheries Programme bids farewell to one of its dedicated staff members, Antoine Teitelbaum, who left SPC at the end of August this year. Antoine had been the Aquaculture Officer (Mariculture) since October 2006 and was instrumental in assisting SPC with developing the region's aquaculture sector. His contribution to the growth of SPC's Aquaculture Section was immense and he leaves behind the challenges for a new successor to fill his shoes.

Antoine has a passion for aquaculture development of ornamental species, and plans for his next life will partly focus on this area.

Staff of the Coastal Fisheries Programme wish Antoine the very best in his future plans, and look forward to continue working with him on other projects.

Public-private partnerships are paying off in PNG inland aquaculture

There is an increased level of private-sector involvement in inland aquaculture in Papua New Guinea (PNG), which has stemmed from past government-initiated projects and demonstration facilities in hatchery and feed-making technologies.

SPC's Aquaculture Section staff took part in a training needs assessment for PNG's National Fisheries College in Kavieng, and made visits in July to key PNG aquaculture areas and installations. The vigour and enthusiasm with which small-sale, household level businesses or community projects are being based on and around inland aquaculture of tilapia (*Oreochromis niloticus*), carp (*Cyprinus carpio*) and trout (*Oncorhynchus mykiss*) is impressive.

There is now an emerging trend among the more successful and motivated farmers to specialise in certain parts of the fish aquaculture custody chain. Private-sector tilapia and carp hatcheries are being established as stand-alone businesses (i.e. they are not a subset of bigger growout-pond farm operations that sells eatable fish, or part of a government department), and these now act as district-level distribution centres for both fingerlings and feed, each supplying as many as 100 other farmers.

These advanced-level private farmers tend to have received training from government staff from PNG's National Fisheries Authority (NFA), provincial fisheries offices, and government-trained field agents now working with non-governmental organisations such as Bris Kanda in Lae. Some farmers have benefitted from work experience attachments at the Highlands Aquaculture Development Centre in Aiyura. This training is being put to good use and has created a ripple effect, whereby more and more household farms can be supplied through sustainable private-sector businesses and expertise.

It is estimated that there are at least a half-dozen tilapia and carp fingerling and feed specialists in PNG. Below are a few examples.

Potsy Tilapia Hatchery

Managed by Douglas Kawa, a BSc graduate of Uni-Tech in Lae, and his *wantok* Moses Ngandang, this facility is established on family land near Markham Bridge and is a private-sector tilapia fingerling distribution centre for Morobe Province. The facility is run as a stand-alone business that deals exclusively in the sale of tilapia fingerlings for pond stocking. Five people work there full time, and another two casual hires assist with harvesting and packing fingerlings. Attachments have received training at Aiyura and a short training at Erup government station. The hatchery is at the centre of a cluster of several dozen tilapia ponds that are managed by

Douglas Kawa (second from left) of Potsy Tilapia Hatchery and Jacob Wani (second from right) of NFA watch as tilapia fingerlings are harvested ready for delivery to a tilapia farm in Morobe Province.

different households in the immediate neighbourhood, supplied with fingerlings and feed from this hatchery. There are other farms farther afield in Morobe Province whose businesses are now based on tilapia fingerlings supplied from Potsy Hatchery. New farmers can also be trained here through collaboration with other institutions and non-governmental organisations.

Kotuni Trout Farm, Goroka

Established in 1976 but later discontinued, this farm is now being reactivated as a community project with assistance from NFA. The first new culture cycle, brought in as eyed-eggs from Tasmania, is now underway, and a pellet made of local ingredients by government staff in Goroka is now being tested against imported Australian trout feed. If successful, farm staff will need to acquire their own feed-making machinery and be trained in order to be self-sufficient in supplying feed to the farm. The next plan is to recommission the onsite trout hatchery to supply themselves and other farms, of which there are several in Eastern Highlands Province. A separate batch of fish is now being raised to broodstock size, to enable re-commissioning of the onsite trout hatchery.

*Staff of Kotuni Trout Farm near Goroka proudly show a sample of their first new pond cycle of rainbow trout (*Oncorhynchus mykiss*).*
Close-up view of trout.

Western Province tilapia and carp farmers

There are a good number of fish farmers in PNG's Western Province, particularly along the Tabubil-Kiunga Highway. Projects were initiated by the combined efforts of NFA, Western Province Fisheries, and Ok Tedi Fly River Development Program (OTFRDP). Abraham Isok is a farmer who runs a tilapia and carp farm — comprising seven ponds — near Migalsim Village not far from Tabubil. He is not a local landowner, but rather has moved here from another district and has bought a small piece of land that he uses intensively for his livelihood. He harvests every two months and sells fresh fish in bundles at the Tabubil market. Although he is not formally trained, he has received instruction from Aiyura-trained OTFRDP staff. In Kiunga we overheard a conversation with another farmer who had come into the OTFRDP office to strike a deal for distributing fish feed to other farmers from his village-based farm, in partial exchange for providing feed ingredients such as whole rice and sorghum to the fish-feed, mini-mill in Kiunga. This farmer is already trading in tilapia fingerlings.

Sirinumu Dam tilapia cage culture farm

Located about an hour's drive from Port Moresby, not far from the start of the famous Kokoda Track, Jonah Bobogi operates a farm on an islet of Sirinumu Lake. He has built a floating platform with 18 fish cages in the lake, and has built 6 cement ponds (6 m x 5 m) for a tilapia hatchery and broodstock on the islet. Recently, he sold a harvest of 1.4 tonnes of tilapia in Port Moresby. He is one of 60 farmers on this lake, and he is now the main supplier of tilapia fingerlings to the other farmers. Jonah was shown how to farm fish through extension visits by Aiyura-trained NFA staff, and in this way, he has acquired the basic skills needed to establish his business. He intends to expand his family business to become a tilapia fingerling supplier for all of southern PNG.

By PNG standards of primary-sector industry development, inland aquaculture is still a fledgling sector but it is one with enormous potential for future expansion. However, the sheer scale of the present and future needs for trained personnel, and the logistical constraints imposed by distance, topography and infrastructure, are major hurdles to overcome. A district-by-district approach is needed, where small provincial aquaculture centres can serve as ripples in a pool. It is gratifying to see that private-sector uptake of public-funded initiatives in aquaculture can be a successful mechanism for this activity to radiate outward to the district level from the comparatively few places where PNG aquaculture capacity presently exists.

By regional standards, PNG is a leader in inland aquaculture in terms of the sheer number of farmers, volume of production, and economic sustainability of projects. The spirit of enterprise is alive and well in PNG, and farmer motivation is high. Specialisation of activities within the fish custody chain, such as the emergence of private hatchery operators, is one hallmark of a successful and maturing industry. If ongoing efforts to develop the sector remain on their present course, the future of inland aquaculture in PNG will be a good one.

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All images: Tim Pickering

Jonah Bobogi with tilapia that were spawned in his tilapia hatchery, and grown-out in cage culture at Lake Sirinumu near Port Moresby.

Wildlife spectacle and fishery source urgently need protection

Yvonne Sadovy de Mitcheson* and Éric Clua+

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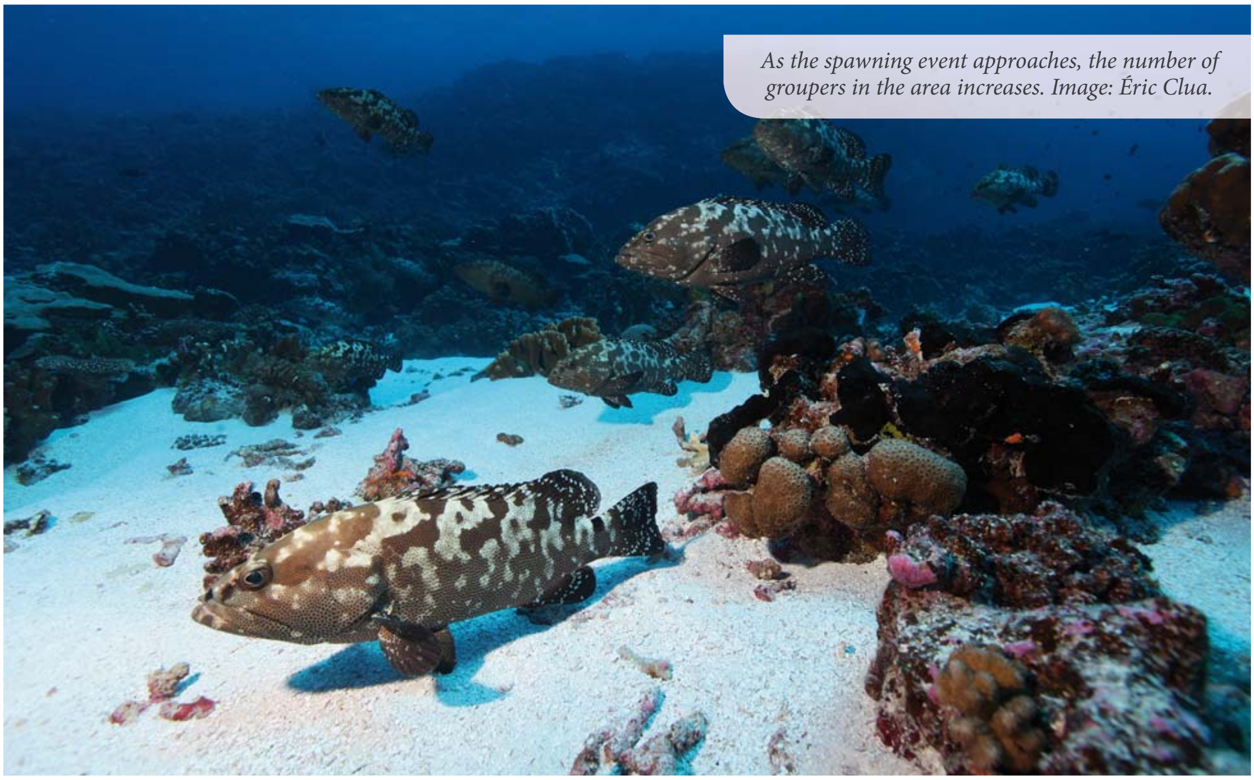
Wildlife spectacles are marvels of nature. They can involve brief gatherings of tens of thousands of individuals for feeding, mating or giving birth. Examples include large nesting seabird colonies, enormous gatherings of monarch butterflies, seasonal mass movements of wildebeest, snake congregations, turtles on nesting beaches, shark birthing areas, and bird migrations. For many species, these are key life history events that are crucial for population regeneration. Today the importance of these massive biological gatherings is widely recognised, and many land-based events receive some protection. Indeed, many wildlife spectacles are now important generators of tourism dollars.

Today few large wildlife gatherings are exploited for food, but the spawning aggregations of many reef fish species are a notable exception in the marine ecosystem. These are exceptional in that they are still widely exploited and are rarely managed; as a result, many are disappearing. Once they stop forming, the fisheries that depend on these aggregations collapse, as has been witnessed in parts of the Caribbean and Southeast Asia. There is a rapidly growing recognition of the importance of protecting spawning aggregations and allowing adult fish to produce young for the future, but this is proving to be a surprisingly difficult challenge.[1]

Reef fish spawning aggregations are found in many species of commercial importance, including prime food fish (e.g. many snappers, larger groupers, jacks, emperors, mullets and rabbitfish). Each year, aggregations of these species typically occur at specific times and locations and may only form for a few days or weeks (a couple of months at most). Some are associated with extensive migrations of large groups of fish that move from their home reefs to assemble with others of the same species to mate. For many of these species the aggregation time and location is the only opportunity to reproduce, making it important for scientists and fishery managers to understand and appropriately protect or manage these gatherings. Of particular concern is the speed with which aggregations can be overfished once they are discovered; globally about two-thirds of all exploited aggregations are yielding declining landings and some have even stopped forming altogether. This situation represents a considerable challenge, both for management and for conducting the research that would help us to better understand these remarkable life history events. Such research is best conducted on unfished aggregations, before they have been reduced or otherwise altered by exploitation, but these are remarkably difficult to find or access.

A small international group of scientists was recently afforded a wonderful opportunity to visit what appears to be a pristine aggregation site and witnessed a massive gathering of reproductive camouflage grouper,

*Yvonne Sadovy records data prior to a camouflage grouper (*Epinephelus polyphekadion*) spawning event. Image: Éric Clua*



As the spawning event approaches, the number of groupers in the area increases. Image: Éric Clua.

Epinephelus polyphekadion. (The location is undisclosed to protect it from possible exploitation.) Aggregation is known to occur during one or two months of the year. This year, the aggregation first began to develop over about a week in June, the initially empty reef slowly became busy as more and more groupers assembled over about a hectare. We think that the fish were mostly males because there were many aggressive interactions as males faced off to each other, angrily jockeying for prime space on the reef; places that are presumably attractive to the ladies! As the number of fish climbed into the thousands, the divers eagerly visited the site each day in the hope of seeing spawning. But, other than for a few very ripe-looking females, their massive bellies full of hydrated eggs — a clear sign of imminent egg release — we saw no spawning. Despite all the excitement of seeing so many active fish, we had to pack up and leave the area without witnessing any mating. We had selected the wrong month!

Several lucky biologists did, however, manage to return the following month and for just two days witnessed incredible spawning events. Tens of thousands of camouflage grouper had gathered this time and intense mating occurred over just two days, accompanied by considerable fighting, colour changes, and many large-bellied hydrated females desperate to release their eggs. Sharks came into the site and as the groupers jostled for spawning partners and rushed up into the water above the reef in small groups to rapidly release their packages of sperm and eggs, sharks used the opportunity to snatch up distracted individuals; a feeding and breeding frenzy of incredible proportions and intensity. And then, by day three, suddenly all the fish had gone — migrating into the lagoon in large groups. This species has just a few days each year for reproduction — a very brief window, but critical for the population to renew itself.

Aggregations such as the one described are, not surprisingly, highly susceptible to overfishing if unmanaged and can disappear within just a couple of years if overfished. One of the biggest challenges to management is that there are so many fish together at one time that it is hard for a fisherman or a manager to believe that any management is necessary. This “illusion of plenty” hides the highly vulnerable nature of these fantastic and important events. Indeed, in many places, aggregations are a seasonal target of fishing. What we are learning, however, is that they really need to be a seasonal target for protection. Let the fish spawn undisturbed and the eggs produced will maintain a healthy fishery for the rest of the year. Lack of action will eliminate these incredible natural wonders and destroy the fisheries they support.

For more information on spawning aggregations, see:

http://www.SCRFA.org

[1] The sustainable management of spawning aggregations in the Pacific Islands region is a major focus of the Secretariat of the Pacific Community, which adresses this challenge in close partnerships with the University of Hong-Kong (SCRFA) and the Insular Research Center and Environment Observatory (CRIOBE) in Moorea (French Polynesia) under funding provided by the French Ministry of Sustainable Development in the framework of the International Coral Reef Initiative (ICRI). The David and Lucile Packard Foundation provides funding for SCRFA.

The quest for active substances from marine sources

SPC-coordinated CRISP project searches the region's waters for new medicines[1]

Claire Dupré* and Éric Clua+

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Many medicines come from substances of natural origin. Amongst the most famous is quinine from the bark of the cinchona tree — traditionally used by the Quechua Indians in South America — which became the first effective treatment for malaria in Western medicine. Indigenous peoples' traditional knowledge of plants and their medicinal uses has long been a source for modern medicine. But the chemical resources of the marine environment remain underdeveloped, in particular in the vast Pacific region. And while indigenous people have often seen little or no benefit from the commercialisation of medicines originating from their traditional knowledge, recent research has emphasised respect for ownership of such biological resources and intellectual property and the need to ensure benefits are distributed fairly.

Bioprospecting for resources

One objective of CRISP (Coral Reef Initiatives for the Pacific), project coordinated by the Secretariat of the Pacific Community (SPC) and funded by the French Development Agency (AFD), was to explore poorly known marine territories and search for new substances in sponges or algae with possible therapeutic uses. The project also worked to ensure proper benefit-sharing. Active substances identified in marine organisms may have anti-inflammatory, anti-malarial, cancer-fighting or other beneficial properties. But it can take 12 to 15 years from the initial collection of an organism to the commercialisation of a medicine. Isolating an active substance is a complex process that starts with in-situ sampling (bioprospection) and continues with identification and classification (taxonomy), chemical extraction, screening, isolation and definition and production of the active compounds (pharmaco-chemistry).

Between 2004 and 2007, bioprospecting in Fiji, Solomon Islands and Vanuatu was conducted by the French Research Institute for Development (IRD) in collaboration with the University of the South Pacific (USP) and local authorities, and in accordance with international and national regulations. The researchers collected 2,500 samples (90% of algae and 10% of invertebrates), which were identified as belonging to 419 species of algae and 169 species of invertebrates.

Promising results

Overall, this bioprospecting led to the discovery of 30 species and one genus new to science as well as the scientific description of remote coral reef habitats never surveyed before. In addition to identifying and classifying specimens, researchers preserved samples and sent them to enrich the collections of various institutions, such as the USP Herbarium, the French National Museum of Natural History in Paris and the Queensland Museum in Australia. Data resulting from the research was also added to scientific databases around the world

Examples of active marine substances discovered in Solomon Islands waters

- ➔ Research on *Agelas mauritiana* enabled the structure of new alkaloids with anti-malarial properties to be described.
- ➔ The sponge species *Theonella swinhoei* and *Coscinoderma mathewsi* were investigated, with the discovery of new metabolites that reveal anti-inflammatory activity.
- ➔ The sponge *Ptilocaulis spiculifer* contained new steroids with cytotoxic activity.
- ➔ Some specimens of the sponge genus *Dysidea* contained substances with anti-malarial and other biological properties.
- ➔ Research on marine brown algae from Solomon Islands led to the discovery of active compounds with anti-inflammatory properties.

[1] This article was first published in Island Business, June 2011.

making a considerable contribution to global knowledge of marine biodiversity.

The actual search for active substances was performed exclusively on material collected from Fiji and Solomon Islands. The work to extract and test substances and to isolate and identify active ingredients, carried out in several laboratories in Europe, led to the discovery of 30 new bioactive substances. The bioprospecting proved exceptionally fertile in Solomon Islands, with only 17 of 174 sponges not showing any bioactivity (see box).

Protecting national interests

In addition to those promising results and to answer the concerns of Pacific Island governments over their biological resources and intellectual property, the CRISP project has, from its start in 2005, emphasised the need to improve legal frameworks in Pacific countries to enable better access to marine biological resources and better sharing of benefits. Field studies in Fiji, Solomon Islands and Vanuatu were conducted to assess national legal frameworks in terms of natural resource management, the conservation of marine and coastal environments, scientific research, intellectual property and trade. International biodiversity law and customary practices were also taken into consideration. The results of those studies are presented in three technical reports that are available on the CRISP website along with a synthesis report including recommendations for improvement.

To further reinforce benefit sharing the CRISP project has also focused on training Pacific Island students in this promising area. Five students from Fiji and two from Solomon Islands were trained — some at USP and some in France — and two of them went on to complete PhDs. Another mark of the success of this initiative is the fact that the research led to the publication of 20 scientific articles in well-regarded journals.

Although the road ahead remains long, the exciting initial results allow hope that this work will lead to new medicines that will benefit the people of the Pacific and all of humanity.

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Tropical marine sponges are great sources of active substances.

Tuna fisheries and fish aggregation device symposium

Arue, Tahiti, French Polynesia, 28 November–2 December 2011

Symposium objectives

Since ancient times, fishers have known about the natural tendency of pelagic fish such as tuna, mahi mahi, sharks and marlins to gather around floating objects. Technical progress — in terms of making large nets — after the mid-20th century made it possible to use this aggregating phenomenon on a larger scale; first along coastal areas (e.g. Philippines, Indonesia) and then farther out in the open ocean. It is currently estimated that nearly three-quarters of the world's tropical tuna catches (i.e. albacore, skipjack tuna, yellowfin tuna and bigeye tuna) come from these floating objects, commonly known as fish aggregation devices, or FADs.

This tendency of large pelagic fish species to aggregate around floating objects has been used at two very different scales.

- In coastal zones, local fishers moor FADS on the sea bottom in depths of 50–2,500 metres to encourage tuna to gather in specific areas known to fishers for daily fishing expeditions. In such cases, FADs can be considered to be effective, small-scale fisheries management tools that make it possible to transfer fishing pressure away from nearshore areas to the open ocean, thereby favouring the harvesting of species (i.e. pelagic) that are less sensitive to local fishing effort.
- In the open ocean, tuna purse-seine vessels use drifting FADs equipped with electronic location emitters, which allows for large-scale tuna harvesting. Given the catch volume they generate around the world, the massive use of drifting FADs should be subject to in-depth studies so as to better assess the potential impacts of this fishing technique in terms of the risks of overfishing and disturbing the balance of the ecosystems involved (the "ecological trap" hypothesis).

By pooling international experience and expertise, the symposium will serve four main objectives:

1. Sharing knowledge to allow consistent and controlled development of moored FADs for the benefit of small-scale tropical island fisheries.
2. Gaining a better understanding of the risks brought about by the large-scale use of drifting FADs by tuna purse-seine fleets.
3. Better defining and implementing fishing techniques designed to avoid bycatch and accidental capture of sensitive marine species such as marine mammals, turtles and sharks.
4. Better understanding why fish aggregate around floating objects and what are the consequences of the deployment of FADs on the ecology of species.

Session schedule

The symposium has six sessions:

Session 1 – Regional overview of moored and drifting FAD use

Session 2 – Moored FADs and coastal fisheries: Technologies and fisheries

Session 3 – Drifting FADs and long-range fishing: Ecosystem impacts

Session 4 – Socioeconomic and fisheries systems (moored and drifting FADs)

Session 5 – Understanding the phenomenon of aggregation (moored and drifting FADs)

Session 6 – Posters

Symposium committees

Steering committee	Scientific committee
Michel Blanc	Michel Blanc
Priscille Frogier	Laurent Dagorn
Loïc Gourmelen	Jean-Claude Gaertner
Pierre Mery	Paul Gervain
Christian Moretti	Olivier Guyader
Bruno Peaucellier	Martin Hall
Tiare Penilla Y Perella	Kim Holland
Alain Santoni	David Itano
Mainui Tanetoa	Beatriz Morales-Nin
Marc Taquet	Lionel Reynal
Bruno Ugolini	Marc Taquet
Stephen Yen Kai Sun	

Registration and call for contributions

Participants are invited to visit http://fads2011.sciences-conf.org to:

- register and obtain a login and a password,
- complete their registration form, and
- submit their contributions (abstracts).

There are no registration fees, although the closing date for registration is 31 October 2011.

Practical information

All documents relating to the conference are available at: http://www.peche.pf

For further information, send a message to: Tahiti.dcp.2011@ifremer.fr

An economic assessment of destructive fishing methods in Kiribati: A case study of *te ororo* fishing in Tarawa

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Introduction

This paper is part of a study that was undertaken for the Secretariat of the Pacific Regional Environment Programme (SPREP) to review the fishing methods and practices used by the people of North and South Tarawa (see Ram-Bidesi and Petaia 2010).

The overall aim of the project was to assess the impact of destructive fishing methods and practices on coastal fisheries and community livelihoods, and to provide recommendations on possible courses of action. The study analysed economic and social impacts by evaluating the current situation in Tarawa's coastal communities.

Kiribati's rapidly growing population is placing increasing pressure on scarce land resources. Fishing activities are seen as the mainstay of the local and national economy as well as the main source of food and protein. Fish consumption is relatively high in Kiribati. The average domestic food fishery supply has been estimated to be around 45–50 kg of fresh and frozen reef and ocean fish per household per month (ADB 2009: 9). This includes fish caught by family members or bought at roadside markets. In the outer islands, the per capita consumption of fresh fish is much higher at 88 kg/person/year in Abaiang and 110 kg/person/year on Kiritimati Island (Awira et al. 2008).

The majority of households in Kiribati fish either on a full-time or part-time basis. This underscores the importance of coastal fisheries for sustaining the livelihoods of local communities. On the other hand, although most of I-Kiribati households fish within nearshore coastal areas close to home, there is increasing reliance on fish caught from fishing grounds farther away from home and in deeper waters. Increased population pressure and demand for resources have led to areas of overexploitation in southern Tarawa where fishers now venture farther afield in search of fish, sometimes using unsustainable fishing practices. In 2006, 78% of households in North and South Tarawa were considered to be engaged in subsistence fishing (Kiribati Fisheries Division 2006:53). Direct employment in the fisheries sector is varied, ranging from domestic commercial fishers, fish sellers, crew working on foreign fishing vessels, and employment at the government-owned marketing and distribution centre known as Central Pacific Producers.

Methodology

Assessing the value of coral reefs is becoming an important policy tool to help determine use and management of reefs and fisheries. The widespread use of destructive fishing methods — such as blast fishing using bombs and dynamite — was brought under control, and marine protected areas were established in Indonesia after a series of studies that assessed the value of coral reefs in exchange for a significant debt reduction (Cesar 1996; Cesar et al.1997; Cesar et al. 2003; David et al. 2007: 2). Although the number of studies on valuing coral reef-associated fisheries has been increasing, the results show a huge disparity in the values derived. David et al. (2007) provide a list of references for variations in value. Their study, however, states that there are two approaches to understanding the value of coral reef environments. One approach involves the use of sophisticated tools and analyses through modeling in order to capture the complexity of the environment into conceptual and methodological patterns of neoclassical analysis, and the other involves a multidisciplinary approach that extends beyond the principles of neoclassical economics (David et al. 2007). This study used the latter approach to allow for a more practical and flexible effort to gather data from various sources given the limited availability of research data on coastal fisheries in Kiribati.

This study used a combination of methods to obtain primary and secondary data, including a literature review, observation of fishing gear and fishing practices, and interviews. Three villages in North Tarawa and three villages in South Tarawa were used as case studies to gather more detailed data through household socioeconomic surveys. An analysis of fisheries management regimes was made by considering the institutional structure, and an economic assessment of fishing practices was made by examining destructive *te ororo* fishing, and by analysing opportunity costs of other uses, and alternative livelihoods.

Fishing methods and practices

While most common gear owned by the majority of households include hooks and fishing line (for handlining for reef and lagoon fish), gill nets have become the most popular gear type in recent times. Splashing the water using metal rods, sticks or crow bars is commonly done to scare schooling fish into gill nets (Government of Kiribati 2004). Other traditional methods include reef gleaning during low tide in the intertidal zone, and trolling for schooling fish such as tuna. Gill nets and encircling nets are also used largely for catching bonefish, mullet and milkfish. Other methods use underwater spear guns and scoop nets (for flyingfish and other reef fish) in conjunction with pressure lamps at night.

Figure 1. A typical gill net commonly used by fishers in Tarawa.

The type of gill net used (in terms of net length and mesh size) and the frequency and/or intensity of fishing effort depend on the fisher and the fishing method. For example, subsistence fishers use shorter gill nets (1–3 nets joined together) with a smaller mesh size (1–2 inches), fish two to three times a week, fish in nearby areas, and use either set netting or drive netting as a fishing method. Artisanal and commercial fishers use longer gill nets (5–15 nets joined together) with a bigger mesh size (3–5 inches), fish three to six days a week, and operate far away from the main village or settlement, including nearby islands. The standard dimension of a single gill net ranges from 30 to 50 meters in length and a depth of two 2 meters.

Fishers can either leave the nets out overnight and periodically check and remove fish from the net, or fishers can drive the fish into the net, remove them from the net, and then move on to another fishing ground. Driving the fish into the net can be carried out in several ways. Some of these methods can be destructive to corals and other marine organisms, and marine habitats in general. For example, splashing the water surface using wooden poles or metal bars to disturb the bottom of the sea and scare the fish out from under coral heads and into nets (which is commonly done in Tarawa) can break coral (Ram-Bidesi and Petaia 2010).

The main fish species targeted by gill netting and handlining include bonefish (*Albula glossodonta)*, paddletail snapper (*Lutjanus gibbus*), goatfish (*Upeneus taenoguta-tus*), spangled emperor (*Lethrinus nebulosus*), mullet (various species), silver biddy (*Gerres* sp.), flametail snapper (*Lutjanus fulvus*), longnose emperor (*Lethrinus olivaceus*), orange-striped emperor (*Lethrinus obsoletus*) and many other species. Bonefish, paddletail, and emperor make up a large percentage (60–70%) of the landed catch (Ram-Bidesi and Petaia 2010). Figure 2 shows a typical catch of bonefish being sold along the roadside.

Overfishing and destructive fishing methods

The term "destructive fishing" has often been used for a wide range of activities, from classical overfishing (non-sustainable use) to outright destruction of the resource and the environment (e.g. use of explosives or other methods) with significant and definitive impacts. Destructive fishing practices or the destructive use of gear in the wrong habitat should be prohibited or strictly regulated so that it affects only a relatively small part of the given habitat. On the other hand, the impact of destructive methods can be so indiscriminate and/or irreversible that they are universally considered "destructive" no matter what circumstance they are used in. Non-selective or destructive methods tend to catch many different species at all life stages, or they can be potentially dangerous to people who use them (e.g. dynamite, cyanide, traditional and modern poisons). Veitayaki et al. (1995) provide an overview of destructive fishing practices in the Pacific Islands. There has been little research done on the above practices, mainly because the people who use these methods are generally not willing to talk about these practices as they know they are either illegal or harmful.

*Figure 2. Bonefish (*Albula glossodonta*) being sold along the roadside.*

Gill nets used in combination with sticks, metal rods and crow bars to scare or drive fish into nets is a destructive practice because of the large surface area covered by using more than two nets. This study shows that gill net fishers who mainly target bonefish and other bottomfish species in Tarawa's lagoon, rely mainly on "splash fishing" — locally known as *te ororo* — which is a destructive method. In some cases, fishers use snorkeling gear and spears to assist not only with herding the fish into nets, but also to break corals in order to scare the fish out from under corals heads and into nets.

Fisheries management regime

In Kiribati, all marine resources are owned by the state or the national government, although in pre-contact days each island had its own fishing rules that regulated who could fish and where. Traditional regulations were abolished in 1967 when Local Government Councils were set up (Hunt 1996). The transition from traditional resource management to open access fishing in Kiribati has been described by Teiwaki (1988). Councils are given the responsibility to control fishing activities in their local areas but council fishery bylaws must be approved by the central government (Hunt 1996).

The Fisheries Ordinance has a provision that allows for preferential access to customary fishing grounds by the rights holders. These rights, however, are not exclusive because anyone who has obtained a license can also fish within customary fishing grounds. Although the provision recognises the access rights of customary rights holders, it does not define the rights and responsibilities with regard to management and conservation (Ram-Bidesi and Manoa 2007).

South Tarawa's increasing population and subsequent economic pressure has exacerbated the problems associated with open access fishing. As resources closer to settlements become overexploited, people venture farther out to other fishing areas. This has been observed with fishers from South Tarawa. Figures 3 and 4 show the typical fishing grounds of fishers from North and South Tarawa. From these maps of fishing areas, it is apparent that fishers from South Tarawa travel farther from their villages than fishers from North Tarawa.

Kiribati's Fisheries Division is poorly resourced with regard to carrying out routine monitoring and surveillance of coastal fisheries. Fisheries extension officers posted in the outer islands are mostly involved in facilitating the marketing of marine products under the Rural Fisheries Development Project.

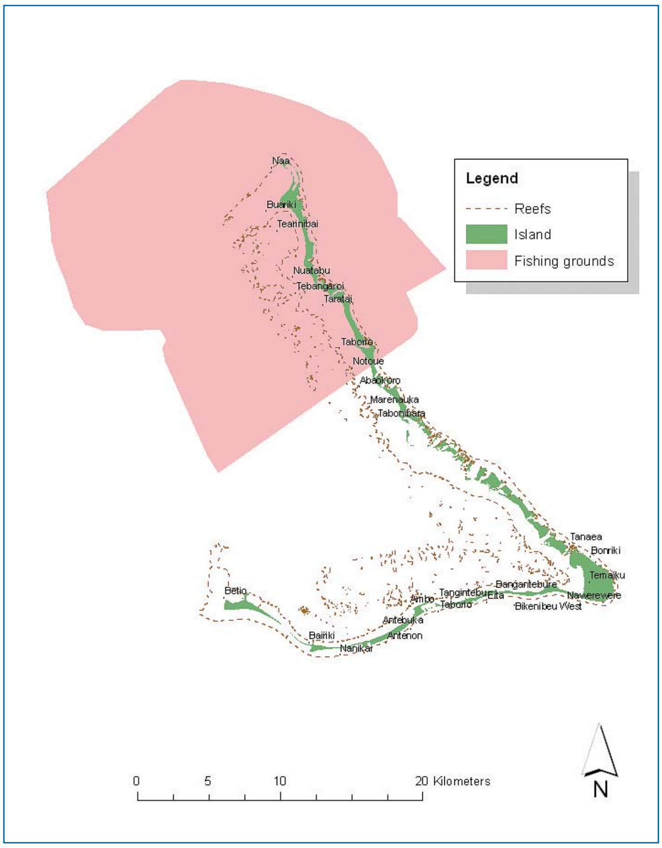

Figure 3. Fishing grounds of North Tarawa fishers.

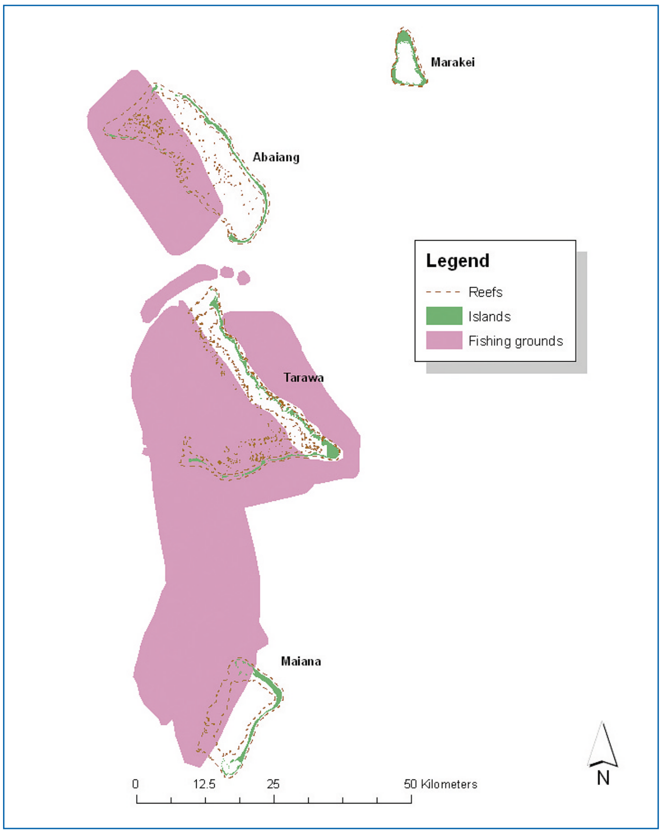

Figure 4. Fishing grounds of South Tarawa fishers.

Many fishers also operate on a part-time basis or fish for subsistence needs. Monitoring and enforcement of fisheries regulations can be an exhaustive task because it requires considerable resources in terms of staff and the capacity of the fisheries management authority. In addition, there is little recourse to punish fishers who are often unemployed or poor.

Therefore, monitoring, control and surveillance of coastal fisheries are weak and local government officials expect fisheries officers to carry out enforcement tasks while fisheries officers rely on local government officers.

The use of the destructive fishing method *te ororo* is regulated under bylaw by the Betio Town Council as well as the Teaoraereke (Teinainao) Urban Council, by designating prohibited zones. However, monitoring and enforcement remains an issue.

Economic assessment of fishing practices

Assessing the economic effects of destructive *te ororo* has required following a series of steps, together with making a number of assumptions. These steps have been carefully stated in order to ensure that the analysis is carefully understood.

- Step 1: The potential productivity of Tarawa Lagoon was estimated in order to assess the optimal level of output.
- Step 2: The impact of destructive *te ororo* on the lagoon area and fishing activities of both part-time and full-time fishers from South Tarawa were determined. (This excluded all oceanic and subsistence fishers.)
- Step 3: The revenues derived from of *te ororo* fishing were determined.
- Step 4: Costs were assessed by taking into account the apparent environmental damage caused by using a crow bar or metal rod. The methodology for assessment was adapted from a study by McManus and Reyes (1997), which looked at anchor damage to coral reefs.
- Step 5: The cost–benefit assessment was done by considering the revenue from destructive *te ororo* against the loss of revenue from non-destructive fishing practices, and change in revenue from tourism and coastal protection.

Assessing the impact of destructive fishing methods in Tarawa's lagoon is complicated because several studies show that lagoon productivity has been affected by increased population pressure, resulting in increased anthropogenic factors such as pollution due to sewage and other wastes, the construction of a causeway, and the mining of coastal beaches. Under such circumstances, any decline in reef and lagoon fisheries production is, therefore, compounded by non-fishery related factors in addition to the increased fishing pressure by different methods and intensity of fishing effort.

Given the structure of Tarawa's lagoon, which consists of several patch reefs and a shallow bottom dominated by reef fish species, the lagoon was considered as a total reef area for the purposes of determining the potential productivity of the lagoon and reef.

Assessing the impact of using destructive *te ororo*

The use of gill nets was found to be the most widespread fishing method in Tarawa, used by all fishers interviewed (in both North and South Tarawa). Fishers from North Tarawa, however, stated that they only occasionally use splash method *te ororo* while using gill nets, and no one indicated that they use encircling nets on reef patches in combination with iron bars, sticks or crow bars. Therefore, the use of destructive *te ororo* was considered to be largely practiced by fishers from South Tarawa. Fishers from South Tarawa did not out rightly admit using coral damaging *te ororo* but reported the widespread use by fishers "in their neighbourhood". Therefore, households from South Tarawa that fished using several gill nets during one fishing trip were assumed to be using coral damaging *te ororo* (in combination with crow bars and metal rods on reef patches).

Summary of results

Assessing the level of damage that *te ororo* may have on coral reefs is complicated because not there is not only an immediate impact but also an accumulated impact on habitat and species composition and, hence, productivity long after initial use. Therefore, the only major indicator of damage that could be assessed was the impact of crow bars and metal rods on coral heads to determine the amount of damage to the reef each year. This study estimates that approximately 3% of coral patches or reef area per square kilometer is damaged each year.

In conducting this economic assessment, both direct and indirect costs and benefits were considered. However, reef functions, such as social and cultural functions and biodiversity, cannot be easily monetised. The study, therefore, considered three uses of reefs: fisheries, coastal protection and tourism.

The methodology used by Pet-Soede et al. (1999) to analyse the impact of blast fishing on Indonesian coral reefs was adapted because the principles of analysis are similar even though the fishing methods used are different. The economic analysis is based on the difference between "with *te ororo*" and "without *te ororo*" scenarios. The without scenario included the commercial fishing practices of North Tarawa

$$NB_{k,t} = NR_{o,t} - (VN + \Delta VT_t + \Delta VC_t) \qquad \text{(equation 1)}$$

Where:

$NB_{k,t}$ = net quantifiable benefits to Kiribati in year t,

$NR_{o,t}$ = net revenue from *te ororo* fishing in year t,

VN = value (foregone revenues of non-destructive fishing in a situation without *te ororo* and at an exploitation level near maximum sustainable yield (constant over time),

ΔVT_t = loss in value of tourism for year t,

ΔVC_t = loss in value of coastal protection for year t (Pet-Soede et al. 1999:85).

The input values for the model parameters were derived from the present quality of Tarawa's coral reef. The losses with change in value of tourism and change in value of coastal protection represent the difference between the values in the "with" and "without" scenarios at time t. The analysis is based through time from when the reef was intact to when 75% of the reef was destroyed (McAllister 1998; Pet-Soede et al. 1999). The analysis is carried out for the total time period needed to destroy 75% of the coral and using a 10% discount rate per year. With a rate of coral destruction, the net present value (NPV) of the individual parameters to the general model was calculated by summation of the annual totals over 75/α year with a 10% discount rate per year using the formula:

$$NPV = \sum_{i=1}^{75/\alpha} \frac{\text{value}_i}{(1+\text{discount rate})^i} \qquad \text{(equation 2)}$$

α = area destroyed by the use of crow bars and iron rods per km^2 per year over an area covered with coral per km^2 of reef. In this instance α = 2.87% or 3%.

$$NR_{o,t} = GR_{o,t} - (C_{o,t} + C_{lt}) \qquad \text{(equation 3)}$$

The yield from *te ororo* fishing was assumed to decrease linearly with destruction of the coral reef. The annual net value of non-destructive fishing, VN, was derived by subtracting the operational costs (Cn) and opportunity costs (Cl) of labour from the total gross revenue for non-destructive fishing, GRn. The VN scenario remained constant through time.

$$VN = GR_n - (C_n + C_l) \qquad \text{(equation 4)}$$

This was derived by considering the operations of part-time and full-time fishers of North Tarawa who were using nets and hook and line but not practicing destructive *te ororo*. The cost structure of fishers from Taratai, Buariki and Nooto in North Tarawa was derived from interviews.

The annual net value of coral reefs for tourism VT_t depends on the level of coral destruction, and decreases linearly at a rate of α from the initial value VT_0, reaching zero when no corals remained (Pet-Soede et al. 1999:87).

$$VT_t = VT_0\,(1\text{-}t\alpha) \qquad \text{(equation 5)}$$

Tourism has been limited in Tarawa, although foreign and local visitors often visit the sandy beaches of Abatao, Biketawa and Naa islets of North Tarawa. The travel cost approach was used to value tourism-related activities of the lagoon. VT_t depends on the level of coral destruction, and decreases linearly with the rate from the initial value of VT_0, reaching zero when all corals are destroyed (Pet-Soede et al. 1999).

The study estimated the annual net returns from tourism to be AUD 4,500 at a 10% discount rate, which gave a tourism value at the end of year 1 of AUD 3,974. At the end of year 26 (assuming 75% of corals to be damaged), the tourism value declines linearly to AUD 96.00.

$$VT_t = VT_0\,(1\text{-}t\alpha)$$
$$\alpha = 2.87\%,\ t = 26 \text{ years},\ VT_0 = \text{AUD } 4{,}500$$

The annual value of a coral reef for coastal protection, VC_t, also depends on the level of coral destruction and decreases linearly with α from an initial value VC_0, reaching zero when no corals remain (Pet-Soede et al 1999:87).

$$VC_t = VC_0\,(1\text{-}t\alpha) \qquad \text{(equation 6)}$$

It is often costly to carry out studies to determine the precise total economic value of coral reefs. In light of this, Cesar (2000) states that it is possible to use a meta-analysis of studies carried out in other comparable areas. The study by McKenzie et al. (2005) for the Marshall Islands estimated the value of coastal protection to be USD 11,153.30 per meter.[1] For Tarawa Lagoon, the the reefs acting as a protective barrier against strong wave damage were estimated to be worth AUD 38,478,885. The value of coastal protection when 75% of the reefs are damaged in 26 years would be reduced to AUD 819,416. Therefore, the coastal protection afforded by the reefs is seen to decline in value by approximately AUD 33,157,439.

The net benefit of using destructive *te ororo* is, therefore, the net revenue from using destructive *te ororo* minus the foregone revenue from the use of non-destructive fishing methods and the change in the value of tourism and coastal protection.

$NB_{te\ ororo}$ = – AUD 1,879,806 – (AUD 41,297,516 + (–AUD 3,878) + (–AUD 33,157,439)) = – AUD 76,338,634

[1] USD 1.00 = AUD 1.01 (October 2011).

Therefore, the annual loss can be conservatively estimated to be about AUD 3 million from the use of destructive *te ororo*. In fact, the annual loss is likely to be much higher given the rapid growth in population, which places additional pressure on the resources. Other costs, such as options or bequest values and indirect benefits, have not been calculated. In comparison, given the government revenue of AUD 59.5 million (excluding grants) in 2007, this amounts to 5% of annual government revenue and equivalent to 3.5% of the gross domestic product.

Alternative livelihoods – substitution costs

Fishers were asked to consider the most likely alternative income source to support their livelihood in the event of loss of fishing opportunities. Responses of fishers from North Tarawa were slightly different from those from South Tarawa. The four options for fishers included working as a wage earner, agriculture, running one's own business, and seafaring.

If fisheries resources declined severely, fishers would be left with limited options and the costs of engaging in other alternatives would be high for them. For example, even if fishers turn to agriculture, there are costs associated with buying or leasing land, which is one of the scarcest resources in Kiribati. Wage employment options are limited in North Tarawa because of limited private sector activities. Fishers would have to move to South Tarawa, where the rate of unemployment is already high (ADB 2009).

Setting up a small business requires up-front capital, which many fishers do not have. In addition, too many small canteens selling similar goods results in lower incomes that are unlikely to meet the daily needs of fishers' families. The analysis underscores the importance of fisheries as a income source for fishers as opposed to other income earning options. This, therefore, demonstrates that the opportunity costs of loss of access to fishery resources would be very high for fishers who are currently relying on fisheries in and around Tarawa Lagoon. Costs associated with alternative livelihood choices must be considered as part of the economic cost of the loss of fishery income due to the use of destructive fishing practices.

Reducing fishing pressure

Controls on fishing effort and limits on catch in Tarawa will need to be imposed in order to achieve sustainability of resources. Direct and indirect strategies will need to be identified to relieve fishing pressure. A combination of policy instruments, ranging from seeking alternative livelihoods and incentive-driven measures to legislative reforms, are required. Some options include:

- Employment as seamen and crew on foreign vessels.
- Small-scale longline fishery for tuna and other pelagic fish around fish aggregation devices.
- Small-scale cottage industries that use solar energy to process tuna for local and export markets.
- Improvements in the post-harvest sector to raise the quality of fish, which can increase the value of fish sold and improve on the price.
- Cottage industries such as handicraft making, including fine mats and baskets.
- Seasonal employment in Australia and New Zealand under special arrangements.
- Nature-based tourism that capitalises on outer island locations near North Tarawa.
- Further strengthening of agricultural diversification under the Taiwan Government initiative.
- Place a higher priority on mariculture of giant clams, trochus and beche-de-mer by restocking reefs.
- Further research and feasibility studies on the deployment of artificial reefs or structures that can act as habitat for fish and areas of fish aggregation.

Fisheries management options

Community-based fishing rights in the Pacific remain a critical aspect of coastal fisheries policy. These rights are seen as more effective forms of coastal fisheries management than centrally controlled fisheries (Ruddle 1996; Johannes and Yeeting 1995; Aswani 1997), and the delegation of some management responsibilities to local people has proven to be more successful. This study also points out that community-based coastal fisheries management in Tarawa is an important option, particularly where community decision-making is still very much dependent on village elders and local councils.

In order to strengthen community-based fisheries management, a multi-pronged approach is necessary in Kiribati, and more so in Tarawa, where previously existing forms of traditional marine tenure systems have deteriorated due to centralized resource management by the government due to urbanization.

Besides the Phoenix Island Protected Area, Kiribati needs other conservation areas to effectively protect its marine biodiversity, nursery and spawning grounds, and other critical and vulnerable habitats.

An integral part of institutional reform, with respect to fisheries management and conservation in Kiribati, also includes parallel reforms with public awareness programmes through formal and informal means. The integration into school curriculum, use of media, campaigns and advocacy, involvement of youth, women, non-governmental organisations and church groups will be required to convince people why the steps taken are necessary and to gain support and legitimacy.

Conclusion

In order for fisheries in Tarawa's reef and lagoon areas to remain sustainable, there is a critical need for policy change and the modification of fishing methods and practices at the individual fisher level. Bringing about such reforms will require adequate consultations between and among the highest levels of government, and individuals and community groups to cooperatively formulate a fisheries management plan for Tarawa. With limited alternative income sources and huge opportunity costs, it is important that fisheries are managed at sustainable levels. The economic costs are relatively high for Kiribati, particularly in light of increasing population in South Tarawa.

The economic costs of destruction from *te ororo* fishing is estimated to be 5.0% of government revenue annually and approximately 3.5% of gross domestic product. The cumulative effects of this loss over time on the economy and people of Kiribati should be underscored for immediate action.

Having an appropriate and effective fisheries management regime will not only require an appropriate institutional framework but also action to reduce fishing effort. This will in turn require further definition of fishing rights and some criteria for their allocation.

The Government of Kiribati should have a clear vision and goal for its coastal fisheries, particularly in ensuring that the lagoon remains in a healthy state. The results of this study clearly demonstrate that the use of *te ororo* is destructive and should be banned, and that regulations on the gill net use should be strengthened.

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The benefits of fish aggregating devices in the Pacific

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Introduction

Fish aggregating devices (FADs) are widely used in Pacific Island countries and territories (PICTs) as a means to improve fisheries production in oceanic and, more recently, inshore fisheries. Traditional FADs have been used since the early 1900s, when Indonesian and Filipino fishermen used floating rafts of bamboo to aggregate schools of fish. Recent developments in and experimentation with modern FAD design, deployment site, and deployment depth has occurred throughout the Pacific as a means to improve yields of and access to artisanal fish stocks.

Significant government capital and human resources have been allocated to the fabrication, deployment and maintenance of FADs, and training of fishermen in FAD fishing techniques. Most importantly, however, significant effort has been dedicated to fishing around FADs as they are thought to provide an array of benefits to fishing communities, both at the commercial and subsistence level.

The assumed benefits of FADs have driven numerous deployment programmes in PICTs. Sims (1988), however, claims that FAD programmes are viewed by governments as short-term development initiatives. This view can be attributed to the lack of supporting data to quantify the economic benefits of FADs and, therefore, FAD programmes have difficulty in attracting long-term financial support.

Numerous studies identify the direct and indirect benefits of FADs; however, few have quantified the financial and economic benefits of FADs to fishing communities and PICT economies. Due to a rigorous data collection programme carried out by Niue's Department of Agriculture, Forestry and Fisheries, a cost–benefit study was completed to determine the financial and economic returns of FADs in Niue.

This paper identifies the benefits and costs of FADs and presents the results of the Niue cost–benefit study. Additionally, this paper presents the key fields for data collection to effectively monitor the effectiveness of FAD programmes.

The benefits of FADs

FADs provide direct and indirect benefits to fishing communities and PICT economies. Some of these benefits are easier to quantify than others, although it is important to recognise that FADs provide an array of benefits. Anderson and Gates (1996) define the benefits of FADs as follows.

Increased fishery production – Due to the aggregating phenomenon of FADs, they are known to increase catch per unit of effort (CPUE), which allows for increased access to protein or saleable product. Increased production plays an important role in food security at the subsistence level while allowing for increased revenue in the commercial sector. Detolle et al (1998) claim that catches at Reunion Island increased by 143% over a period of eight years subsequent to the deployment of FADs.

Reduced pressure on reef resources – Factors such as modern fishing gear and techniques, increasing population, exports, and tourism — to name a few — are placing pressure on inshore and coastal reef resources. In the Pacific, most species of tuna remain underexploited, and FADs provide a means to sustainably access this stock. Aggregating tuna stocks around FADs allow fishermen, who primarily derive their sustenance and income from inshore and coastal fisheries, to access oceanic resources, thereby reducing their reliance on reef and inshore resources.

Import substitution – Increased production reduces the demand and supply gap for protein, thereby reducing reliance on imports. Hotels and restaurants typically import fish, which can be substituted with FAD-caught fish due to increased and more consistent production.

Export creation – Increased production of high value artisanal species enables producers to target lucrative export markets, thereby increasing the opportunity for fishery commercialisation.

Sports fishing – FADs are known among the sports fishing community to increase the probability of catch. Anderson and Gates (1996) estimate that sports fishers spend USD 40,000 for every marlin caught in international game-fishing tournaments. Sports fishing-driven tourism has many flow-on economic benefits, such as government revenue from licensing, increased demand for the hospitality sector, improved sales of fishing gear, increased demand for alternative tourism activities, and an influx of foreign currency.

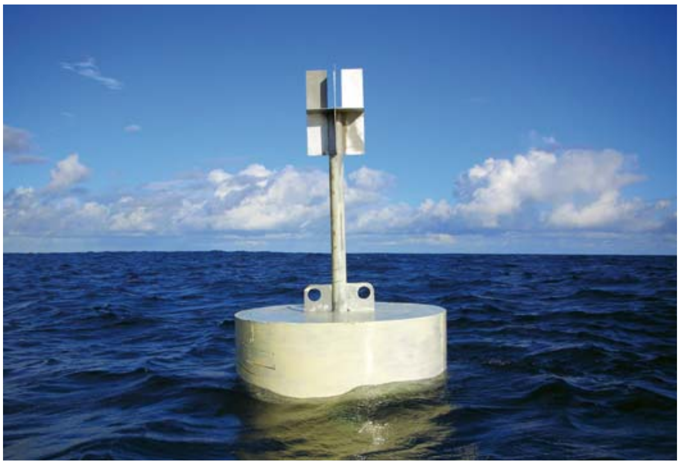
Commercial development – Increased catches resulting from FADs promote market channel development, thereby providing opportunities in the processing sector to add value to the tuna resource. This creates employment and provides economic returns from the tuna resource, which otherwise would only be realised through licensing revenue. A small and inconsistent supply from primary producers often hinders processing industries, and FADs provide a means to fill this supply gap.

Cottage industry development – Increased production provides an opportunity for cottage industry development, such as women's processing groups that produce tuna jerky and fish silage, as well as small catering businesses.

Increased employment – FADs create jobs in fisheries administrations, in terms of planning, fabrication, deployment, monitoring and maintenance of FADs. Additionally, the positive benefits to the primary fishing sector and the processing sector create employment.

Reduced fuel consumption – Defined fishing grounds around FADs theoretically reduce searching time for fish. Reduced searching time, generally leads to increased time spent fishing and reduced fuel consumption, resulting in reduced fishing costs, especially in the case of nearshore FADs. Detolle et al (1998) claim that fuel consumption is reduced three-fold when trolling near FADs compared with open water trolling at Reunion Island.

Safety at sea – Pacific fishing vessels, especially small-scale operators, often overlook basic sea safety practices and there are frequent cases of small vessels being lost at sea. FADs provide a defined fishing ground, which increases vessel activity and improves the probability of stranded vessels gaining assistance from another fishing vessel. This eliminates the need for costly search and rescue operations, which are usually funded by governments.



FADs, which can be moored several miles from the coast, provide a defined fishing ground where small fishing boats venturing offshore have a better chance to be found if in trouble.

FADs maintain fishing interest – Reduced catches from overexploited resources can result in fishers abandoning their profession for more lucrative opportunities. Abandonment of primary production has adverse effects for PICT economies, ranging from a decline in protein availability, increased dependence on imports, increased pressure on land resources to fill the protein gap, decline in cottage and commercial value-adding operations, decreased employment, and diminished export potential. Increased catches from FADs (or reduced effort required to maintain production quantities) allow fishers to remain in the industry.

This section has underscored the theoretical benefits of FADs. It is, however, recognised that FAD programmes can have undesirable impacts, and these are detailed below.

Adverse impacts of FAD programmes

Adverse impacts of FADs can usually be attributed to poor research, planning and preparation, which can result in the resources allocated to FAD programmes being wasted. Anderson and Gates (1996) define the adversity of FAD programmes as follows.

Market saturation – An oversupply of fish can result in a decline in the market price, which can reduce the profitability of commercial fishing operations. It can also discourage fishermen from fishing and motivate them to take up employment in another industry. Detolle et al (1998) claim that tuna prices fell from USD 6.50/kg to USD 4.50/kg over a 10-year period at Reunion Island subsequent to the deployment of FADs.

Introduction of species that are not in demand – Tuna are not traditionally a major species for subsistence use and domestic markets, and in many PICTs, demand for tuna is weak. Pelagic species, which are primarily caught around FADs, may have low demand and would, therefore, be low value.

Vandalism – The cutting of FAD mooring lines has occurred throughout the Pacific for unknown reasons. Some suggest that it is done to discourage new entrants to the industry, keep catches low as a means to sustain the fish resource, and obtain the floats, which are used for other purposes. Unfortunately, vandalism can take place before the desired results are achieved, which results in wasted programme funds.

Natural disasters – Cyclones and tsunamis can break FADs from their anchors. Fortunately, subsurface FADs are less susceptible to this and careful planning of FAD deployment time can ensure greater longevity of FADs. For example, deployment of a FAD after the cyclone season will ensure that the FAD will not be broken until the next season, which might give sufficient time for the positive benefits to be realised.

Overexploitation of a resource – This paper focuses on the benefits of FADs to domestic and subsistence fishers, however it must be noted that fishing techniques, such as purse-seine fishing around FADs, can result in biologically unsustainable yields.

Monitoring FAD programmes in PICTs

To measure the direct benefits of FAD programmes in PICTs, ongoing collection of fishery and socioeconomic data is required. It is acknowledged that countries are constrained by financial and human resources to collect and monitor FAD data; however, data are important for justifying ongoing investment in FAD programmes.

To fully realise the direct benefits of FADs, several types of data should be collected in order to effectively monitor FAD programmes.

Catch and effort data – It is unrealistic to collect catch and effort data for every fishing trip; however, a representative sample should be collected, which can be extrapolated to represent the total fishery. The following information should be frequently collected:

- fishing area or FAD number and/or name;
- fishing method;
- time spent practicing each method; and
- total number and weight of each species caught by the fishing method used.

SPC's Regional Artisanal Logbook is designed to collect the above data and it is recommended that fishers be encouraged and trained to complete a logsheet for every fishing trip. From these data, time series catch estimates can be calculated at different fishing areas under differing fishing methods. CPUE can be calculated from these data, which allows for the determination of change in CPUE at different fishing areas, including FADs.

Financial data – The collection of financial data enables the profitability of fishing vessels to be calculated for different fishing grounds. This allows for quantification of the benefits derived from different fishing grounds, including FADs. The following financial information should be collected:

- time of vessel departure and return (to account for labour);
- cost of fuel, bait, ice and other expendable items used during the fishing trip; and
- price received per kilogram for each species of fish.

These data allow for the estimation of the financial performance of the whole fishery and enables the analyst to determine the change in profitability to the sector from fishing different fishing grounds, including FADs. These data also allow for the determination of change in costs incurred, such as fuel, when fishing at different grounds.

The total value of the fishery to the economy can be calculated by combining financial data with catch and effort data. It can also be used to determine the net economic benefit of FADs when comparing benefits such as improved yield, with the costs of FAD programmes.

Market information – In addition to gathering financial data from fishers, it is important to complete surveys of various wholesale, retail, export, import, and informal (road side or other) markets. Generally, the information that should be collected includes price (sold), cost of goods sold (purchase price) and quantity.

These data enable the analyst to determine: where value is added throughout the marketing channel; what proportion of total catch is marketed and what is consumed; change in price over time; the correlation between FAD programmes and imports (import substitution); and the correlation between FAD programmes and exports.

FAD usage – An estimate of the number of commercial and subsistence fishers using FADs is required in order to determine whether the intended purpose of the FAD is met. For example, if a FAD was deployed to relieve pressure on reef resources and an increasing number of subsistence fishers are recorded to be fishing around FADs, then one can assume that the programme is effective. Conversely, if FADs are not seen to be used, then management must determine why: Are they ineffective in aggregating fish? Is there a need to raise community awareness? Is there a requirement to teach FAD fishing techniques?

FAD usage data also allow managers to make informed decisions when expanding their FAD programme, and to determine deployment site, education and awareness requirements, and the optimal number of FADs to be deployed.

Case study: Cost–benefit of FADs in Niue

Niuean fishermen have been filling out fishing logsheets since 2001, and the data have been collated and recorded by the Data Management Section of SPC's Oceanic Fisheries Programme up until 2008. These data were used to compute the cost–benefits of FADs.

Key data that were used to complete this assessment include:

- fuel consumption per trip;
- hours of each fishing activity per trip;
- fishing activity;
- location; and
- catch, both in terms of the number of fish per species and the weight per species.

Fishing effort

In total, 2,933 fishing trips and 12,140 hours of effort were recorded for the period 2001 to 2008. Figure 1 represents the total fishing trips (left axis), FAD fishing trips (left axis) and total effort (hours of fishing; right axis).

The number of fishing trips peaked in 2003 and declined in subsequent years. For the purpose of this case study, it was assumed that fishing trips per annum remained steady at the peak level in 2003 of 972 trips per annum. This assumption is justified for the following reasons.

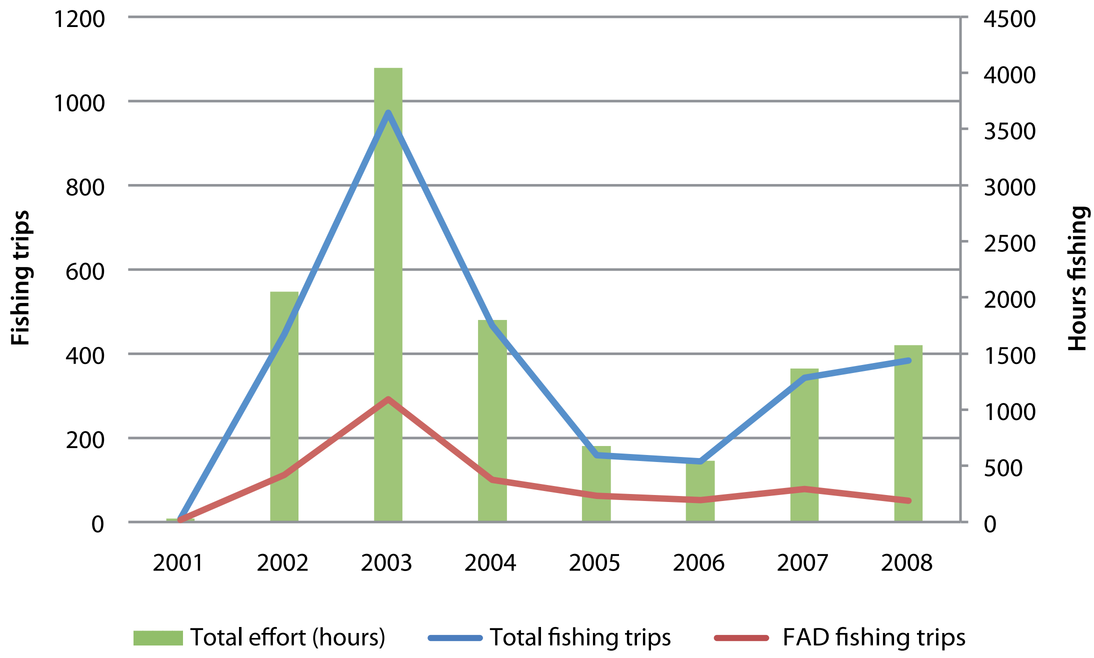


Figure 1. Total fishing trips, FAD fishing and effort (hours).

- Communication with Niue Department of Agriculture, Forestry and Fisheries revealed that similar numbers of boats are registered, with the same number of people on the local fishing license list. Niue Department of Agriculture, Forestry and Fisheries' interpretation of the decline in reported trips can be attributed to the slow distribution of logbooks.
- SPC (2005) states that catch data only represent between 20% and 40% of actual effort, so the assumption of continued effort at the 2003 level is deemed conservative.
- Commercial and subsistence fishing in Niue is entirely dedicated to supplying the domestic market. Therefore, the industry is not subject to shocks in global demands for fish, which might explain a dramatic decline in production. Given that fish is a main source of protein in Niue, it can be assumed that the domestic demand for fresh fish is fairly steady.

Fishing methods

In total, 12 fishing methods were recorded:

- open water trolling;
- offshore FAD trolling;
- inshore FAD trolling;
- bottom fishing;
- vertical longlining;
- drop stone;
- single hook drift line;
- scoop net (for flying fish);
- jigging;
- handlining; and
- palu-ahi.

Of these, the most commonly practiced fishing methods are open water trolling, offshore FAD trolling and inshore FAD trolling. Inshore FADs are classified as FADs located in depths of less than 600 m, while offshore FADs are classified as those located in depths of more than 600 m.

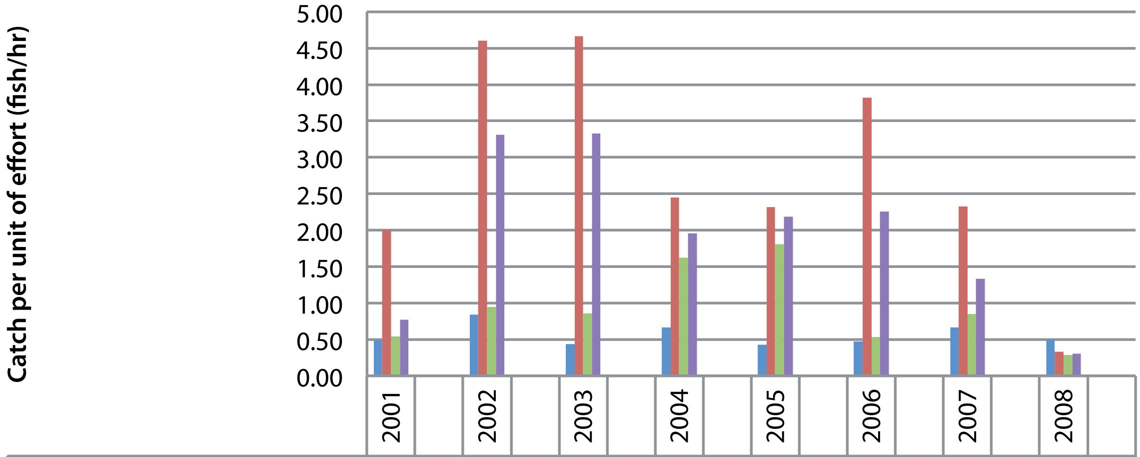
It is widely known that CPUE differs greatly by fishing method. Because of this, the cost–benefit study only compares CPUE of open water trolling and FAD trolling (inshore and offshore) to allow for a "like-for-like" comparison. This ensures consistency in CPUE comparison, although it understates the value of production around FADs because "other" fishing methods are omitted from the cost–benefit analysis.

Catch per unit of effort

For this study, a unit of effort is defined as one hour of fishing per vessel.

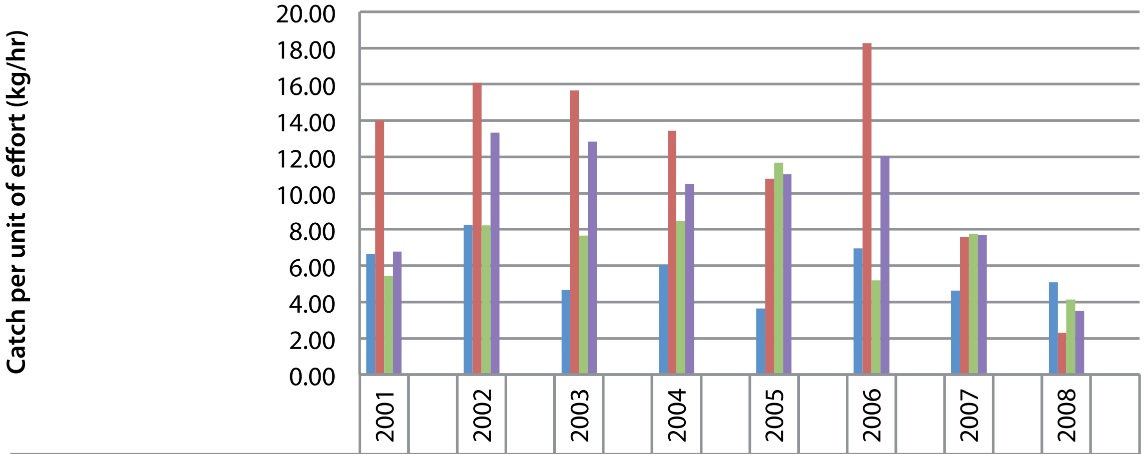
CPUE was calculated to account for the number of individual fish caught per unit of effort and weight of catch per unit of effort. CPUE data are presented as CPUE (fish/hr) and CPUE (kg/hr) for each respective calculation.

Figures 3 and 4 display CPUE in fish and weight respectfully for open water trolling, offshore FAD trolling and inshore FAD trolling. Additionally, a combined CPUE was formulated to present the combined CPUE of FAD trolling in comparison to open water trolling. "Combined CPUE" is simply an aggregation of catch and effort for offshore and inshore FADs, which makes it possible to compare the CPUE of "with FADs" and "without FADs". This gives a baseline comparison of the impact that FADs have on CPUE.



	2001	2002	2003	2004	2005	2006	2007	2008
Open water CPUE (fish/hr)	0.49	0.84	0.44	0.66	0.42	0.47	0.67	0.49
Offshore FAD CPUE (fish/hr)	2.00	4.60	4.67	2.45	2.31	3.82	2.32	0.33
Inshore FAD CPUE (fish/hr)	0.55	0.95	0.86	1.62	1.80	0.53	0.85	0.28
Combined FAD CPUE (fish/hr)	0.77	3.31	3.33	1.96	2.19	2.25	1.33	0.30

Figure 2. CPUE (fish/hr) comparison of different fishing methods, 2001–2008.



	2001	2002	2003	2004	2005	2006	2007	2008
Open water CPUE (kg/hr)	6.65	8.27	4.68	6.05	3.64	6.94	4.64	5.08
Offshore FAD CPUE (kg/hr)	14.0	16.1	15.6	13.4	10.8	18.2	7.58	2.29
Inshore FAD CPUE (kg/hr)	5.45	8.21	7.66	8.47	11.6	5.20	7.78	4.15
Combined FAD CPUE (kg/hr)	6.77	13.3	12.8	10.5	11.0	12.0	7.71	3.49

Figure 3. CPUE (kg/hr) comparison of different fishing methods, 2001–2008.

Figure 2 presents CPUE in terms of number of fish. CPUE (fish/hr) increases both when fishing offshore and when fishing inshore FADs for all years, with the exception of 2008. Offshore FADs have the greatest impact on CPUE (fish/hr), although it is clear that inshore FADs also improve CPUE (fish/hr).

Figure 3 presents CPUE in terms of catch weight. CPUE (kg/hr) increases when fishing at offshore FADs for all years, with the exception of 2008. Inshore FADs show increased CPUE (kg/hr) in 2003, 2004, 2005 and 2007. Although offshore FADs have the greatest impact on CPUE (kg/hr), it is clear that inshore FADs also improve CPUE (kg/hr).

Fish caught by artisanal gear in Niue are sold by weight (NZD/kg), and the financial and economic components of this cost–benefit study also value fish by weight. Therefore, for the remainder of this paper, catch is discussed in terms of weight (kg) and not in terms of pieces. It is, however, recognised (as displayed in Fig. 2) that CPUE (fish/hr) generally increases when fishing around FADs.

Table 1. Average CPUE (kg/hr) for trolling at different fishing grounds, 2001–2008.

	2001	2002	2003	2004	2005	2006	2007	2008	Average
Open water CPUE (kg/hr)	6.65	8.27	4.68	6.05	3.64	6.94	4.64	5.08	6.29
Offshore FAD CPUE (kg/hr)	14.00	16.10	15.65	13.45	10.81	18.27	7.58	2.29	17.83
Inshore FAD CPUE (kg/hr)	5.45	8.21	7.66	8.47	11.67	5.20	7.78	4.15	8.69
Combined FAD CPUE (kg/hr)	6.77	13.32	12.84	10.51	11.03	12.05	7.71	3.49	13.26

Table 1 presents CPUE (kg/hr) for open water, offshore and inshore FADs, and combined FAD trolling. The last column represents the average CPUE per hour of trolling for each of the different fishing areas for the whole period (i.e. 2001–2008). Interestingly, average CPUE (kg/hr) for offshore FAD trolling is approximately three times the average of open water trolling; while the average CPUE (kg/hr) for inshore FAD trolling is approximately one-third greater than the average for open water (non-FAD) trolling. Combined CPUE (kg/hr) for offshore and inshore FADs is double that for open water trolling.

These figures present the incremental increase in CPUE when fishing around FADs. The averages will be used to determine the increased value of production as a result of FADs at 2003 effort levels, and to compute the cost–benefit of FADs.

Fuel consumption

The data presented in Table 2 show that fuel consumption per hour of fishing is approximately 0.5 litres less when fishing around FADs than when open water trolling. Although this figure sounds trivial, when multiplied by the total effort of open water trolling in 2003, this equates to a fuel savings of 979 litres per annum. That is, if fishermen allocated their entire effort of open water trolling to FAD trolling, fuel consumption would be reduced by 979 litres per annum.

Financial analysis

This section determines the net financial gain per annum as a result of the increased CPUE and reduced fuel consumption when fishing around FADs. All prices are in New Zealand dollars (NZD).[1]

The major assumptions adopted for this financial assessment include:

- Annual effort is assumed to remain steady at 2003 levels;
- Average fuel consumption for the period 2001–2008 is applied;
- Average CPUE for the period 2001–2008 is applied;
- Average cost of fuel and 2-stroke oil mix is NZD 2.05 per litre;[2] and
- A price of NZD 7.50 per kilogram is assumed.[3]

To understand the net financial gain from FADs, we adopt a "with FAD and without FAD" scenario, incorporating the above assumptions. First we will determine the effect on production; second we will determine the effect on cost; and finally, we will determine the net combined financial gain from FADs.

Table 2. Litres of fuel consumed per unit of effort (L/hr) at different fishing grounds, 2001–2008.

	2001	2002	2003	2004	2005	2006	2007	2008	Average
Open water trolling (L/hr)	7.35	4.89	6.64	5.81	5.50	5.75	6.19	5.65	5.92
Offshore FAD trolling (L/hr)	8.00	4.54	5.84	4.99	5.23	5.85	7.46	6.92	5.53
Inshore FAD trolling (L/hr)	5.45	4.25	5.31	4.73	5.69	5.28	5.88	6.60	5.26
Combined FAD average (L/hr)	5.85	4.44	5.65	4.84	5.35	5.58	6.39	6.71	5.41

1 NZD 1.00 = AUD 0.78 = USD 0.79 (October 2011)
2 Cost of fuel is calculated at NZD 1.70 per litre of petrol and NZD 0.35 per litre of oil mix.
3 A consultation with Niue Department of Agriculture, Forestry and Fisheries revealed that 2009–2011 prices for wahoo, tuna, mahi mahi and other pelagic species ranges from NZD 8–9 per kilogram. In times when there is an oversupply, prices fall to NZD 6–8 per kilogram. Therefore, a mid-point of NZD 7.50 has been adopted for this study.

Table 3. Annual catch (kg) and revenue (in NZD) with and without FADs.

	CPUE kg/hr	Effort hrs	Catch kg	Price NZD	Revenue NZD
With FADs					
Offshore FAD trolling	17.83	733	13,069	7.50	98,020.42
Inshore FAD trolling	8.69	399	3,463	7.50	25,972.89
TOTAL		1,132	16,532		123,993.31
Without FADs					
Offshore trolling	6.29	733	4,611	7.50	34,579.28
Inshore trolling	6.29	399	2,507	7.50	18,799.71
TOTAL		1,132	7,117		53,378.98
Net gain from offshore FADs			8,459		63,441.15
Net gain from inshore FADs			956		7,173.18
TOTAL NET GAIN			**9,415**		**70,614.33**

Changes in annual production from fishing FADs

Table 3 presents the with FAD catch scenario of trolling around FADs and the without scenario with open water trolling. This calculation accounts for the change in average CPUE as a result of trolling around FADs in comparison to open water trolling, while holding effort levels steady.

Assuming that fishing effort remains steady at the 2003 level, a net annual increase in total catch (9,415 kg) and total revenue (NZD 70,614) is achieved as a result of increased average CPUE from fishing around FADs. Of this total increase, NZD 63,441 is attributed to offshore FADs.

Changes in annual cost of fuel from fishing around FADs

Table 4 presents the cost scenario for fishing with FADs and without FADs. This calculation accounts for changes in fuel consumption per unit of effort as a result of fishing around FADs, or more generally, changes in cost of fishing per hour. Table 4 uses 2003 data for total effort.

Table 4 shows that a net gain (cost saving in fuel) of NZD 1,125 is achieved per annum by fishing around FADs at 2003 effort levels.

Total annual financial gain from FADs

Tables 3 and 4 present the net production gain and the net cost (fuel) saving, respectively.

By combining the net production gain with the fuel cost saving, we derive a net financial gain of NZD 64,027 from offshore FADs and NZD 7,712 from inshore FADs. This results in a total combined gain of NZD 71,739 per annum from FADs in Niue.

Table 4. Annual cost of fuel with and without FADs.

	Fuel consumption L/hr	Total effort (2003) hrs	Total fuel consumption L	Cost per litre NZD	Total cost NZD
With FADs					
Offshore FAD trolling	5.53	733	4,053	2.05	8,309.65
Inshore FAD trolling	5.26	399	2,096	2.05	4,297.13
TOTAL		1,132	6,150		12,606.79
Without FADs					
Offshore trolling	5.92	733	4,339	2.05	8,895.69
Inshore trolling	5.92	399	2,359	2.05	4,836.32
TOTAL		1,132	6,699		13,732.01
Cost saving from offshore FADs					586.03
Cost saving from inshore FADs					539.18
NET COST SAVING FROM FADs					**1,125.22**

Economic analysis

SPC (2005) has calculated the investment expense for fabricating and deploying inshore and offshore FADs in Niue and their ongoing maintenance expense as follows: NZD 4,767 for fabrication and deployment of offshore FADs, NZD 3,405 for inshore FADs, and NZD 700 for their annual maintenance. This section determines whether a positive economic return is achieved when comparing the total gains from FADs with the government investment required to fabricate, deploy and maintain FADs.

It is assumed that FADs need to be replaced every two years and that maintenance of FADs occurs once every two years. This assumption is conservative as experience has shown that FAD longevity in Niue is four to eight years, as stated by the Niue Department of Fisheries.

Table 5 provides a breakdown of the returns (cash inflow) and investments (cash outflow) of FAD programmes.

The Niue FAD programme is financially and economically profitable, at a 5% discount rate (Table 5). The critical point for determining when an investment is economically viable is where the net present value (NPV) equals zero. That is, when NPV is greater than 0, the investment is considered to be economically profitable; if it is less than zero, then the investment is not economically sound at a 5% discount rate.

Table 5. Cashflow and net present value of FADs in Niue.

	Year 1	Year 2
Financial gain (cash inflow)	NZD	NZD
Offshore FAD	64,027	64,027
Inshore FAD	7,712	7,712
TOTAL GAIN	**71,740**	**71,740**
Cost of FAD (cash outflow)		
5 x offshore FADs	23,839	
3 x inshore FADs	10,215	
TOTAL INVESTMENT	34,054	
Maintenance of FADs (cash outflow)		
5 x Offshore FADs		3,706
3 x Inshore FADs		1,969
TOTAL MAINTENANCE		5,675
Cash flow		
Offshore FAD	40,188	60,321
Inshore FAD	-2,503	5,743
NET CASH FLOW	37,686	66,065
Cumulative cash flow	37,686	103,750
Net present value or NPV (5% discount rate)		
Offshore FADs NPV	92,987.55	
Inshore FADs NPV	2,825.94	
TOTAL NPV	95,813.49	

In this situation, government investment of NZD 39,729 provided an economic return of NZD 95,813 over a two-year period. At the point where NPV equals zero, financial returns from FADs justify a government investment of NZD 134,658 over a two-year period.

Results of the financial and economic analysis

The results of this study are positive, although they are considered to be a conservative estimate of the total financial and economic gains from FAD programmes in Niue. Data are not available to determine the full financial and economic benefits associated with FAD programmes; however, the author estimates that these results could be doubled to represent a more realistic figure of benefits. The reasons for this being:

- logsheets that are submitted do not represent the entire fishing effort per annum, even in 2003 when the submission of logsheets peaked;
- trolling was the only fishing method considered in this study, although trolling only represents 87% of catch (kg);
- the benefits of FAD-driven demand for sports fishing tourism was not considered or quantified in this study; and
- other cost savings were omitted, such as the reduced cost of search and rescue for troubled fishing vessels.

The results of this study are that inshore and offshore FADs increase total catch per annum by a value of NZD 70,614 and reduce fuel costs by NZD 1,125, creating a net annual financial gain for the Niuean fishing industry of NZD 71,739.

In terms of the economics of government investment in FAD programmes, a positive NPV is indicative that ongoing investment in FAD programmes should be supported.

Policy implications and conclusion

This paper presents the theoretical benefits of FADs, of which some are supported by the Niue cost–benefit study. From the results, conclusions can be made about the total benefit of FADs and the government investment policy that should be adopted for future deployment, maintenance, monitoring and replacement of FADs.

The case study is indicative that FADs provide benefit in the form of increased catch rates and reduced fuel consumption. Sims (1988) estimates that the average economic return of FADs to Cook Islanders is NZD 0.91 per line per hour (one hook) or a total benefit of NZD 37,000 per annum.

Given the positive financial returns, FADs provide a positive economic return (on investment) over a two-year period.

Policy implications

It is recommended that PICTs adopt the following recommendations.

- The private fishing sector is encouraged to fabricate, deploy and maintain FADs.
- Government should continue to invest in FAD replacement, fabrication, deployment and maintenance. However, assuming diminishing returns to scale, governments should not adopt a policy to deploy more FADs than are needed. That is, policy should be adopted to replace all FADs that are lost, and continued support should be given to the deployment of new FADs up until a point where diminishing returns to scale are identified.
- There should be continued promotion and support for data collection as defined in this paper.
- Fishermen should be trained in FAD fabrication and deployment, and in FAD fishing techniques.
- The benefits of FADs to the private sector should be promoted.

FAD maintenance may require diving operations. Their cost must be accounted for. Image: Richard Story.

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