Fisheries Newsletter

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In this issue

Editorial

The table of contents for this issue reveals a theme that is very common to fisheries: a mix of hope and worry. Most articles fall into the hope category, and are related to development, with titles including words such as "new", "improved", "successful", "creating", "promising" and "project". But other article titles make use of words such as "burning", "yellow card", "microplastics" and "hot issues", a reminder that fisheries stories are not all good news.

These articles reflect a challenge that government bodies and agencies involved in fisheries constantly face: finding the right balance between development and management efforts.

In the Pacific Islands region, all of the major fisheries have already been developed, several of them "overdeveloped". There is scope for the limited development of a few minor fisheries (e.g. aquarium fish, coastal pelagic fish and giant squid), and aquaculture certainly has potential. But, these will not produce enough to replace coastal fisheries if these are not properly managed. In other words, if the main focus is not on management, these development efforts may be little more useful than a band-aid on a wooden leg.

In his article on page 53, Robert Gillett writes: "In fisheries management, the hardest task is often the placing of controls on fishers to prevent resource degradation". He notes that alternative development schemes are often used as ways to avoid necessary restrictive management. Interestingly, he names it "management distractions" and cites it as one of the hot issues in Pacific Island coastal fisheries.

Development or management, development and management... Pacific Island fisheries require that development become no more than a fully integrated part of management.

Aymeric Desurmont

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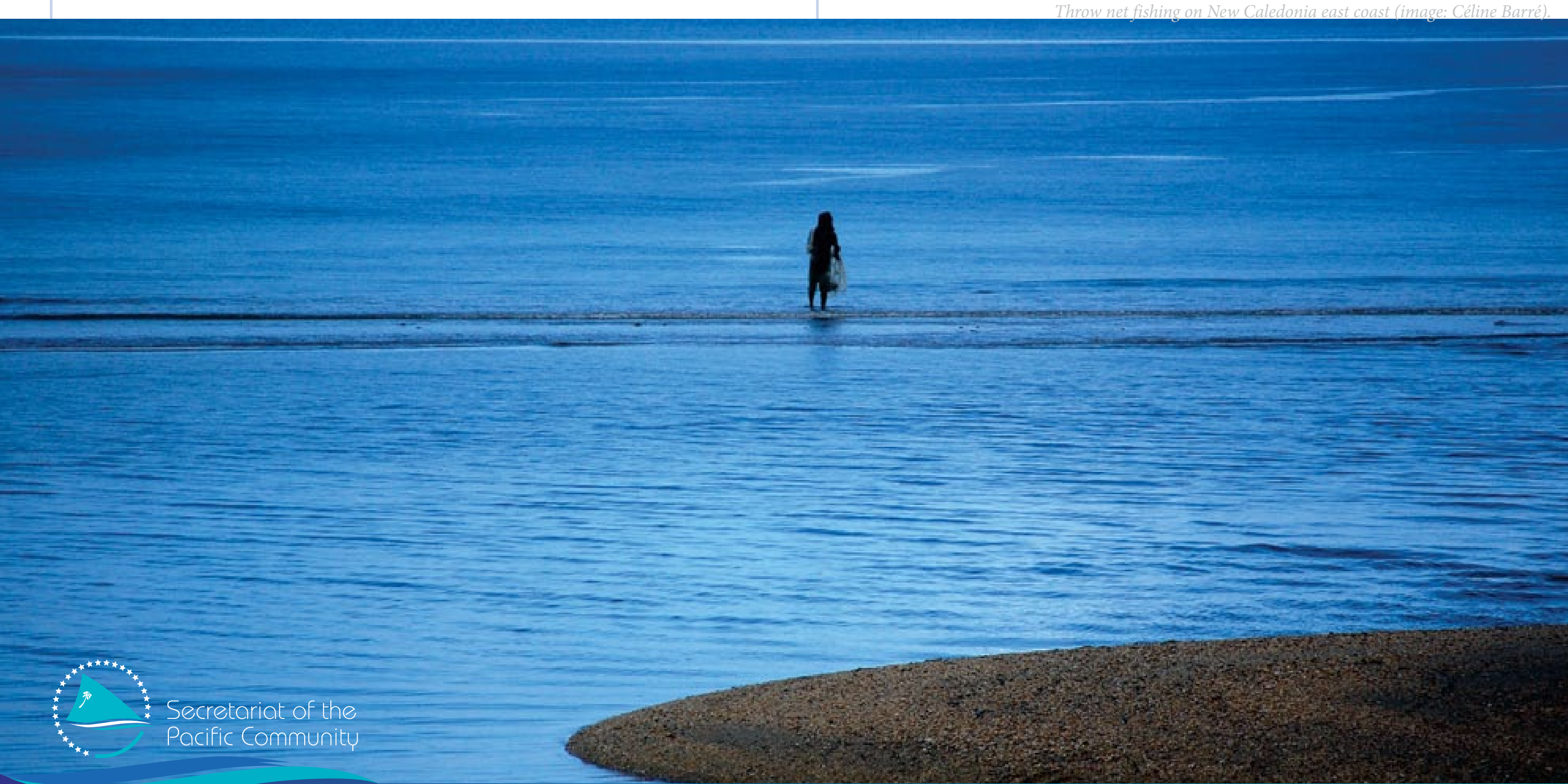

Throw net fishing on New Caledonia east coast (image: Céline Barré).

Secretariat of the Pacific Community

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

Integration of fisheries and protected areas management for Palau's northern reefs

Despite notable gains to establish protected areas and promote conservation in Palau, strategies to address declining fisheries in the northern reefs are limited. At the same time, fishing pressure has increased as fishery resources across Palau have diminished. Improved access and better fishing technology — as well as changes from traditional subsistence fishing to commercial fishing — has led to a decline in fishery resources. Other factors contributing to increased fishing pressure include: 1) economic development and an increase in tourism; 2) high per capita fish consumption compared with other regions in the Pacific; 3) high demand for reef fish at cultural and traditional functions, family events and local food markets; 4) access to advanced fishing gear and increased harvesting potential; and 5) the low prices for fish, and market dynamics. Currently, marine protected areas (MPAs) are one of the few fishery management tools available in Palau, and there are issues with enforcement and potentially with the spatial design of MPAs to support fisheries goals. In addition, there is a lack of scientific data to support fisheries management, a lack of participation by fishermen in management, and a very open access fishery with few regulations governing commercial and subsistence fishing.

There is a growing awareness on the part of fisheries officers that protected areas alone are insufficient to address fishery concerns, and that there are limited data to assess stocks, guide fishery management measures, or develop spatial plans to support the rebuilding of fish stocks. A recent data-poor assessment conducted by Dr Jeremy Prince (Murdoch University, Australia) estimates that 60% of fish captured are immature; an estimation reinforced by fishermen's views that fish sizes have decreased.

Palau's states of Kayangel and Ngarchelong have had a long history of working to care for their marine resources. Despite significant efforts to protect biodiversity and marine resources, including the establishment of MPAs, many marine resources and fisheries that are of importance to local communities are exhibiting downward trends in abundance and productivity.

Through consultations and leadership summits, communities in Kayangel and Ngarchelong states have expressed a desire to establish stronger cooperation with regard to the management of fisheries and protected area management under Palau's protected areas network (PAN). With enhanced fisheries capacity, improved understanding of fish stock status, implementation of spatial and non-spatial management measures, community involvement, and better enforcement, it is anticipated that populations of some fish species could be rebuilt within a few years.

Palau's northern reefs, which are north of Babeldaob Peninsula, extend out to Velasco Reef, a 20-mile submerged reef system at the northern tip of the Palauan archipelago. The relatively untapped marine resources in this area — from the low water mark out to 12 nautical miles (nm) — are under the ownership and management of Ngarchelong and Kayangel states.

Ngarchelong State is home to some of Palau's most abundant and productive fishing grounds and marine environments. As part of the northern lagoon, the Ngarchelong Marine Managed Area includes 197 km^2 of reef, channels, lagoon, mangrove, and open ocean out to 12 nm. The Ebiil Conservation Area was established in 2003 to protect Ebiil Channel and surrounding reefs.

Kayangel is the northernmost state in Palau and one of only two sandy atolls in the country. It is approximately 40 km north of Babeldaob. The PAN includes the 12 nm of nearshore waters of Kayangel (1,685 km^2), Ngkesol barrier reef (163 km^2), Ngeruangel Marine Reserve (34 km^2), Ngeriungs Globally Important Bird Area (0.34 km^2), as well as two forest preserves (Chermall Sacred Natural Site and Ngerusebek Sacred Natural Site). The network includes important coral reef habitats (barrier and patch reefs), seagrass beds, turtle nesting beaches, atoll forests, fish spawning and aggregation sites, and breeding areas for seabirds.

Reversing declines in fisheries and other marine resources in Ngarchelong and Kayangel states has been identified by local communities as a key management challenge and a priority.

A partnership involving the Ngarchelong and Kayangel states, The Nature Conservancy, the Palau Bureau of Marine Resources, the Palau Conservation Society, and the Palau International Coral Reef Center has been established to implement a three-year project focused on implementing new fisheries management approaches that are cost-effective, involve local resource users, and can be clearly integrated into PAN management. Some key areas of strategic engagement will be:

- ✓ building capacity for community-based fisheries co-management;

- ✓ implementing data-poor stock assessments linked to management measures;
- ✓ integrating spatial and non-spatial fisheries management with protected areas management;
- ✓ strengthening enforcement and compliance; and
- ✓ demonstrating economic benefits from improved fisheries and alternative livelihoods.

The vision for the fisheries management project in Palau's northern reefs is to achieve sustainably managed and profitable coastal fisheries where fisheries and no-take reserves are integrated into the management of Palau's PAN, and where fishermen play an integral part in the co-management of fisheries. As a result, local citizens and tourists will have reliable access to abundant fresh seafood. Over time, the network of no-take reserves and improved fisheries management will continue to provide spillover benefits to enhance fishing, marine biodiversity, and the resilience of marine ecosystems and the communities who depend on them, in the face of climate change.

SPC's Fisheries, Aquaculture and Marine Ecosystem Division was requested to provide technical assistance on rearing giant clams (for domestic and export markets) as a possible alternative income-generating activity for isolated coastal communities in Ngarchelong and Kayangel, and to suggest fishing alternatives for local communities in these two states.

In September 2013, SPC's Aquaculture Section assessed the primary needs and expectations of northern coastal communities with regard to giant clam farming, and identified suitable farming strategies and sites for a giant clam nursery and grow-out station. In April 2014, SPC trained farmers in Ngarchelong and Kayangel on improved farming strategies (e.g. improved floating and submerged systems, and measures to control predators and diseases). As a result of these two missions, around 30 northern families have initiated clam farming activities. It is too early to provide conclusive data on survival and growth rates, but farmers are working hard and clams are growing well.

On the fisheries diversification side, SPC recently conducted a two-week training workshop in Ngarchelong on fishing methods that are not commonly used in Palau. SPC brought John Uriao, a fisherman from Rarotonga, Cook Islands, to show local fishers from Ngarchelong and Kayangel how to catch flying fish, locally known as *kok*. Cruising outside the reef at night, trainees using a high-powered spotlight mounted on a helmet, and scooped up flying fish swimming near the surface with a net mounted on a three-meter-long handle.

The training workshop included sessions on constructing the necessary equipment and nightly fishing trips. Two two-hour-long fishing trips yielded an average of 80 fish. The flying fish were grilled over the fire, fried, and even eaten raw. With a mild flavour tasting slightly like gold spot herring (*Herklotsichthys quadrimaculatus*; *mekebud*), flying fish are sure to become a sought-after food fish. Flying fish are also good bait for larger pelagic fish such as Spanish mackerel (*Scomberomorus commerson; ngelngal*), barracuda (*Sphyraena* spp.; *ai*), and dogtooth tuna (*Gymnosarda unicolor; kerngab*). Fishers from Kayangel and Ngarchelong are excited about this new fishery, and Palauans will certainly start looking for flying fish at upcoming night markets. Other prospective markets also exist, such as the Palau Sport Fishing Association (bait for big game fishing charters) and the

Some of the fishermen involved in the flying fish fishing experiments. They hold the two scoop nets constructed during the training. The third gentleman from the left wears the "pink helmet" fitted with a powerful LED-projector that quickly became very popular among fishermen (image: Michel Blanc) numerous Japanese restaurants in Koror. Those markets will be further assessed while Palau's Bureau of Marine Resources and The Nature Conservancy will ensure that data from ongoing exploratory fishing for *kok* are collected in order to better understand the resource (species, size, spawning time, seasonality) and the economics of this newly introduced fishing technique.

SPC also brought in Carl McNeal, a fly fishing expert from New Zealand to scout for areas in the northern reef area and to assess the potential for fly fishing ventures in that area. Ngarchelong fishers took Carl and SPC Fisheries Development Adviser Michel Blanc to look for potential sportfish along inner reefs, sand flats and mangrove fringes. Saltwater sportfish include species such as bonefish (*Albula* spp., *suld*), milkfish (*Chanos Chanos*; mesekelat), trevally (Carangidae; *erobk, oruidel*), snappers (Lutjanidae), emperors (Lethrinidae) and groupers (Serranidae). Fly fishing is a popular sport in other places in the world and successful community-based operations already exist in the Pacific. Fly fishing is sustainable ("catch and release") and if managed properly, has the potential to bring in considerable economic benefits to local people. Bad weather prevented extensive surveys, and so other productive areas such as fish aggregation devices, outer reef slopes, and Kayangel Atoll will have to be assessed by local partners. If enough target species or productive fishing areas are found, SPC will train prospective guides on fly fishing and cast fishing, maintaining gear and tackle, tying flies, and the art and skills behind guiding.

It is believed that the development of alternative and non-extractive fishing methods will assist in allowing populations of reef fish to recover from the current heavy fishing pressure. Coupled with increased management and enforcement, fisheries diversification and aquaculture will contribute towards the ultimate goal of the northern reef project, which is the recovery of coastal fish stocks in Ngarchelong and Kayangel states.

Sashimi dishes of flying fish were trialled at local restaurants in Palau (image: Michel Blanc).

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Saiky Shiro (left) and Carl McNeal searching for "fighters" on the reefs flats (image: Michel Blanc).

New assessments for WCPFC to ponder

The 10th meeting of the Western and Central Pacific Fisheries Commission (WCPFC) Scientific Committee (SC10), was held in Majuro, Marshall Islands, in early August. The meeting considered new information on the regional tuna fishery, the catch of which in 2013 reached approximately 2.6 million tonnes, the second highest ever (Fig. 1), with a landed value of USD 6.2 billion.

A key contribution to the meeting was the presentation by SPC's Oceanic Fisheries Programme (OFP) of new assessments on the status of key regional tuna stocks, including skipjack, yellowfin and bigeye. The assessments show that skipjack and yellowfin tunas remain in a reasonably healthy state, but bigeye tuna, the mainstay of the tropical longline fishery, has now been reduced to less than 20% of its unfished stock size — the size at which the stock would be if fishing had never taken place. The assessments were a major analytical challenge, incorporating over 60 years of fisheries and biological data for an area spanning from Japan to Hawaii in the north, and Tasmania to French Polynesia in the south. Stock assessment scientists at OFP had 40 computers running night and day for three months in order to complete the work.

The reduction of bigeye spawning biomass to below 20% of unfished levels is significant because this is the limit that the WCPFC has decided represents an unacceptable risk to the stock. The WCPFC should now take firm action to reduce catches of bigeye and allow the stock to rebuild. While bigeye tuna is only 6% of the total regional tuna catch, it represents about 12% of the value of the catch. It is an important species for several Pacific Island countries that have longline fisheries in their waters.

For the other tuna species — skipjack and yellowfin — the assessments were considerably brighter. Skipjack, which accounted for 68% of the total tuna catch of 2.6 million tonnes in 2013, is estimated to remain at around 50% of unexploited levels, which is a desirable situation for the stock and the purse-seine fishery, and reflects the management targets that have been discussed by WCPFC. Yellowfin, which made up 21% of the tuna catch in 2013, has been reduced to about 38% of unexploited levels, still a reasonably comfortable situation for the stock. However, catches for both species are likely at their full potential. With more large purse-seine vessels coming into the fishery, even these fairly healthy stocks may fall to levels that could impact their biological health and the profitability of the fishery unless agreed on limits are adhered to.

In response to the assessments, SC10 made the following key recommendations:

- ✓ Fishing mortality for bigeye tuna should be reduced by 36% from the average levels for 2008–2011, which would return the fishing mortality rate to a level consistent with taking the maximum sustainable yield (MSY);
- ✓ The yellowfin tuna catch should not be increased beyond the 2012 level, and measures should be implemented to maintain current spawning biomass levels until WCPFC can agree on an appropriate target reference point.
- ✓ WCPFC should take action to avoid further increases in fishing mortality for skipjack in order to keep the stock at around current levels, and a target reference point and harvest control rules should be adopted.

In addition, SC10 expressed concern regarding the ongoing unavailability of operational-level logsheet data for key longline fleets fishing in the region, and recommended that all such data, including those for high seas areas, should be made available for future assessments. SPC will be working with the fishing nations concerned to (hopefully) achieve this for assessments of South Pacific albacore and Pacific-wide bigeye tuna, which will be undertaken in 2015.

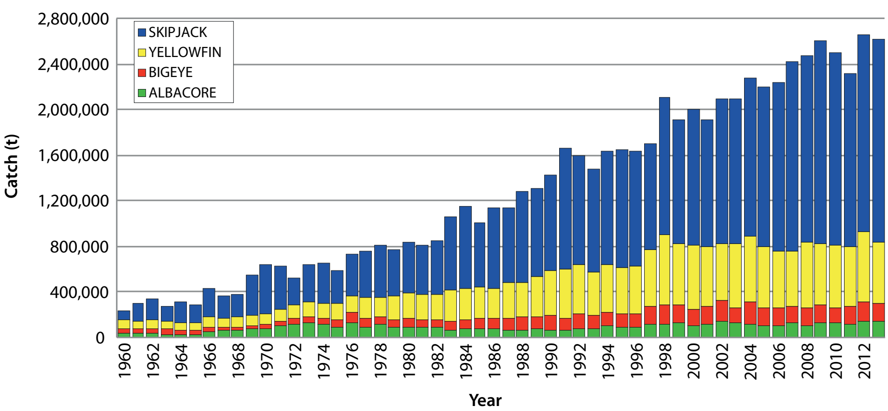

Figure 1. Catch of skipjack, yellowfin, bigeye and albacore tunas in the Western and Central Pacific Fisheries Commission Statistical Area.

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Tuna tissue bank for ecosystem management in the Pacific

What is the tuna tissue bank (TTB)?

Since 2001, SPC's Oceanic Fisheries Programme (OFP) has been coordinating the collection of biological samples of pelagic species from all over the Pacific Islands region on behalf of its member countries. Initially, this collection was focussed on stomach, muscle and liver samples to understand the trophic structure of the pelagic ecosystem (i.e. who eats who, where, and when); however, this has expanded to include gonads (reproductive organs), otoliths (ear bones), spines and blood, giving the opportunity to study reproduction, age, growth and contaminant concentrations. The collection is ongoing thanks to the partnership with the fisheries observer programmes operating in the western and central Pacific Ocean (WCPO).

A group of experienced senior "at sea" observers and port samplers participate by collecting samples from each trip or unloading they participate in. Rather than collect numerous samples from a single trip or unloading, they collect samples from a small number of individuals from each sampling session. This ensures that the sampling activity does not take too much time and that many more fishing trips and vessel unloadings are sampled to achieve OFP's collection targets.

OFP aims to have approximately 2,000 fish sampled for each species in order to allow Pacific-wide studies to be undertaken. The ongoing status of the collection means that as some samples are withdrawn from the collection for scientific analyses others are deposited to maintain the collection for future analyses. The collection is also supplemented by scientific surveys that are undertaken by SPC and other organisations.

Presently, sampling activities are coordinated in the Philippines, Palau, Papua New Guinea, Solomon Islands, Federated States of Micronesia, New Caledonia, Vanuatu, Fiji, Marshall Islands, Kiribati, Samoa French Polynesia and Japan.

How the collection is used

The application of ecosystem-based management in the WCPO means that decisions are made by balancing positive and negative impacts of proposed actions on the ecosystem. To assist decision-makers with this balancing, the tuna tissue bank (TTB) has been used to analyse the trophic structure of the western Pacific in order to construct ecosystem models to explore the effects of fishing and environmental variations.[1]

Assessing the status of tuna stocks is also reliant on the estimation of the species' biology. The TTB has recently been used to estimate the length-at-age relationship and reproductive biology of the albacore stock in the South Pacific.[2] This was the first stock-wide analysis of these parameters for a tuna stock in the WCPO. Similar analyses are underway for bigeye tuna in the WCPO.[3]

The French Institute for Research and Development is currently implementing a study to determine the origins of mercury and its accumulation and distribution in top predators, and is withdrawing muscle and blood samples from the TTB. Mercury levels are used to track tuna foraging habitats and tuna migration as well as revealing possible public health problems.

An important area that the TTB will contribute to is the emerging application of fisheries forensics to assist with the validation of catch documentation, traceability and surveillance for illegal, unreported and unregulated fishing activities. Genetics, genomics, chemistry and forensics are becoming well-established tools for this purpose. They are also increasingly valuable tools for indirectly monitoring movement, stock structure and reproductive dynamics. Recent withdrawals from the TTB have been used to examine movements and spawning locations in South Pacific albacore using elemental and isotope chemistry.[4] Withdrawals have also recently been made to understand the genetic structure of albacore, skipjack, bigeye and yellowfin tunas in the western Pacific.[5]

1 Examples of these models can be sourced from the following links:
http://www.wcpfc.int/node/3230
http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0036701
http://cdn.spc.int/climate-change/fisheries/assessment/chapters/4-Chapter4.pdf

2 http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0039318
http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0060577
http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0083017

3 http://www.wcpfc.int/node/19010

4 http://www.sciencedirect.com/science/article/pii/S0967064514000472
http://www.sciencedirect.com/science/article/pii/S0967064513004499
http://www.sciencedirect.com/science/article/pii/S0165783613001859

5 http://www.int-res.com/articles/meps_oa/m471p183.pdf
http://aciar.gov.au/project/fis/2009/059

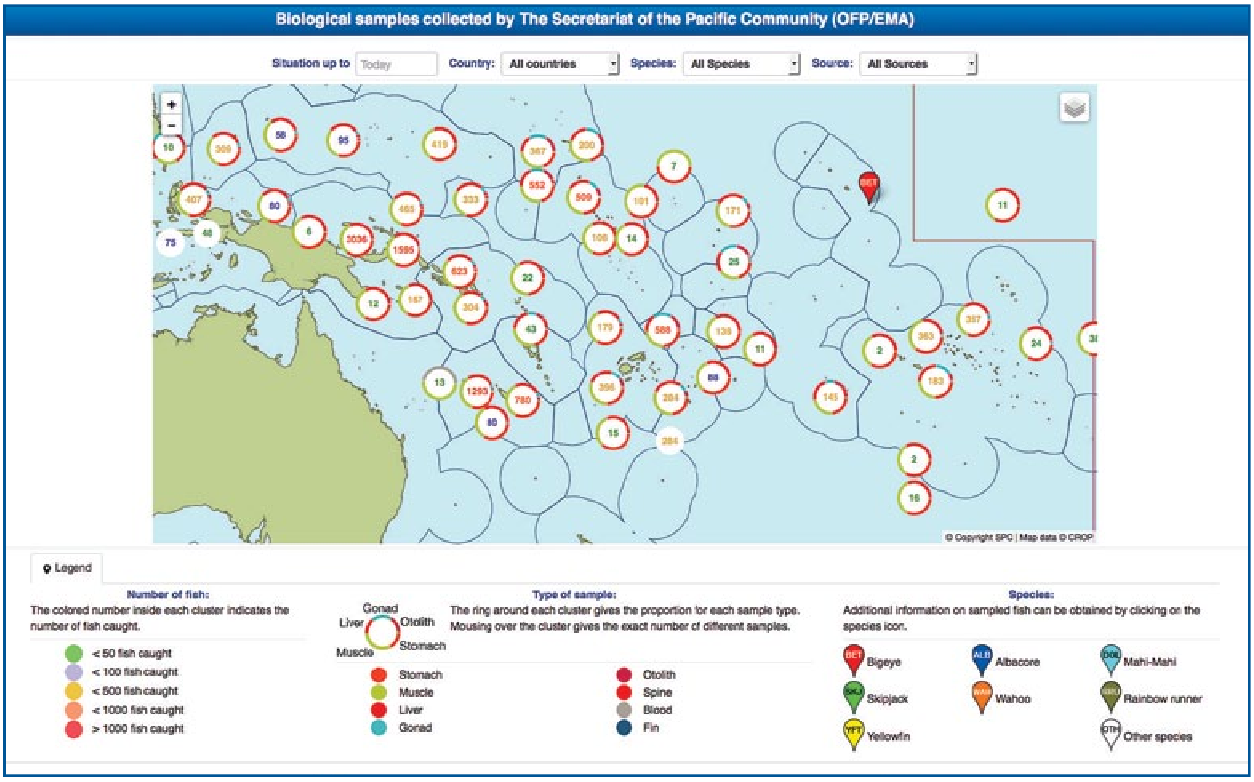

Figure 1. A screen shot of the interface of the web query tool for the tuna tissue bank.

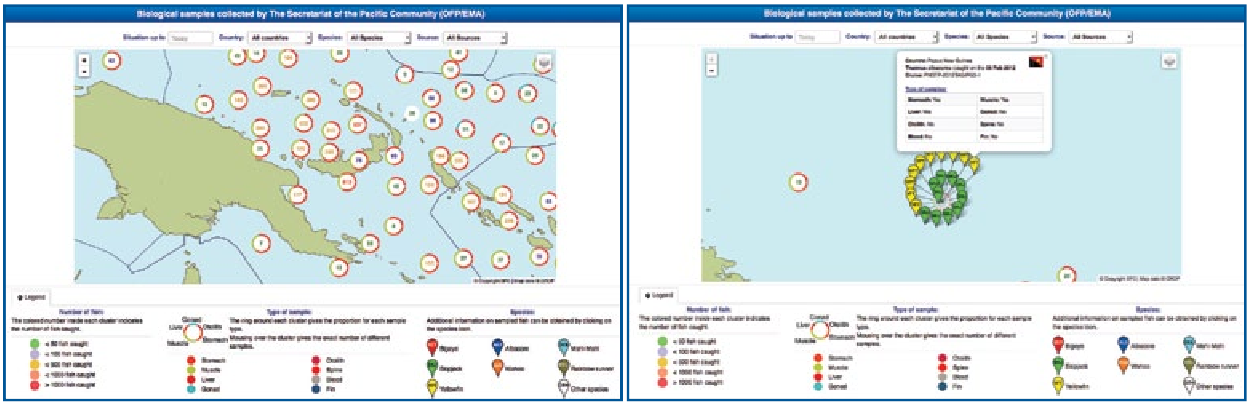

Figure 2. Two screen shots showing the increased display of information provided by the web query tool for the tuna tissue bank with zooming on the map. Left panel shows the increasing detail of samples for Papua New Guinea when zooming in on this exclusive economic zone. At maximum zooming, the details of each sample can be viewed (right panel).

How to check the TBB balance

A relational database has been established to store all information on the samples that is currently housed at SPC in Noumea. Web-based tools have been developed to allow the database to be queried online.[6] These tools include interactive maps (Fig. 1) where the user can obtain information on the number, type, species and length classes of samples collected from particular exclusive economic zones or high seas areas. More detailed information on each sample (e.g. date and location of sample and types of samples taken from the individual, sample quality, the reference to the analyses if it has already been withdrawn from the TTB) can also be viewed by zooming in on each location (Fig. 2).

Making deposits to and withdrawals from the TTB

The TTB is designed to be inclusive and encourages collaboration with other organisations collecting samples or with an interest in undertaking analyses of Pacific Ocean ecosystems. Contributions to the TTB do not

[6] http://www.spc.int/tagging/webtagging/BioDaSys/BioDaSys/Samples

need to be housed centrally and generally remain with the collecting organisation. Organisations collecting samples can contribute by providing the metadata associated with the collection of their samples (e.g. type, condition, species, location and date of sample collection) to the TTB.

The withdrawal process is slightly more complicated because many contributions to the TTB have contractual requirements associated with them or are attached to specific projects. To ensure that access to the TTB is fair to all contributors, some straightforward rules and procedures have been developed for withdrawals. These are not onerous, but those wishing to use samples from the TTB are requested to provide a written application that specifies the project's objectives, number of samples to be withdrawn from the bank (e.g. number, type, species, any location/sex/date limits), the methods for processing and analysis, intended collaborators, timelines and intended outcomes and proposed reporting. Because the Western and Central Pacific Fisheries Commission (WCPFC) has been an initiating organisation for the TTB, the researcher or organisation is requested to also provide an annual report to WCPFC's Scientific Committee on the study's progress. In cases where the analyses involve the preparation of secondary products, such as sectioned otoliths and histological slides, preference may be given to studies where these products are to be provided to the WCPFC at the completion of the study for future comparative reference. In instances where the sample size is small for particular spatial or temporal sectors, consideration may be given to the sequencing of analyses. In such cases, priority will be given to analyses that do not modify or destroy samples (i.e. analyses that require samples to be modified or destroyed will be undertaken last to ensure that the maximum information is extracted from each sample). For example, otolith weight and morphometric analyses may be prioritised before sectioning, which may be prioritised before chemical analyses. Researchers or organisations must also acknowledge the TTB in any publication of results from the study undertaken. In addition, preferential access to the TTB will be given to: 1) researchers or organisations who have contributed samples to the collection; 2) collaborative projects; 3) requests that are part of the WCPFC Scientific Committee's research and work plan; and 4) projects whose spatial scale is regional (in preference to local). Depending on the quantity of samples, a fee may be charged for the cost associated with preparing the samples for shipping and cost recovery for freight or transport agent fees.

TTB partners

The TTB is the result of collaboration between SPC and its member countries, the Commonwealth Scientific and Industrial Research Organisation, WCPFC, the University of Hawai'i, the National Research Institute of Far Seas Fisheries and the French Institute for Research and Development. Additional financial support has been provided by DG MARE, the European Development Fund (SciFish and SciCoFish projects), New Zealand Agency for International Development, the Australian Agency for International Development, the Government of Korea, the National Fisheries Authority of Papua New Guinea, and the Global Environment Facility (OFM project).

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Observer onboard a purse-seine vessel, opening a fish to collect stomach and liver samples

Creating an aquaculture industry for a new type of freshwater prawn in Papua New Guinea

Tim Pickering[1*], Gideon Pama[2], Avinash Singh[1], Jone Varawa[1], Ralph Mana[3], Robin Totome[3]

The first ever successful spawning and rearing (from egg to juvenile stage) of the Papua New Guinea (PNG) river prawn, Macrobrachium spinipes, *took place in the first half of 2014. This success is Phase One of a project to evaluate commercial aquaculture of this prawn in PNG. The undertaking involved a team of SPC, PNG National Fisheries Authority (NFA), and University of Papua New Guinea (UPNG) scientists and students.*

There is a demand for prawns and other seafood in PNG, but freshwater prawns have never been commercially farmed there, even though *M. spinipes* (formerly classified as *M. rosenbergii* "eastern strain") is indigenous to PNG. The main barriers to freshwater prawn farming in PNG have been a lack of capacity to culture prawns through the technically demanding hatchery phase, and a lack of scientific knowledge about the breeding and growth characteristics of this PNG prawn variety.

Prawn post-larvae being counted ready for delivery from the hatchery to a commercial grow out pond at Sogeri near Port Moresby.

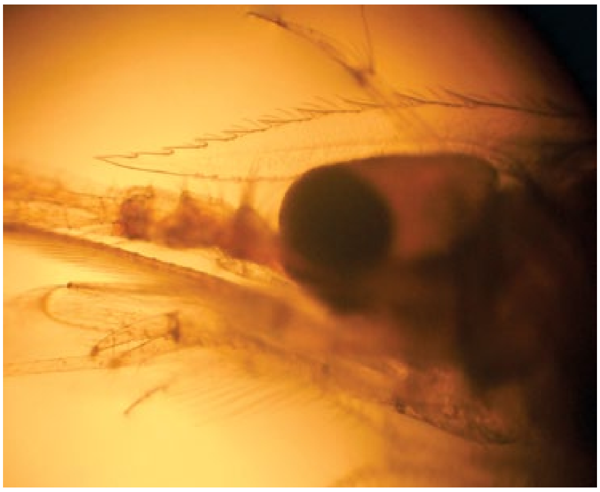
Project background

In order to address capacity and knowledge gaps, NFA requested SPC to develop a research project, which would be supported by the Government of Australia. The Australian Centre for International Agricultural Research project FIS/2011/049, "Evaluation of the potential for commercial aquaculture of the freshwater prawn *Macrobrachium* in Papua New Guinea", is a research collaboration between prawn farming experts in SPC's Aquaculture Section, NFA's Freshwater Aquaculture staff, and academics and students of the School of Natural and Physical Sciences at UPNG's Waigani campus.

Phase One of the project involved building a prawn hatchery in Port Moresby, and conducting exploratory fishing to find a reliable source of broodstock prawns among the rivers of PNG's Central Province.

Phase Two consisted of hatching prawn eggs in captivity and rearing the planktonic larvae through to the juvenile adult stage, and training PNG nationals in prawn hatchery techniques.

For the third and final phase, we will conduct an economic analysis of prawn grow-out and marketing, and then develop a package of information about freshwater prawn aquaculture that will be made available to investors in PNG.



Presence of teeth on both the upper and lower sides of the rostrum confirm that this specimen of Macrobrachium spinipes *has developed to the post-larval stage.*

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[2] National Fisheries Authority, Papua New Guinea
[3] University of Papua New Guinea

Hatchery technique

A prawn hatchery was constructed and equipped at UPNG's Waigani campus in Port Moresby. Prawn broodstock-bearing eggs were collected using crab traps in Agevaru River, which is a three-hour drive from Port Moresby. We used a green water (water enriched with micro-algae) hatchery technique based on standard methods developed in Fiji for *M. rosenbergii*. Green water was created from tilapia tank water, and this was added daily to the prawn larvae tank water to stabilise the water quality and act as a pro-biotic. The larvae were fed live brine shrimp (*Artemia*), egg custard and squid custard. The tank water was hanged when deemed necessary from observations of water quality and larval condition, and this averaged about one 50% change per seven days, which greatly saved on the amount of seawater that needed to be brought in by truck.

The first hatchery run of *M. spinipes* was attempted in April–May 2014. We expected the first attempt to fail because there are always problems at the start. But to our pleasant surprise, the larvae progressed steadily through all 11 larval development stages. The first post-larvae, which appeared in the tanks on day 27, were strong, active, clean-shelled, and brightly coloured — all indicators of good larval health.

We observed a wide variety of larval sizes and stages from the same egg clutch: stage V through X could be seen in the tank at the same time. All stages ultimately metamorphosed from larvae into post-larvae. Our conclusion is that *M. spinipes* poses no special challenges in the hatchery compared with *M. rosenbergii.*

From left to right: Gideon Pama (NFA), Cornelius Aiyapi (UPNG) and Jone Varawa (SPC) at work in the prawn hatchery constructed under the ACIAR project at UPNG in Port Moresby.

The UPNG prawn hatchery hosts a visit by John Kasu, Managing Director of PNG National Fisheries Authority (2nd from right) and Jacob Wani, Principal Scientist of the NFA Aquaculture and Inland Fisheries Unit (far right). Tim Pickering of SPC holds a bowl of prawn larvae, while Ralph Mana (2nd left) and Robin Totome (3rd left) of UPNG's Division of Biology look on.

Grow-out to market size

Once acclimated from the brackish water conditions of the hatchery to fresh water, the post-larvae were released into tilapia ponds and into tilapia cages, at a commercial tilapia farm in Lake Sirinumu near Port Moresby. Because the quantity of post-larvae produced was in excess of requirements for this trial, some were sent by air to Lae and placed in ponds at another tilapia farm at Potsie (near the Markham River bridge). A further batch of prawns has been stocked into ponds purpose-built for a prawn grow-out trial at Kanosia in Central Province. Culture characteristics of *M. spinipes* during grow-out will be assessed, and any technical constraints will be identified for follow-on research.

A technical and economic information package about this prawn species will be developed, based on the project results. This will be made available to potential investors in freshwater prawn aquaculture in PNG. Meanwhile, NFA staff and UPNG staff and students have been trained in prawn hatchery operations. They are now preparing for another hatchery run of their own, scheduled for later this year.

We are aware of only one other successful rearing of an "eastern" strain of *M. rosenbergii* (now re-named *M. spinipes*), which was by Samoan MSc candidate Malvine Lober under the supervision of Chao Shu Wu at James Cook University in Townsville, Australia. According to results of Peter Mather's genetics research group at Queensland University of Technology, theirs was a different lineage from the PNG "eastern" variety. So this is the first time that the genetic type of prawn found in PNG has been successfully bred and reared in captivity.

The hatchery team who completed the first hatchery run of *M. spinipes* included Timothy Pickering, SPC FAME Division, Inland Aquaculture Specialist; Avinash Singh, SPC European Union-Increasing Agricultural Commodity Trade project (IACT) Aquaculture Officer; Jone Varawa, SPC EU-IACT Aquaculture Technician; Gideon Pama, NFA Manager Freshwater Aquaculture;, Robin Totome, Lecturer, Division of Biology, School of Natural and Physical Sciences, UPNG; Ralph Mana, Lecturer, Division of Biology, School of Natural and Physical Sciences, UPNG; David Anan, student, UPNG; and Cornelius Aiyapi, student, UPNG.

Improved cottonii (*Kappaphycus alvarezii*) seaweed variety transferred to Kiribati and Fiji

The red seaweed, Kappaphycus alvarezii *(cottonii), has been ranked by SPC as one of the highest priority commodities for aquaculture in the Pacific Islands region under the 2007 SPC Aquaculture Plan. Cottonii farming has been strongly promoted in the Pacific Islands region because it: 1) requires low levels of technology and investment; 2) does not require high-tech post-harvest processing within the country; 3) is normally compatible with traditional fishing and other subsistence uses of the inshore environment; and 4) is a potential source of income and employment in rural areas with few other income-generating opportunities.*

Cottonii seaweed farming has become a significant income-generating activity in certain coastal communities of Fiji, Kiribati, Papua New Guinea and Solomon Islands. In 2013, total cottonii seaweed production from the Pacific was 3.090 tonnes in dry weight. Kiribati and Solomon Islands were the main producing countries at 1,700 t and 670 t, respectively (Fig. 1).

Currently, the mainstay of cottonii seaweed produced in the Pacific Islands region belongs to the *tambalang* variety, but because of its thick structure (thalli), it can take up to three to five days to sun-dry, which can be problematic in areas with high average rainfall. Furthermore, the *tambalang* variety is not very productive when using off-bottom systems (seaweed seedlings cultured in shallow areas, 30–40 cm above the sea bottom), due to the high presence of sediments, nutrients and decreased water clarity. Moreover, this variety is not well adapted to fluctuations in salinity, temperature and pH, which can be high in certain coastal areas of the Pacific Islands region.

For all these reasons, it was decided to assess possible cottonii varieties that were better suited to the local context and water conditions of the Pacific's main producing countries.

In recent years, SPC's Aquaculture Section has developed a strong relationship with the National Seaweed Centre of Indonesia (Lombok). In 2013, Indonesian experts, in collaboration with SPC aquaculture officers, assessed the context and characteristics of the major producing countries and areas, as well as main limitations and constraints for production expansion and improvement in the Pacific Islands region. After this initial assessment, it was decided to introduce a new cottonii variety, called *maumere* (which has been the focus of a strict selective programme for more than 15 years in Lombok), into Kiribati and Fiji. Both countries officially requested SPC's technical assistance with the promotion and improvement of their seaweed sectors.

The new variety was introduced to both countries in March 2014. In both countries, strict quarantine measures and protocols were implemented before the seedlings were released to farming locations. Initial trials have been conducted at Kadavu Island in Fiji, and Abaiang Atoll in Kiribati, with very promising results in terms of adaptation, growth and survival. It is expected that initial propagation activities will end soon so that the improved seedlings can be disseminated to farmers and communities for initial trials (in order to compare growth and survival differences between the old *tambalang* variety and the new *maumere* variety).

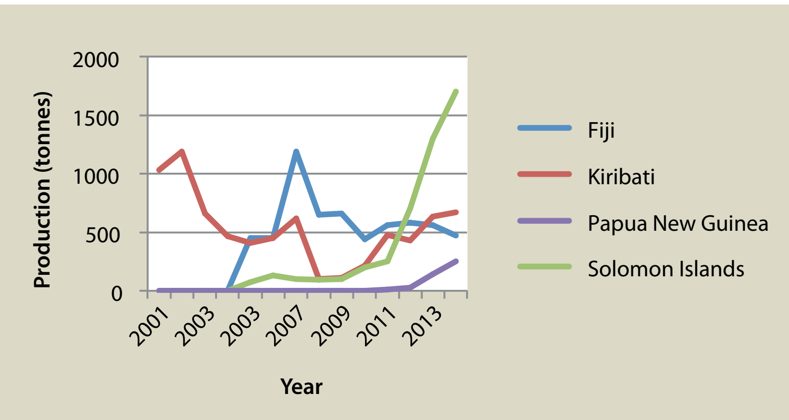

Figure 1: Pacific Islands cottonii seaweed production (source: FAO fishstatplus 2013).

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New aquaculture project that targets communities

While community-based aquaculture is important in addressing food security, it is not without a number of key challenges. Under the auspices of the Australian Centre for International Agricultural Research (ACIAR), SPC is commissioning a new project to address some of these challenges. A key element is to focus on species that have a demonstrable track record of suitability for aquaculture in the Pacific Islands region. The project will address key constraints such as capacity, and feed and seed supply, which are particularly challenging in remote coastal and inland communities. The outcome of detailed country consultations during the project's formulation will be to place emphasis on tilapia culture in Fiji, Samoa and Vanuatu; freshwater prawn culture in Fiji and Vanuatu; and sea cucumber (sandfish) culture in Fiji and Kiribati.

It has been difficult to quantify: 1) the number of people engaged in aquaculture, either full time or part time; 2) the roles of women and children in community-based fish farming; and 3) how economies of scale could be enhanced to bring aquaculture to a higher level. One thing is certain though: community-based aquaculture must be formulated around the way of life of the rural people who most need the support.

By identifying and addressing these and other challenges, the project's goal will be to find ways of increasing the production of promising aquaculture commodities, and better understanding the factors relating to greater engagement in aquaculture among communities. The project's objectives are to:

- ✓ Address technical and capacity constraints in community aquaculture through interventions in four countries. This will necessitate improving appropriate hatchery and grow-out systems and trainings to meet national requirements for seed supply, and improving the marketing of products with the aim of increasing production and investment.
- ✓ Apply and evaluate community-based approaches to strengthen the impacts of small-scale aquaculture. This includes organising farmers into clusters and identifying those farmers who will be able to operate as lead farmers to specialise in fingerling or feed production to supply others in the group.
- ✓ Ascertain the impacts that community-based aquaculture can have on household income, nutrition, and status of women and children in the four countries. This will involve undertaking detailed socioeconomic surveys of households, disaggregated by gender and age group, in order to determine the level of engagement in aquaculture activities, income and fish consumption.
- ✓ Integrate community sea cucumber aquaculture with coastal fisheries management. The purpose here will be to strengthen community-based fisheries management approaches, and involves the development of sandfish hatchery and release techniques, and applying these approaches as an incentive to introduce management rules for fisheries.

The project requires a multi-disciplinary effort that spans the biological, technical, economic and social science fields. Specialist inputs will also be provided from other partner institutions in the region such as the WorldFish Center, James Cook University, Queensland University of Technology, and the University of the South Pacific Institute of Marine Resources. Expertise from within SPC's Fisheries, Aquaculture and Marine Ecosystem Division and other programmes within SPC will also be used (e.g. in the areas of community-based management, gender and statistics). Four Pacific Island country governments and partner administrations are involved: Fiji Ministry of Fisheries and Forests, Kiribati Ministry of Fisheries and Marine Resources Development, Samoa Ministry of Agriculture and Fisheries, and Vanuatu Department of Fisheries. These agencies will be bringing their experience of working with communities on the main species of interest. The identification and formation of links with suitable partners from other national government agencies, civil society organisations and private sectors will also be part of the implementation process.

SPC has recently recruited Beero Tioti (Kiribati) as the project officer who will oversee the implementation of the new community-based aquaculture project in the selected countries.

It is hoped that one result of the project will be a better understanding of the future role of Pacific Island aquaculture (at the community level) in meeting food security requirements and providing livelihoods in response to population growth, increasing demands for cash income, and urbanisation. In addition, the project will explore ways for aquaculture to integrate with fisheries and, where possible, provide incentives for communities to support better coastal fisheries management.

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Beero Tioti, new SPC Community-based Aquaculture Officer

SPC's Aquaculture Section has hired a new Community-based Aquaculture Officer, Beero Tioti. Beero worked previously with the Kiribati Ministry of Fisheries and Marine Resources, and has also worked with the Australian Agency for International Development in Kiribati as a Program Manager for the Community Projects and the Fisheries Incentive Program. He holds a bachelors degree in biology from the University of Papua New Guinea and a Master's degree in aquaculture from James Cook University in Australia.

Beero took up the post of Community-based Aquaculture Officer in May 2014 and his background encompasses both marine and brackish water aquaculture. Much of his recent work has been in assisting with the establishment and management of giant clam farming with the Kiribati Fisheries Department and a private sector company involving rural communities. Along with SPC's Aquaculture Adviser Robert Jimmy, Inland Aquaculture Specialist Dr Tim Pickering, Mariculture Specialist Ruth Garcia, and SPC's Fisheries, Aquaculture and Marine Ecosystem/Increasing Agriculture Commodity Trade Aquaculture Officers, Avinash Singh and Jone Varawa, Beero's arrival brings the strength of SPC's Aquaculture Section's back-up to six.

Beero's role with the SPC/Australian Centre for International Agriculture Research community-based aquaculture project is to assist partner countries in strengthening aquaculture production systems in order to improve nutrition and livelihoods for local communities.

Beero Tioti (grey shirt) with other Suva-based members of the SPC Aquaculture team, working on experimental fishpond cleanup at the Naduruloulou Aquaculture Research Station of the Fiji Ministry of Fisheries and Forests.

Successful diamondback squid fishing trials in Fiji

The diamondback squid (Thysanoteuthis rhombus) *is found in tropical and subtropical waters. While it is not a traditional fishery and most fishing communities do not know that it even exists, it is potentially an untapped resource for Pacific Island countries. The neon flying squid (***Ommastrephes bartramii***) is another large squid species found in the same areas. This squid is smaller than the diamondback but is much larger than the commonly seen species at the surface. The average size of a diamondback squid (mantle length) ranges from 60–100 cm and it can weigh up to 30 kg, although it averages around 20 kg (Fig. 1). The neon flying squid has mantle lengths that range between 25 cm and 60 cm and can weigh between 5 kg and 13 kg. An awareness of the presence of diamondback squid in the Pacific Islands region followed two successful trials carried out by SPC in New Caledonia in 2012 and the Cook Islands in 2013.*

Fishing trials were again conducted from 30 June to 4 July 2014, this time in Fiji in waters north of Kadavu Island and south of Suva to ascertain the presence of diamondback squid there. This was prompted by a request from the Fiji Fisheries Department to first confirm the presence of the species and to disseminate information about it to local fishermen and entrepreneurs with the hope that they will source local markets to supply their catch to. The project was facilitated by SPC's Fisheries Development Officer, William Sokimi. The trials were conducted over four fishing days.

This exploratory fisheries development work is part of the SPC Nearshore Fisheries Development Section's mandate and work programme to strengthen food security, create new livelihood opportunities, and initiate fisheries diversification projects in order to identify new resources or utilise existing resources that are commercially viable but have not been tapped. The section's role is to also introduce capture methods to make these resources available as food security alternatives or as potential market products. Assistance in Fiji was made possible through programme funding from the New Zealand Aid programme for project costs, and the Government of France and the Australian Agency for International Development for SPC technical support. The Fiji Fisheries Department met all of the logistical costs for crew and participants, and for fishing vessel trip costs, gear construction venue, use of a crane truck, and other associated operational costs. Graham and Mathew Southwick of the Fiji Fish Marketing Group Ltd provided the much needed longline reel and horizontal mainline that was used during the trials.

Fishing gear and catch method

The full fishing trial operation was conducted over two weeks. During week 1, gear was assembled at the Fiji Fisheries Department workshop in Lami and then transferred to the FMV *Bai Ni Takali* to be set up for the fishing operations. Fishing gear preparations and fishing operations were carried out by selected Fisheries Department technical staff and crew of the FMV

Figure 1. Some of the diamondback squid caught during the Fiji trials.

Bai Ni Takali. Fishing operations were conducted during week 2.

The fishing method is basically a series of vertical longlines set approximately 600 m apart on a horizontal longline. The vertical longline system (Fig. 2) consists of stainless steel wire as the main dropline to which a trunkline is attached. A watertight light and three lures with hooks are connected to the trunkline with a leaded lure at the end. Each dropline is made of 450 m of 1.05 mm (212 lb test) flexible stainless steel wire. The trunkline was made up of 6 sections:

- ✓ one section of 20 m x 2 mm red monofilament line (400 lb test),
- ✓ one section of 5 m x 4 mm elastic absorber (250 lb test),
- ✓ four sections of 2.0 mm red monofilament line (400 lb test).

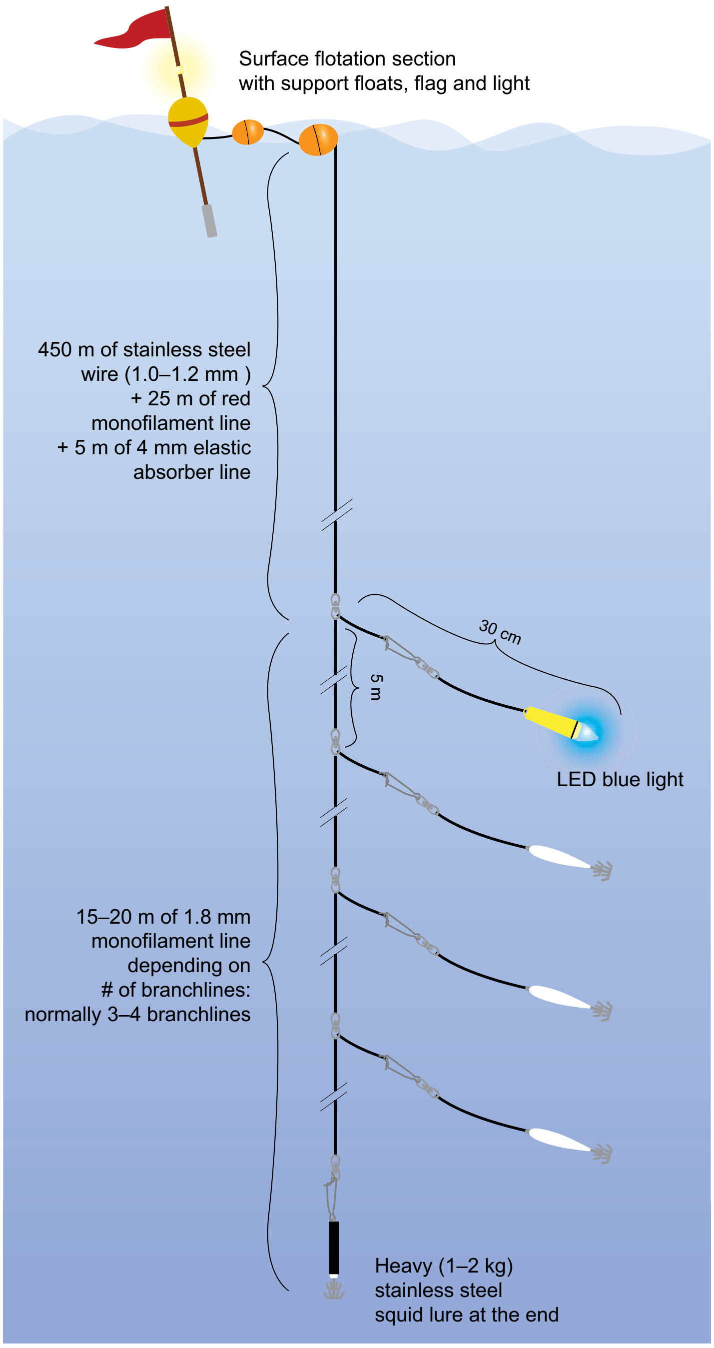

Figure 2. Diamondback squid vertical longline gear (illustration: Boris Colas).

Fishing reel

The fishing reel is a model NKAF-3A from Fuji Kizai Co. Ltd, Japan. Three extra spools were ordered, making four reels in all. Each spool contained five sets of 1.05 mm (212 lb test) stainless steel wire mainline. The NKAF-3A weighs 38 kg, has a haul-back power of 30 kg with a haul-back speed of 46–80 m/min and a spool capacity of 2500–2600 m of 1.05 mm stainless steel wire. The reel is powered by DC 12 volts and draws up to 50 watts (Fig. 3).

Catch and effort

During this trial, 15 vertical longlines were set on day 1, 18 on day 2, and 15 on each of the last two days. Catch consisted of:

- ✓ Set 1 (15 lines/60 hooks): 17 pieces caught, 3 missed. All diamondback
- ✓ Set 2 (18 lines/72 hooks): 26 pieces caught, 5 missed. 25 diamondback, 1 neon flying squid
- ✓ Set 3 (15 lines/60 hooks): 5 pieces caught, 6 missed. 4 diamondback, 1 neon flying squid
- ✓ Set 4 (15 lines/60 hooks): 11 pieces caught, 7 missed. 10 diamondback, 1 neon flying squid

Total catch: 56 diamondback squid, 3 neon flying squid, 21 missed.

Table 1 summarises the catch, effort and catch per unit of effort (CPUE) obtained during the trials is Cook Islands, Fiji and New Caledonia. The greatest CPUE was obtained in Fiji (0.230 squid per hook set vs 0.083 in Cook Islands and 0.125 in New Caledonia), where the composition of the catch was largely dominated by diamondback squid (95% of the catch). Diamondback squid has a higher market value than the neon flying squid.

Table 1. Summary of the results obtained during the three experimental squid fishing campaigns.

	Total no. of hooks set	Total catch (no. of squid)	CPUE (no. of squid per line)	CPUE (no. of squid per hook)	Ratio of diamondback squid	Ratio of neon flying squid
Fiji	252	59	0.90	0.230	95%	5%
Cook Islands	180	15	0.33	0.083	53%	47%
New Caledonia	560	70	0.50	0.125	50%	50%
All experiments combined	992	144	0.58	0.150	69%	31%

Figure 3. NKAF-3A reel mounted on the starboard quarter of the MFV Bai Ni Takali.

Comments

The diamondback squid resource is currently unexploited in the Pacific Islands region. Therefore, it may appear to be abundant when first fished but Okinawan diamondback squid fishery indicates that the resource is fragile and needs to be managed with caution in order for sustainable harvests to take place.

After the successful fishing trials in Fiji (Fig. 4), the Fiji Fisheries Department planned to continue fishing trials to identify other fishing areas around the country and to better assess and understand the resource. Potential local markets will be investigated with local fishermen, and fishing companies will be encouraged to take an interest in the fishery. Immediate attention will be directed at the local market, targeting hotels and restaurants. Japanese market prices appear to be too low to make exports economically viable but there should be some immediate potential with local hotels and restaurants. However, while the export market may seem uneconomical, it is up to the entrepreneur to ascertain this with trial exports.

The diamondback squid is consumed as sashimi and sushi in Japan. A diamondback squid recipe booklet (with 53 recipes) has been published by the Dominica Fisheries Division in Cooperation with the Japan International Cooperation Agency. This booklet will be distributed with sample pieces to hotels and restaurants. A questionnaire will also be issued with the sample pieces in order to get feedback from chefs on their customers' responses to the dishes.

If the marketing trials are successful, then the catch method should be adapted for use on small vessels so that small-scale fishermen can also benefit from this development.

At this stage, limited licensing should only be issued to local fishing companies to further evaluate the potential of the fishery and to gradually fortify the development bases for a local industry.

Recommendations

- ✓ Continue fishing operations to better assess and understand the resource and to identify the best fishing zones around Fiji.
- ✓ Focus on first developing a local market for the squid, targeting the tourism industry and restaurants.
- ✓ Consider selecting a local fishing company to adopt the fishery and to pilot the marketing angle.
- ✓ Plan to adapt the fishing method to small vessels so that their owners can tap into the industry and support the pilot company with squid catch.
- ✓ Assess data and carry out a stock assessment when practical.
- ✓ Limit licensing until more is known about the fishery's potential.

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Figure 4. Diamondback squid releasing ink while being hauled in.

Promising results for sandfish and white shrimp farming in Fiji

A number of positive developments have taken place in the marine hatchery at Galoa Fisheries Station (part of Fiji's Ministry of Fisheries and Forests) during the past few weeks.

The Galoa hatchery has been intermittently involved in giant tiger prawn (*Penaeus monodon*) for the last five years, but with limited results due to the average quality of available brooders, microalgae production difficulties, and poor adaptability of the species to fluctuations in salinity and commercial feeding regimes.

Given these limitations and the high demand for shrimp products in Fiji from farmers and retailers (for domestic consumption and the tourism industry), the hatchery decided to import a high-performing strain of a new species of shrimp (*P. vannamei*) from Thailand to carry out some breeding and farming trials. White shrimp is relatively hardier, less demanding in terms of nutrition and management, easy to breed, and better adapted to salinity fluctuations.

In August 2013, the first run of white shrimp (*P. vannamei*) broodstock has produced about 150,000 post-larvae, of which, 77,500 have been distributed to small- and medium-scale farmers on Viti Levu, while the hatchery has kept the remainder as future broodstock and for performing some grow-out trials and research activities.

The hatchery has also managed to produce 2,558 juveniles of sandfish (*Holothuria scabra*, locally known as *dairo*) of around 6 mm in size, which have been transferred to 1-m^2 "hapas" located in earthen ponds at the same hatchery. The hatchery manager is planning to keep these juveniles until they reach 5–10 g in weight, at which time they will be transferred to coastal communities for grow-out and restocking, using sea ranching techniques. The Galoa hatchery has also been involved in sandfish breeding and larvae rearing, with limited results due major technical and financial constraints. The situation has changed in the past few months, however, and the hatchery is now fully operational with new highly motivated skilled staff, a microalgae laboratory that has been upgraded, properly maintained grow-out ponds, and a set of tanks and raceways that have been reconstructed.

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Hatchery-produced sandfish juveniles (insert) are placed in hapa nets for further grow-out (images: Teari Kaure).

Over USD 1.3 million in 48 days of harvest
Palau shares lessons on sea cucumber management

by Kalo Pakoa[1], Percy Rechelluul[2] and Lora Demei[3]

Most sea cucumber fisheries in the Pacific Islands region are overfished, but as countries look for working models of sustainable sea cucumber fisheries and improved economic returns, Palau has some valuable experience to share.

Palau, like many other Pacific Island countries, experienced overfishing of its sea cucumber stocks from the 1980s to 1990s. Since 1994, Palau has enforced a ban on the commercial harvest and export of six of its main commercial species. Sea cucumber species consumed locally, referred to as "subsistence species", were not included in the 1994 fishery ban and continue to be harvested for subsistence use: both for local sale, and for export to Palauans living abroad. Seventeen years later, in 2011, a seven-month open season was permitted in order to trial a new harvesting strategy. At a time when the beche-de-mer supply across the region was in decline, Palau had the perfect opportunity to trade its sea cucumber products at an optimal value. The harvesting season was permitted in Ngardmau State for two of the non-banned species: hairy grayfish (*Actinopyga* sp.), locally known as *eremrum*, and brown sandfish (*Bohadschia vitiensis*) locally known as *mermarc*.

New harvesting strategy

From June to December 2011, a twice-weekly harvest was permitted (on Mondays and Thursdays), with catches landed at designated landing points in Ngardmau State. This allowed 100% coverage of observation recordings by the Palau Bureau of Marine Resources and the Nagrdmau State Rangers. Harvesting was later allowed in seven other States (Ngarchelong, Airai, Aimeliik, Koror, Ngiwal, Ngatpang and Ngaraard) as it became difficult to control harvesting activities in other states and the movement of catches across to Ngardmau State. An additional three landing sites were set up in Ngarchelong, Airai and Koror to record catches from those states. Only Palauan residents of each state were allowed to harvest sea cucumbers, and they had to do so within their own state waters.

All landed catches were sold fresh to the five processors based at Ngardmau, Airai and Koror (Fig. 1a). Buyers were present at the landing site each fishing day at around 15:00 to make their purchases.

Sea cucumbers were sold fresh in a standard 18-litre bucket unit weighting 22.5 kg when full of sea cucumbers (Fig. 1b). A bucket full of brown sandfish contained, on average, 30 pieces of large size specimens and a full bucket of hairy greyfish contained, on average, 300

Figure 1. a) Boatloads of brown sandfish at a landing site in Koror (image: Eyos Rudimch, Director of Koror State Government Office) and b) hairy greyfish in a typical bucket used in Palau during the 2011 open season (image: Kalo Pakoa).

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individuals squeezed together. Sea cucumbers were sold at USD 10.00–12.00 per bucket of brown sandfish and USD 12.00–46.00 per bucket of hairy greyfish. Detailed catch data were recorded at landing sites, including the number of buckets per species by fishers, number of people per fishing group, fishing area and selling prices. During the seven-month season, fishing was undertaken in 48 days.

Landing and export production

In total, 51,573 buckets of sea cucumbers were landed, equivalent to 1,160 tonnes. The landed catches were sold to processers for a total purchase value of over USD 1.3 million. It was a windfall for local fishers in Palau; "never did fishers earn so much money so easily", according to one fisher from Ngardmau State. This amounted to 72 tonnes of dried beche-de-mer exported at a total declared value of over USD 1.1 million. The five export operators belonged to foreign-owned companies in joint arrangement with local Palauan nationals. It was likely that only a small proportion of the exported value stayed in Palau as is usual in other Pacific Island sea cucumber fisheries. Hairy greyfish represented 70% of exported products by weight and generated 86% of purchase value at USD 1,123,208; brown sandfish made up 30% of the landed catches and 14% of the purchase value. While other species appeared in harvest records (tigerfish, greenfish, curryfish and deepwater blackfish), their quantities were minimal.

The declared total export value of USD 1.1 million was slightly lower than the total purchase value of USD 1.3 million. However, considering that all export operators were keen to renew their licenses, there is little doubt that their operations were profitable. Export values were, therefore, certainly under evaluated. Under valuation of beche-de-mer exports is a common feature of Pacific Island sea cucumber fisheries; this was revealed in a 2012 study of sea cucumber fisheries in Melanesian countries and in Tonga, in which the estimated current value of the fishery was USD 17 million, while an additional estimated value of USD 13 million could be made by these countries if the fishery was well managed and product quality improved (Carleton et al. 2013).

Product prices and lost potential

While fishers made a record income, the purchased prices of US 0.33 for a single brown sandfish and US 0.04–0.15 for a single hairy greyfish might have been too low. Local fishers would have earned an additional USD 472,596 from their hairy greyfish if the US 0.15 per sea cucumber purchase price had been set at the start of the season.

Prices paid in Palau seem low when compared with prices paid in some other Pacific Island countries. In Fiji for instance, the purchase price of fresh brown sandfish was USD 2.14 per kg (FJD 4.00 per kg); this would be equivalent to USD 48.00 per bucket (bucket size used in Palau) or an estimated USD 1.60 per sea cucumber — almost five times the price paid in Palau. The purchase prices for medium-value hairy blackfish (*Actinopyga miliaris*), which is in the same group as hairy greyfish (genera *Actinopyga*) — and could possibly be the same species — was USD 20.00 per kg for fully dried high-grade product (Carleton et al. 2013). Hairy blackfish was sold by fishers in Fiji at FJD 6.00 (USD 3.20) per kg in 2009. At the highest bucket prices of USD 46.00 used in Palau in 2011, this would be equivalent to USD 2.04 per kg, which is 40% lower in price than the related species purchase price in Fiji.

Generally, the purchase prices of the two products could have been raised to around US 0.30 per sea cucumber or USD 90.00 per bucket for hairy greyfish and USD 1.00 per sea cucumber or USD 30.00 per bucket for brown sandfish prior to the open season. This would likely have doubled or tripled fishers' income in Palau for the 2011 season.

Hairy greyfish (*Actinopyga* sp.)

Known locally as *eremrum, Actinopyga* sp. (Fig. 2) has long been incorrectly referred to as stonefish or blackfish and was referred to as "grey gold" because of its value in the 2011 harvest. It is mostly found in seagrass meadows.

The species is highly valued by the Palauan people as a food resource and as an export commodity. It is an important local delicacy eaten at home, processed into packages and sold at the local market (Fig. 3), or exported to relatives living abroad in Guam, Hawaii and the United States. But, it has not yet been correctly identified by taxonomists (Dr Alexander Kerr, pers. comm., 2014). The unidentified species is found only in Palau and the Federated States of Micronesia (in Yap proper and Pohnpei proper). The name "hairy greyfish" was given by the former Minister of Fisheries of Palau, Harry Fritz, at a sea cucumber management consultation meeting organised by SPC in December 2012 to assist with its proper identification.

Because of the high market demand, stocks of hairy greyfish are in danger of being overharvested. For example, stocks in Ngapang and Ngarchelong have been reduced by 70–90% from the 2011 harvest (Golbuu et al. 2012; Pakoa et al. in press). However, it presents certain characteristics that could make its management successful:

- ✓ it can be easily managed by communities because its habitat is restricted to seagrass beds that can be clearly marked out and protected;

Figure 2. Typical hairy greyfish aggregation (image: Kalo Pakoa).

Figure 3. Hairy greyfish meat on sale at a local shop in Koror (image: Kalo Pakoa)

✓ it can reach high densities within a small area; and

✓ it is relatively easy to locate, which is an advantage for accurate stock estimates and the monitoring of harvestable quotas.

A no-take marine protected area in Ngardmau State is an example of this; the stock held in the area was not harvested in 2011 because it was under strict surveillance during the open season by the Ngardmau State Rangers.

Lessons and ways forward

Decision-makers in Palau have learned from the experiences of overfishing sea cucumber stocks in other Pacific Islands. While fishers in Palau earned their highest income in this fishery, there is little doubt that more income could have been made if certain management measures had been put in place. The open season in 2011 has revealed gaps in the management system that need to be fixed to ensure effective control of the fishery through efficient catch monitoring mechanisms and better product pricing so that fishers receive the highest possible economic return from the resource. Actions that could be taken to fill these gaps include:

✓ set an open season for each state at a time that facilitates effective control;

✓ issue separate licenses for processors and exporters with conditions detailing areas of compliance by operators;

✓ establish a better recording system of products being transferred from processors to exporters;

✓ maintain better records of export quantities and value by species; and

✓ look at ways to localise the sea cucumber industry.

The total ban on commercial beche-de-mer harvesting, processing and trading activities enforced as of January 2012 was a timely step in the right direction. When there is a need for a new management strategy, it is better to close the fishery to allow stock recovery while allowing time for changes to be made and new regulatory measures to be passed. SPC and the Palau Bureau of Marine Resources (BMR) have begun developing a new sea cucumber management plan and set up resource assessment protocols for BMR and the Palau International Coral Reef Centre.

Because many countries and territories are looking for models that work best in sea cucumber fisheries, Palau's experience provides useful lessons, including:

- ✓ The sea cucumber resource belongs to the people of each state in Palau who have the right to harvest and sell the product themselves, with no support from processors and/or exporters. And because it is their resource, fishers have a sense of responsibility and respect for it and will tend to comply with management advice.
- ✓ It is possible to effectively control harvesting activities at the fishing ground level through designated landing sites where 100% recording of catches can take place at agreed on fishing days and times.
- ✓ With good cooperation, it is possible to get full engagement of communities, fishers, processors, local government officers and fisheries officers working together to effectively monitor and organise sea cucumber fishing activities.
- ✓ Sea cucumber processing to produce high-grade beche-de-mer can be a costly activity that requires skills and equipment that few fishers can afford; fishers should, therefore, be given the opportunity to sell their product raw at the best possible prices; as has been proven in Palau, they can still earn a good income.
- ✓ Sea cucumbers are a lucrative commodity and setting minimum reference purchase prices by species and for different levels of processing (e.g. live, salted, frozen, dried) must now be encouraged, where possible, to prevent unnecessary price fluctuations, which are at this stage only set by buyers, often at the disadvantage of fishers.
- ✓ Restricting processing to licensed processors, as practiced in Palau, guarantees the production of high-grade beche-de-mer by those who possess the know-how and resources to do it. It ensures that the maximum value is derived from the resource, and minimises the production of poor-grade products and wastage resulting from many unskilled fishers processing poor-quality products.
- ✓ Closing commercial sea cucumber fishing for 17 years allowed for stocks to recover and build up; the high income earned in 2011 can be related to reaping the profits of a fixed deposit in a bank that has been allowed to earn interest over 17 years. People of Palau now know that waiting for 17 years is not a loss.
- ✓ Extended closures and short open seasons, when resources have sufficiently built up and market values of the product are high, may be the way forward in sea cucumber fisheries. Short open seasons also facilitate effective control of compliance to management measures and create scarcity of supply, which usually increases the product's market value. For small-scale fishers, however, very short periods of high income followed by long periods of no income from the sea cucumber fishery may be an issue that will need to be addressed when establishing a sea cucumber fishery management plan.

A national report documenting the state of Palau's sea cucumber fishery will soon be published (Pakoa et al. in press).

SPC's support to Palau is funded by the European Union-funded SciCoFish project, which provides scientific support for the management of coastal and oceanic fisheries in the Pacific Islands region.

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Community-based fisheries management project in Kiribati: First steps

Tarateiti Uriam[1] and Aurelie Delisle[2]

A community-based fisheries management (CBFM) project was recently initiated in Kiribati to empower communities in managing their own coastal marine resources. Marine resources are very important to I-Kiribati communities, and coastal fisheries in particular, are the main support for subsistence and livelihoods, and are vital for the maintenance of cultural values. As such, these coastal fisheries need to be managed to ensure their sustainable use for future generations of I-Kiribati.

This CBFM project is funded by the Australian Centre for International Agricultural Research and is a component of a larger initiative being jointly conducted in the Solomon Islands and Vanuatu. The CBFM team in Kiribati works in partnership with Australian National Centre for Ocean Resources and Security at the University of Wollongong, WorldFish Center, and SPC, and is supported by the Ministry of Fisheries Marine Resource Development of Kiribati. In May 2014, two local staff (Tarateiti Uriam and Ben Namakin) were recruited by SPC as community-based fisheries management officers. The pilot phase of this project is initially for three years during which time the project aims to work with three island communities. Two of the communities, Butaritari in the northern Gilbert Islands, and north Tarawa in the central Gilbert Islands, have already been involved, a third island site will be determined in 2015, based on expressions of interest by island communities and lessons learned from Butaritari and north Tarawa.

The first phase of the CBFM project consisted of consultations with local government agencies (Island Councils) to follow local processes and to ensure that the project would be accepted. Island Council consultations were individually conducted on north Tarawa in March and on Butaritari in May of this year. The team consisted of two SPC staff members, and staff from the Ministry of Internal Affairs, the Ministry of Fisheries and Marine

Figure 1. Island Council consultation on Butaritari. Standing is the vice mayor; men in black and white are council members (image: B. Namakin).

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Figure 2. View of Butaritari Island (image: B. Namakin).

Resource Development and the University of Wollongong. Presentations of the project explained its overall objectives, the need to manage coastal fisheries, and the roles of communities in fisheries management. Following the presentations, Island Council members raised questions about the project, took time to decide whether to accept the project, and decided on the pilot communities. After intensive discussion, councillors from each Island Council nominated three pilot communities: Buariki, Tabonibara and Buota on north Tarawa, and Kuuma, Tanimaiaki and Bikati on Butaritari.

Subsequently, visits to pilot communities were conducted to explain the overview of the project, acquire a clear understanding of the context of each village, and understand the status of each village's coastal fisheries and the issues and concerns village members have towards their local coastal marine resources. During the discussion, villagers were given a strong sense of ownership and were told that they were the experts on their local resources and have a role to play in managing their coastal fisheries; villagers know where and when fish spawn, are aware of when a resource is declining, and know the possible reasons. This message encouraged communities to identify issues with their fishery resources and discuss some of their destructive fishing methods and gear types used. Having a meeting with the whole community, however, was not enough because some people did not feel confident expressing their ideas in front of everyone. However, working in groups was a more efficient way of getting more detailed information. Different groups were formed according to age and gender (e.g. groups for women, youth, elderly men, and middle-aged men). In each group, members were encouraged to draw maps to outline their village and lagoon and identify fishing grounds, spawning aggregation sites, important marine ecosystems and the direction of water currents. Matrices were filled out to capture information about the fish they catch, who catches the fish, use of catch (cash, barter or food), seasonality of catches, where fish spawn, perceived status and conditions of the stock. From those village consultations, a few main concerns were raised by village members, including the use of small mesh-size nets, the impact of causeways on migration and the life cycle of important marine species, crow-of- thorns starfish (a threat to coral reefs and giant clams), poaching and the lack of legal support for effective bylaws.

Out of the six pilot communities, only Buota in north Tarawa remains unvisited with consultations planned for September. Buota is a large community, consisting of people from Buota and people from other parts of Kiribati and is the village closest to the largest population centre in Kiribati, south Tarawa. Due to these challenges, the team is still working out the best way to undertake community consultations.

The next phase of the CBFM project includes further community visits as well as hosting a stakeholder workshop at the end of October. The workshop will welcome participants from different government agencies and partner agencies, and will also invite representatives from the project's two pilot island communities. The main purpose of the workshop is to raise the profile of CBFM in Kiribati to a national and regional level, and to design a model for the implementation of CBFM in the country.

We are "burning both ends of the candle"

Source: "View from the Industry". A blog from the Pacific Islands Tuna Industry Association (PITIA): http://www.pitia.org/uploads/7/1/1/6/7116608/view_from_industry_burning_both_ends_of_the_candle.pdf

"There are just too many boats", is a phrase PITIA has used multiple times before in reference to the southern longline albacore fishery. However the same sentiment is equally true when it comes to the concerns repeatedly raised over the state of the bigeye stock.

In 2008, the Western and Central Pacific Fisheries Commission (WCPFC) was commended for reaching consensus and adopting a measure that would address growing concerns over the state of the bigeye (*Thunnus obesus*) stock.

Each year since then, the stock situation has grown worse, whilst at the same time the measure to manage this stock has grown more rigorous. Parallel to this, the number of boats continue to increase and with greater efficiency. There is something wrong with this equation!

For a number of annual sessions now, the work of WCPFC has been dominated by the negotiations of this very conservation and management measure (CMM) for the bigeye tuna. For the most part, members behind closed doors debate for hours on end, the content of the measure to put into effect the following fishing year.

Each year, the measure grows to be more about accommodating allocation, and less about conservation.

This growing dominance of discussions concerning bigeye tuna has come at a serious cost. Other crucial fisheries issues are marginalised in order to make way for the discussions on this endangered stock, leaving little time for the management of other fisheries.

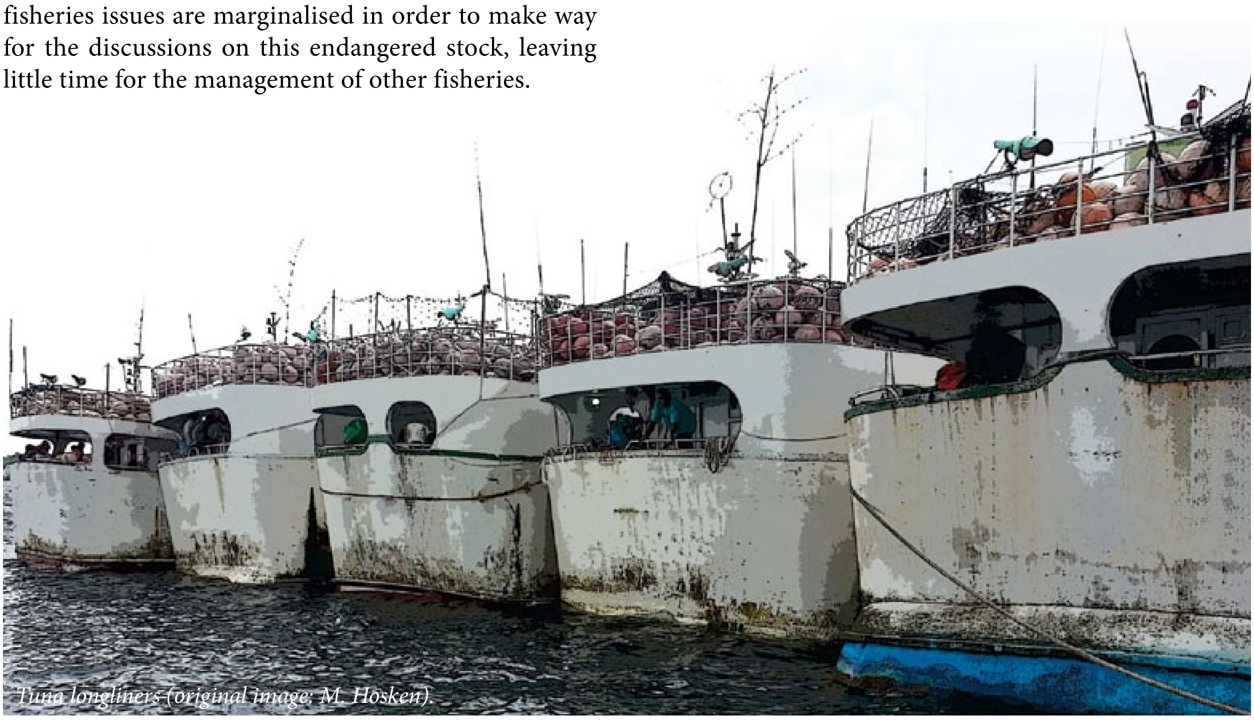
Although appreciating the complexity in managing a stock that gets plundered by both the longline and the purse-seine fisheries, WCPFC has failed to impose enough reduction in fishing effort to bring about the conservation that the science calls for.

The SPC assessment of the fishery being presented to the Scientific Committee of the WCPFC meeting in Majuro this week, paints a very clear picture. "We continue to burn both ends of the candle".

The agreed FAD closure, where juvenile bigeye is almost exclusively caught, has not quite met the anticipated outcomes; the assessment shows purse-seine catches have exceeded the catches of longliners.

PITIA would like to urge members of WCPFC's Scientific Committee currently meeting in Majuro, to bring to the Annual Session in December, clear and robust recommendations that addresses the situation.

PITIA encourages WCPFC members to come to the table in December ready to make the necessary sacrifices, to give the bigeye stock room to recover.



Tuna longliners (original image: M. Hosken).

Assisting Papua New Guinea with the European Union "yellow card" for IUU fishing

Francisco Blaha[1]

Source: http://www.franciscoblaha.info/blog/

In June the European Union (EU) (via DG Mare) enacted two decisions (2014/C 185/02 and 03), warning the Philippines and Papua New Guinea (PNG) that they risk being identified as countries it considers non-cooperative in the fight against illegal, unreported and unregulated (IUU) fishing.

The decision highlights that these countries (in the EU's view) are not doing enough to fight illegal fishing. It identifies concrete shortcomings, such as a lack of a system of sanctions to deter IUU activities or a lack of actions to address deficiencies in monitoring, controlling and surveillance of fisheries.

The decision does not, at this stage, entail any measures affecting trade. Both countries are being given a "yellow card" warning and a reasonable time to respond and take measures to rectify the situation. The European Union has also proposed an action plan for each country to address the shortcomings. Should the situation not improve within six months, the EU could take further steps, which could entail trade sanctions on fisheries imports, as was done recently with Guinea, Belize and Cambodia (IP/14/304).

The decisions follow a long period of informal discussions with the countries in question since 2012. A formal procedure of dialogue with these countries to resolve the identified issues and implement the necessary action plans will now take place.

And as it happens in these cases there is a bigger and longer history behind… PNG and the Philippines have been "fishing bedfellows" for a while now, hence both had to be in the spotlight even if the Philippines carries a much bigger "fault" on this than PNG… they have been quite complacent too.

PNG has a big EEZ and the northern waters are very good tuna fishing grounds, Purse-seining is by far the most significant fishery, accounting for 98% of the total tuna catch (over 700,000 tonnes). Not surprisingly, PNG has an established onshore tuna processing industry with four companies in three locations; these plants collectively employ more than 8,000 workers as well as generating further upstream and downstream benefits.

PNG is an ACP (Africa, Caribbean and the Pacific) country, and as such has tariff-free access to the EU market under the Cotonou Agreement. Duty-free access to the EU market, coupled with the recent Rules of Origin relaxation under global sourcing provisions, enables PNG to compete against lower cost sites of production for exports to the European Union countries.

Philippine companies were clever and over 12 years ago took an early advantage of this opportunity, and diverted much of its processing capacity and fleet to PNG. And it paid off… (but they took a big gamble, PNG is not an easy place).

In parallel, during 1998/1999 (my fist time there) under an Asian Development Bank programme, they came up with a new operating model for its fisheries authority, instead of the usual ministry or department that get its (normally pathetic) operating funds from the Ministry of Finance/Treasury. PNG created an independent National Fisheries Authority (NFA) that directly collects all fisheries-related revenues, covers it budget, and then passes the surplus funds to treasury (a brilliant move).

Fisheries-related income exploded, and as a consequence, NFA has been the best-funded Fisheries Authority I ever worked with… but as we seen before (not only in fisheries) economical expansion and growth need to be accompanied by a parallel development on controls and transparency… and that has not been the case.

In 2013, of the 259 purse-seine vessels authorised to fish and land in PNG, only 15 were PNG-flagged, 43 were PNG-chartered (domestic-based mostly Philippine-flagged vessels) and 201 were foreign vessels fishing under access agreements. Imagine the difficulties arising from managing and controlling such a fishery, particularly when you have various different access agreements and the pressures that distant water fishing nations (with no regards for transparency) can exert.

At the same time, the Spanish-based tuna industry did not like this tuna catching and processing explosion because it relies on foreign-caught whole tuna that it could process there and add value to, hence having that tuna caught and processed by competitors in other places that allowed Spain to enter duty-free their market wasn't part of the idea. They have been on each other case for years now.

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With the introduction of the EU IUU regulation and Catch Certification Scheme, the EU closed its market to fish that cannot be proven to come from legal origins, and that it is the exclusive responsibility of the "flag State" to validate the certificates, saying that the fish were legally caught. So from that perspective, PNG should only deal with the landings of its "own" 15 vessels, but at the same time deal with tons of certificates provided by other countries and deal with "processing and non-processing statements" over these catch certificates.

But the EU points out:

> "The PNG authorities confirmed their awareness that information on catch certificates issued by flag States for fish directly landed in PNG for processing are regularly incorrect. This incorrect information in catch certificates is mainly due to the fact that PNG authorities do not share data available to them, in particular Vessel Monitoring Scheme (VMS) and landing declarations, with the flag State, and not even in cases where irregularities are established. Consequently, the flag State authority has to base its catch certificates on the information available to it, which may be incomplete, incorrect and not verifiable. PNG authorities however sign processing statements in full awareness that the catch certificates issued for the catch processed in PNG are incorrect."

Now this has a few readings: on one side, if the other nations do not have the "the information available to it, which may be incomplete, incorrect and not verifiable" how come they validate their certificates? They should *just not do it* until they get the necessary information. Furthermore, under which authority does PNG become a "policeman" type role where it becomes its responsibility to question the "legality" of these other countries certificates?

Carrying a big yellowfin tuna to the local market (image: H. Walton).

Now this does not exonerate PNG of responsibilities under Port State Measures and it is very clear as well that they have not lived up to their own required standards in terms of monitoring, control and surveillance, and licensing arrangements, where lack of transparency and clarity leads to a confusing situation, particularly with their bilateral arrangements as "special conditions" are applicable to approximately 80% of PNG fishing licenses.

So my job here is to support capacity building of the NFA personnel that may strengthen its role to satisfy their international obligations and the EU's objections.

Further context

In parallel to all this, PNG is going trough a resources explosion bonanza… gas, oil, mining and so on are fuelling the economy to an incredible pace, and with that the issues of transparency and the dripping down effect of wealth are major. Added to that, the country pretty much went from a completely fragmented tribal structure to a fully independent nationhood in a period of less than 100 years. Politics are quite complex here (a year ago the country had two parallel governments at once!). Infrastructure is very basic on one side and completely out there on the other (I have seen there the biggest helicopters ever).

And you do not have to dig deep to find that clan structure and traditional beliefs are still very present, almost in your face (if you are a good observer) along the latest mobile phones, late model Land Cruisers, fully fenced compounds, great smiles and full on, in your face violence and danger.

I am not even mentioning the untouched beauty of some of the places and the difficulties of making a nation with over 700 distinctive languages.

I never worked anywhere as challenging and fascinating as PNG, and after so many years I come to work with friends. Yes, they have many issues, but they are doing what they can with the same right to make mistakes the rest of the world has made over 1,000 years without punishing scrutiny.

Disclaimer

The EU made a game changer with the IUU Catch Certificate and the IUU regulation, with all its intrinsic failures it requires countries to upgrade their fisheries control systems and that is a good thing. We just need to make the system better and fairer. Furthermore, while the EU makes the rules (beyond how good they are) they also provide assistance to countries. I'm here via funds from the New Zealand government and a EU-funded programme.

In a nutshell: Microplastics and fisheries

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An important and emerging issue for fisheries in the Pacific is the increasing prevalence of microplastics in ocean habitats. Recent evidence suggests they present increasing physical and toxicological risks to marine organisms (Law and Thompson 2014; Teuten et al. 2009) with the potential for compromising Pacific food security and trade initiatives. Furthermore, there is mounting evidence of their increasing abundance and global distribution (Cole et al. 2011; Law et al. 2010). This includes the coastal and oceanic habitats in the Pacific region.

What are microplastics and how do they get into our oceans?

Microplastics are microscopic particles of plastic typically smaller than 1 mm but also includes plastics that are less than 5 mm. The sources of this type of pollutant are diverse (Browne et al. 2011). Some are the direct result of small granules that are manufactured for industrial applications (e.g. microbeads, resin pellets) that enter marine ecosystems through accidental spillage (both at sea and on land), and failure to adequately contain waste from processing plants and their inappropriate use (Cole et al. 2011; Thompson et al. 2009a). Others are formed in the marine environment as a consequence of the breakdown of larger plastic material (Thompson et al. 2009a). More recently, studies have identified diffuse origins of microplastics such as the shedding of synthetic fibres from textiles by domestic clothes washing and from the use of microbeads in the cosmetics industry (Browne et al. 2011). In both of these cases the microplastics enter marine ecosystems through poor wastewater management (Browne et al. 2011).

Although the sources of microplastics may be localised, due to their buoyancy and longevity, they can become distributed throughout the marine environment through hydrodynamic processes (Law et al. 2010; Lebreton et al. 2012). Densities of microplastics are reported to be higher in regions that are nearer to the point source of the pollution, such as urban centres, harbours, and coastal habitats (Barnes et al. 2009; Claessens et al. 2011; Desforges et al. 2014; Todd et al. 2010); however, they are also reported in the coastal sediments of remote islands where there is little or no local plastic production (Baztan et al. 2014; Ivar do Sul et al 2009; Ivar do Sul et al. 2014; Pruter 1987) and in the open ocean, in particular, accumulations within subtropical gyres (Goldstein et al. 2012; Law et al. 2010; Lebreton et al. 2012; Martinez et al. 2009; Moore et al. 2001). Densities as high as 100,000 plastic particles per cubic meter of seawater have been reported in an area adjacent to a polyethylene production plant (Wright et al. 2013) and 33 particles per cubic meters in the north Pacific tropical gyre (Goldstein et al 2012).

The risk to marine fauna

Information of the ecological consequences of microplastic pollution is nascent; however, there is increasing evidence of direct and indirect effects associated with the ingestion by organisms and the toxic responses from inherent contaminants leaching from the microplastics and from extraneous pollutants that adhere to them (Cole et al. 2011; Teuten et al. 2009). The size of microplastics is equivalent to many plankton species and it has been hypothesised that planktivores, filter feders and suspension feeders passively ingest microplastics during normal feeding patterns (Wright et al. 2013). Once microplastics settle into sediments, they also become available for incidental ingestion by detritus feeding organisms (Murray and Cowie 2011; Thompson et al. 2004), including sea cucumbers (Graham and Thompson 2009). The ingestion of microplastics is hypothesised to have the same effect as that observed for ingestion of macroplastics in vertebrates, including internal and/or external abrasions and ulcers, and blockages of the digestive tract, resulting in reduced reproductive fitness, and increases in natural mortality rates due to increased potential for drowning, diminished predator avoidance and impairment of feeding ability (Wright et al. 2013).

The manufacture of many plastics often includes additives (e.g. polybrominateddiphenyl ethers, nonylphenol, triclosan) to extend the longevity of the product, and these additives are potentially toxic to biota if they leach out during ingestion (Barnes et al. 2009; Browne et al. 2007; Thompson et al. 2009b). Microplastics also provide surfaces for the attachment of other waterborne-pollutants, including metals (Ashton et al. 2010; Holmes et al. 2012), and POPs (persistent organic pollutants) (Hirai et al. 2011; Mato et al. 2001; Rios et al. 2007; Teuten et al. 2009), some of which are endocrine-disrupting chemicals (Rochman et al. 2014). POPs are hazardous humanmade chemicals such as polychlorinated biphenyls (PCBs), different sorts of organochlorine pesticides (e.g. DDTs and HCHs) and brominated flame-retardants. All of these toxins can impact the mobility, reproduction and development, and immune responses and carcinogenesis in wildlife and humans (Barnes et al. 2009; Cole et al. 2011; Teuten et al. 2009). POPs accumulate in fatty tissues of marine organisms. Although bioaccumulation has been detected in marine organisms (Cole et al. 2011; Besseling et al. 2013; Teuten et al. 2009) the importance of microplastics as a vector for magnification of persistent, bioaccumulative and toxic substances in higher trophic organisms remains uncertain (Gouin et al. 2011).

Microplastics may also act as a vector for more indirect ecosystem change. Species that were once restricted by a lack of hard substrate are potentially able to proliferate from the increase in surfaces for attachment (Goldstein et al. 2012; Gregory 2009). The consequences to industries that are reliant upon current ecosystem structures (e.g. some mariculture businesses) may be detrimental if such species are invasive.

The international response

The prevalence of microplastics in the marine environment is likely to increase in the immediate future given the rising consumption of plastics worldwide (Thompson et al. 2009a). International awareness and response on microplastics, however, is gaining momentum. Global initiatives such as the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, the International Convention for the Prevention of Pollution from Ships, and the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter have been in existence for several decades. More recently national initiatives have been initiated. For example, in the United States, legislation banning microbeads has been introduced to the US House of Representatives. Similar legislation has also been introduced to legislators in New York, and recently passed in Illinois and California. The European Parliament has also voted to phase out plastic bags that fragment rather than degrade.

The implications of microplastics for Pacific fisheries

The implications for fisheries from microplastics are poorly understood and largely speculative due to a lack of knowledge in key areas for policy formation. The prevalence of microplastic pollution across the Pacific needs to be clarified. There is sufficient evidence to indicate higher densities in the north Pacific tropical gyre and the coastal habitats of Asia, Japan and the Americas, although information on the prevalence of microplastics in the coastal regions of the Pacific Island countries and other oceanic habitats is missing. Based on observations from other oceans and modelling, microplastics can be expected to be present in those areas as well. A surveillance programme for Pacific Island countries would resolve this data gap but also identify which fisheries are most likely to be impacted. For example, a better understanding of microplastic distribution may assist with planning for sea cucumber aquaculture and/or mariculture investments in the region to avoid potential for lowered performance or product contamination.

Similarly, initiatives to improve food security through increases in fish consumption in the region may be compromised from bioaccumulation of toxins in coastal and oceanic fishes. Designing a surveillance programme that establishes a baseline reference of toxin accumulation in food security species would determine the potential for acute or chronic health consequences for Pacific Island communities from exposure to this pollutant.

A better understanding of the spatial distribution of microplastics and the bioaccumulation in higher order predators may also assist with the trade associated with the region's tuna fisheries. Opportunities may exist to obtain a higher price for products that come from areas with very low or zero prevalence of microplastic pollution.

The longevity and buoyancy of microplastic means that pollutants can cross several jurisdictional boundaries before they settle into sediments. The transboundary nature of the pollutant calls for both regional and national policies to minimise impacts. Developing a regional strategy for microplastics would be an important first step that would guide the development and implementation of surveillance activities, identify risk to industry and trade (e.g. invasive species), and guide the development of appropriate national policies on this topic.

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Shark-watching ecotourism in the Pacific islands: A move towards "payments for ecosystem services"?

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Introduction

Ecotourism based on observing iconic animal species in their natural habitats has become increasingly popular around the world and the Pacific Islands are no exception to this trend. Among these iconic species, sharks hold a special place as an attraction for tourists, including tourists who are not divers. One of the characteristics of this activity is the need for artificial feeding to ensure that there are enough animals present in a specific spot to be observed. So, while shark watching undeniably provides significant levels of income to local economies, it does, however, raise a certain number of problems in terms of its impact on the ecosystem, human safety and even a legitimate distribution of the dividends it generates (Clua et al. 2011). Another advantage of this activity is that it strengthens sharks' economic value in the eyes of decision-makers at a time when these animals are generally being overfished throughout the world (Clarke et al. 2006), in spite of scientific warnings about the need to preserve these super-predators within their marine ecosystems. Against a backdrop in which environmental arguments have shown their limits over the past few decades in terms of providing any real protection, an economic approach appears to be both complementary and necessary to ensure the sustainable development of shark populations in the South Pacific (Vianna et al. 2012). The purpose of this article is to present the general outlines of such an economic approach, highlighting ecotourism as a virtuous use of sharks that makes it possible to generate income while maintaining them in their ecosystem. Nevertheless, this approach is not totally virtuous unless it respects the three fundamental aspects of sustainable development: 1) environmental, 2) social, and 3) economic. This goal will only be reached through the implementation of "payments for ecosystem services" as we will attempt to demonstrate.

Basis of an economic approach to sharks

It was undoubtedly the article by Constanza et al. (1997) in the journal *Nature* in the late 1990s that embodied the idea that the planet's ecosystems can be assigned an economic value, especially in terms of the ecosystem services they provide to humans (see Box 1). This article defended the idea that every ecosystem can be divided up into its various components and services, each of whose value can be estimated on the basis of the data provided by the many different studies that describe and quantify biological functions, before shifting over to the economic domain. These values, divided on the basis of "use values" and "non-use values", range from the most tangible such as the price that can be gained from selling all or part of a natural asset to the most abstract such as the value attributed to the continued existence of that asset for the enjoyment of future generations (heritage or bequest value). The cumulative sum of all those values leads to the concept of "total economic value" (TEV), which obviously can be applied to sharks (Fig. 1). This TEV concept is far from perfect conceptually (see Box 2), but it has the merit of making it possible to grasp the diverse range of values that can be attached to a natural asset. That is, how to differentiate from among the direct use values, those that are "consumptive" and those that are not. Consumptive direct-use values are mainly based on fishing, which provides a profit from shark catches by selling products such as their meat, but more particularly their fins, which gives rise to a very profitable business. However, this use is consumptive because it contributes to the disappearance of sharks from their habitat with some well-known adverse effects, particularly through cascading effects on ecosystems (Myers et al. 2007). Such uses, therefore, appear less sustainable than non-consumptive direct uses, which keep the animals in their ecosystems. The best example of a non-consumptive direct-use value is nature tourism or ecotourism (Fig. 1).

Economic value of shark-watching ecotourism

Shark ecotourism first developed in the late 20th century but mainly involved whale sharks, *Rhincodon typus*, a plankton-eating animal that is more like whales in ecology and behaviour than carnivorous sharks. Economic analyses of the dividends drawn from observing this animal were done in Australia, which is still the top site in the world for this industry, which began in 1989. In 2006, each tourist in the Ningaloo Reef region

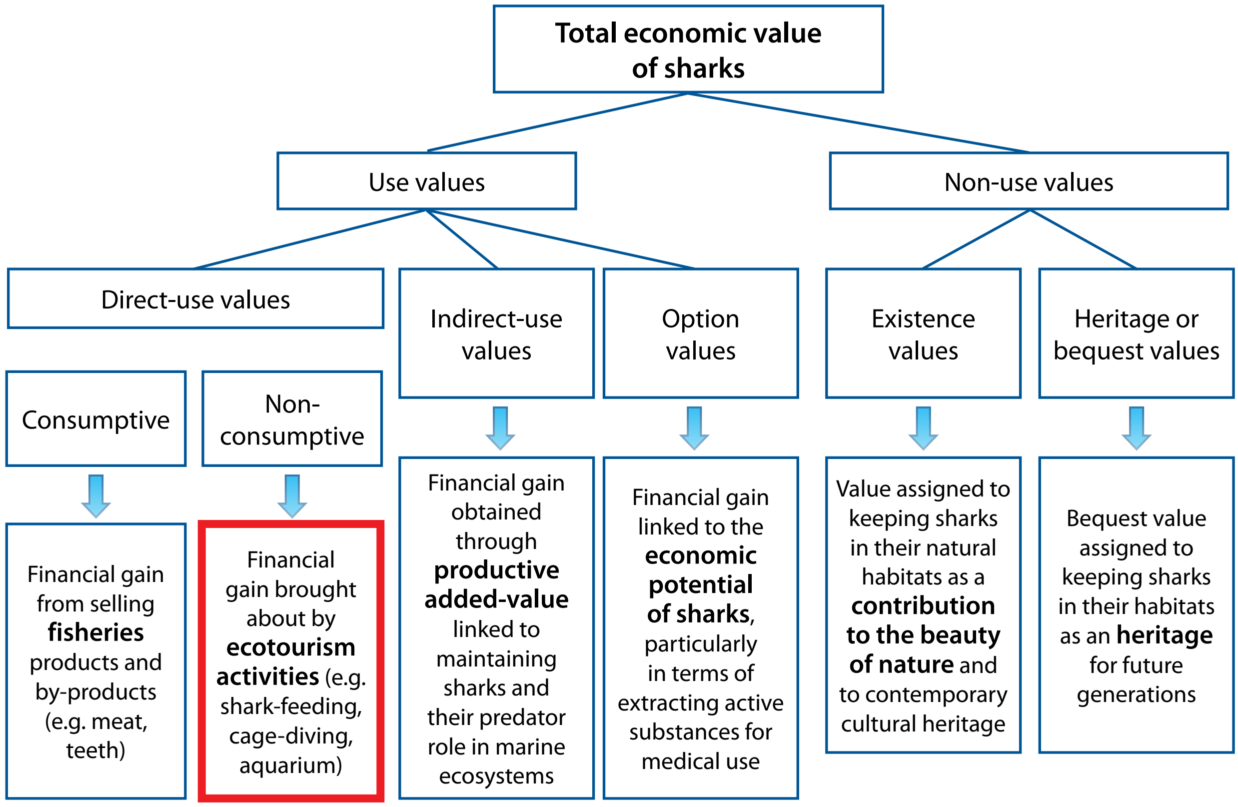

Figure 1. Chart of the total economic value of sharks. This chart gradually moves from the most concrete values on the left to the most abstract ones on the right.

of Western Australia spent about USD 758 per shark-watching trip and the cumulative annual total for all tourists was about USD 5 million (Catlin et al. 2009). Diving trips to spot carnivorous sharks also began in New Caledonia in the 1990s. Artificial feeding there focused on grey sharks (*Carcharhinus amblyrhynchos*) in Boulari Pass, just outside Noumea. However, no data have been published on the economic impact of this activity (which came to an end in the early 2000s after several accidental bites), without the authorities having to take any action. It was at that time that shark feeding began in Fiji on the island of Beqa (south of Viti Levu), to observe bulldog sharks (*Carcharhinus leucas*) (Brunnschweiler 2009), an activity that continues today. The eastern Pacific, particularly French Polynesia, also witnessed the development of this activity at the end of the last century. Based on a more than five-year study on a cluster of sicklefin lemon sharks (*Negaprion acuridens*) on the island of Moorea, it was shown that a "resident" lemon shark " (which serves as the basis for the quality of the ecotourism service sold) yields an average annual economic benefit of USD 370,000 (Fig. 2) and that the 30 or so sicklefin lemon sharks involved in shark-diving tourism brought in about USD 5.4 million to the island of Moorea. The study concluded that "when a live shark is involved in ecotourism, it has an intrinsic higher value than a shark that is caught" (Clua et al. 2011). More recently, the same type of study, designed to demonstrate that keeping sharks alive brings much more into local economies than fishing does, was carried out in Palau and concluded that shark-based ecotourism generated USD 18 million per year, contributing 8% of the country's gross domestic product, particularly through an annual payroll to operators in Palau of USD 1.2 million (Vianna et al. 2012). Some authors even attempted

Box 1: What is an ecosystem service?

The most commonly accepted definition of "ecosystem" or "environmental services" is the one given in the Millennium Ecosystem Assessment (MEA 2005), which stated that these are the benefits people obtain from ecosystems without having to act to get them. "Services" have to be distinguished from the "ecological functions" that produce them: ecological functions are the natural functioning and maintenance processes of ecosystems, whereas services are the result of those functions. Such services are, for example, producing oxygen in the air; naturally purifying water; or the biomass that feeds domesticated, fished or hunted animals.

Box 2: Is the "cost–benefit analysis" approach more effective and illustrative than "total economic value" (TEV)?

The TEV concept is often rightfully contested by certain environmental economists as, while it is fully justified to assign an absolute "monetary" value to very concrete aspects such as the price of products from fisheries or those inherent to ecotourism (set by existing markets), this is a much less plausible approach for the much more subjective dimensions related to culture or heritage. Caution needs to be taken in assessing such values because the use of the contingent valuation approach (or of "willingness to pay"), consists of asking people how much they would be ready to spend in order to maintain a certain species in its natural habitat. This approach is less open to criticism when a relative line of reasoning is used by asking people to list certain natural assets in their order of importance (joint analysis method). In any event, the economic cost–benefit analysis does have many advantages with regards to such approaches, which are based on human behaviour and, therefore, subject to bias. It consists of calculating the economic differential that exists between the cost of investing in a conservation or economic development activity and the economic benefits that can be drawn from that activity. So whatever the absolute value of the asset that this method is applied to (which may be of questionable accuracy), the economic differential between investments and benefits remains much more precise and legitimate conceptually, even if it does add a measure of incertitude linked, for example, to the discount rate. A concrete example of this approach is based on calculations done in Kiribati that showed that the economic value of sharks in terms of the increase in reef fisheries productivity, even without being combined with other existence or option values (related to ecotourism), was more advantageous than the current benefits provided by finning (fishing method consisting of simply removing sharks' fins before releasing them into the wild without any hope of survival) (Walsh and McCormick 2009)

to calculate the overall non-consumptive direct-use value for sharks worldwide by identifying as many existing operations as possible across the planet. An initial summary identified 376 ecotourism operations at 83 different sites in eight large geographic regions. In one case study, this analysis also showed that sharks' non-consumptive use values were higher than their consumptive use values (Galagher and Hammerschlag 2011). Finally, a more recent analysis evaluated the annual number of tourists who pay to watch sharks at about 590,000, a budget of more than USD 314 million. This budget is currently less than the USD 630 million that shark fisheries bring in but we have to consider the fact that shark catches are declining due to overfishing and if the upward trend for ecotourism continues, the number of shark watchers could double over the next 20 years and the annual budget could exceed USD 780 million (Cisneros-Montemayor et al. 2013). So the economic value of shark ecotourism is already significant around the world and it is rising rapidly. The South Pacific is no exception to this trend and, in that regard, is well placed for setting up sustainable development mechanisms for sharks by recovering part of the flow of revenues generated by tourism.

Figure 2. According to Clua et al. (2011), during its 20-year lifespan, a French Polynesian sicklefin lemon shark involved in ecotourism activities can bring about USD 2.64 million into the local economy (image: E. Clua).

Need to implement "payments for ecosystem services"

As we have just seen, we should accept the fact that nature, through all the ecosystems around the planet, provides "services" to humans. We have also shown that sharks contribute to that phenomenon, particularly through fisheries or ecotourism, and that the latter activity generates considerable revenue, which is vital for certain Pacific Island economies. Such income is even more important because at the present time, these services are provided free of cost to humans. This comment obviously also applies to fisheries. Everything would be perfect if nature had an unfailing ability to provide this service or, at least, to ensure that the service is ongoing and consistent. But such is not the case for sharks because human activities impair the service. This is obvious with fisheries, which, due to their uncontrolled nature, have a negative impact of shark populations' ability to regenerate, going so far as to threaten the survival of certain species (Field et al. 2009). It is less obvious with ecotourism but the risks of abuse likely to alter balances within the ecosystem do exist. The main threats are changes to the animals' biology, with a risk of them becoming accustomed to unhealthy food (keeping them from varying their diets), increased parasitic infections (linked to the concentration of animals in a limited space), and increased interbreeding (linked to an increased attachment to feeding sites and changes in natural movement). On a broader scale and in relation to the animals becoming used to staying a single spot, it can also be assumed that they will no longer be present in other parts of the ecosystem to play their role of predators (Clua et al. 2010). From a fully pragmatic, economic perspective, it does, then, seem worthwhile to set up financial mechanisms to make it possible to re-inject part of the dividends from ecotourism into maintaining or even restoring the ecosystem service this activity is based on. This is the "payment for ecosystem services" (PES) principle. The resulting funding, in the form of payments by beneficiaries (service providers and users) of ecotourism activities, which would not undermine their profitability, could serve to support various actions to promote the sustainable development of shark ecotourism.

Figure 3. A Solomon Islands fisher with a shark whose dorsal fin and the bottom half of the tail fin he has just removed to meet the demands of the Asian market for such products (image: E. Clua).

Possible uses of "payments for ecosystem services"

The three pillars of sustainable development are economic, environmental and social concerns, which continually interact. With regards to shark ecotourism, the economic aspect is well developed, as we have shown. In contrast, in general no significant attention is currently being paid to the environmental and social aspects. For the environment, part of the funds recovered by public authorities should be reinvested in two areas. The first is scientific support for shark-feeding operations to ensure that such operations are harmless for the animals and the environment as well as for people in terms of safety (managing the risk of accidental bites, which have a very negative impact on the activity as they frighten off potential customers). Such scientific monitoring would make it possible to reduce such incidences by making recommendations about activity management in real time (e.g. a halt in feedings during key periods of the year when breeding competition, combined with competition for access to food, creates a temporary increase in the aggressiveness of certain animals (Clua et al. 2010). The second area concerns implementing shark protection and conservation measures, particularly through mechanisms such as marine protected areas. This is the case in Palau and in French Polynesia, where enough sanctuaries to protect sharks exist but where the resources to ensure effective surveillance are inadequate and could be strengthened through PES. For the "social" aspect, consideration must be given to the fact that when the government decides to protect sharks, particularly by promoting development through ecotourism, this is often done to the detriment of fishers, who lose a food or trade resource (Fig. 3). So, it would be good for part of the PES to be used to compensate the efforts made to no longer fish for sharks; for example, through actions to promote sustainable fisheries techniques that would benefit the fishers involved, such as deploying fish aggregation devices not too far from the coast. If their legitimacy and effectiveness needs to be shown, such compensatory mechanisms already exist, without being called "payments for ecosystem services" although they are based on the same principle (see Box 3 for an example in Fiji). Concentrating reinvestment efforts on

Box 3: Shark feeding at Beqa, Fiji: An early model of "payments for ecosystem services"?

An ecotourism operation was developed in the early 2000s on the island of Beqa in Fiji, located south of Viti Levu, based on scuba diving to observe bulldog sharks, *Carcharhinus leucas*, fed by the leader of the dive group. In addition to the profits made by the two dive clubs who hire local staff, each of the five villages involved in creating the marine reserve where the spotting dives are made receive an annual budget of about USD 60,000 to be used as they see fit (Brunnschweiler 2009). In particular, these payments help compensate the efforts of village fishers to respect the reserve and not to fish for sharks outside the reserve. Even if this mechanism is not presented as a PES, it adheres completely with its principles and has proven its effectiveness over a period of more than 20 years in the clearly social and potentially environmental domains (image: E. Clua).

environmental and social aspects does not mean that efforts cannot also be made in the "economic" area. It would be possible, for example, and as part of a spiral, for public authorities to use a portion of the PES to promote the country's tourism industry internationally, so as to better sell the "shark ecotourism" destination and lead to higher PES. The existence of mechanisms such as those just described, based on the sustainable development concept, would most probably also prove to be great marketing tools for tourists who are increasingly leaning towards sustainable green tourism.

Conclusion

We hope that we have shown that all of the necessary ingredients to implement PES in the shark ecotourism sector exist, particularly at the legal and judicial levels, in the Pacific, which has recently become a world leader in shark conservation (Techera 2012). Setting up PES in this region would be a first worldwide. Still, while this principle is clear and legitimate, certain legal and institutional hindrances need to be removed. That would require the involvement of those with authority in those areas, who will have to work side-by-side with marine biologists, economists and other social anthropologists, using an extremely cross-cutting and multi-disciplinary approach.

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Presenting a new direction for small-scale marine protected area design

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Introduction

This article presents a new method for conducting coral reef species surveys over a small area and determining priorities for small-scale marine conservation programmes. The method outlined here was first described in a paper published by this author in May 2014 in the journal *PLOS ONE,* titled "Combining natural history collections with fisher knowledge for community-based conservation in Fiji."[1] The work was done by researchers from the Drew Lab at Columbia University in the United States in the summer of 2013.

Small-scale marine protected areas (MPAs) have become increasingly common around the world and especially in the Pacific, with the goal of safeguarding depleted fishing stocks and preserving endangered habitats. In particular, a move towards community-based management efforts has placed the establishment and governance of MPAs in the hands of local groups rather than national governments or international nonprofit organizations. One such example is the village of Nagigi in Fiji, where fishermen are calling for a traditional fishing closure, or *tabu*, to be set up on their local fishing ground, in response to their concerns about overfishing.

No matter who governs an MPA, any successful programme needs a reliable baseline of the ecosystem's health before the start of the programme. Tropical ecosystems in particular are complexly interconnected in ways that make it difficult to gather reliable baseline data without time-consuming and expensive periods of data collection. As pioneering marine ecologist R.E. Johannes put it in the late 1990s, "No other fisheries involve so many species, such complex and diverse habitats, so many fishers, gear types, landing sites and distribution channels per unit of catch. In the face of such Gordian complexity there is little consensus among fisheries biologists concerning even the basic dynamics of such fisheries" (Johannes 1998).

The new method outlined here involves a two-pronged approach to compiling a species list of reef fish that can be used as a baseline measure for the health of a small area of habitat. By gathering data about species diversity using two complementary strategies — destructive sampling[2] on the reef and fisher interviews — researchers could create a much more comprehensive picture of reef biodiversity than they could with either method alone. The two techniques were deployed over a brief period and over a small area, creating a snapshot of the reef's biodiversity at a moment in time. Although in this instance the techniques were used in a coral reef ecosystem in Fiji, it has the potential to be adapted for use in a variety of coastal ecosystems and inshore fisheries around the globe.

Methods

Fish collection

As part of the baseline project, over 200 specimens of finfish were collected on Nagigi's reef using spearfishing and the fish anesthetic MS-222. Fish were identified to the species level using field guides, and then preserved in formalin and shipped back to New York for inclusion in the ichthyology collection of the American Museum of Natural History. This gave us a preliminary measure of the reef's total biodiversity, but without any sense of the relative fishing pressure on various species.

Fisher interviews

At the same time, we conducted interviews with village male and female fishers about their fishing practices, long-term environmental changes on the reef, and their support of a potential conservation programme. Interviews were conducted in English, which is a national language in Fiji, with a Fijian translator available when necessary. Interviews were based on a questionnaire prepared in accordance with Columbia Institutional Review Board protocols for human research, and participants' written consent was obtained. Most interviews occurred in participants' homes, but a few occurred while female fishers fished or gleaned on the reef at low tide, and one

[1] http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0098036

[2] Destructive sampling involves invasive methods. It applies to any procedure that results in the permanent destruction or alteration (sometimes invisible) of all or a part of a natural history specimen for the purpose of performing scientific analyses (source: http://nature.ca/pdf/collections_vds_e.pdf).

interview took place during a kava-drinking session in front of the village hall. Interviews lasted anywhere from about ten minutes to over two hours, depending on context, language barriers, and interviewees' knowledge. For instance, one interview in which participants knew little to no English lasted only ten minutes, while the kava-drinking session lasted more than two hours. In total, 22 villagers were surveyed singly and in small groups across 15 interviews.

Results

Partial species list

In total, we recorded 150 species of finfish on Nagigi's reef. Fijian names were recorded for 82 species, and several additional family-level or generic-level Fijian names were recorded based on interviews. The most species-rich families were Pomacentridae (16.7%) and Labridae (10.7%). Only 11% of the species on the list were both present in the specimen collection and mentioned in interviews, which shows the importance of this dual approach in capturing a full picture of the reef's biodiversity.

Targeted species and fishing practices

Based on the frequency with which it was mentioned in fisher interviews, we determined that the thumbprint emperor (*Lethrinus harak*, Lethrinidae) is the finfish most heavily targeted by Nagigi's fishers. Octopus (*Octopus* spp., Octopodidae) and giant trevally (*Caranx ignobilis*, Carangidae) are also heavily fished, along with several other species in high demand (Table 1). Fisher interviews provided us with details about common fishing practices and life history patterns for several local populations of targeted fish that we could not have obtained otherwise. For instance, a local population of yellowstriped goatfish (*Upeneus vittatus,* Mullidae) spends most of the year in a salt lake inland of Nagigi village but migrates to a mangrove forest on the shoreline once a year to spawn. This spawning event, which occurs between October and November, is an intensive period of harvesting in Nagigi, with the entire village collaborating to celebrate the windfall. Villagers wear fine clothes and flowered garlands for the event, and the fish are shared among the villagers instead of being sold at the market.

Based on interviews, some reef species are fished primarily for selling at the market (artisanal fishing), while others are fished more for home consumption (subsistence fishing). Sea cucumbers (holothurians), for instance, are not eaten in Fiji, but are harvested exclusively for export abroad. In contrast, finfish such as emperors, trevallies, and parrotfish are caught for both home consumption and selling at the market. One female fisher described selling octopus and any fish longer than her forearm and hand (about 40–50 cm) at the market and keeping any

Table 1. At-risk reef species. The most heavily targeted species based on the number of villagers who claimed to target them. Includes perceived changes in the population of these species and the number of interviewees who made these assessments.

Fijian name	Scientific name	Number of times mentioned	Perceptions of population change
Kuita	*Octopus* sp.	8	Decreasing size (n=1) and abundance (n=3)
Kabatia	*Lethrinus harak*	6	Decreasing abundance (n=1)
Saqa	*Caranx ignobilis*	6	Decreasing abundance (n=1)
Kanace	*Moolgarda engeli*	6	Smaller, scarcer, and harder to catch (n=1)
Ulavi	Gray or white parrotfish >30 cm	5	Increasing abundance (n=1)
Vonu	Sea turtles	5	Decreasing abundance (n=2)
Labe	*Halichoeres trimaculatus*	5	N/A
Nuqa	*Siganus vermiculatus*	5	Decreasing abundance (n=1) or increasing abundance (n=1)
Kawakawa	*Epinephelus polyphekadion*	4	Decreasing size and abundance; increased fishing effort necessary (n=5)
Ta	*Naso unicornis*	4	N/A
Tabace	*Acanthurus triostegus*	4	N/A
Dridri	3 *Acanthurus* sp.	4	Increasing abundance (n=1)
Vasua	*Tridacna gigas (giant clams)*	4	Decreasing abundance (n=1)
Deou	*Upeneus vittatus*	4	N/A

N/A = not applicable

smaller fish she catches for herself. Nagigi has a substantial population of Seventh Day Adventists who do not consume or harvest shellfish, octopus or sea cucumbers.

Changes on the reef

We deliberately chose to interview older and more experienced fishers for this project, and our participants had an average age of 50. Interview subjects had an average of 44 years of experience fishing on Nagigi's reef although levels of experience varied; one young interviewee had just moved from a village farther down the shore, where an MPA had been in effect for the preceding five years.

Villagers claim to have seen a general decline in reef productivity over their years in Nagigi, with the most heavily targeted species becoming smaller, less abundant, and harder to catch in the recent past. Participants described having to go farther or work longer to catch enough fish. Octopus in particular were noticed to have declined; as one villager noted: "Before, they used to catch eight, nine [octopus] sometimes. But now, you can just catch two or three." Two villagers reported that *nuru* (in Fijian, any fish shorter than a finger's length) have become scarce and that inshore coral heads, which are an important source of habitat for *nuru*, have become degraded. Two IUCN red-listed species, the bumphead parrotfish (*Bulbometopon muricatum,* Labridae) and the humphead wrasse (*Cheilinus undulatus,* Labridae) were described as becoming scarce as well. Yellow boxfish (*Ostracion cubicus,* Ostraciidae) have apparently disappeared from the reef entirely.

Participants had varying perceptions of the root causes of the changes they had observed on the reef, and a number of causes were mentioned in multiple interviews (Table 2).

Table 2. Perceived causes of reef dynamics over participants' lifetimes, by frequency with which they were cited.

Perceived cause of environmental change	Number of times mentioned
Increase in fishing pressure for market instead of subsistence, especially for "quick cash"	9
Poaching by outsiders	6
Increasing population of Nagigi	3
Coral smashing, either as a fishing method to flush out *nuru* or by accident while walking on the reef	3
Night fishing	3
Profitability of beche-de-mer fishery and toxicity of injured holothurians	3
Increased cost of living	2
Changing climate patterns and sea level rise	1
Demand for sea prawns from local resorts	1
Unusually hot season in 1998, which placed stress on coral ecosystem	1
Ongoing upstream development flushing sediment and weed killer onto reef	1
Use of duva root as fish poison	2
Use of nets with small openings that catch juveniles	1

Nine villagers attributed overfishing on the reef to an increase in selling fish at the market instead of keeping them for home consumption, especially by young men searching for "quick cash," and six mentioned poaching by outsiders. Other common concerns were Nagigi's recent population increase, which has led to overfishing; night fishing, which yields a higher catch for less effort and can also lead to overharvesting; and the increased profitability of the sea cucumber fishery. Several of these concerns are interrelated, and we found it convenient to represent them graphically in the form of a flowchart (Fig. 1).

Conservation attitudes

All 22 participants in this study supported the establishment of a small, short-term MPA on Nagigi's reef. The MPA's size and location, based on a conversation with the *turaga ni koro* (elected village headman) of Nagigi, were set at one square kilometer on the reef flat and seagrass bed habitat directly in front of the village (Fig. 2). This is by no means the entire area, or even the majority, of the village's fishing ground, and no participants suggested that the MPA should extend farther. Ideas about how long the MPA should last varied considerably, from a single year to ten years or "the longer the better." The *turaga ni koro,* who has been one of the most vocal proponents of the MPA plan, believes that the closure should last five years. Three young men who often fish to make "quick cash" using destructive fishing methods such as night fishing believe that a three-year closure would be enough for most fish, including the International Union for Conservation of Nature red-listed bumphead parrotfish, to regain their former size.

No fishers expressed concern about losing fishing income or subsistence catches during the period of the closure, and several spoke about their apprehension for the future if conservation steps were not taken. As one man put it, "For the sake of future generations, if we want to have an abundance of resources again, we should encourage an MPA on the fishing grounds. Our main concern is that if we're not aware of what's done, future generations won't know what those species are

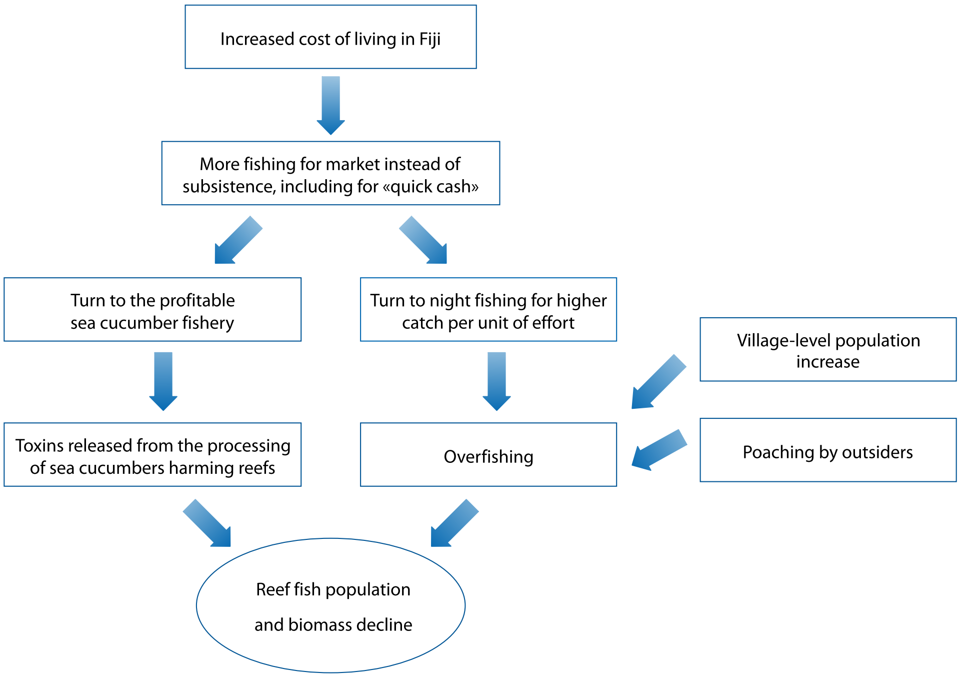

Figure 1. Summary of the perceived reasons for why reef species populations decline.

or recognize the need to gain back what they've lost." Another villager expressed the hope that the effects of the fishing closure would spill over beyond the designated MPA, leading to increased fish populations throughout the village's entire fishing ground. Only one interviewee was sceptical about the MPA plan; she had noticed that when a neighbouring village established an MPA on part of its reef, the villagers came to Nagigi's reef at night to poach. She believes that if an MPA is established in Nagigi, the village's fishermen will do the same.

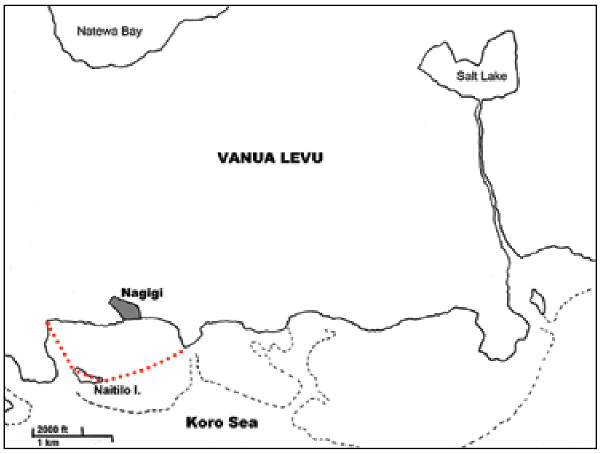

Figure 2. Nagigi's proposed marine protected area covers one square kilometre of reef flat and seagrass meadow directly in front of the village. Black dashed lines indicate fringing reefs, while the red dotted line indicates the marine protected area site proposed by the village's turaga ni koro *(elected village headman).*

Recommendations

Life history and location

One important consideration when designing an MPA is to take into account the life histories and ecological needs of the species that the MPA is designed to protect. Based on the frequency with which it was mentioned in fisher interviews, we designated the thumbprint emperor as one prime conservation target of Nagigi's MPA, and considered its ecological needs as they have a bearing on the protected area's design. Thumbprint emperors use seagrass and mangrove habitats as nursery grounds and then migrate to reef habitat later in their life cycle, suggesting that all three habitats are critical to the population's health (Unsworth et al. 2009). As proposed, the Nagigi MPA would contain small portions of reef habitat and seagrass beds but would not enclose any mangrove forest, leaving juvenile thumbprint emperors vulnerable to fishing pressure. In addition, lethrinids like the thumbprint emperor can move up to 700 m, usually at night, making them vulnerable to poaching and night fishing. To keep them protected under these conditions, Jupiter and Egli (2011) suggest that no-take areas should be twice this length (1.4 km) on each side, for a total area of about 2 km^2. In Nagigi, this would mean doubling the proposed size of the MPA and including a greater diversity of habitats, especially mangrove forest.

Life history and duration

As mentioned above, villagers' estimates of the Nagigi MPA's ideal duration varied widely, from a single year to a long, indefinite period. Villagers had great faith in species' ability to recover in biomass and abundance in a short period, but a closer look at the life histories of heavily targeted species paints a different picture. The thumbprint emperor is a hermaphroditic species that begins life as a female (protogynous hermaphrodite), becoming sexually mature after one or two years, with some individuals making the transition to males at age three or four. Because of this later transition, a short-term MPA of only one or two years would not be enough to protect an entire age cohort of thumbprint emperors through complete sexual maturity.

"Our bank is in the sea"

Nagigi's coastal fishery unquestionably provides an important source of income for its many male and female fishers. As well as providing sustenance and petty cash, it has proved to be an engine of social mobility for particularly skilled fishers, such as the couple who have used fishing income to pay school fees for their four children. As one parent put it, "our bank is in the sea." The treatment of coastal fisheries as a bankable resource that can be saved up (through marine closures) or spent (through fishing) is a longstanding one in Fijian culture, and even predates Western contact. In one recent case documented by Jupiter et al. (2012), villagers on Fiji's Kia Island jointly decided to suspend their MPAs for a few days in order to raise money for community goals. Originally, the villagers aimed to raise FJD 12,000 (~ USD 7,500 at the time), but when they exceeded this goal on the fundraiser's first day, they decided to continue the harvest for five weeks. During this period they netted an estimated FJD 200,000, with a significant drop in the biomass of large-bodied fish such as acanthurids, carangids, and scarids up to a year later. Based on interviews with Nagigi's villagers, it is likely that they, too, will consider opening the MPA for short periods to pay for special projects or to feed villagers. However, as valuable as fisheries products are to communities like Nagigi, the experience of the Kia Islanders emphasizes the extent to which boosting their flagging fish populations will depend on keeping the MPA unbroken for the agreed-on period.

Next steps in Nagigi

In the summer of 2014, members of the Drew Lab returned to Nagigi to continue collections and present the results of this paper to the study participants and other villagers. In response to the ideas recommended here, the villagers decided to expand the proposed MPA across the entire bay in front of the village (see Fig. 2). This will marginally expand the total area of the closure and protect the mangrove swamp in which the yellow-striped goatfish spawns. The reef's thumbprint emperor population will also benefit from the mangrove forest inclusion because mangroves are an important nursery habitat for this species.

Conclusions

Although the recommendations presented here are necessarily specific to a particular location and conservation programme, it is hoped that the general techniques outlined here will be adapted in the future to a variety of different ecosystems and community-supported conservation plans. The "quick-and-dirty" species survey plan outlined above, which uses destructive or visual sampling in tandem with fisher interviews, should be especially well suited to remote and biodiverse ecosystems such as South Pacific coral reefs. The strategy of identifying heavily targeted species through fisher interviews is especially important in this context because it allows researchers to focus MPA or long-term reserve design on the habitat needs of the most vulnerable populations without intensive research efforts. Although MPA size, location and duration recommendations were made based primarily on the needs of, in this case, a single species, the technique can easily be expanded to take into account the life histories of multiple at-risk species.

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New FAD development approach strengthens community-based fisheries management in Vanuatu

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Community-based management is practiced widely in the Pacific Islands region but often, fisheries management and development activities are not well aligned with the social and economic fabric of community life and the rural fisheries development and management priorities of national fisheries departments. Developed during the Japan International Cooperation Agency-funded "Grace of the Sea" project,[5] an initiative to strengthen community-based fisheries through an improved offshore fishing technology using fish aggregating devices, value adding, and capacity building of communities is attracting interest in Vanuatu. The shift in fishing effort from nearshore to offshore fishing, and the increase in the landing and marketing of catches have worked to reduce pressure on reef fish and lobster resources while improving income needs for communities. Resources traditionally harvested for commercial sale such as trochus, green snail, lobster, reef fish and sea cucumber, are no longer heavily harvested because communities have come to realize the need to allow these stocks to recover to economically viable levels. The initiative has been adopted as a model community adaptation to the impact of climate change in the fisheries sector. Several donors and implementing partners are supporting the initiative, including Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), World Vision, New Zealand Aid, Wan Smol Bag Theatre, and the local Game Fishing Charter Association. The Secretariat of the Pacific Community (SPC) FAME Division also established a memorandum of understanding with JICA in July 2012 for cooperation to the implementation and the promotion of the Grace of the Sea project Phase II in Vanuatu.

Background

Reef resources are important in the Pacific Islands region for food security and livelihood; they are, however, under increasing fishing pressure because of an over-reliance on them. Tuna resources in nearshore areas are underexploited yet their contribution to food and income for communities is far less than that of reef resources (Bell et al. 2011). SPC has been supporting its Pacific Island member countries to lessen their over-reliance on reef resources by increasing tuna landings through fish aggregating device (FAD) fishing (Sharp 2012; Chapman et al. 2005). FADs are human-made objects deployed at sea to concentrate pelagic fish in an area for capture. Pelagic fish such as marlin, tuna and dolphinfish are attracted to FADs for various reasons, including shelter, phototactic behaviour,[6] the presence of small prey, the smell and sound of the FAD structure. FADs also act as a breeding area and attract the schooling of certain species (Dempster and Taquet 2005). FADs come in many designs (Anderson and Gates 1996; Chapman et al. 2005) but the common ones used in inshore waters are static FADs that consist of a float anchored to the ocean floor. Static FADs reduce a fisherman's search time (for fish) and fuel costs, provide fishers with a relatively guaranteed fishing ground (fishing location is known), and better catches when compared with trolling in offshore waters (FAO 2012).

But many FAD programmes in the Pacific have encountered difficulties due to the high cost of gear, complicated logistics of deployment, high rates of loss, and a lack of awareness about the usefulness of FADs. In Vanuatu, the initial FAD programme in the 1980s deployed 131 FADs at Efate, Santo, Malekula, Pentecost, Pamma, Lopevi, Epi and Tongoa. These FADs rarely survived more than five months on average, and 24% were lost on deployment. In the early 1990s, FAD fishing was trialled in several Vanuatu islands with the aim of attracting the interest of fishers. But, local fishers at the time were fishing mainly for subsistence purposes and saw little need for FAD fishing (Anderson 1994). FAD fishing was not popular in subsequent years with the exception of modest activity in Efate and south Santo with a few FADs deployed and used by game fishing charter boat operators. While a lack of funding is a common challenge, the lack of awareness about FADs and their usefulness was the main reason fishermen did not make better use of them. FAD development has recently been highlighted as an opportunity to shift fishing effort away from reefs,

[5] Project for Promotion of Grace of the Sea for Coastal Villages in Vanuatu, Phase 2. Supported financially by JICA and coordinated locally by the Vanuatu Fisheries Department the project will last 34 months, from January 2012 until November 2014.

[6] Phototactic behaviour is the movement of an organism in response to light variation.

which would allow coral reef resources to build up and be more resilient to the impacts of climate change. This has led to a renewed effort to develop FAD technology that is economically viable for resource-limited island communities. We present here the results of an innovative approach to FAD fishing development and community-based management in Vanuatu.

Community-based FAD fishing approach

Coastal and inshore ecosystems contain a range of resources for communities: invertebrates, coastal pelagic fish, reef fish, coastal demersal fish, deep-slope demersal fish, and offshore fish resources (Fig. 1). Under the Grace of the Sea Project, communities are trained to: 1) manage their reef resources by developing pelagic fisheries using FADs, 2) improve the processing and marketing of catches, and 3) develop ecotourism. Deep-bottom snapper resources are relatively less abundant and should be tapped only to make up the income shortfall from pelagic catches, while reef fish, sea cucumbers, trochus, green snails and land crabs should not be targeted to allow for their recovery. The marketing of tuna and snapper catches has been focused on local markets (rather than Port Vila) to which communities have easy access, and training assistance has been provided to improve value adding. Opportunities in ecotourism related to the marine environment were assessed and, when possible, developed as an alternative income source for each area.

FAD development and management

FAD design and deployment

A cost-effective FAD design referred to as a "Vanuatu FAD" has been developed (Fig. 2). The submerged component (anchor and rope) is based on the Caribbean FAD design (Horner 2011) and the float component is based on the Indian Ocean design used by SPC (Chapman et al. 2005). The main components are a mix of purse-seine and pressure floats, pieces of purse-seine nets, 12-mm rope, pieces of tarpaulin, plastic bottles filled with sand, mid-water pressure float and a sandbag anchor (Fig. 3a). The lifespan of the synthetic sand-filled bags is supposed to be several years. Sand-filled bags conform to the sea floor bottom, thus limiting the possibility of displacement on slopes as opposed to a rigid cement or engine block. The number of sandbags per FAD depends on the depth and current; a FAD anchored in 300–400 m of water uses 12 sand bags, each weighing 60 kg, and a FAD anchored in 1,200 m of water uses 14 sandbags, or even 16 sandbags in areas with strong currents. The modified FAD is more durable in rough seas or from the impact by a passing vessel.

Prior to deployment, a fishing activity map of the area was drawn up using local experience. The map indicated areas used for trolling and frequented by flocks of birds, reef fishing areas, deep-bottom fishing areas, marine protected areas, wind direction, current flow and bathymetry copied from marine charts. Potential deployment locations were first identified on the map, and then visited in order

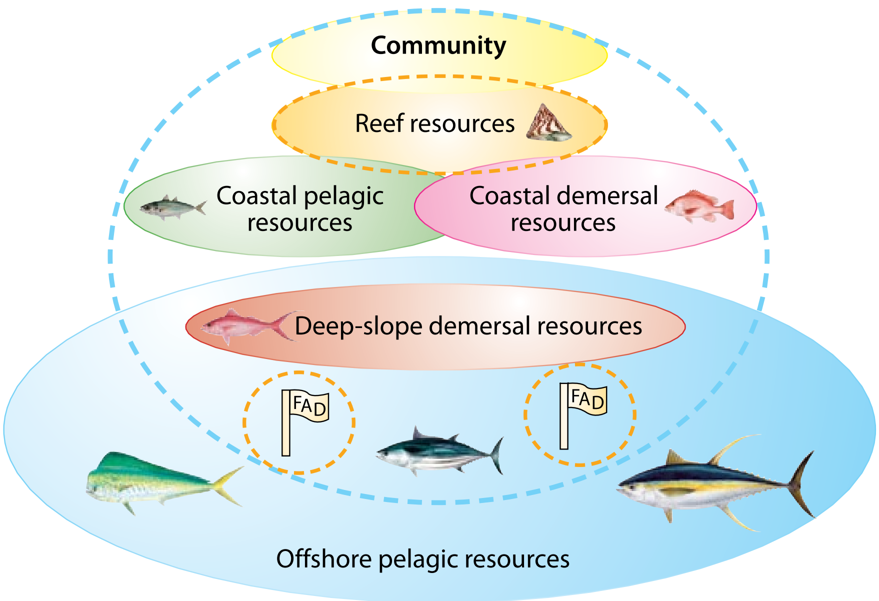

Figure 1. Nearshore and reef fisheries resources available to coastal communities (illustration: Motoki Fujii).

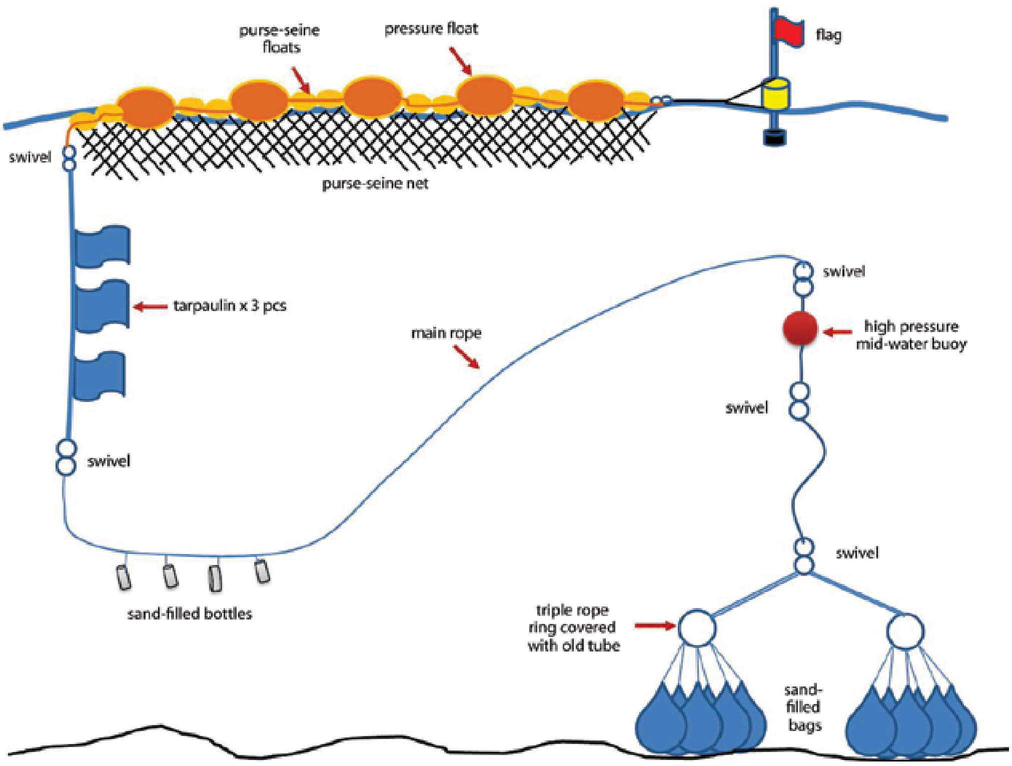

Figure 2. The "Vanuatu FAD" design based on the Caribbean design and the Indian Ocean FAD used by SPC and modified by George Amos, Fisheries Development Officer, Vanuatu Fisheries Department (illustration: Motoki Fujii).

to record depths and positions using a depth sounder and a global positioning system device. FADS were deployed using two small boats (for more details see: JICA and IC Net Limited 2012); one carrying the float and rope, and the other carrying the sandbags (Fig. 3b). At the deployment site, the first boat offloaded the float and rope and moved away. Sandbags were then suspended in the water from the side of the second boat by a rope connecting the pairs of bags. Once the main line was in the water and clear, the suspension rope was cut to let the bags sink to the bottom. A set of three or more FADs was deployed at each site, along tuna migration routes at three miles and eight miles offshore, in the hopes that the FADs would attract schools within the area as they travelled from FAD to FAD.

FAD management and user pay

Community FAD management guidelines were developed for each community. The guidelines set out the rules of FAD use, monitoring and maintenance, safety of fishers around FADs, user registration, and the collection of management fees. FAD development is part of the community's overall community-based fisheries management action plan. A FAD Management Committee was set up in each area to implement the community FAD guidelines in collaboration with the Vanuatu Fisheries Department. FAD users include community members, fishing charter operators and community fishers associations.

Figure 3. FAD construction and deployment at Uripiv, Malekula. a) Filling and tying sand bags; b) En route to the deployment site using small boats (images: T. Takayama).

The only boats allowed to fish around a community FAD are the ones registered by the FAD Management Committee. Non-community members wishing to use the FAD must apply to the respective FAD Management Committee and pay a membership fee to be registered. Troll fishing is permitted 20 m away from the FAD and dropline and deep-bottom fishing are permitted 300 m away. Spearfishing and gillnetting are not permitted around FADs, and mooring to FADs is discouraged. Incomes from registration fees are spent on fuel for monitoring and maintaining the FADs. Monthly FAD checks are carried out on buoys, and six-monthly checks are conducted on line connections. Catch and effort information is recorded in logbooks and submitted to the Vanuatu Fisheries Department.

Fishing technology training

Fishers were trained on using vertical longlines (Fig. 4) for mid-water pelagic fish, deep-bottom snappers, and diamondback squid, and five new trolling gear types (Fig. 5). Diamondback squid has been trialled as a potential "new" fishery in New Caledonia (Blanc and Ducrocq 2012) and Cook Islands (Sokimi 2013). Careful exploitation of this resource could open a new fishery in Vanuatu. FADs can also be a source of baitfish to support other fishing activities, thus the importance of maintaining FAD appendages (nets and tarpaulins) so that the FADs continue to be effective in aggregating small fish. Training was conducted on small fishing boats in collaboration with respective provincial administrations.

Marketing support and value adding

The marketing of fish within the community was based on existing opportunities. At Aneityum, fish caught were sold locally at the Mystery Island tourist market, which has an unsatisfied demand for seafood. Food preparation training was conducted for interested fishers in collaboration with the Provincial Tourism Association and the Department of Tourism. Solar-powered ice freezers were provided as less-costly fish preservation facilities and ice fish-bags were used to keep fish fresh during fishing trips.

As required to export fish to Port Vila market, the community fish market at Uripiv Island, Malekula, was HACCP (Hazard Analysis and Critical Control Point) certified by the Fisheries Department Seafood Verification Unit. Training on shell crafting and equipment support was provided to respective communities, again in collaboration with the Department of Tourism.

Figure 4. new vertical longline gear presented to community members (images: K. Nishiyama and T. Takayama).

Invertebrate restocking

Stock enhancement of commercial invertebrates — trochus, green snail and giant clams — was carried out during the first phase of the project from 2006 to 2009.

Stocks of green snail and trochus from Aneityum Island and *Tridacna gigas* from Tonga were introduced to the Lelema area. The offspring of green snail established in Efate were further translocated to Uripiv in 2013. As part of the initiative, the locally extinct giant clam species was introduced from Tonga and placed in a giant clam garden at Lelema. In addition, hatchery production was developed for locally present giant clam species *T. maxima* and *T. squamosa* for community farming.

Figure 5. New trolling gear.

Results and impacts

FAD fishing reduces pressure

Deployment of more Vanuatu FADs increased in 2012 (Fig. 6) and by the end of 2013, 15 FADs were in the water at Efate, Aneityum, Malekula and Santo. By the end of 2014, 24 new FADs will be deployed: 11 at project sites, and the rest at new sites including Tanna, Emae, Santo, and Vanua Lava in the northern province of Torba. The deepest FAD deployed so far was off Hat Island in a depth of 1,200 m. The cost of the new FAD, including materials, construction and fuel used for deployment, varies by depth: USD 760.00 for a FAD anchored in 300 m, USD 950.00 for a FAD anchored in 400 m, and USD 1,300.00 for a FAD anchored in 1,200 m of water. Transport costs of materials to the deployment sites and the hiring of small boats for the deployment are not included in these costings. Deployment by small boats and the use of sandbags as anchors are major cost reductions and provide a solution to the logistical difficulty faced in the past with heavy cement or engine blocks. On average, two FADs of the new design can be constructed and deployed per day. So far no loss has been recorded since deployment began in 2012, despite the passage of three tropical cyclones.

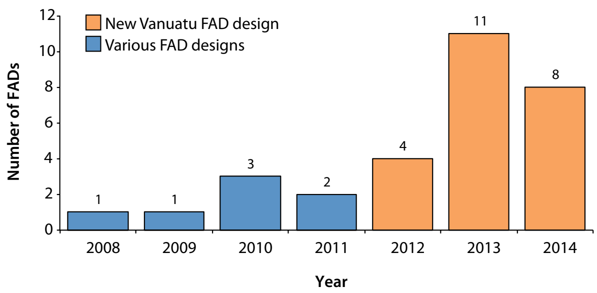

Figure 6. Number of fish aggregating devices deployed in Vanuatu since 2008.

Local interest in the new FAD grew among partners as more communities saw the need for it in their areas. In 2013, four were deployed at south Santo and Hog Harbour, funded by the World Vision Melanesia Office. GIZ has funded two new FADs, which have been deployed at its pilot site at Pele Island on north Efate. The Game Fisheries Association donated materials to the Vanuatu Fisheries Department for an additional 10 FADs. Another 10 FADs were funded by Wan Smol Bag Theater for the Tasi Vanua communities of north Efate. The FAD Management Committees of Uripiv, Lelema and Aneityum have raised sufficient funds, ranging from VUV 100,000 (USD 1,050) to VUV 300,000 (USD 3,150) within a year to meet the cost of at least one new FAD.

The bottom-set, vertical free floating line has made deep-bottom snapper fishing easier than the traditional bottom dropline fishing from a stationary boat. Fishers have come to realize the importance of FAD fishing as a source of economic opportunity other than just for bait fishing. In 2013, the majority (74%) of fishing activities in Anelgouhat, on Aneityum Island, were trolling around FADs for wahoo and tuna, and bottom fishing for deep-bottom snappers (Fig. 7a). This shift in fishing effort towards tunas and snappers resulted in a 95% drop in lobster landings by Anelcouhat fishers between February and June 2013, as fishers no longer relied on lobsters (Fig. 7b). In Uripiv Island, the landing of reef fish dropped by 76% as fishing shifted from the reef to FADs and over deep slopes. Deep-bottom and pelagic species became the main targets both in Lelepa and Aneityum islands (Figs 8 and 9).

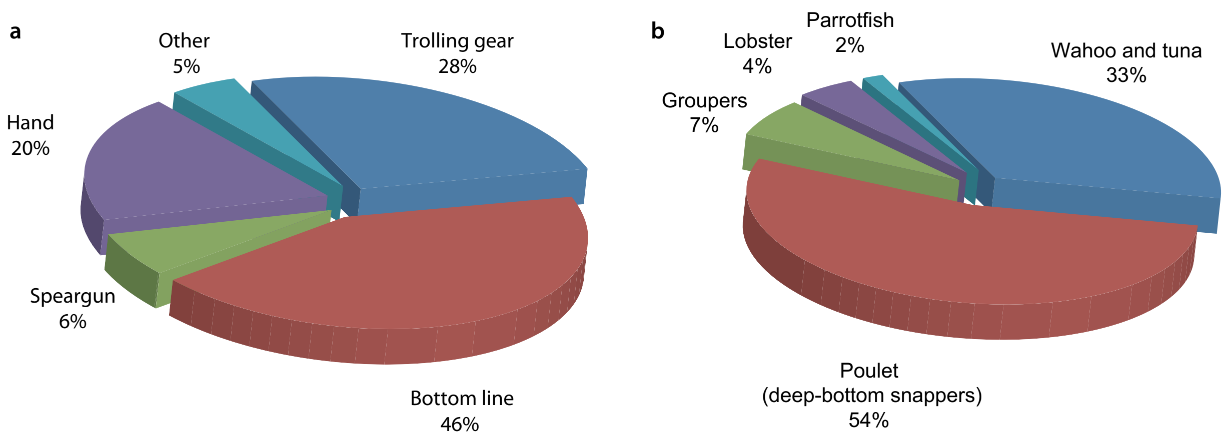

Figure 7. a) Frequency of fishing gear use; b) catch composition for 2013 at Anelgouhat, Aneityum Island.

Figure 8. Deep-bottom catch from Lelepa Island, Efate (image: T. Takayama).

Trial fishing for deep-sea squid landed a diamondback squid for the first time using a small boat and hand reel fishing eight miles southwest of Aneityum Island in November 2013 (see related article on p. 43, this newsletter. This single catch was the third recorded in the region, the first catch of diamondback squid and neon squid were caught in New Caledonia (Blanc and Ducrocq 2012) and in Cook Islands (Sokimi 2013).

Production and marketing of fish

Solar-powered freezers and ice bags with a capacity to hold ice up to eight hours were provided to rural fishers to keep their fish fresh. Catches from Uripiv Island were exported to hotels in Port Vila and Santo. Improved seafood preparations, especially those for snapper and wahoo, have increased sales at the Mystery Island market (Fig. 10). Lobster fishers at Aneityum have decided to raise the minimum harvest size limit of spiny rock lobster to 250 mm — the national limit is 220 mm — to safeguard their stock. Efate is a good market for fish and has so far absorbed catches from the community. Poulet (deep-bottom snappers) are being caught just off the island using bottom-set, vertical free floating lines, which is an indication of the availability of stocks in nearby fishing grounds.

Shell handicraft production

Locally made shell handicrafts are sold at the local tourist markets in Aneityum and Port Vila. Resource owners have realized that their local shells could be worth much more if transformed into handicrafts rather than sold as raw shells. For example, a handicraft producer in Aneityum recently earned VUV 12,000 (USD 130.00) from selling jewellery made from a single trochus shell. As interest grows, more families have purchased their own tools and equipment to make handicrafts (Fig. 11).

Figure 9. Pelagic catch from Aneityum (image: T. Takayama).

Figure 10. A plate of seafood at a Mystery Island market restaurant, Aneityum Island (image: K. Nishiyama).

Figure 11. Shell jewellery produced by community women and presented for sale (image: T. Takayama).

Figure 12. Giant clam garden at Lelepa used as a tourist tour site (image: T. Takayama).

Figure 13. Game fishing charter boat trolling around a fish aggregating device (image: T. Takayama).

Ecotourism and invertebrate stock recovery

Introduced *Tridacna gigas* grown in a garden at Lelema are surviving well and are being monitored by the community and used as part of tourist tour to generate income (Fig. 12). Green snail and trochus, which have been overexploited in the area, have been re-established in a wider marine protected area declared in early 2014 and covering all of the reefs owned by the community of Lelema. Income from fees paid by tour operators are used to fund monitoring and maintenance of the giant clam garden and the marine protected area.

Game fishing charter boat operators are the major beneficiaries of FADs on Efate (Fig. 13). Ten charter boat operators have registered with the Lelema FAD Management Committee and are cooperating to provide catch data to the Vanuatu Fisheries Department. Game fishing activities have been organised at Anelcouhat to support cruise ship visitors. At Uripiv, new moorings have been deployed at Crab Bay lagoon for use by yachts visiting the area, and New Zealand Aid has agreed to assist with the funding of mangrove ecotourism activities in the Crab Bay Conservation Area, which is part of the Uripiv and Crab Bay managed area.

Lessons learned and ways forward

The renewed approach is a working model for rural fisheries development that Vanuatu Fisheries has adopted to strengthen its rural fisheries work. Stock enhancement of trochus and green snail at Lelema has helped re-establish these resources on Efate and the low-cost FAD development and associated fishing technology has revived coastal tuna fisheries development in Vanuatu. Delegating management responsibility to communities has reinforced their sense of resource ownership. User registration for FAD use can be seen as a solution to sustainable FAD programmes. Less costly fish preservation methods using solar power and local marketing of products, as close as possible to each community, have also increased economic returns for communities.

Within a short period, the approach has had a positive effect on reducing fishing pressure on reef resources by 70–80% as seen with the lobster fishery in Anelcouhat and for the reef fish fisheries of Uripiv and Efate. Moving fishing effort outside the reef across the country can be achieved with FAD programmes using the FAD design developed for this project. In a short period, the use of the innovative approach has spread to other communities in Efate, Emae, Malekula, Santo and the Banks Islands, and a increasing number of partners have stepped forward to support the initiative. Community-based management in the three areas where the project was developed was strengthened, with communities deciding to keep their sea cucumber fisheries closed, and to expand their managed areas beyond existing boundaries.

It is hoped that lessons learned can be replicated widely within and outside the country.

For more information

For more information about the Vanuatu community-based fisheries management approach and/or the new "Vanuatu FAD", please contact George Amos, Fisheries Development Officer, Vanuatu Fisheries Department at sio.amos@gmail.com or Graham Nimoho, Manager for Fisheries Development Section at gnimoho@gmail.com.

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Diamondback squid and egg mass record in Vanuatu

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Diamondback squid (Thysanoteuthis rhombus) *is relatively unknown in the tropical Pacific Islands region. An assessment of potential fishable stocks in the region has identified potential stocks of diamondback squid in New Caledonia, Cook Islands and recently in Fiji (Blanc and Ducrocq 2012; Sokimi 2013, 2014). One other method of indentifying potential stocks of diamondback squid is by tracing egg masses (Aiken et al. 2007) and sighting stranded or dead diamondback squid. A first catch of diamondback squid was made at Aneityum Island in southern Vanuatu and an egg mass was sighted at Efate in 2013 as part of the activities of the Japan International Cooperation Agency-funded "Grace of the Sea Project". The findings could indicate the presence of a breeding population of diamondback squid in Vanuatu waters.*

Diamondback squid fishing

The large oceanic diamondback squid (DBS), *Thysanoteuthis rhombus*, is a deep-sea resource that has yet to be exploited in the Pacific Islands region (Blanc and Ducrocq 2012). DBS is present in tropical and subtropical seas around the world. In Japan, occasional sightings of dead and stranded DBS have been recorded since before the 1960s, probably in connection with the seasonal migration of this species along the warm Tsushima Current in the Sea of Japan (Nishimura 1966). The commercial fishery for this species began in the early 1960s (Bower and Miyahara 2005). DBS annual catches in Japan increased from 339 tonnes (t) in 1989 to almost 6,000 t in 2001, averaging close to 4,900 t during the period 1998–2003 (Bower and Miyahara 2005). About 90% of DBS catches are made in the Sea of Japan and around Okinawa. In the Sea of Japan, annual catches ranged from 1,600–3,700 t during the period 1998–2003, while at Okinawa, annual catches increased from 15 t in 1989 to 2,300 t in 2003 (Bower and Miyahara 2005). These increases may have been related to an increase in biomass due to unusually warm temperatures in the Sea of Japan (Miyahara et al. 2006).

In the summer, DBS move to shallower waters along Japan's western coast as they migrate north, following the Tsushima Current (Nishimura 1966). The real expansion of the fishery in Japan began with the introduction of an innovative fishing gear known as *taru-nagashi* (Fig. 1) (Bower and Miyahara 2005).

DBS fishery development in other parts of the world has been slow for two reasons: the lack of proper gear and the abundance of other resources to be exploited (e.g. the Canary Islands; Perez et al. 2012). In the

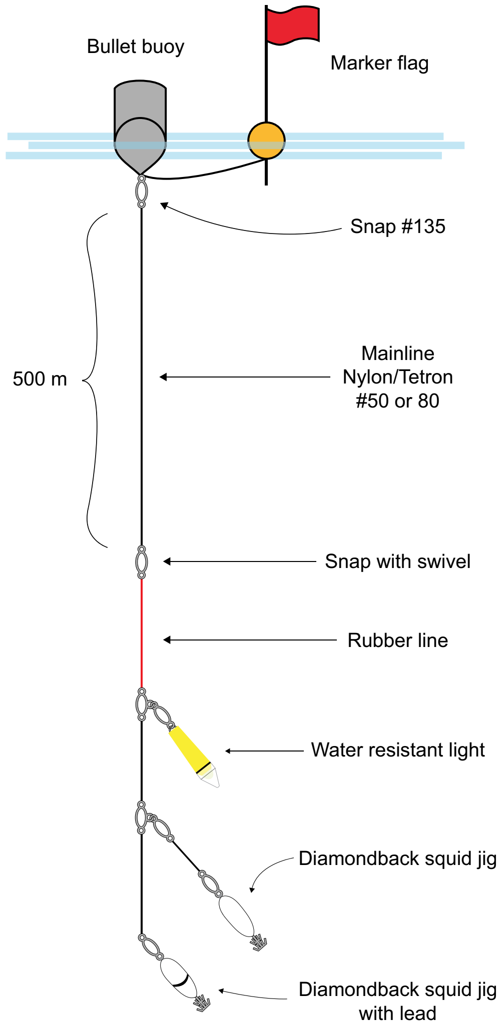

Figure 1. The taru-nagashi *(free floating dropline) gear.*

Caribbean Islands, potential fishing grounds were identified near Grenada and Tobago in 2001 but local fishers were more interested in catching tuna, which was abundant. In the Neves Islands, a small-scale DBS fishery and FAD fishery were developed in 2001 with the support of the Japan International Cooperation Agency, with catches sold to hotels (CRFM 2010). DBS meat in Japan is eaten raw as sashimi and sushi and can also be cooked in several ways.

Test fishing from relatively large (16–37 m) vessels in New Caledonia, Cook Islands and recently Fiji by the Secretariat of the Pacific Community has recorded the presence of DBS and neon flying squid resources (Blanc and Ducrocq 2012; Sokimi 2013, 2014), and more tests are planned for other Pacific Island countries and territories. But test fishing using vessels of these sizes is an expensive exercise. Another way of identifying the presence of DBS stocks is to interview local fishers about possible sightings of egg mass (showing them pictures of DBS egg masses) or dead DBS. The method based on local knowledge about egg masses is known as "the egg trace method". Use of this method in Jamaica led to the location of a DBS fishing ground, which was confirmed by successful test fishing (Aiken et al. 2007). Test fishing can be done from small artisanal fishing craft, which means that it can be done in any Pacific Island country or territory where egg masses or dead DBS are sighted. Here, we report on the first recorded catch of diamond back squid from small boats in Vanuatu, as well as the sighting of an egg mass.

Biology and vertical distribution of DBS

The vertical distribution of DBS varies. During the day it stays deep (at around 400–650 m) but moves to shallower waters (50–100 m) to feed at night, and can be found in depths of 100 m off of islands and down to 500 m in open ocean (Miyahara et al. 2006). DBS grow to a maximum of 100 cm in mantle length and up to 20 kg in total weight. Sexual maturity for both males and females is reached at around six to eight months, and their life span is approximately one year (Guerra et al. 2002; Nigmatullin et al. 1995;).

Sexually mature DBS move to shallow waters to breed (Miyahara et al. 2006; Yano et al 2000). Mating and spawning season in the Northern Hemisphere occurs from November to May and female squid move to shallow waters to lay eggs. DBS egg masses (see Fig. 6): are cylindrical in shape; large, gelatinous and planktonic; vary in length from 0.6–1.8 m and their diameter from 110–300 mm (Nigmatullin et al 1995); changes colour, going from redish-pink before hatching to white after hatching (Perez et al. 2012). Each egg mass contain between 35,000 and 75,000 eggs that are arranged in two rows of spirals over a sausage-shaped gelatinous structure that can be close to two meters in length (Nigmatullin et al 1995).

The redish-pink colour indicates an advanced embryonic stage before hatching; after hatching, the egg mass turns white, indicating the remains of egg shells (Perez et al 2012). Sightings and recordings of DBS egg masses are uncommon worldwide, with only 29 records in total from the Atlantic, Mediterranean and Pacific (Perez et al. 2012). Sightings of DBS egg masses in the Pacific have been recorded in five sites around Japan (Miyahara et al. 2006) and in several sites in Indonesia (Billings et al 2000).

DBS is known to spawn in waters associated with strong currents and throughout the year in tropical regions, and during the warm season in temperate regions (Nigmatullin et al. 1995). The high capture of DBS in shallow waters has been linked to strandings during migration (Nishimura 1966), but it could also be linked to spawning aggregation events. Another indication of the presence of DBS is from sightings of dead DBS in coastal waters due to stranding or natural mortality. But, sightings of dead carcasses of DBS in the Pacific Islands region are rare.

Trial fishing for DBS

In November 2013, trial fishing for DBS was conducted in Aneityuim Island as part of the coastal fisheries diversification activity of the "Grace of the Sea project, Phase II", which was funded by the Japan International Cooperation Agency. The Japanese free-floating dropline gear *taru-nagashi* — a 500-m-long line with two large squid jigs attached at the bottom end and a pressure float with a flagpole at the top end (Fig. 1) — was used for the trial fishing. Squid are attracted to the gear by a pressure-resistant light snapped onto the mainline and above the squid jigs (Perez et al 2012). Fishing technology training for local fishers was led by fishing technology expert Motoki Fujii and local counterpart George Amos.

The gear was deployed during daytime from 7-m-long fibreglass skiffs, 9 miles southwest of Anelcouhat, Aneityum in the vicinity of the offshore FAD, which is moored in 1,000 m of water (20°18.918' S and 169°37.471'E). The weather during the fishing trial was fine, with gentle southeast winds and a moderate westerly current. The gear was hauled an hour after setting the gear, when the pressure float movement signalled a catch. The first DBS caught weighed 15 kg, had a total length of 146 cm, and a mantle that was 80 cm long by 66 cm wide (Fig. 2). The specimen was a fully mature male, identified by its fully developed gonad of 15 cm in diameter and 100 g in weight.

Figure 2. First diamondback squid catch at Aneityum Island, Vanuatu.

Preparation and tasting

In Japan, the meat of DBS is more valuable than that of other deep-sea squids. It is mostly consumed raw as sashimi and sushi rolls. In the Pacific Islands, it is a new food resource that is little known (Sokimi 2013). In Aneityum, Motoki Fujii showed fishers how to gut DBS, identify the sex by the presence the gonads, peel off the outer skin layer and cut the meat into steak size pieces (Fig. 3). Steak pieces were wrapped in plastic for freezing and prepared into sashimi for tasting. Over 95% of the squid is edible, including the skin; the only parts that are thrown away are the teeth, intestinal waste, and a set of fin cartilages. Samples of the meat were brought to Port Vila for more tasting. It was a positive exercise, and people immediately appreciated the taste as sashimi. It was considered far tastier and softer than the meat of the familiar common octopus (*Octopus cyanea*).

Sighting of DBS egg mass

On 5 December 2013, one month after the squid fishing trial, an egg mass was discovered floating in shallow (~ 2 m) water near Havannah Resort at Havannah Harbour, at west Efate by Takuma Takayama. Photos of the egg mass were confirmed by Dr Kazutaka Miyahara, one of the leading Japanese experts on DBS. The colour of the egg mass was between red and pink (Fig. 4), indicating that the eggs were yet to hatch, a characteristic

Figure 3. a and b) Squid fishing expert Motoki Fujii showed community members how to prepare the diamondback squid mantle for local distribution; c) plastic-wrapped pieces; and d) immediate sashimi testing.

already recorded in the Canary Islands (Perez et al 2012). A search on the web allowed finding a similar picture of an egg mass sighting by an unnamed snorkeler in shallow waters of Madang in Papua New Guinea, in 2008 (Fig. 5). These are the only reported egg mass sightings in the Pacific Islands region. Because DBS is fairly unknown in the region, people will unlikely not know what an egg mass is if sighted. Dead DBS carcasses are commonly seen where DBS populations are present and have been used as an indication of existing stocks. However, sightings of dead carcasses are rarely recorded in the Pacific Islands region. Once such sighting of a DBS carcass was reported at Emae Island in central Vanuatu in 2013 (Moses Amos, Director of Fisheries, Aquaculture and Marine Ecosystems at the Secretariat of the Pacific Community, pers. comm.), pointing to another potential fishing ground.

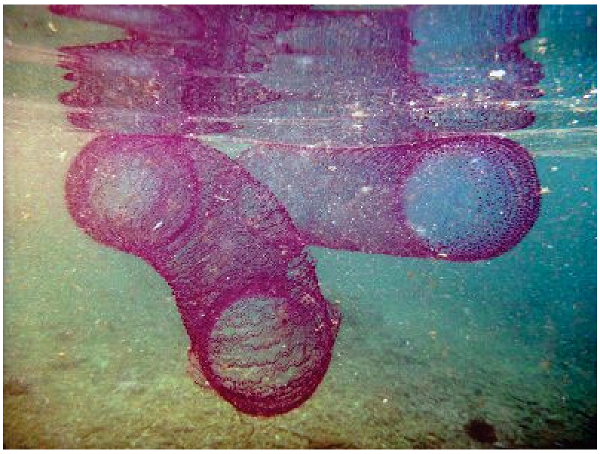

Figure 4. First sighting of a diamondback squid egg mass at Havannah Harbour on Efate, Vanuatu (image: T. Takayama).

Conclusion

Diamondback squid (*Thysanoteuthis rhombus*) has been fished for the first time in Vanuatu waters and could be a source for a potential new fishery. The sighting of an egg mass at Efate and of a dead carcass at Emae Island are an indication of the presence of DBS, and further test fishing could be done to locate new fishing grounds. Raising awareness about DBS, using photographs of adult DBS and egg masses, is needed to increase chances of locating other potential fishing grounds. Fishing trials indicate that small artisanal boats can be used to catch DBS and the Japanese free-floating dropline *taru-nagashi* could be the gear of choice for small-scale DBS fishing in the Pacific Islands. The fishing trial confirmed the successful results of similar experiments done in the Caribbean Islands (CRFM 2010). Further test fishing, following the "egg trace method", or dead carcass sightings are recommended to locate potential fishing grounds.

Figure 5. A diamondback squid egg mass at Madang in Papua New Guinea (source: https://morealtitude.wordpress.com/2008/10/13/, downloaded on Thursday 17 July 2014).

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Hot issues on Pacific Island coastal fisheries

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In early 2014, the Economic and Social Commission for Asia and the Pacific (ESCAP) commissioned a study on the major issues and challenges in Pacific Island fisheries. The paper (soon to be available on the ESCAP website) covers a variety of topics, and this article summarizes the discussion of coastal fisheries "hot issues".

Not everybody involved in fisheries in the region will agree on what is "hot" in terms of coastal fisheries, but it is hoped that the subjects covered and the associated views will provoke some debate. Although many of the issues and challenges covered require extensive discussion for a thorough understanding, the purpose here is to briefly highlight the major points in a concise form. In some cases, an issue might not be the absolute or most critical, but rather an important emerging issue that has not received adequate attention.

Population pressure

Currently, many of the coastal fishery resources are overexploited, especially those close to urban areas where the concentrated population creates the greatest demand for fish. It is likely that in the Pacific Islands region the situation will become worse in the future: two important features of Pacific Island populations are 1) sustained high levels of natural increase throughout most of the Pacific; and 2) urbanization becoming more prominent. The region's population will grow by about one-third in the next 25 years (i.e. an increase in people by "one New Zealand"), with growth especially high in Melanesia. In 25 years, about one-third of the population of Melanesia, one-half of Polynesia, and three-quarters of Micronesia will live in urban areas. Some of thee fisheries implications of population increases and urbanization are:

- ✓ There will be an increase in overfishing conditions due to expanding urban populations and fishing intensively close to those populations.
- ✓ The production from coastal fisheries that are accessible to urban residents will probably decline due to overexploitation and habitat destruction.
- ✓ Given the large population growth, there is likely to be a growing gap between what coastal fisheries can produce and the demand for production from coastal fisheries, raising the cost of fish.
- ✓ A growing number of people in cities will result in a higher proportion of the population not being able to catch sufficient numbers of fish to provide for household consumption.
- ✓ Much more of the coastal fish consumed by Pacific Islanders will be purchased and shipped in from less populous areas, which may equate to exporting urban-type fisheries problems to rural areas.
- ✓ Many of the above points will contribute to more expensive fish.

This situation is especially tragic considering that most fish consumed by Pacific Islanders comes from coastal fisheries. The extraordinarily high consumption of fish by many Pacific Island countries underscores the vital contribution of fish to the food security of the Pacific. Nowhere else do as many countries rely so heavily on subsistence fishing to supply the majority of the protein needed for good nutrition.

Coastal fisheries management: Needs and benefits

With the importance of food from coastal fisheries and their likely decline in productivity of those fisheries in the future, there is a great need to mitigate the factors that may be contributing to the decrease. A large-scale study by the Secretariat of the Pacific Community (SPC) across the region (Pinca et al. 2010) revealed half of all sites studied appear to be exposed to unsustainable fishing on both finfish and invertebrate populations. Some factors may be difficult or impossible to control, but many can be addressed through fisheries management, with reducing excess fishing being the most important at many locations. As stated in SPC policies, strong fisheries management is needed to maximize the yields of demersal fish and invertebrates, and reduce the size of the "food gap" between available seafood and that required to meet the needs of growing populations in the region. Using various management techniques — such as closed areas, closed seasons, and restrictions on the numbers and types of fishers — fishing effort can be reduced to a level where the productivity of a fishery is not greatly diminished. This basic concept is well known to most fisheries specialists in the region. Problems occur, however, when:

- ✓ governments in the region perceive there is considerable opportunity to increase fisheries production — which in some cases can equate to predicating development on "non-existent potential";
- ✓ there is a lack of political will to either allocate adequate resources for effective coastal resource management or give it priority over other activities of the government fisheries agency;
- ✓ governments equate "helping fishers" with providing the means to harvest more fish (often before an election), it is frequently not sustainable and can come back as harming fishers;
- ✓ there is a lack of enthusiasm to encourage and empower coastal communities to address problems with their coastal fisheries. Creating an enabling climate for traditional authorities to effectively manage their own fishing areas has been spearheaded by non-governmental organizations (NGOs) in several countries, but there are often insufficient efforts to institutionalize the concept within the regular work programs of government fisheries agencies; and
- ✓ there is no clear policy for the government fisheries agency that the priority in coastal fisheries should be resource protection, rather than the promotion of increases in production.

The poorly-managed sea cucumber fisheries

Beche-de-mer — dried and processed sea cucumbers — is likely to have been the basis of the first export fishery in the Pacific Islands. Now the trade is extremely important to the region, second only in value to the significantly larger tuna trade. The non-perishable nature of the product and the simple low-technology method of processing make it an ideal commodity for production by rural areas of the Pacific Islands. There is wide recognition that the persistent overexploitation of sea cucumber resources is substantially depressing the overall value of this trade, and in doing so is also creating hardship in hundreds of coastal communities that have come to depend on this fishery as a source of cash income. This situation is being further exacerbated by a lack of transparency in the management and practice of this trade and, where moratoria have been imposed, to significant illegal fishing and trading activity (Carleton et al. 2013).

Processed white teatfish, one of the high-value tropical sea cucumber species (image E. Tardy).

Some notable points:

- ✓ The region's sea cucumber stocks are so depleted that each "boom and bust" cycle yields less than half the volume of product as it did formerly.
- ✓ If it had been managed on a more precautionary basis that moved exploitation away from the boom and bust cycle that typifies this fishery, medium-run revenues derived from the beche-de-mer trade could be double those that have been achieved.
- ✓ The general quality of beche-de-mer processing in the region is not good; greater care and attention is given to processing the high-value species, but overall up to 30% of value is lost due to poor processing (Carleton et al. 2013).

Various techniques have been used by Pacific Island countries to prevent overfishing of sea cucumbers, but their failure has resulted in the necessity of closing down the fisheries in the major producing countries of the region to prevent a collapse of the resource. Such moratoria can have devastating impacts on coastal communities. If even a small portion of the amount of attention that has been focused on the tuna resources of the region had been channelled into sea cucumber management, it is doubtful that the resource would be in such poor condition as it is today.

Clearly, there is justification for countries to invest more in upgrading the management of sea cucumber fisheries. What is good for sea cucumber management is generally good for the residents of the outer islands. The documentation on the region's fisheries makes many useful suggestions, but in order to improve the situation, governments need to give sea cucumber fisheries much more attention.

Small-scale fishers and the large tuna resources of the region

More tuna is harvested in the western and central Pacific Ocean than in any other ocean area. Small-scale fishers take only a tiny fraction of the 2.5 million annual tonne tuna catch in this region — about 2% according to one study (Gillett 2011). Because of the limits of coastal fisheries (which currently appear to have reached their maximum of about 150,000 tonnes annually), it is generally recognized that if Pacific Islanders are to maintain their present rate of fish consumption, there must be greater use of the large offshore tuna resources.

Currently, the various small-scale fishing activities that catch tuna can be placed mostly in three categories: 1) fisheries that target tuna (e.g. alia longlining in Samoa, drop-stoning in many locations); 2) fisheries that target pelagic fish in general (e.g. trolling in Niue, sportfishing in Tonga); and 3) fisheries that are more general in nature, opportunistically trolling and handlining (e.g. the fishing from banana boats in Papua New Guinea and of the fibreglass outboard fleets in Fiji and the Solomon Islands). Small-scale tuna fishing in the region is relatively more important in small, resource-poor islands than in large, fertile islands. For example, Vanuatu has a population of about 245,000 but little small-scale tuna fishing, while Kiribati, with small islands and less than half the population, has a tuna catch from small-scale fishing that is over a thousand times greater.

There have been numerous attempts in all Pacific Island countries to encourage small-scale fishers to harvest larger amounts of tuna. These have included:

- ✓ deploying fish aggregating devices (FADs);
- ✓ governments constructing appropriate small tuna fishing vessels;
- ✓ providing subsidies and grants for vessels and gear;
- ✓ providing hire vessels for offshore fishing;
- ✓ encouraging production of tuna jerky and salted tuna;
- ✓ experimenting with novel tuna products;
- ✓ installing freezers on outer islands for holding tuna;
- ✓ collecting tuna caught by outer islands fishers;
- ✓ establishing schemes for purchasing tuna from artisanal fishers at subsidized prices;
- ✓ longlining from small boats;
- ✓ promoting "ika shibi" fishing;
- ✓ copying Maldivian tuna fishing;
- ✓ promoting small-scale pole-and-line fishing with live bait;

Building and setting fish aggregating devices is one of the few initiatives that has been successful and continues to contribute to the success of small-scale fisheries (images: W. Sokimi).

- ✓ sponsoring overseas study tours;
- ✓ upgrading fishers to medium-scale longlining; and
- ✓ many other schemes.

It should also be pointed out that many government fishery agencies in the region are planning to implement additional types of small-scale tuna fishery development projects.

In reviewing the history of the development of small-scale tuna fisheries, one of the few initiatives that has been successful and continues to contribute to the success of small-scale fisheries are FADs. Despite decades of small-scale tuna development efforts throughout the Pacific Islands, FADs remain one of the few innovations that allow small-scale fishers to economically take advantage of the region's large tuna resources. Other attempts may have had sporadic success or special applicability in one country, but overall, nothing comes close to producing ongoing benefits to small-scale tuna fishers as FADs. Noting the relative success of FADs, it is ironic that very few countries in the region have an effective ongoing FAD programme. By this, it is meant a FAD programme that is financed by national sources (rather than dependent on volatile donor funding) and in which, as one individual stated, "a lost FAD gets replaced in five days, not five months or five years". Although a scarcity of funds is often cited as the reason for the lack of an effective FAD programme, the reality is that, given appropriate priority, such a FAD programme is not beyond the recurrent budgetary resources of most Pacific Island fisheries agencies. It also should be noted that some of the other schemes planned for helping small-scale tuna fishers (e.g. fish collection schemes, grants for vessel purchases) could be both more expensive than a FAD programme and less likely to be successful. Another positive aspect of FADs is that SPC has been actively promoting FAD fishing as a climate change adaption mechanism (Gillett 2003).

The above suggests that any country that is serious about assisting small-scale fishers to take advantage of the large tuna resources should have an active and well-managed FAD programme. Because SPC (which has assisted countries with FADs) simply does not have the resources to deploy and maintain all of the FADs that the region deserves, FAD programmes should be institutionalized within government fisheries agencies in terms of technical expertise and funding.

Management distractions

In fisheries management, the hardest task is often the placing of controls on fishers to prevent resource degradation. Generating the political will for management initiatives, carrying out research, or drafting management plans are not easy, but they are often relatively simple compared with restricting fishers from fishing as they wish to. Examples of such actions are community leaders preventing fishing in marine protected areas (MPAs) large enough to be effective, or a fisheries department blocking the use of scuba gear in spearfishing. In close-knit island societies, confronting fishers and restricting activities can be even more difficult. To avoid this situation, easy alternatives are often sought — so there would be less need to limit fishers.

A number of such alternatives to restrictive management have been used in the Pacific Islands region over the years. These have included re-establishing resource populations through the use of aquaculture ("reef ranching") and the promotion of alternatives to coastal fishing to reduce fishing pressure, including aquaculture, fishing outside the reefs (deep-slope and offshore) and activities outside the fisheries sector. These activities are more politically acceptable than placing restrictions on fishers.[1]

The problem is that these alternatives to restrictive management are not very successful for the objective of mitigating declines in coastal fisheries resources. Although aquaculture, deep-slope fishing, and FADs may have significant benefits and have important roles in economic development, several studies in the region have examined past experience and concluded that these are not effective alternatives to restricting fishing.

- ✓ The implications of reef ranching in the Pacific Islands have been studied with respect to beche-de-mer, coconut crab, mangrove crab, spiny lobster, green snail, trochus, pearl oyster, and giant clam. The conclusion was that reef ranching needs to be considered as part of an overall management approach and not as an alternative to management. Overseas experience underlines the fact that simply releasing large numbers of juveniles into the fishery does not produce population increases unless the fishery is also subject to some form of management that allows the released juveniles to reproduce and thus make a contribution to population growth. Reef ranching should be viewed as one of a set of management tools, and not as an easy way out of management (Preston and Tanaka 1990).
- ✓ Four main types of alternative activities have been promoted in the region to reduce coastal fishing pressure: aquaculture, FADs, deep-slope fishing, and alternatives outside the fishing sector. In reviewing the situation over the last 30 years, it is difficult to identify cases where the use of these activities could be considered clearly successful. Past experience in the use of alternative activities points to

[1] Y. Sadovy (pers. comm. 2014) refers to this ineffective approach as "anything but management"

some important overall conclusions. Perhaps the most important lesson learned about alternatives to restrictive management in the Pacific Islands is that its performance has not been to the level where it can be considered an effective resource management tool (Gillett et al. 2008).

Lack of adequate data on coastal fisheries

Above it was stated that government fisheries agencies typically give low priority to estimating the total amount of domestic catches. In general, the smaller the scale of the fishing, the less is known about production levels, with quantitative information being especially scarce for the subsistence fisheries in most countries. Estimating the production from coastal fisheries in about half of the Pacific Island countries is largely guesswork — in very few countries are the levels of coastal catches well known.

The lack of knowledge of the catches from Pacific Island coastal fisheries is especially troublesome, in view of the concept of "what gets measured gets managed" (and its converse). The lack of data is also a factor in the underappreciation for these fisheries in many countries. Poor data on coastal fisheries production create considerable difficulty in accurately portraying fishery benefits, especially in the areas of gross domestic product contribution, employment and nutrition. The protection of village food fish supplies is arguably the most important objective of the management of coastal fisheries in the Pacific Islands, but to know if such management efforts are effective overall, some idea of the gross coastal fisheries production and its trends are required. In terms of government priorities, it seems that a lack of production information tends to lead to a lack of attention. Because coastal fisheries have great direct effect on the lives of Pacific Islanders, coastal fisheries data collection deserves more attention.

The above should not be taken as an argument for the establishment of systems of ongoing and extensive data collection from the coastal fisheries of the Pacific Islands (i.e. detailed information for stock assessment purposes). Such systems are expensive to the point of rarely surviving the withdrawal of donor support. What is required in most countries are cost-effective mechanisms for periodically learning about major trends in coastal fisheries.

Economic analysis: The need for economic reality in coastal fisheries

In coastal fisheries there is a generally recognized need for greater economic scrutiny of development proposals and the evaluation of economic implications of management options. Seventeen years ago Tiller (1997)

Collecting artisanal catch data in Nauru (image: B. Yeeting).

noted, "For more than 20 years, flawed activities have undermined donor and recipient confidence in fisheries developments and consumed vast quantities of scarce development capital. Even the most tenacious donor is now nervous about fisheries development proposals." That statement is quite applicable today and is especially relevant to coastal fisheries. In the 1980s the assistance provided to Pacific Island countries by the Pacific Islands Forum Fisheries Agency (FFA) included support for the analysis of the economics of small-scale and coastal fisheries. In the early 1990s, when FFA changed its focus to concentrate almost entirely on tuna fisheries, the organization virtually ceased its involvement in the analysis of small-scale coastal fisheries. For nearly two decades, any expertise in fisheries economics was largely consumed by offshore fisheries, both at the national and regional levels.

The task of coastal resource economic analysis was not taken up by SPC or any other regional organization until recently when SPC created the position of "Fisheries Development Officer (Economics)". Although some very good work has come from that economist, he is a "one-man band" and cannot possibly service all of the needs of countries in the region that have no economic expertise available for coastal fisheries. Few fisheries staff at the national level have formal economics training, so the concepts are always new and difficult to grasp in short workshops and courses that SPC is now able to provide.

There is a great need to get basic economic analysis into the decision-making process for coastal fisheries (i.e. countries need to develop a capacity to evaluate, in economic terms, the benefits offered by the various development and management scenarios). It is likely that sustainability, investment decisions and project viability could be significantly improved even with simple economic analysis. An example of this is the situation of rural fisheries centres, which have suffered in most countries from a lack of attention from economists.

NGO involvement in coastal fisheries management: Their appropriate role

From a fisheries perspective, NGOs appear to have played a major role in coastal fisheries management. In the Pacific Islands region they spearheaded the change in focus from fisheries development to fisheries management and had a major role in emphasizing community participation in the fisheries management process. In the region, a very large number of coastal communities have received assistance from NGOs leading to positive improvements in their interaction with their fisheries resources. Those organizations popularized the use of MPAs. Many Pacific Island government fisheries agencies have either directly or indirectly changed for the better through exposure to the work of NGOs.

The work of NGOs is not spread evenly across the region, nor are all NGOs equally effective. It can, therefore, be difficult to make generalizations but nevertheless, some value can come from doing so.

In some respects, NGO success is ironically creating a major difficulty. In several cases energetic, flexible, hard-working, well-funded and well-intentioned NGOs have become involved in coastal fisheries and they often have performed better than the public servants of the government fisheries agency. This has typically been done in a sensitive manner and has resulted in considerable "cooperation" with fisheries officials. This cooperation has, however, on occasion evolved to include taking on regular tasks of a fisheries department — often to the delight of fisheries officials, both in the field and at senior levels as they can use staff and/or funding for other purposes or, worse, be shielded from criticism for inactivity of those staff in coastal fisheries. Fisheries governance is a major problem in Pacific Island countries. NGOs should contribute to improvements rather than usurping the legitimate role of a government fisheries agency — and making the long-term situation worse. The funding that NGOs use does not go on in perpetuity and, even if it is long term in nature, the focus may change with respect to both geographic areas and subject matter.

NGOs need to put more effort into encouraging fisheries agencies to carry out their mandated duties in coastal fisheries, rather than carrying out that work themselves. A final point on this issue is that when an improper role is assumed by an NGO, this may be more apparent to an observer outside the NGO community as is the case of the present study.

Offshore fisheries improvements at the expense of coastal fisheries

Over the previous two decades there have been significant improvements in the management of offshore fisheries, but at least some of that has occurred by drawing human and financial resources away from the management of coastal fisheries. The importance of tuna resources, their benefits to the region, and the value of regional organizations that deal with tuna are unquestionable. The reality is, however, highly experienced and competent staff of the national fisheries agencies of the region tend to gravitate toward tuna fisheries. Because of limited staff, this attention to tuna by senior staff is often at the expense of coastal fisheries. According to a recent FFA Annual Report, 71 tuna-related regional and international meetings and workshops of relevance to the region were held in that year. Attendance at the growing number of meetings on tuna detracts from the attention that can be given by senior staff to the management of coastal fisheries. Routine tasks related to coastal fisheries can often continue in the absence of the "movers and shakers" of a fisheries department, but bold decisions, decisive action, and high-level attention to emerging issues (what is sorely lacking in coastal fisheries management in many countries) is often delayed or downgraded during the absence of senior staff.

This contention is supported by Clark (2006) who stated: "The few people with fishery and corporate management skills are heavily involved in regional fishery meetings and other activities that diminish their capacity to govern national fishery activities".

Coastal MPAs: Over-reliance

In the Pacific Islands there has been a large increase in the number of coastal MPAs established over the last two decades. These have mostly been established by communities with the assistance of NGOs, but government fisheries agencies have also supported the creation of these no-take zones. Govan (2009) indicates that more than 500 MPAs of various types have been established in South Pacific countries.

Benefits of MPAs include habitat and biodiversity conservation, food security, a recruitment source for important marine organisms, and the creation of awareness of the need for conservation. MPAs have also had a role in revitalizing management by communities of their adjacent marine resources. Typically, an MPA is not prohibitively expensive for communities to establish and maintain.

MPAs also have their problems. Many fisheries specialists in the region feel there is currently an over-reliance on MPAs as a management tool (especially by some NGOs); they feel that an MPA should be considered one of a number of mechanisms that can be used to safeguard fish stocks and for other purposes. For example, trochus management using MPAs exclusively is unlikely to be very effective, whereas a combination of a no-take zone, minimum size, and a quota could be very successful. Exclusive reliance on MPAs can be especially detrimental in situations where the protected area is occasionally open to fishing (i.e. an absence of any controls on fishing) or when the MPA has been badly established, such as the area being too small or not encompassing suitable habitat.

Many fisheries specialists in the region feel there is currently an over-reliance on marine protected areas as a management tool (image: O. Carrasso).

Rural fisheries centers: White elephants or useful rural development tools?

Fisheries centers have often been used over the years to promote the commercialization of fisheries in rural areas and outer islands of Pacific Island countries. These facilities go by a variety of names in the region, including community fishing centres (Tuvalu), coastal fisheries stations (PNG), fish bases (Marshall Islands), and rural fisheries service centres (Fiji). Fisheries centers have assumed a very important role in Pacific Island countries, and most countries in the region have many of them. In many countries, the centers are often the largest government expenditure in the fisheries sector and/or consume a substantial portion of overseas aid. In addition, much rural fisheries development in the region is predicated on the centers, and many are planned for the future.

About 150 fisheries centers have been established in Pacific Island countries in the past few decades. One of the most remarkable features of fisheries centers is that few, if any, have been commercially viable. The lack of economic viability does not imply that centers have been a waste. On the contrary, many centers have provided valuable services to the communities in which they were established (e.g. increasing cash income, generally improving standards of living) and to the wider society (e.g. helping to stem rural-urban migration, increasing domestic fish supplies). These social objectives are far less amenable to quantification than financial performance and are likely to be less appreciated by non-villagers.

Handing fisheries centers over to island councils or provincial governments is often the solution when national governments feel burdened by the ongoing expenses of the centers. In many cases it is really dumping the centers on communities that cannot afford to provide the required subsidy.

Reflecting on the overall situation, the outer islands typically have business conditions that are very difficult, the logistics are horrendous, and the people or agencies that operate the fisheries centers rarely have much business experience. On the other hand, the various options for a government to improve the welfare of residents in the outer islands through any sector are quite limited, and promoting the fisheries trade through fisheries centers in many cases may be the best opportunity (Gillett 2010).

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