



# Fisheries Newsletter

NUMBER: 134 (January–April 2011)

ISSN: 0248-076X



Proud of his catch, Vanuatu (image: N. Pascal)

## Editorial

According to the smile of this young fisherman from Vanuatu, there must be some benefits to the establishment of marine protected areas monitored by coastal communities. Nicolas Pascal summarised (p. 41) a cost-benefit analysis he made of five community-based marine protected areas in Vanuatu. Unfortunately, his conclusion is not a complete “thumbs up”, as he notes that “not all investments in MPAs have been recuperated after the first five years, and for some, there is no return on investment even after 25 years of projections.”

Collecting data from artisanal fisheries and developing tools to analyse and use these data for management is a challenge for many, if not all, Pacific Island countries and territories. Guillemot and Ducrocq describe in their article (p. 34) the work done in New Caledonia; how the three provinces have worked at standardising the type of data they collect from fishermen and how relevant management indicators have been developed to monitor small-scale commercial fisheries.

Among the 18 other articles that make up this issue, you will read about some of SPC's work related to climate change (p. 2); efforts made in Solomon Islands to improve food security, using fish aggregating devices (p. 6) or aquaculture (p. 17); training on tuna biological sampling in Pohnpei (p. 9), copepod culture in Australia (p. 23), pearl jewellery in Majuro (p. 19); and more. I hope you find this menu to your taste.

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Secretariat of the Pacific Community

### Climate change study on Majuro Atoll, Marshall Islands

*Climate change and its possible impacts on coastal fisheries resources are well documented. However, no one knows what the scale and intensity of the changes will be or the degree to which these changes will affect people's lives. Monitoring activities are the only means of detecting changes in marine and fishery ecosystems.*

For the first time this year, SPC is implementing the "Vulnerability and adaptation of coastal fisheries to climate change" project, which is funded by the Australian Agency for International Development. The aim of the project is to assist Pacific Island countries and territories in designing and field-testing a monitoring programme that can be implemented by countries themselves over the long term. The pilot study will identify areas that countries need to address when developing long-term climate change monitoring programmes, and will determine whether changes are occurring in the productivity of coastal fisheries and whether these changes are caused by climate change or other impacts such as fishing, pollution and sedimentation.

A set of monitoring methods was selected during a workshop in April 2010 on the "Vulnerability and adaptation of coastal fisheries to climate change: Monitoring indicators and survey design for implementation in

the Pacific". These methods include monitoring water temperature using temperature loggers, fish and invertebrate resource assessments using SPC resource assessment protocols, and habitat assessments using photo-quadrats. Five countries were selected for this pilot study: Marshall Islands (Majuro), Tuvalu (Funafuti), Kiribati (Abemama), Papua New Guinea (Manus) and Federated States of Micronesia (Pohnpei). These countries were selected based on their proximity to the equator where there is likely to be an increase in the intensity of seawater surface temperatures. In addition, these sites already have fish, invertebrate and socioeconomic data collected by the Pacific Regional Oceanic and Coastal Fisheries project, as well as from the Pacific Islands Applied Geoscience Commission multi-temporal image comparisons, and SEAFRAME gauges.

In April this year, two SPC Coastal Fisheries staff (Maria Sapatu, Pacific Islander attachment and Kalo Pakoa, Fisheries Scientist – Invertebrates) were in the Marshall Islands to initiate monitoring by conducting a baseline assessment. For reasons of cost and ease of follow-up monitoring by the trained team, Majuro Atoll was selected as the monitoring site. The team consisted of seven participants from the Marshall Islands Marine Resource Authority, Marshall Islands Environmental Protection Agency, College of the Marshall Islands, and the Marshall Islands Conservation Society.

Background information on the climate change project and on methodologies and materials used for monitoring the benthic environment was delivered at the start of the training. Additional information was given on data entry protocols, quality assurance of data, storage and analysis using the climate change online database. In the field, trainees learned how to lay a transect line and photograph quadrats using a special frame that allows divers to take photographs one meter above the substrate and to record the position of each photo taken at every meter along the transect line using a GPS.

Two stations of photo-gradrat samplings were completed at Laura, on the western side of Majuro Atoll, at the lagoon reef flat and reef front, totalling 18 photo-quadrat transects altogether. The photos will be used to produce habitat baseline information for the western side of Majuro. A similar sampling will be completed in a follow-up survey in May on Majuro's eastern side. The invertebrate resource baseline assessment and preliminary results of the assessment in Majuro are covered in a separate article on sea cucumber resources (see p. 4, this issue).



Maria conducting a photo-quadrat survey.

## SPC ACTIVITIES



Members of the Marshall Islands training team.

The first part of the training was an introduction for the trainees leading up to the second stage of training planned for May. In the second training, temperature loggers will be deployed at Laura, two stations of photo-quadrats will be completed on Majuro's eastern side, and a baseline assessment of finfish resources will be made. The follow-up climate change work will be led by Maria Sapatu while the finfish resource baseline assessment will be led by Being Yeeting, SPC's Reef Fisheries Scientist (finfish).

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### The photo-quadrat monitoring method

A photo-quadrat transect is one where a diver uses a typical quadrat frame and measuring tape, but in addition, takes a photograph at every meter along the transect so that the benthic environment (e.g. live coral) can be monitored over time. The length of the measuring tape, and the area and height of the quadrat frame varies depending on the monitoring focus. For the SPC Climate Change monitoring project, transects are 50-meters long on a selected area of the sea floor. The photographed area ( $\sim 0.25 \text{ m}^2$ ) is taken from a height of about 1 m.

About 1,800 photos will be taken at each pilot site: two stations in a managed area and two stations in an open-to-fishing area. Within each of these stations, three, 50-meter-long transects are laid out in three different reef zones (coast or fringing reef, back reef and outer reef) at depths of 5–15 m. The location of each photograph is recorded in track mode and coordinates of the start and end point of each transect are recorded using a global positioning system for mapping purposes and for re-surveying the same locations. It is planned to repeat the full operation every second year.

Habitat photographs are then analysed using SPC software (available online at: <http://www.spc.int/CoastalFisheries/CPC/BrowseCPC>, see picture), similar to the Coral Point Count (CPCe) analysis software by Kohler and Gill (2006)<sup>1</sup>. This software automatically creates five random points on the downloaded photographs (see picture) for which the researcher must identify the type of substrate by genus level. Results are then summarised in an MS Excel table, averaged by transect/category (genus of corals, algae, etc.) and grouped by class (live coral, dead coral, algae, etc.).

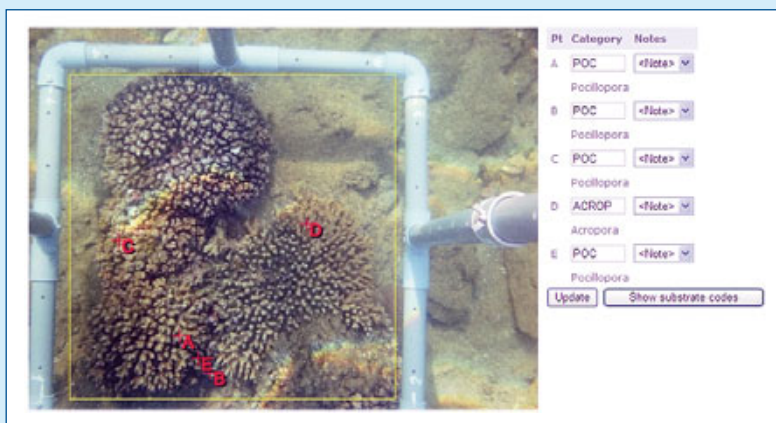


Photo-quadrat showing the five randomly selected points (A, B, C, D, E) that must be identified.

This type of monitoring method presents several challenges:

- Bad visibility and high turbidity of some areas may make details in photographs difficult to see.
- Strong wave action may make it difficult for divers to remain steady when taking pictures.
- The relief of the coral reef may make it hard to stabilise the quadrat frame.
- Depth (5–15 m) can make it very difficult to notice whether the camera and GPS are malfunctioning; double-checking this before starting each dive is very important.

<sup>1</sup> Kohler K.E. and Gill S.M. 2006. Coral Point Count with Excel extensions (CPCe): A Visual Basic program for the determination of coral and substrate coverage using random point count methodology. *Computers and Geosciences* 3(9):1259–1269.

## Managing the Marshall Islands' sea cucumber fishery

*The high demand for beche-de-mer products in Asian markets, and the ongoing trend of resource over-exploitation of more accessible sea cucumber species, has resulted in beche-de-mer buyers and exporters moving to more remote locations to buy beche-de-mer products. In Pacific Island countries, species of lower commercial value are now being targeted because higher value species are becoming depleted. Because mounting pressure to exploit sea cucumbers is outpacing the region's capacity to tighten existing management systems, Pacific Island fisheries agencies are finding it challenging to ensure the sustainability of this resource.*

In the past year, the Marshall Islands Marine Resources Authority (MIMRA) has been trying to manage the fast-developing and vulnerable beche-de-mer fishery. Some problems include 1) the lack of a licensing and permitting system for processors and exporters; 2) restrictions on efficient but destructive methods such as the use of scuba and hookah for collecting sea cucumbers; and 3) poor reporting of processed or export quantities of beche-de-mer. In addition, there are reports of frozen sea cucumbers being sold to large commercial tuna fishing vessels that use Majuro's port for tuna fisheries-related bunkering and transshipping services. Reliable production data are not available but fishing activities have been reported in Ebon, Woje, Maloelap, Arno and Majuro atolls, and prices paid for high value species start at USD 40/pound of dried product. Due to these management constraints, in March 2011, MIMRA introduced a moratorium on commercial exportation of beche-de-mer along with shark fin, until formal management arrangements are put in place.

In 2010, SPC was requested to assist the Marshall Islands in drafting a management plan and associated regulatory measures. Effective control of the beche-de-mer fishery requires better understanding of the resource and the fishery by local research officers. Kalo Pakoa, SPC's Fisheries Scientist (Invertebrates) and Maria Sapatu (Pacific Islander Attachment) went to Majuro to initiate a training for officers from local resource monitoring agencies, including MIMRA, Marshall Islands Environmental Protection Agency, College of Marshall Islands, and the Marshall Islands Conservation Society. The purpose of the training was two-fold: to respond to the Marshall Islands' sea cucumber management needs and to generate baseline information for the climate change monitoring pilot study on Majuro Atoll. Five participants from the four agencies were trained in using non-scuba resource assessment techniques, which are relatively simple to use, cost effective and provide robust data for assessing the status of sea cucumbers. Trainees were trained in selecting habitats and laying the belt



Sea cucumber survey along a belt transect.

transect line, conducting manta tows, using observational techniques, identifying and measuring species, recording protocols, cross-checking and understanding records, using GPS to log station positions, and understanding safety issues. Background information on the sea cucumber fishery in the Pacific region and within the Marshall Islands was provided.

Follow-up capacity building training will involve data entry, analysis, interpretation and reporting of the results by one or two trainees attached to SPC's Coastal Fisheries Programme. A similar field survey will be conducted by the trainees themselves to test the skills they learned.

The data generated from this assessment will provide baseline information for the climate change pilot monitoring study on Majuro Atoll. Maria Sapatu's participation in this training will benefit her work as she expands the implementation of the climate change monitoring pilot studies to the rest of the remaining sites. Preliminary results of the sea cucumber resource assessment show that lollyfish (*Holothuria atra*) and amberfish (*Thelonota anax*) are the most abundant sea cucumber species on Majuro Atoll.

SPC technical assistance was provided under the European Union-funded Sci-COFish (Scientific Support for the Management of Coastal and Oceanic Fisheries in the Pacific Islands Region) project. SPC is also providing assistance to MIMRA staff in preparing a more formal management approach (fishery management plan and regulatory arrangement) for the Marshall Islands' sea cucumber fishery.

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*Trainees Tamera Heine (MIEPA) and Candice Guavis (MIMRA) verify data.*



*Dried prickly redfish at Woje Atoll.*



*Packing beche-de-mer for export from Majuro.*

## FAD assistance to the Solomon Islands Ministry of Fisheries and Marine Resources

*The WorldFish Center (WFC) in Gizo, Solomon Islands in collaboration with the University of Queensland (UQ) in Australia, is involved in promoting conservation awareness of both terrestrial and marine resources in the Solomon Islands. The two institutions are working closely with the Solomon Islands Ministry of Fisheries and Marine Resources (MFMR) to encourage sustainable management of fishing practices in order to maintain the ecological balance of coastal areas. The implementation and management of marine protected areas (MPAs) is a high priority. In order to encourage local communities to comply with the concept of an MPA, MFMR, WFC and UQ realised that they needed to implement alternative activities to help divert fishing activities away from MPAs. This includes shifting fishing effort from reef to pelagic fish species, as well as providing fishermen with alternate means of maintaining food security for their families and communities.<sup>1</sup> Installing fish aggregation devices (FADs) that are accessible to canoe fishermen is one method to achieve this. With assistance from MFMR, WFC and UQ deployed several nearshore FADs in 2008 and 2009 that proved effective in diverting fishing effort; unfortunately, these FADs have since broken away. In an effort to revamp the FAD programme WFC, UQ and MFMR requested SPC's participation in conducting another round of FAD training and deployments.*

WFC and UQ provided funds to purchase FAD materials while SPC's Nearshore Fisheries and Development Section chipped in with AusAID funding. It was agreed that three designs (see Table) would be trialled to observe their durability and design weaknesses. With the combined funding, orders were placed for 40 FADs; 20 SPC-designed FADs, 15 WFC-designed FADs and 5 UQ-designed.

### Technical assistance

Specific objectives included providing technical assistance on FAD construction, site surveys, and FAD deployment. This assistance was carried out by SPC's Fisheries Development Officer, William Sokimi, in collaboration with MFMR, WFC and UQ staff.

The team included Alex Carlos, Lionel Luda, Peter Kenilorea, Alan Alba and George Tavake (MFMR); Willie Kokopu (Guadalcanal Provincial Fisheries Officer); Simon Albert, Albert Chris, Veira Taleilotu and Morgan Jimuru (UQ); Joelle Albert, Cletus Oengpepa, Ambo Teiwake and Regon Warren (WFC); and Andrew Bana (Gizo Provincial Fisheries Officer).

At the end of the project, 11 nearshore FADs had been constructed with 7 of these deployed at selected sites in the Western Province. Four FAD systems were constructed in Honiara as part of a training exercise for MFMR officers but are being kept in reserve for deployment around Guadalcanal at a later date.

The Peava, Biche and Zaira FAD work was mainly a joint effort between MFMR, UQ and SPC while the Pienuna and Obobulu work was between MFMR, WFC and SPC.

The FADs were deployed in depths of 380–450 m and at a distance from the reef edge of 0.6–1.2 km.



Top: Connecting aggregators on the Peava FAD.

Bottom: SPC nearshore FAD after deployment.

The seven deployment sites were surveyed beforehand to evaluate the suitability of bathymetric conditions. Briefings were carried out at each of the villages where the FADs were deployed, and also at Niami and Suava on

<sup>1</sup> See also the article published in issue #130 of this newsletter: Nearshore fish aggregating devices: A means of habitat protection and food security in post-disaster Solomon Islands by J. Prange et al. ([http://www.spc.int/DigitalLibrary/Doc/FAME/InfoBull/FishNews/130/FishNews130x\\_19\\_WorldFish.pdf](http://www.spc.int/DigitalLibrary/Doc/FAME/InfoBull/FishNews/130/FishNews130x_19_WorldFish.pdf))

## SPC ACTIVITIES



Ranongga Island to promote FAD awareness, discourage vandalism, and to highlight the importance of data collection and FAD monitoring. The villages of Peava and Biche are on Gatogae Island, Zaira on Vangunu Island, and Pienuna, Obobulu, Niami, and Suava on Ranongga Island. The communities of all of these villages were consulted and trained in all aspects of the FAD work, which included site selection, construction and deployment.

Two more FADs were initially planned for deployment off the Roviana area on New Georgia Island but these had to be cancelled as members of the Roviana Conservation Federation felt that they still needed to expand their FAD awareness programmes over a wider area first before FADs could be deployed. These awareness

programmes were important for gaining the cooperation of communities to assist in maintaining FADs and to reduce the likelihood of vandalism.

When all FAD work was completed, debriefings were carried out with WFC and UQ staff on Gizo and MFMR heads of sections in Honiara.

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### Three 500-m depth FAD designs

	SPC	UQ	WorldFish
Floating elements	5 pressure floats 4 purse-seine floats 5 m of 20 mm nylon rope (buoyancy: 116 kg, max depth: 200 m)	4 pressure floats 13 purse-seine floats (buoyancy: 145 kg, max depth 200 m)	5 pressure floats 14 purse-seine floats (buoyancy: 180 kg, max depth 200 m)
Connecting parts	SS thimble 16 mm SS swivel (no shackles used) SS thimble and 3 x 5 mm copper swages	One length of rope / no connecting parts.	One length of rope / no connecting parts
Upper mooring	100 m of SS 5 mm wire	100 m x 20 mm nylon rope	Only one length of rope used in the whole system: 600 m polypropylene rope
Connecting parts	SS thimble and 3 x 5 mm copper swages 16 mm SS swivel (no shackles used)	Splice (no connecting parts)	
Lower mooring	500 m of 12 mm polypropylene rope 2 x 1.8 L pressure floats	500 m x 22 mm polypropylene rope 2 x 1.8 L pressure floats	
Connecting parts	12 mm galvanised swivel 13 mm hi-load safety shackle	#3 Nylite connector 22 mm hi-load shackle 22 mm short bow swivel 22 mm hi-load shackle	Bottom end of polypropylene rope spliced directly to anchor girdles with protective plastic hose over spliced eye
Anchoring elements	20 m of 13 mm galv. chain 1 grapnel made with 76 mm galv. pipe and 25 mm rebar	10 m of 20 mm regular link chain Discarded heavy machinery or cement block	3 m of 13 mm chain 2 half-drum cement anchors + one grapnel anchor
Approx. total cost	AUD 1,200	AUD 1,500	AUD 750

## 5<sup>th</sup> Regional Tuna Data Workshop, 18–22 April 2011, Noumea, New Caledonia

*With five workshops under its belt the “Regional Tuna Data Workshop” (TDW) is becoming an important annual feature on the region’s tuna fisheries calendar. The workshop is targeted at Pacific Island National Tuna Data Coordinators (NTDC) who are generally senior fishery officers who play a major role in compiling their country’s annual tuna catch statistics for submission to the Western and Central Pacific Fisheries Commission (WCPFC). WCPFC requires that countries submit the annual tuna catch estimates for their national fleet before the 30th of April. Compiling annual tuna catch estimates for national fleets is the central focus of this workshop and for this reason the workshop is always held in mid-April. This timing allows participants to avail themselves of additional support to finalise their data submission before the WCPFC’s deadline.*

The TDW attempts to offer participants an appropriate blend of plenary presentations and discussions, along with group and individual exercises to explore tuna data issues, but also sufficient time to compile their annual catch estimates and review any country-specific data management issues. Data Management and Fisheries Monitoring staff of SPC’s Oceanic Fisheries Programme (OFP) was again on hand to assist participants in compiling their data, estimating their catches, and offering database training and general guidance. Since its inception in 2006, the TDW has been a forum for offering participants the latest developments in database tools, presentations and reporting formats provided by OFP to streamline the job of compiling annual catch estimates.

That said, compiling annual catch estimates is not a simple step-by-step process. The key is to take time during the year to ensure that available data are acceptable, both in quality and quantity. The TDW takes the time to look beyond the preparation of catch estimates into the many processes that come beforehand and which affect the quality of available data. In the first instance, it is acknowledged that having strong legislative support is a fundamental first step in receiving timely and true data. The Pacific Islands Forum Fisheries Agency (FFA) representative at his year’s TDW explained the different elements of fisheries legislation, and encouraged participants to study their national legislation to see whether it contains the essential elements to support data submissions. The essential elements suggested included:

- a “Head of Power” statement (i.e. one that gives the government the authority to collect data, or places obligations on fishers to supply data); and
- a statement of requirements of what fishers are required to do: who, how, when and what).

These elements can be written into any of the different components of national legislation (e.g. fisheries act, regulations, licensing conditions). However, some thoughts on the most appropriate place for these statements were shared with the group. Finally, but most importantly, having appropriate penalties that are issued consistently

against incorrect and untimely submission of data will guarantee that fishers comply with data requirements. FFA noted that it will review national Fisheries Legislation in a number of countries this year and that it will also support attachments to its legal section to help with this work.

A major part of the workshop focused on the use of current database systems developed by OFP and offered to member countries. The latest developments in TUFMAN (Tuna Fisheries database Management for commercial vessels) — TUF-ART (for artisanal vessels) and TUBs (for observer data) — were presented, and exercises were used to reinforce newly acquired skills. The exercises were well received and some participants strongly voiced their recommendation that the proposed regional TUFMAN training workshop be conducted as soon as possible. A further session allowed participants to suggest the areas they would like future database development to focus on.

Auditing is a word that is mostly associated with financial systems, but the concept is also used in tuna fishery data to identify weakness and to suggest improvements to enhance data quality. The concept of self-auditing



*Left to right: Vakuru Bola, Leontine Baje and Thomas Usa, from the National Fisheries Authority, Papua New Guinea.*



*Alitia Cirikiyasawa (left) and Hilda Lobendahn (right)  
from the Ministry of Fisheries and Forestry, Fiji.*

countries can identify them. The auditing topic evolved into a broader overview of how databases can be used to reconcile different data types and to identify data gaps. It included a presentation on the use of vessel monitoring system data to check the coverage of logsheet data submissions.

Invitations to the workshops are sent to all SPC member countries, as well as the Philippines, Indonesia and Vietnam, which also provide data and annual catch estimates to WCPFC. To further convey the ideas shared at the TDW, the information feeds into national tuna data workshops, and previous and current workshop material is made available on SPC's website at <http://www.spc.int/oceanfish/en/meetingsworkshops/tdw>

was first introduced in earlier workshops. To give participants practical experience in a self-auditing, an enjoyable practical session was offered during the 2010 workshop. Participants were asked to “audit SPC’s port sampling programme”. There were a few smiles when SPC’s Observer and Port Sampling Supervisor (Peter Sharples) threw in a few deliberate mistakes to see if participants could spot them. The theme of auditing continued at the 2011 TDW with a presentation on typical problems encountered in logsheet reporting and how

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## Biological sampling workshop in Pohnpei

*The first observer trainer training in the Pacific region was held in April in Pohnpei, Federated States of Micronesia (FSM). Nine participants from fishery departments in FSM, Kiribati, Marshall Islands, Papua New Guinea and Solomon Islands were trained in using biological sampling techniques and their related data recovery. Caroline Sanchez and Malo Hosken from SPC’s Oceanic Fisheries Programme delivered the courses and workshops. The objective was to teach and train participants in understanding the role of biological sampling and the importance of correct data collection for scientific studies and research.*

The training included various seminar presentations and practical workshops, which were held at the Western and Central Pacific Fisheries Commission. Participants learned about the various types of biological information and samples that could be collected and their use in scientific assessments, as well as the importance of quality tag recovery data. The practical workshops demanded participants to demonstrate adequate skills for identifying and collecting suitable biological samples such as stomachs, gonads, and livers. The more challenging part of the training for participants was mastering different otolith<sup>1</sup> extraction techniques. Depending on whether the fish needs to be in high quality condition, or whole for market purposes, different techniques can be used to extract otoliths, using various tools such as drills, cutters or saws. Otolith analysis (generally, incremental counts)



*Trainees Elton Clodumar, Ramon Kyle Aliven and Benaia Bauro  
preparing tagged skipjacks for biological sampling.*

<sup>1</sup> Otoliths are small bones in the cavities of a fish’s head; they are sensitive to gravity and linear acceleration

## SPC ACTIVITIES



a: Trainee John Still Vili preparing a tuna head for biological sampling, and  
b: sawing it to give access to otolith cavities.  
c: Trainer Caroline Sanchez extracting the otoliths.  
d: Recording data.  
All images: Malo Hosken.

produces information on the age of the fish, which is of great importance for fisheries management.

Luen Thai Company, based in Pohnpei, supported the workshop by providing tuna heads as well as a facility to work in for the workshop's practical sessions. During the course of the workshop, around 160 heads were drilled, cut and meticulously inspected for otolith extraction. As the week passed, the observer trainers and other participants showed growing interest in marine biology topics and acquired enough skills to confidently deliver the same type of training to future observers.

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## Countries encourage SPC to continue delivering quality fisheries assistance at the seventh Heads of Fisheries meeting

*The seventh Heads of Fisheries (HOF) meeting began with various reports from SPC's Fisheries, Aquaculture and Marine Ecosystems Division. In coastal fisheries, the call was for "more of the same" in areas such as FAD deployment, fishing skills and small boat safety. Delegates learned that SPC's Coastal Fisheries Programme was in the process of hiring new staff with skills in economics and post harvest and export development work. The main area of interest was the assessment of deepwater snapper resources, and meeting participants endorsed a proposal to seek extra funds to address this. The seventh SPC Heads of Fisheries meeting (HOF) was held in March at SPC headquarters in Noumea. It followed a one-day session of steering committee meetings for the three European Union-funded fisheries projects in which SPC is now involved.*

The HOF meetings developed out of the Regional Technical Meeting on Fisheries, which was first held in 1969 as an annual meeting of fisheries officers from SPC member countries and territories. In 1999, the name changed to the Heads of Fisheries meeting. While much has changed in Pacific fisheries since the late 1960s, HOF is still one of the few occasions in which senior fisheries staff from Pacific Island countries and territories can meet to discuss just fisheries. Meeting topics cover coastal fisheries and aquaculture, as well as the science behind the region's tuna management initiatives.

At the seventh meeting of HOF, concern was expressed regarding the introduction of new species and strains — an issue that has been controversial for many years. Meeting participants agreed that decisions on such introductions are the responsibility of member countries, but urged that careful consideration be given to both the benefits and risks of an introduction before a decision is made. Participants supported a regional approach to aquatic animal health and biosecurity, and encouraged further work on developing appropriate, locally made feeds for aquaculture.

Meeting participants expressed appreciation for SPC's Oceanic Fisheries Programme and its work in areas such as observer training and stock assessment workshops. Two new products were showcased: 1) a first release of the Tuna Management Simulator (TUMAS) programme, which allows anyone with a computer to see what different management controls will do to the region's tuna stocks; and 2) new secure national websites that provide the data needed for reporting to the Western and Central Pacific Fisheries Commission. Meeting participants supported more work on new issues such as port sampling for small-scale tuna fisheries, tuna ecosystem modelling information requirements, and tuna tagging to help research the impacts of climate change on tuna distribution.

Since the last HOF meeting, SPC's capacity in fisheries has increased significantly due to the Pacific Islands Applied Geoscience Commission becoming a part of SPC. Meeting participants were briefed on the work of the Islands and Oceans Programme, which provides many opportunities for countries — and for FAME and SOPAC — to work together on fisheries issues.



*SPC's 7th HOF meeting was chaired by Leban Gisawa from Papua New Guinea's National Fisheries Authority.*

In particular, the programme has the responsibility of helping many of SPC's member countries with maritime boundaries. Fisheries heads were concerned to learn that a number of their exclusive economic zones are not well defined, and that much more work is needed to put proper legal boundaries in place.

The seventh HOF had a special one-day session on fisheries and climate change. For the past two years, SPC has taken a lead role on a project that brings together a team of international experts to assess how climate change is likely to affect fisheries across the region. While the final results of this study are not due until October, a number of these experts came to the meeting to talk about their findings in six main areas:

1. The way in which climate and the ocean are expected to change under different scenarios of greenhouse gas emissions;
2. The effects of these expected changes on the habitats that support fisheries and aquaculture in the region (i.e. the open ocean, coral reefs, mangroves and sea-grass beds, and rivers and estuaries);

3. The projected effects on the distribution and abundance of fish and invertebrates that support oceanic fisheries, coastal fisheries, freshwater fisheries and aquaculture in the Pacific community;
4. The implications of changes in fish stocks due to climate change for economic development, government revenue, food security and livelihoods throughout the region;
5. The management measures and policies needed to take advantage of the opportunities, and reduce the threats expected to occur, as a result of climate change; and
6. The remaining uncertainty, knowledge gaps, and the research required to fill them.

Participants learned that impacts on coastal fisheries are expected to be severe, with potential production reduced by as much as 50% — a possibility by 2100.

Impacts on mariculture are also expected to be negative, although conditions for freshwater aquaculture could improve. The distribution of tuna stocks is expected to shift more to the eastern Pacific as oceanographic conditions change. Speakers emphasised, however, that there is an immediate need to improve the management of fish stocks and their habitats. Good management now will help ensure that these resources can better stand the impacts of climate change in the longer term.

The seventh HOF meeting was chaired by Leban Gisawa of Papua New Guinea's National Fisheries Authority, who kept the meeting firmly on track and on time. In his closing remarks Leban thanked SPC for organising and smoothly running the meeting. The next HOF meeting will be held in early March 2013, and there will be a one-day informal meeting in the lead up to the Forum Fisheries Committee sessions in May 2012.

### A record of the outcomes of the seventh HOF meeting,

as well as all meeting papers, can be downloaded from SPC's website at:

<http://www.spc.int/fame/en/component/content/article/82-seventh-spc-heads-of-fisheries-meeting>



## New expertise comes to SPC's Nearshore Fisheries Development Section

*2011 marks the beginning of a new era for SPC's Nearshore Fisheries Development Section. At its inception in the early 1980s, the Section focused primarily on capture fisheries. Since then, it has undergone a number of phases, including the promotion of deep-bottom, hook-and-line fishing for snappers in the 1980s; support and development of small-to-medium scale tuna longline operations in the 1990s; and, more recently, the promotion of mid-water fishing techniques around shallow-water fish aggregation devices (FADs). However, despite the valuable assistance it has provided to fisheries throughout the Pacific Islands region, reviews of SPC's Coastal Fisheries Programme (CFP) regularly point to a lack of post-harvest and economic efforts. This point, however, has recently been addressed through a number of changes in the Section's structure.*

One of the Section's two Fisheries Development Officer (fishing) positions was redesigned to focus on economic assessments of fishing and aquaculture ventures. While this change means a reduction in the Section's more traditional role — fishing technology and techniques — (see boxed text on next page), the new position of Fisheries Development Officer (Economics) brings new capacity in economic, financial and market evaluation that will benefit CFP and SPC member countries. This broad area focuses on the economics of coastal fisheries and generally aims to improve the efficiency and financial performance of fisheries sectors (whether for food security or income generation). Some of these capabilities include investment decisions for new projects with differing investment options, cost-benefit analyses, financial assessments of new and existing enterprises, value chain analyses, and market analyses. The Section will also be able to build capacity and provide technical advice in these areas. Michael Sharp joined the Section in February as the Fisheries Development Officer (Economics). He arrived in time to attend the 7<sup>th</sup> Heads of Fisheries meeting, which gave him the opportunity to meet with key national fisheries stakeholders. Since then, Michael has been regularly communicating with fisheries personnel from member countries, which has resulted in the identification of a number of interesting projects that will soon be implemented, including 1) a cost-benefit assessment of FAD programmes in Niue and Samoa; 2) an economic feasibility study to establish a marine ornamental trade in Samoa; and 3) some economic inputs into a regional review of mariculture in the Pacific. It is envisaged that Michael will also undertake economic analyses of fishing vessels for cost reduction, and that he will assess the benefits of sports fishing operations for coastal communities and the greater economy of island countries. Economic assessment is important for justifying investment or lending, determining initiatives' long-term financial viability, quantifying the benefits derived from an activity, and increasing efficiency or profitability of an activity. For sustainable business development, market assessment and economic feasibility studies should be completed prior to embarking on any new initiative.

In addition to economics, the Section acquired a much needed capacity in post-harvest, thanks to funding

support from the Australian government. In late 2010, AusAID approved an SPC funding proposal and the establishment of several new positions within SPC's Division of Fisheries, Aquaculture and Marine Ecosystems. One of these positions is Fisheries Development Officer (Post-Harvest and Exports), which was filled in May 2011. Timothy Numilengi, who holds this position, previously worked as the coordinator of the Food Safety Auditing and Certification Unit at the Competent Authority of Papua New Guinea. His role at SPC will be to provide technical assistance, advice and training in seafood safety, quality and value adding. Timothy will work closely with seafood companies in the region, helping them meet the importing requirements of countries such as Australia, the European Union, Japan, and the United States (USA). Timothy will collaborate with the Pacific Islands Forum Fisheries Agency's Development Section and the DevFish-2 project, which are already involved in this area. The establishment and/or the strengthening of national competent authorities will be high on Timothy's agenda, and work is underway to assist the competent authorities of Vanuatu and Solomon Islands.



**Michael Sharp,**  
Fisheries Development Officer  
(Economics)

*Michael is from Australia. He holds a bachelor's degree in agricultural economics and a master's degree in economics. In 2005, he worked in Vanuatu as an Australian Youth Ambassador for Development where he provided training in agriculture and small business management, and facilitated the implementation of community-based projects. Michael returned to Sydney in 2007 to work in corporate banking for the Australia and New Zealand Banking Group Ltd. In 2009, he worked for the Ministry of Amerindian Affairs (in Guyana) as a Marketing and Finance Specialist under the National Hinterland and Secure Livelihoods Programme. He provided assistance to Amerindian communities in designing, financing, and implementing agricultural, apiculture, and aquaculture development projects for the purpose of introducing non-traditional income sources.*



**Timothy Numilengi,**  
**Fisheries Development Officer**  
**(Post-Harvest and Exports)**

*Timothy is from Papua New Guinea (PNG). He holds a Bachelor of Science degree in food technology and a diploma in management. Before joining SPC, he worked for 10 years with the PNG*

*National Fisheries Authority as the Coordinator for Food Safety Auditing and Certification services. He has experience in establishing, implementing, evaluating and managing food safety systems, including harvesting areas and vessels, transport systems, and landing, processing and export establishments. He has experience in establishing a Competent Authority, market access requirements (e.g. for markets in Australia, the European Union, Japan, and the USA). He is also skilled in the thermal processing of canned fish having been trained in Canada, New Zealand, Thailand and the USA. Using these skills, Timothy provided technical assistance to competent authorities and the fish canning industries in PNG and Solomon Islands.*

### **For more information,**

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## **The end of a 15-year cruise with SPC!**



It is with heavy hearts that FAME Division staff wished all the best and said goodbye to Steve Beverly.

Steve is now a semi-retired fisheries specialist with more than 20 years of experience in the Pacific Islands region. Steve started with SPC in the mid-1990s, initially as a consultant (his first project was in Rabaul, Papua New Guinea in 1995), and then as a full-time Fisheries Development Officer. As part of his SPC duties, Steve travelled to all of the SPC member countries and territories, delivering training and conducting projects for fisheries administrations or the private sector. A well-known and respected fisherman, Steve has contributed immensely to the development of domestic tuna longlining in Pacific Island countries, the strengthening of national FAD programmes, and the increased safety of fishing vessel operations. More recently, Steve became a bycatch mitigation expert, winning the World Wildlife Fund International Smart Gear Competition in 2004. Our team is deeply grateful for his 15 years of contributing to safer and more sustainable fishing in the Pacific region.

Thanks for everything and happy sailing (and fishing!), Steve.

## Deep Blue: Pacific Island fisheries observers in action

*After several months of preparation, several weeks at sea, and numerous days of interviews, shooting and editing, The DVD Deep Blue is finally here. Deep Blue presents one observer's trip on a tuna purse seiner and all the tasks he carries out onboard. It then follows him when he returns to land to show what happens to the data, information, samples, tags and other information he has collected.*

### Observers and fisheries management

Observers are instrumental in improving tuna fisheries management: they collect data at sea, which are then entered into nationally and regionally maintained databases and, once analysed, serve to guide regional and national fisheries management and policies.

In 2008 concerns about excessive fishing pressure on bigeye and yellowfin tuna stocks served to further highlight the importance of observer data, and led members of both the Parties to the Nauru Agreement and the Western and Central Pacific Fisheries Commission to require that all purse-seine fleets of their member countries be monitored by observers. Since 2010, every purse-seine vessel in the western and central Pacific must carry an observer onboard during their fishing trips. The observers collect data on the geographic location, species and quantities of catches, and get biological samples from fish for analysis.

### An information and training tool

Pacific Island countries and territories have had to recruit and train more observers. In collaboration with the Western and Central Pacific Fisheries Commission, the Pacific Islands Forum Fisheries Agency and SPC, certification and training standards have been developed for Pacific Island Regional Fisheries Observers (PIRFO), and a large number of training sessions have been carried out with the support of international donors, making it possible to train observers from all member countries.

The DVD *Deep Blue* is an information and training tool. When broadcasted on national TV, it leads to a better understanding of the work observers do and encourage young people to join this profession. When shown during observer training sessions, it allows young trainees to gain a realistic idea of fishing issues in the Pacific, observers' working conditions, their responsibilities, and the qualities needed to be a good observer.

During training sessions, the video also makes it possible to look at the different tasks in detail using images, and to explain how observers are organised at the country level.

### Cooperative effort

This video, filmed in Papua New Guinea, provided an opportunity for constructive collaboration, which is the key to responsible and sustainable tuna fisheries in the future: the ship's crew, observers, the fishing company, public authorities, the film and editing crew, and SPC staff worked on this production. Funding from the European Union, via the SciCOFish project, allowed them to create a new tool to better manage tuna fisheries, a tool that is already being used with success during training sessions. The DVD was originally produced in English and will soon be available in French.

*Observers will continue to be out there as the eyes and ears of the fisheries and nations.*



*Deep Blue, a 30-minute DVD, presents the work of observers.*



*PIRFO ensure the collection of targeted, high quality data on tuna fisheries.*

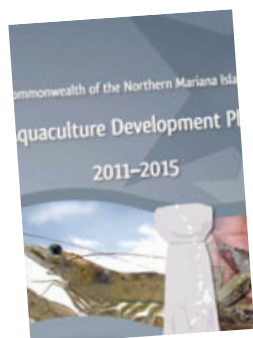
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## New publications from SPC's FAME Division



### *Commonwealth of the Northern Mariana Islands aquaculture development plan for 2011-2015*

The completion of an aquaculture development plan for the Commonwealth of the Northern Mariana Islands (CNMI) could not be timelier: CNMI has witnessed a recent and drastic economic downturn. Spurred by the need for economic diversification, the CNMI Department of Commerce sponsored an economic summit in 2009, which identified aquaculture as one of the four new pillars of the economy.

This development plan was developed in collaboration with the Northern Marianas College Cooperative Research Extension and Education Service, represented by Michael Ogo, and former SPC Aquaculture Section Advisor Ben Ponia<sup>1</sup> and his team; as well as associated consultants Jacky Patrois and Simon Ellis. A consultation was carried out over a three-day period when the expert team flew to Saipan, Rota and Tinian.

Priority commodities were reviewed and analysed for suitability and potential impact in the three main islands. The review process took several months.

The online version is available from SPC's Aquaculture Section website:

[http://www.spc.int/aquaculture/index.php?option=com\\_docman&task=doc\\_download&gid=380&Itemid=3](http://www.spc.int/aquaculture/index.php?option=com_docman&task=doc_download&gid=380&Itemid=3)

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### *Beginner's guide to remote sensing for offshore tuna fishermen*

Remote sensing is a way of acquiring information about the earth's surface without actually being in contact with it. Remote sensing is done by receiving and recording energy that is either emitted or reflected by the earth's surface. There must, therefore, be a source of electromagnetic energy, a target, and a sensor. The source can be the sun or a satellite, depending on the type of energy being monitored. The target, in the case of remote sensing that may be useful to fishermen, is the sea surface.

Ocean charts showing sea surface colour, sea surface temperature, sea surface height, currents and weather are available from a variety of sources on the Internet. They can be used to plan a fishing trip from the shore or as a fishing tool on the boat during a trip. For example, two oceanographic features of the sea surface that are interesting to longline fishermen, and that show up on sea surface temperature and sea surface height charts, are frontal zones and eddies. These are often good tuna fishing grounds.

This guide was designed to give a very basic knowledge of remote sensing to offshore tuna fishermen.

The online version is available from SPC's Fisheries Digital Library at:

[http://www.spc.int/DigitalLibrary/Doc/FAME/Manuals/Beverly\\_11\\_Remote\\_sensing\\_guide.pdf](http://www.spc.int/DigitalLibrary/Doc/FAME/Manuals/Beverly_11_Remote_sensing_guide.pdf)

For more information, please contact: Michel Blanc, SPC Fisheries Development Adviser (MichelBl@spc.int).

<sup>1</sup> Ben Ponia is now Secretary for the Cook Islands Ministry of Marine Resources.



*This issue of SPC's Fisheries Newsletter was produced with the financial support of the European Union.*

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

### Aquaculture and food security in Solomon Islands

*Pacific Island countries and territories (PICTs) are some of the most vulnerable nations to climate change. Growing populations, combined with climate change and overfishing of inshore reef fish, will compound food security problems arising from an increasing gap between fish demand and supply. Along with some other PICTs, Solomon Islands recognises the need for new sources of fish to meet future food security requirements. Options include fish imports, increasing access to offshore tuna fisheries such as with inshore fish aggregating devices, and aquaculture development. The Government of Solomon Islands has identified inland aquaculture as one means of addressing the gap between fish supply and demand.*

The Australian Centre for International Agricultural Research project “Aquaculture and Food Security in the Solomon Islands” was formulated to assist the Government of Solomon Islands in better understanding the future demand for aquaculture; in particular, to “develop a strategy to guide future development of sustainable inland aquaculture to support food security and secure livelihoods for the Solomon Islands in response to rising populations and climate change”. The project was implemented through a partnership of three agencies: The WorldFish Center, the Solomon Islands Ministry of Fisheries and Marine Resources (MFMR) and SPC’s Aquaculture Section.

Initiated in 2010 and completed at the beginning of 2011, the project included wide-ranging consultations with stakeholders, fish-farm site visits and field work, social survey work, and application of GIS techniques to find out the opportunities and challenges for inland aquaculture in Solomon Islands as a way of addressing food security challenges. Major findings of the project include:

- Future scenarios for fish supply-and-demand suggest that significant investment in aquaculture is required to ensure food security in Solomon Islands.
- Tilapia is the only food fish farmed in Solomon Islands. There is a market demand for tilapia, that is expected to continue to grow as urban populations expand and acceptability of the species increases.
- Existing tilapia (*Oreochromis mossambicus*) and farming systems are insufficient to meet future fish demands. While some small yield improvements to present farming systems and practices may be possible, if tilapia is to remain a priority fish for food security, then it will be necessary to introduce a more productive species such as Nile tilapia (*Oreochromis niloticus*).
- Inland pond farming of Nile tilapia is technically feasible, and environmentally suitable sites exist within Solomon Islands.
- Farming of a native fish species is a further option. Milkfish (*Chanos chanos*) is the most obvious candidate but, unlike tilapia, it is not yet ready and requires further research, especially to establish the localities and seasonality of milkfish fingerlings in the wild for possible capture-based culture.
- A formal analysis to assess ecological risk and identify risk management measures is advocated, and the Solomon Islands government should take this into account when making any decision on the importation of an improved strain of Nile Tilapia. This is

now being addressed through a separate initiative guided jointly by SPC, WorldFish Center, MFMR and the Pacific Regional Environment Programme. Milkfish is native to Solomon Islands and, thus, requires no import risk analysis.

- Investment in farming of improved strains of Nile tilapia, milkfish or a combination of the two species appears to provide opportunities for viable businesses, from household to larger scale commercial enterprises. Low-cost fish production systems will be needed for the product to remain competitive in markets and benefit poorer consumers.
- Investment in a combination of smallholder household enterprises, school ponds, and small to medium enterprises, plus supporting infrastructure, institutions and policy, could benefit consumers and households in rural and urban areas.
- An annual production of 2,500 tonnes of food fish will require investment in infrastructure and operating capital. Preliminary estimates suggest that at least USD 1.2 million in farm construction and infrastructure and USD 2.6 million/year in operational funds will be required, but will generate over USD 3.7 million/year in farm-gate sales, plus employment and improved food security.
- Some elements for inland aquaculture in Solomon Islands are in place, but are incomplete.



*There are an estimated 50 household ponds for Mozambique tilapia in Solomon Islands, all characterised by low yields because this variety of tilapia is not suitable for aquaculture. However, these households are enthusiastic about culturing fish.*

- Further investment in research, strengthening of institutional and regulatory capacity and partnership building is required to develop systems and bring together the skills and resources necessary for responsible growth of inland aquaculture.

In conclusion, aquaculture production of fish appears to be a necessary component of future food security in Solomon Islands, and market demand and opportunities exist for competitive inland aquaculture enterprises. Based on the findings of the ACIAR project, an integrated approach based on five major themes will be necessary to move forward. Implementation will require bringing complementary skills and investments together via partnerships, involving both public and private sectors.

### 1. Improving fish yields and productivity

Aquaculture for food security requires a species other than Mozambique tilapia; one that can deliver higher yields competitively under culture conditions. An indigenous species may be used if suitable, or if tilapia is preferred, then an improved species such as Nile tilapia must be imported. Low-cost pond input options need development (feed, fertilisers, use of byproducts, management systems). Farming systems, management practices and business models require elaboration for different enterprise types.

### 2. Building skills and organisational arrangements

Inland aquaculture will require people with technical farming skills, as well as necessary business, management and marketing skills, with actual requirements depending on the scale of operation. Aquaculture extension and knowledge dissemination systems will need to be developed to impart skills to farmers and businesses. Assisting interested households with organising into more economically efficient “clusters” needs investigation, along with possibilities for mutually beneficial links between households and medium and larger aquaculture enterprises and value chains (e.g. contract nursing, farming, input and output markets).

### 3. Access to finance for infrastructure and operations

Inland aquaculture will require access to investment; in pond construction and associated water supply and drainage, possibly roads for larger enterprises and seed, feed, labour and other routine operational costs. Nile tilapia will require additional investment in hatchery infrastructure. One central publicly controlled Nile tilapia broodstock nucleus and quarantine facility will be required to receive and manage imported Nile tilapia, with trained people and sustained financing. Such an investment in milkfish may not be necessary initially, should trials confirm that wild seed is available in sufficient quantities for farming; it may be necessary in the longer-term, however.



*Apart from introducing a more productive strain of Nile tilapia, aquaculture of an indigenous species can be investigated. Milkfish (Chanos chanos) is one of the few candidate species with some potential, although it needs research.*

### 4. Market access

Existing marketing systems and value chains could absorb some increased household production of tilapia, but more organised systems of marketing will be needed as tilapia or milkfish farm production increases. Marketing strategies that enable access by poorer consumers also need further investigation.

## Public policy and institutions

A conducive public policy environment and the development of regulations will be needed to support the implementation of 1–4 above. Investments in institutional strengthening — such as staff training and operational budgets — will be needed for national and provincial government management of aquaculture.

Land use, site selection criteria and spatial plans should be prepared to support medium-scale investments in inland aquaculture. Particular attention will need to be given to the existing land use and ownership patterns, with reference to customary land use norms and conditions.

The key activities indicated in this article are a basis for follow-up work to take these ideas further. These will be scrutinised by partners in order to develop an appropriate strategy and investment plan for inland aquaculture development in Solomon Islands. A national advisory group containing representation from households, public and private sectors may be considered to facilitate progress.

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## Technical assistance for pearl jewellery training in the Marshall Islands

*Simon Ellis and Dr Maria Haws*

*Handicraft making is an excellent way to enhance byproducts of the pearl industry. Discarded shells and imperfect pearls can gain tremendous value if they are turned into a nice looking piece of jewellery or a handicraft. Across the Pacific Islands region — in places such as Kiribati, Federated States of Micronesia (FSM), Tonga, Tuvalu and, more recently, the Marshall Islands — workshops on these techniques have been fairly common over the past few years.*

In November last year, a pearl jewellery and marketing training was held on Majuro Atoll in the Marshall Islands. The primary sponsor of the workshop was the Marshall Islands Marine Resources Authority (MIMRA), with technical and financial assistance from the University of Hawaii Hilo (UHH) – Pacific Aquaculture and Coastal Resources Center (PACRC), the Marine and Environmental Research Institute of Pohnpei (MERIP) and SPC. Other partners included the College of the Marshall Islands and the communities of Rongelap and Namdrik atolls. Both communities have been developing black pearl farming, and both recently harvested their first pearls.

Training was conducted by Dr Maria Haws and Simon Ellis who are faculty members at UHH-PACRC. Simon Ellis is also director of MERIP, an FSM-based non-governmental organisation that promotes sustainable aquaculture in the Pacific Islands region. Haws and Ellis have combined experience of over 30 years in pearl farming development in the region. Orders for jewellery settings and tools were handled through MERIP. The UHH-PACRC program provided co-funding for the workshop

in the amount of USD 6,500 and MIMRA provided their conference room for the training and on-the-ground assistance from MIMRA personnel Florence Edwards and Darren Nakata.

Following the training, the communities organized a pearl auction and sale the following week. Combined sales from the events raised USD 31,000, which will go toward further pearl farming development on Rongelap and Namdrik atolls. Fifteen individuals participated in the training, and MIMRA technical staff gained valuable exposure to the pearl industry.

### For more information:

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*Trainees are being taught pearl mounting techniques by trainer Simon Ellis (standing).*

## New Caledonia lobster aquaculture trials: The season is here!

*Antoine Teitelbaum*

*Over the last couple of years, New Caledonia's provincial fisheries offices have aimed at implementing a small experimental lobster aquaculture industry based on wild *Panulirus ornatus pueruli*, which are mainly caught as they settle into the lagoon. In 2009, fisheries officers from New Caledonia had the opportunity to attend a study tour in Vietnam where they witnessed all aspects of the industry, from collection to grow-out in sea cages.*

The process is quite simple but it is critical to first identify suitable settlement areas. Afterwards, larvae collectors are deployed. The principal target species in New Caledonia is *P. ornatus*, which spawns during the warm months of September to January. Given the extended larval life of this lobster species, it was anticipated that collectors should be in place by March or April. Once pueruli are seen on the collectors (mostly around the time of a new moon), they are harvested and placed in sea cages where they are fed and grown until they reach market size.

Initial trials took place in 2009 in Ouano Bay (near La Foa), a well-known lobster settlement area. The trials were successful enough to invest more effort into developing this new industry. Initial lobster recruits from these trials averaged a few hundred that were caught on of a couple longlines with collectors; there were not enough, however, to jump-start the industry in New Caledonia. Grow-out techniques on a larger scale will be demonstrated at a later date.

As a result, North Province and South Province, together with New Caledonia's Agency for Economic Development (ADECAL), with some assistance from SPC's Aquaculture Section, decided to invest in a lobster industry development trials for 2011, and identified two areas to focus on: 1) increasing the number of juveniles by collecting from a variety of places around New Caledonia; and 2) determining the technical feasibility of lobster grow-out in sea cages on a commercial scale.

Two fishermen from the North Province (one from Canala and one from Kone), and two from the South

Province (one from Thio and one from Yaté) were selected for training, in addition to the fishermen who had been part of the pioneering aquaculture venture of Ouano Bay (Société Aquacole de Ouano). All of the selected fishermen came from areas where lobsters were known to recruit. In April 2011, the fishermen gathered in Ouano to build the larvae collectors, which would be deployed later that same month.

A floating cage raft was built and deployed in Ouano Bay. All juveniles collected during 2011 will be kept by fishermen for several days before being transferred to grow-out cages at Ouano.

Everyone involved is hopeful that out of the five collection sites, there will be enough lobster pueruli to increase the development of this new and exciting industry. The grow-out, if done correctly, will allow animals to reach plate size within 6–9 months. *Panulirus ornatus* is the fastest growing tropical lobster, so why not imagine locally grown lobsters being available for New Year's Eve 2011!

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*Freshly collected lobster puerulus. Image: Henri-Luc Fogliani.*

### What is a lobster pueruli trap?

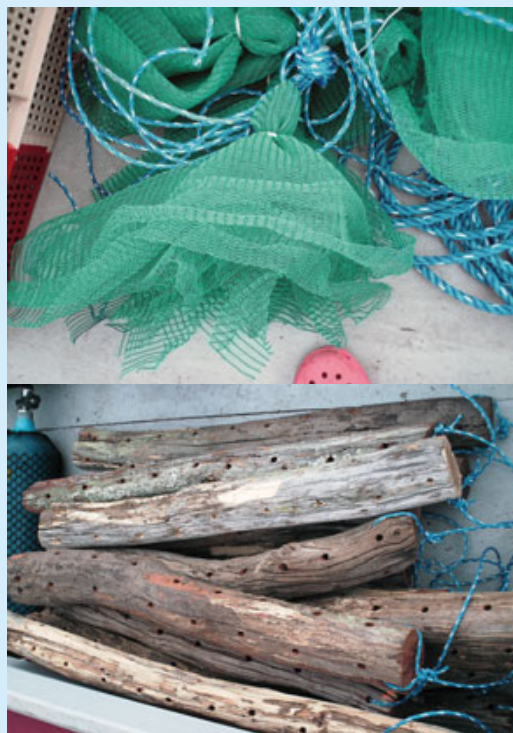
Lobster pueruli collectors can be made out of just about anything. The collectors must, however, be placed in the water at the right time and in the right area in order to attract lobsters as they settle onto a substrate. Lobsters will tend to stay away from the bottom where predation is higher. In some areas of New Caledonia where recruitment takes place, one can see hundreds of small pueruli on the underside of floats, boat hulls or mooring ropes.

For this project, the fisheries services used what was developed in Vietnam, mostly because it has proven to work well. The lobster pueruli collectors in New Caledonia are deployed on longlines (floating) that hang just below the surface.

While looking for places to settle, lobsters will come into contact with the collectors and hide. The longlines can later be pulled from the surface where the pueruli are removed from the collectors. The larvae are then ready for the grow-out phase.

*In New Caledonia, collectors were made out of mesh shade cloth and wooden sticks with holes drilled into them.*

*Images: Henri-Luc Fogliani.*



## Aquaculture health training trip to Western Australia

**Rarahu David**

*Head of the Health Programme for Non-Pearl-Oyster Aquaculture Facilities  
in French Polynesia's Fisheries Department*

*In 2008, following a series of exchanges with Western Australia's Department of Fisheries Animal Health Laboratory (FHL), the Biotechnical and Pearl Quality Laboratory (LBQP) of the French Research Institute for Exploration of the Sea (IFREMER), and the Pearl Oyster Department (PRL), Dr Brian Jones and his colleague, Dr Fran Stephens, visited the PRL-IFREMER-SPE (French Polynesia's Fisheries Department) research station in Vairao, Tahiti. This visit allowed useful exchanges about diseases at pearl oyster farms but also about shrimp and fish diseases. FHL is, in fact, in charge of diagnosing aquatic animal diseases (except for mammals) in the state of Western Australia, and Dr Jones, the lab's head pathologist, is an internationally known aquatic disease researcher.*

In order to further their training in specific diagnostic techniques for the marine setting, particularly in microbiology and histology, FHL and SPE jointly arranged to have FHL host an SPE agent (Rarahu David, head of the Health Programme for Non-Pearl-Oyster Aquaculture Facilities) and an IFREMER agent (Pevatunoa Levy, head of histology at LBQP) for two weeks in September 2010.

The trip provided an opportunity to review the information gathered for an histopathological atlas dedicated to the species *Platax orbicularis*, currently in draft. This

project, initiated in Tahiti, will benefit from the guidance of Dr Jones.

Pevatunoa Levy received training in the histological techniques used at FHL, particularly the use of decalcification solutions (to soften bones and scales before samples are processed).

At the same time, Rarahu David was hosted by the microbiology laboratory of Dr Nicky B. Buller (author of *Bacteria from fish and other aquatic animals: A practical*

identification manual, 2004<sup>1</sup>). Dr Buller was trained in the various diagnostic techniques routinely used in that lab to identify bacteria that infect marine organisms. The lab carries out about 15 biochemical and enzyme assays similar to those used in Tahiti. Dr Buller trained Rarahu David in how to conduct various microbiological diagnostic tests (methodology, growth on specific culture mediums) and introduced her to a wide range of pathogenic bacteria that could pose a threat to the Paraha peue aquaculture facilities in Tahiti. A photo database was created to facilitate implementation of diagnostics in French Polynesia.

A trip was organised to visit the Cone Bay fish farm (<http://www.marineproduce.com/barramundi.html>). This farm, located in northwestern Australia, raises barramundi or *Lates calcarifer* in floating sea cages. The farm produces more than 10 tonnes per week and will soon reach 45 tonnes per week. The fish are sold throughout the year at an average weight of 3.5 kg and a price of AUD 4.00 per kg. During our visit, the in-water biomass was 1,365 tonnes spread out over 14 cages of 4,000 m<sup>3</sup>, 1 cage of 2,000 m<sup>3</sup> and 2 cages of 1,000 m<sup>3</sup>. This farm, located around Turtle Island, the company's living base, has been in operation since 2003. Initially, it was a pearl oyster farm (Maxima Pearling Company Pty Ltd) that experienced high levels of mortality and converted to fish farming.

Some of the eggs produced in Darwin are sent to a hatchery in Fremantle (near Perth), while the rest are raised in Darwin. Once the eggs have reached the juvenile stage, the fish produced in Darwin and Fremantle are transported by truck and then shipped to the Cone Bay site. An acclimation phase takes place in a land-based pond at the Cone Bay farm on Turtle Island. Once fish fry can eat 2 mm-sized pellets, they are transferred to nursery cages at sea using fish pumps. They are fed twice a day by hand or with a pellet gun.

Each cage is cleaned systematically every month. Metal mesh keeps out marine predators (e.g. crocodiles and sharks) and nets above the cages keep out flying predators (birds).

Currently, samples are taken every month in all of the cages. In order to limit the handling of animals, video systems are being tested to replace sampling (by estimating the weight of filmed specimens).

Aqui-S is used to anaesthetise the fish during sampling. During our visit, we were able to watch and take part in routine sampling by FHL in Perth. For each fish sampled, fresh gill and skin conditions are checked, and blood samples are taken while the fish is still alive. Once they are dead, fish are dissected to check the various organs in

the internal cavity and to take histological samples (preserved in 10% formalin). Bacteriological samples are also taken from external wounds and internal organs (digestive tube) by using a system that allows the samples (live microorganisms) to be kept alive until they are cultured in the lab several days later.<sup>2</sup>

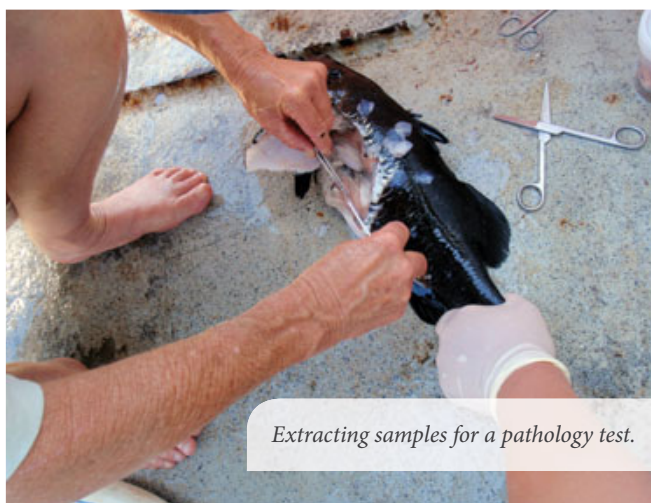
On the way back, in the outskirts of Broome, we visited a *Pinctada maxima* hatchery (Paspaley Pearl Hatcheries Pty Ltd). Bryan Webster, the hatchery director, took us around the entire facility, which produces 40 million spat per cycle and has very strict hygiene measures and uses no antibiotics.

A third visit was arranged to the Australian Centre for Applied Aquaculture Research (ACAAR), a research centre for aquaculture based in Fremantle, Australia.<sup>3</sup> ACAAR has a hatchery that supplies barramundi fry to the Cone Bay farm. It works with several other species, including *Seriola lalandi*, *Argyrosomus japonicus*, *Pagrus auratus* and *Acanthopagrus butcheri*. The facility offers various degrees in the area of aquaculture<sup>4</sup> but also acts as consultant for aquaculture companies.<sup>5</sup>

All of these instructive visits and meetings have allowed us to continue to improve the diagnostic and preventative techniques used in French Polynesian aquaculture facilities and to pursue exchanges on the topic with FHL and collaboration on the Paraha peue (*Platax orbicularis*) histopathological atlas.

This trip was made possible, in part, by financial support from SPC and the Australian government.

We would like to acknowledge everyone who has contributed to the success of this trip, particularly those in Australia: Dr Brian Jones, Dr Fran Stephens, Dr Nicky B. Buller, and Daryn Payne for the welcome to the Cone Bay farm on Turtle Island.



Extracting samples for a pathology test.

<sup>1</sup> [http://www.sharingmatrix.com/file/15384495/Bacteria\\_from\\_Fish\\_and\\_Other\\_Aquatic\\_Animals.pdf](http://www.sharingmatrix.com/file/15384495/Bacteria_from_Fish_and_Other_Aquatic_Animals.pdf)

<sup>2</sup> See: <http://www.mwe.co.uk/mwe/mwe.php?c=3&s=8&p=67>

<sup>3</sup> See <http://www.challenger.wa.edu.au/Workingwithindustry/acaar/Pages/aboutthecentre.aspx>

<sup>4</sup> See <http://www.challenger.wa.edu.au/Workingwithindustry/wamaritimetrainingcentrefremantle/Pages/AquacultureTraining.aspx>

<sup>5</sup> See <http://www.challenger.wa.edu.au/Workingwithindustry/acaar/Pages/ConsultingTrainingServices.aspx>

## Aquaculture training: Cooperation between Australia and New Caledonia

*New Caledonia is attempting to diversify its aquaculture, which up until now, has mainly involved shrimp farming. Marine fish farming has become a reality in the Territory and now there is a need for training in specific hatchery techniques.*

As part of his Aquaculture Business Management studies within the Conservatoire National des Arts et Métiers at the Institut National des Sciences et Techniques de la Mer — and through an agreement between Antoine Teitelbaum (SPC Aquaculture Officer) and Richard Knuckey (Principle Scientist at NFC) — Thibaud Moléana from New Caledonia spent two weeks at NFC, an Australian government-run hatchery in Cairns. During the training, Thibaud dove straight into hatchery operations and worked with the team, particularly with Daryl Harper, Angela Anderson and Matthew Reason.

NFC is working on culturing the larvae of tropical groupers such as *Epinephelus lanceolatus* and *Plectropomus leopardus*, which requires new techniques, especially the use of copepods.

The primary goal of copepod production is to produce an adult population and maintain it so that once specimens have been transferred to larval culture tanks, they can reproduce, and small-sized nauplii (about 60 µm) can then be absorbed by fish larvae in the first few days after hatching

NFC has facilities ranging from an isolation room with 60 L and 200 L tanks (Fig. 1) to 500 L outdoor ponds that are 2 m<sup>3</sup> in size for *Parvocalanus crassirostris* farming.

### Complex management

The complex task of managing the rearing tanks is done by controlling farming parameters, monitoring the copepods' physiological status, and providing microalgae such as *Isochrysis* sp. and *Tetraselmis* sp. Farming density is low (on average, from 2–4 adult specimens



Figure 1. Tanks used for copepod culture at NFC.

per mL) but the nutritional benefit that the copepods provide to fish larvae offsets this low production level. In terms of management, this type of innovative farming should play a role in conventional protocols for larval culture operations that require special attention. Over the long run, successful copepod production should allow improved biosecurity, optimal use of space for larval culture, better planning in terms of algal production, and decreased work time needed for all of these operations.

#### For more information:

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### What are copepods?

Copepods are a group of small crustaceans found in the sea and nearly every freshwater habitat. Some of the marine species are planktonic (drifting in sea waters), some are benthic (living on the ocean floor). They play a vital role in feed for marine fish larvae. Recent progress in understanding and mastering the reproductive cycle of certain copepods has led to significant advances in marine fish production.

Picture: Uwe Kils,  
source: WikiMedia commons.



## CNMI expresses interest in offshore aquaculture

by Antoine Teitelbaum

SPC Aquaculture Officer (AntoineT@spc.int)

*Worldwide, open ocean cage aquaculture (or offshore aquaculture) is regarded as an industry with huge potential and which is largely underdeveloped. The Commonwealth of the Northern Mariana Islands (CNMI) has recently expressed interest in developing this industry. Earlier this year, CNMI organised an open ocean cage aquaculture symposium on Saipan. This is a significant development in a region where marine finfish aquaculture is only just being considered.*

### Marine finfish in the Pacific: Background information

Remote islands and faraway markets, high operation costs and lack of skills needed for aquaculture — these constraints are often mentioned when discussing marine finfish development in the Pacific Islands region. “We can’t compete with Asian neighbours!” seems to be the main complaint of this non-developing industry while everywhere else, finfish farming is developing steadily. However, in recent years, this line of thought has changed. Pacific oceanic waters are pristine, broodstock are easily sought and free of pathogens and suitable aquaculture sites are numerous. Also, several places have no regulation in place yet, and regulations can be developed “in collaboration” with the aquaculture industry. Last, with an increase in population and a change in life style, domestic markets are growing and the demand for fresh marine fish from Pacific Island countries and territories (PICTs) is high.

A few PICTs have made marine finfish aquaculture a national priority, and have invested tremendous amounts of time and effort in setting up marine finfish hatcheries in which the final aim is to supply small- to medium-scale farmers who will sell their products to local markets.

Below are several examples of marine finfish initiatives that are currently underway in the region.

- In French Polynesia, the batfish (*Platax orbicularis*) — locally called paraha peue — hatchery will soon be operational and it is expected that a number of farmers will be able to supply local markets with this species in 2011. Paraha peue, a native species, is considered to be a delicacy.
- In New Caledonia, a national hatchery project will be operational in 2012. The aim will be to produce grouper and snapper species, and assist farmers in rural area to produce fish as an alternative to shrimp, or simply as a new activity. Although the original plan was to target export markets, the project has now changed its strategy to targeting local markets. If production reaches economies of scale, export markets for live or fresh chilled fish within the region will be considered.

- Also in New Caledonia, a private sector-based project is nearly ready to begin producing hatchery-reared rabbitfish. *iganus lineatus* is a species that is receiving increasing global interest because it is herbivorous (easy to feed) and popular as a food item (easy to sell).
- In Palau, grouper species are being closely looked at in the national hatchery. The country has hopes of developing an export market aimed at the Asian live fish market. Milkfish also has been selected as a priority commodity, most likely because of the large Asian community there, which favours this fish. Milkfish is relatively cheap to buy, but has huge sales potential (in terms of volume), as this fish is the daily dish for middle class households.

More projects are being developed throughout the region but the above examples are some of the highlights. The reality is that marine fish aquaculture in the Pacific is becoming commercially viable, although open ocean aquaculture is a different story.

### Offshore aquaculture in the region: The CNMI example

At the recent symposium in CNMI, pioneers of open ocean cage aquaculture in Hawaii were invited as resource people. Neil Sims from Kona Blue relayed his experience with farming amberjack (*Seriola rivoliana*) off the Kona coast, and Randy Cates, from Cates international, shared his moi (*Polydactylus sexfilis*) farming experience on Oahu. Both of these operations produce about 500 tonnes of product per year. Although they have hatcheries, these ventures receive support from, and continue to rely on, assistance from the Hawaii Oceanic Institute (represented by Charles Laidley during the conference) for their supply of fingerlings. It was said that these venture required an initial capital investment of about USD 5 million each.

Because offshore aquaculture requires large capital investment, it is dedicated to markets that can absorb large quantities of product. An interesting question is whether offshore aquaculture is transferable to CNMI in particular and to PICTs in general.

### Open ocean aquaculture



Open ocean aquaculture is the farming of marine fish in large sea cages in offshore areas, in water that is sometimes more than 50 metres deep. It requires large capital investment and high skill levels for operating. Offshore aquaculture is difficult to do because of sea conditions, swells and winds, but presents great advantages in that it poses no conflicts with other coastal zone users the way that conventional sea cage aquaculture does. If the aquaculture site is properly selected, offshore cages offer pristine growing conditions for fish due to clear, clean seawater (i.e. no pollution due to runoff or turbidity). Offshore aquaculture is usually developed in places where there are no other options. Open ocean aquaculture occurs around the Pacific Islands region, mostly in Hawaii, Asia and Mexico. The species that are farmed are usually fast growing, carnivorous, and avid swimmers (e.g. cobia, amberjacks, tuna).

There are no clear answers. CNMI has competitive advantages and is in need of ventures that will help boost its economy. The textile industry, which employed thousands of people, has collapsed. The tourism industry, which had flourished over past decades, has also dropped and is down to half of what it used to be. These factors, plus the recent economic downturn in the United States, have caused CNMI authorities to consider a range of economic activities, including aquaculture. CNMI (through the Northern Marianas College – the competent authority for aquaculture in the territory) has identified offshore farming as a potential tool for development. Land use is restricted but ocean access and bathymetrical charts show good geographical potential for offshore farming.

Hawaii's experience, as detailed by Cates and Sims, is an excellent lesson for CNMI and other PICTs. Offshore farming technology requires a high level of specific skills and some high technology inputs in terms of cage structure, navigation, and feeding processes. Cates and Sims demonstrated different strategies and approaches: Cates farms exclusively for local markets while Sims focuses on, among other things, targeting the overseas sashimi market and producing high-end products. Both have their constraints and opportunities, demonstrating that this type of farming needs to be studied on a case-to-case basis.

### Offshore farming in the Pacific

A common mistake when developing a list of priorities for aquaculture projects is to place greater importance on “technical feasibility” than on “markets and access to them”. It has been shown that offshore farming is feasible in places such as Hawaii but it is also known that Hawaii went in this direction because there were no other options.<sup>1</sup>

In the case of offshore aquaculture in PICTs, local markets are likely to be too small to absorb production from offshore farms, given that these must reach a high tonnage threshold before they break even (e.g. several hundred tonnes). If PICTs ventured into offshore farming, the only option would be to target export markets.

Fish species that can be sold in large volume, whole or processed, and which will guarantee weekly sales, must be identified while also determining whether it is possible to break even financially. Several questions that should be asked immediately include: How much are freight costs for importing containers of aquatic feed? How much are freight rates for exporting products, whether frozen (by sea) or fresh (by plane)? How much are labour costs? What sort of taxes will the company pay on imported equipment?

While offshore aquaculture is a huge challenge, in today's global context where quality food items, environmentally friendly aquaculture ventures, and production traceability are of concern to the end customers, these consumers may be ready to pay a premium to purchase fish from the Pacific that are raised in aquaculture facilities.

Another consideration are the markets that can be reached from any given PICT such as local restaurants, domestic trade, export (live, whole, processed or filet). Should we then produce live fish, expensive fish, “day-to-day” fish?

The choice will determine the scale of production that must be achieved in order to supply a particular market. Once these elements have been considered, then the entrepreneur will decide on a species or two and the appropriate technology to produce them (i.e. offshore aquaculture, open top floating cages, small-scale artisanal enterprises).

<sup>1</sup> There is a lack of protected coastal areas where traditional, open top cages could be deployed without conflicting with other sea users.

## Challenges to domestic tuna industry development in the Pacific

by Naitilima (Tima) Tupou

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*While some issues and constraints to domestic tuna industry development in the Pacific Islands region are generic, each country has a unique set of circumstances that affect the degree to which development can take place.*

Each fishing method, such as purse-seine or longline, has specific problems and issues. In recent years, the skipjack purse-seine industry has thrived while the longline industry has languished somewhat, with prices for large tunas remaining static.

There has been minimal domestic tuna fisheries development in much of the Pacific, although this has not been the case in the more established Pacific fishing nations such as Fiji, Papua New Guinea, Solomon Islands, and more recently, Vanuatu whose fishing fleet has expanded rapidly. Conversely, remote Pacific Island countries (PICs) tend to rely on fishing access fees from distant water fishing nations (DWFNs) as the main source of income generated from their fishery resources. This option provides the best return for geographically isolated and sparsely populated PICs.

Some PICs have concentrated their efforts on developing onshore infrastructure while others have concentrated on expanding their domestic fleets (or a combination of both). While each country is different, all have two things in common: 1) they lie within a region where it is extremely costly to operate, and 2) they are totally reliant on distant world markets, without which there would be no fishery at all.

### Cost of doing business

Operating costs — both at sea and onshore — are high within the region. Transport costs for imported goods such as fuel, bait, processing materials and fishing gear comprise a large component of operating costs. Approximately 65% of the operating costs of a Pacific Islands-based longline vessel are for imported goods. The cost of these inputs is further increased by import duties. Because PICs have a low “pay-as-you-earn” revenue stream (i.e. an income tax on wages), they apply a high rate of duty and taxes on consumable goods. Depreciation allowances (for tax purposes) are inadequate. The net result is that a domestic-flagged vessel is fiscally penalised compared with a DWFN vessel based out of the same port.

### Labour issues

Fishing vessels that are crewed by Pacific Islanders, whether domestic or foreign flagged, provide a large employment opportunity within the region. The Pacific Island Maritime Codes are outdated and have not followed changes adopted by other maritime nations or

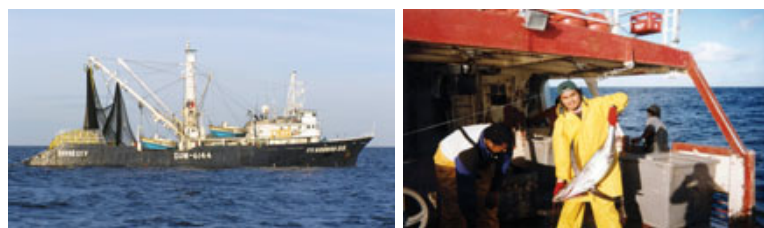
DWFNs. As a consequence, domestic-flagged vessels are disadvantaged, and more importantly, the advancement of Pacific Islanders to senior level positions is restricted by sea time requirements and extremely lengthy courses at Pacific Island maritime schools.

There is also a cultural difference with regard to working habits that needs to be addressed if PICs are to compete in the world labour market. Properly trained workers are in short supply and their understanding of the expectations of international customers is poor.

### Investment and finance

Almost without exception the major recent investments within the Pacific for shore processing and vessels have been initiated by private sector foreign investors. These investments have been in conjunction with local shareholders who hold varying percentages in the equity as required by the coastal state. Finance for these ventures has typically been provided almost in total by the foreign investor. While some may criticise the concept, it is a consequence of limited or no financing being available locally. A very positive advantage is that the foreign investor brings with them the expertise and knowledge of this complex and difficult industry. Foreign investment, through joint venture partnerships, “fast tracks” technology transfer from willing partners to PIC nationals.

A period of stabilisation will be necessary before trading banks in the Pacific view the fishing industry favourably. Various government support schemes for total indigenous ventures in the region (other than artisanal fisheries) have not generally been met with great success. Too many government-led ventures have failed, but in most cases they have provided the nucleus for subsequent successful purchases and increased investment by the private sector. The creation of national fishing companies was a first step in promoting local participation, but



*Foreign flagged or domestic purse seiners (left) and longliners (right), provide a large employment opportunity within the Pacific Islands region.*

governments need to go further and encourage funding support either internally or from donor agencies. Some major problems are:

- Donor funds for infrastructure initiatives (onshore or at sea) appears to be unavailable or lacking;
- DWFNs still receive fishery subsidies in the form of fuel rebates, accelerated depreciation, and soft loans that are not available to PICs; and
- Interest rates throughout the Pacific are among the highest in the world.

### Tenure and security of investment

A sustainable Pacific fishery is crucial to future PIC investment, yet the lack of tenure and security of licences in many PICs creates a nervous investment climate. Governments need to make investors feel confident in investing in domestic tuna fishery ventures in the region, and actively support enabling legislation that has a certain life and not subject to constant change. There is uncertainty among certain individuals and organisations about the effectiveness of the Western and Central Pacific Fisheries Commission as a regional fisheries management organisation.

### Access to markets

Domestic fisheries in the Pacific can only exist with continuing access to world markets. Only three PICs are on the European Union (EU) list of third countries<sup>1</sup> from which imports of fishery products for human consumption are approved. Sanitary and phytosanitary rules for access to international markets such as the USA are being tightened and others will follow, yet many PICs do not have laboratory or inspection facilities to comply. This will deter investment in the more isolated PICs and mitigate against vessel registration or reflagging. Basic training in food hygiene is necessary — starting at the most junior level position — to ensure that products originating from the Pacific Islands region meet all sanitary requirements. Continued preferential duty access to the EU for fishery products under African, Caribbean and Pacific country rules remains an important factor.

### Representation at international fora

At various international fora, PICs do not always negotiate as a group, often because of their diverse interests. Yet few countries have the resources to negotiate independently. This has recently been exemplified in the US Fisheries Multilateral Treaty and European Union Economic Partnership Agreement negotiations, where PICs are often represented by one lone delegate. Foreign consultants have taken the lead with trade negotiations at the World Trade Organization (WTO), General

#### What is PITIA?

The Pacific Islands Tuna Industry Association is a private sector organisation that works to promote and protect the commercial interests of the Pacific Islands domestic tuna fishery. From the more northern equatorial islands to the eastern subtropical states, the interests and level of development are diverse although the issues are often common.

The association was incorporated in the Federated States of Micronesia in 2005, a direct industry reaction to the formation of the Western and Central Pacific Fisheries Commission and the multiple conservation and management measures that continue to be developed in an effort to sustain tuna stocks in the western and central Pacific Ocean.

During an industry consultative process in 2004, held specifically to discuss the impact of the Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean on domestic tuna development, it was clear that there were substantial commonalities among PICs, and representatives agreed that the most effective way of addressing the issues would be as a collective.

PITIA member countries include Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu. Representation to the organisation, where it exists, is the national association and where organisations do not exist, a prominent member of the industry takes on the role

Agreement on Tariffs and Trade, and similar organisations. While consultants have performed this task in many PICs, it does not appear that local counterparts are being trained to take over this role. In some PICs, other industry interests take precedence over fisheries in trade or access negotiations.

Only a limited number of PICs have established and effective trade organisations, and it is a primary role of PITIA to facilitate the extension of these. Well meaning government officials attend major fora that have a commercial bias without seeking the input of industry. Generally, the voice of industry is weak throughout the Pacific, and this has worked to the detriment of fisheries development.

To provide further and expanded development of the domestic tuna industry, it is necessary to ensure that both sea and onshore domestic operations in the Pacific have the opportunity to be internationally competitive. Many internal restraints and regulatory controls need to be removed or reviewed to achieve this. Access to finance for infrastructure development remains a priority, both for PITIA and the fishing industry in coming years.

PITIA is governed by a directorate that is drawn from the entire range of business enterprises described in this paper. The Secretariat manages PITIA so that directors can remain active in their businesses or associations, thus ensuring that their input to recommendations is drawn from current understanding and involvement in Pacific tuna commercial affairs.

<sup>1</sup> *Third countries* is the term used in EU legislation to designate countries outside the European Union.

## Bycatch information consolidated in WCPFC database

by Larissa Fitzsimmons

Research Officer, Ecological Monitoring and Assessment, SPC Oceanic Fisheries Programme (LarissaF@spc.int)

*The bycatch of seabirds, sea turtles and sharks in the western and central Pacific Ocean (WCPO) is a concern for the region's tuna and billfish fisheries. One reason for this concern is that public perception of the sustainability of fishing practices can affect the market for tuna and billfish. The Western and Central Pacific Fisheries Commission (WCPFC) is responsible for the sustainable management of target and non-target (or bycatch) species in the WCPO. However, information about ways to limit and manage bycatch is found in a variety of sources. The WCPFC has sought to consolidate such information within the Bycatch Mitigation Information System (BMIS), an online database accessible at: <http://bmis.wcpfc.int/index.php>*

The BMIS is different from other bycatch databases in that it focuses on tuna and billfish fisheries in the WCPO (although information in the BMIS is relevant to other oceanic fisheries around the world). Only mitigation methods relevant to longline, purse-seine, pole-and-line, and troll fishing are considered. Similarly, only those methods shown to reduce, or have the potential to reduce, the bycatch of seabirds, sea turtles and sharks, are included.

Literature forms one section of the BMIS. Other sections include mitigation methods, decisions (regulations) and a list of target and bycatch species.

Within BMIS, it is possible to search the citations, abstracts or introductions of over 250 scientific and technical documents. Many of these source documents are journal articles, while others are meeting papers, project reports, fact sheets, or official guidelines, such as those from the WCPFC and organisations such as the Food and Agriculture Organization of the United Nations (e.g. FAO guidelines on reducing sea turtle mortality in fishing operations).

BMIS descriptions of mitigation methods summarise the latest knowledge on bycatch and bycatch reduction methods. For example, there is a discussion on circle hooks and their affect on turtle and shark species. Similarly, there is a review of research on fish aggregating device (FAD) management, such as building an ecological FAD that fishes as well as other designs, and the possibility of enticing sharks away from a FAD prior to closing a purse seine.

The BMIS also houses links to WCPFC decisions (e.g. resolutions and conservation and management measures) and those of other tuna regional fisheries management organisations that refer to and/or require the use of particular mitigation methods to protect seabirds, sea turtles or sharks.

It is also possible to search a list of target and bycatch species recorded in the WCPO Observer Database. Only those species that have been noted as "caught by gear" are included.

BMIS contains links to other websites and documents of interest, such as Birdlife International's seabird bycatch mitigation factsheets, SPC's longline terminal gear identification guide, and FAO's illustrated shark catalogues. A type of web feed has been added, making it possible to follow updates to BMIS and bycatch mitigation news.

There is a wealth of bycatch information available in WCPFC's BMIS. Because the database is still under development, comments on ways to improve the database would be appreciated.



BMIS website home page (<http://bmis.wcpfc.int/index.php>).

# Proper fish handling for quality and safety

**Steve Beverly**

*Fisheries consultant (stevebeverly@hotmail.fr)*

*Whether you are fishing to earn spare money or working as a full-time commercial fisherman, it is very important that you know how to handle fish properly. This is for your own safety, the safety of those who will be eating the fish, and so that the fish you deliver to the customer will be of high quality and have the highest value possible.*

## Introduction

Fish have intrinsic qualities that are unique to each species (e.g. flavour and texture) that are otherwise beyond the control of the fisherman; and extrinsic qualities that are a result of how they were handled by the fisherman. The fisherman has no control over intrinsic qualities, which are part of the fish regardless of what is done to them. Extrinsic qualities, however, can be controlled by handling fish properly and by cleaning and chilling them as soon as possible. Fish that are fresh and have been handled properly look better, smell and taste better, are safer to eat, and are more valuable than poorly handled fish.

Intrinsic qualities	Extrinsic qualities
Species	No damage from gaffing or handling
Size	No scale loss, skin shiny and firm
Sex	No bruising or gaping
Market appeal	No blood in flesh
Flavour	No burned flesh
Fat content	Gills red, eyes clear
Diseases present or not	Fresh seaweed smell
Parasites present or not	Core temperature between -1.0°C and 4.0°C

In addition to food safety, you should also be concerned with safety in the workplace. Fishermen can be injured from the tools they use to catch fish, but can also be injured by the fish that they catch. From the time a fish is caught until it is delivered to the first customer it can be a hazard because fish have sharp teeth, have spines that are often poisonous, are coated with bacteria, can contain toxic substances, and can give off poisonous gases if allowed to rot. Fish can cause serious injury, disease, or even death during handling if care is not taken.

## Fish handling and quality

### *How to tell if fish is fresh and was properly handled:*

- High quality fish have a seaweed-like smell and not a fishy odour
- Gills, if present, should be red, not brown or grey
- Skin should be shiny and firm to the touch with no bruising
- Scales should not fall off
- Eyes should be clear and bright
- Core temperature should be between -1 °C and 4°C

### *Fish quality is lost because of:*

- Bacterial spoilage
- Enzyme activity
- Chemical changes
- Physical damage
- Dehydration
- Contamination

### *Bacterial spoilage*

Bacterial spoilage is the most important factor affecting fish quality. Bacteria are present on the skin and gills, and in the guts of fish, but not in the flesh of living fish. A fish's immune system protects the flesh from bacteria but only while the fish is alive. Once a fish is dead, bacteria can invade the flesh and reduce quality. Bacteria can enter the flesh through cuts and other damage to the flesh. Bacterial growth on fish is slowed by proper cleaning, dressing and chilling. One type of food poisoning that people can get from eating poorly handled fish is called histamine, or scombroid, poisoning. Histamine poisoning occurs when bacteria convert histadine, a naturally occurring amino acid, into histamine. Histamine poisoning is most common in tuna (*Scombridae* spp.) and mahi mahi (*Coryphaena hippurus*) that were not chilled properly.



*Clear eyes, shiny skin, properly iced... these mahi mahi will certainly attract top prices at the United Fish Agency longline auction, Honolulu, Hawaii.  
Image: Naomi Blinick/Marine Photobank.*

## Enzymes

Enzymes are naturally occurring chemicals that fish use for digestion and for muscle movement. After a fish dies, enzymes begin to digest the flesh causing the flesh to burn or become soft and mushy. One way this happens is that the natural sugars in the flesh are converted to lactic acid. This happens when the sugars are digested without any oxygen, or under anaerobic conditions.

The flesh does not receive any oxygen after the heart stops beating but does continue trying to convert sugar to energy. The result is the formation of lactic acid, which causes a condition called burned flesh syndrome, where the flesh turns brown and has an off-flavour. This can be avoided by properly stunning and then spiking the fish so that all muscle activity stops. Enzyme activity is also slowed by chilling.

## Chemical changes

Chemical changes, including oxidation, causes a fish to have a fishy odour. Chemical changes can be slowed if the fish is kept out of sunlight, is kept covered and moist, and is chilled properly. One particular chemical change causes the fish to become stiff (called rigor mortis). This is normal and the fish may stay stiff for several hours. It is important not to handle fish too much during rigor mortis, and they should not be processed or moved around. Mishandling during rigor mortis can cause gaping.

## Physical damage

Physical damage includes bruising, gaping, and mushy flesh. Fish muscle tissue is fragile compared with muscle tissue of other animals (e.g. cow and pig), and is easily damaged. Bruising occurs when blood seeps into the flesh and clots, and the flesh then becomes soft and discoloured. Gaping occurs when layers of muscle tissue separate. Tossing fish, slamming them onto the deck, or throwing them into a fish box will cause bruising and gaping. Over-filling a fish box so that fish on the bottom are squashed will also cause bruising, gaping, and mushy flesh. Bending a fish can cause gaping. Bruising and gaping can occur several days after the fish is caught so it is important to always handle the fish gently from catching to off-loading. Bruising, gaping, and mushy flesh can all be reduced if fish are handled gently and chilled quickly.

## Dehydration

Dehydration, or drying out, can occur if fish are left uncovered or in the sun. Dehydration can be avoided if fish are chilled quickly and kept covered with ice or chilled seawater. Chilling the air inside a fish hold or fish box is not a good way to cool a fish because it takes longer to get the temperature down to 0°C and because the fish will dehydrate.

## Contamination

Contamination can be caused by fuel and oil, chemicals, bird and rat droppings, and cockroaches and flies. Oil and chemical contaminants can ruin the smell and flavour of a fish. Contamination from pests can introduce bacteria that cause spoilage. Contamination can also be caused by using dirty ice. Sometimes contaminated fish are considered spoiled and must be destroyed. This results in a total loss for the fisherman.

Contaminants should be kept away from fish and from surfaces that come in contact with fish. Fuel, oil, paint, cleaners, and other such chemicals should never be stored in a fish hold. Oil spills should be cleaned up immediately, and animal and insect pests should be eliminated. Only clean ice made from potable water should be used to chill fish.

1. A cold chain is a temperature-controlled supply chain. An unbroken cold chain is an uninterrupted series of storage and distribution activities that maintain a given temperature range. (Source: Wikipedia [http://en.wikipedia.org/wiki/Cold\\_chain](http://en.wikipedia.org/wiki/Cold_chain)).

### *Three keys to fish quality*

- Always handle fish properly
- Chill fish quickly and maintain the cold chain<sup>1</sup>
- Practice good sanitation

### *Proper handling — general*

Proper fish handling has a significant impact on quality. Fish are handled three or four times between the time they are caught and the time they reach the first customer. With each handling they become more fragile; therefore, handling should be minimised. Good handling practices reduce physical damage, which in turn reduces bacterial spoilage.

Only minimal handling is needed for smaller fish such as mackerel, skipjack tuna, and small bottom fish. These fish should be chilled immediately after landing with no further handling. Medium sized fish such as groupers and snappers can be spiked and bled right after landing, and then chilled. Larger fish, such as wahoo, billfish, and yellowfin and bigeye tunas should be gaffed and then landed on a foam pad or carpet and not directly on a hard deck. Fish that are gaffed should be gaffed in the head only. They should then be stunned immediately with a fish bat if they are thrashing, and then spiked and bled and dressed as soon as possible.

Care should be taken not to cut into the flesh when dressing the fish. Throughout this process, all fish should always be treated gently. Fish should not be thrown or slammed onto the deck or into a fish box or fish hold. Small fish should be lifted by the head, not the tail. Larger fish should be lifted by the tail and throat, avoiding bending the fish or breaking the isthmus (the connection between the jaw and throat) as this will cause gaping. Fish should never be stepped on. Fish holds and fish boxes should not be overloaded. All fish should be chilled as quickly as possible. Spiking, bleeding, and dressing vary according to customer requirements and the size of the fish. Some customers prefer gilled and gutted (G&G) or headed and gutted (H&G) fish, others prefer whole, undressed fish. Some customers ask that fish be spiked and bled but not gilled and gutted. Spiking and bleeding improve fish quality, including bottom fish and troll-caught fish, but are probably more important for larger fish such as sashimi-grade tunas.

### *Proper handling — spiking*

Spiking kills the brain and reduces enzyme activity. Fish such as snappers, can be spiked by inserting the spike under the gill cover and penetrating the brain from the bottom of the skull. Fish with thick, hard skulls, such as mahi mahi and opah, can be spiked by inserting the spike into the back of the eye socket and piercing the bottom of the skull by shoving the spike up and back at a 45-degree angle. Larger fish, such as tuna, can be spiked by piercing the skull from the top between the eyes and shoving the spike back at a 45-degree angle.

### *Proper handling — bleeding*

Bleeding improves fish quality by reducing enzyme activity and by preventing blood clots from forming in the flesh. Bleeding is best done on most fish by making a cut in the throat just in front of the heart, severing the blood vessels that supply blood to the gills. It is important to rinse away all blood immediately with clean sea water. Bleeding on tunas is sometimes done by cutting the blood vessels on both sides of the fish that lie just under the skin on the pectoral fin recess just behind the pectoral fins. A seawater hose is then inserted into a cut in the gill cavity to rinse away all blood.

### *Proper handling — dressing*

Dressing can include gilling and gutting (removing the gills and guts) but can also include heading (removing the head) and finning (removing the fins). Gilling and gutting improve fish quality by reducing the amount of bacteria present in the fish. Heading and finning are usually done at the buyer's preference to reduce freight costs. Sometimes dressing is done on shore before fish are shipped or delivered to a buyer. Before chilling dressed fish on a boat, all blood, slime, and bits of flesh should be rinsed away with clean seawater. If fish are dressed after they are unloaded from the boat they should be rinsed with chilled potable water, not ambient temperature water and never with seawater from a harbour.

## Chilling

Chilling and maintaining the cold chain slows bacterial growth, slows enzyme activity, keeps fish moist, and helps to reduce physical damage. The ideal temperature for fresh fish is 0°C. Fresh fish should not be kept at a temperature below -2°C or above 4°C. Maintaining the cold chain means that the fish stay within this temperature range from the time they are caught until they reach the first customer. There are three ways to chill fresh fish on a boat – icing, refrigerated seawater (RSW), and chilled seawater (CSW).

### *Icing*

For icing fish, flake ice or tube ice made from potable water are best. Crushed ice may damage fish if the chunks of ice are large. Seawater ice is too cold in most cases, and may cause fish to freeze. It is important to start with a bed of ice deep enough so that as the ice melts the fish will not come in contact with the bottom of the fish hold or fish box. Fish should be placed in rows, back up and belly down, side-by-side but not touching each other, and should be covered completely with ice. It takes about 2 kg of ice to properly chill 1 kg of fish. Only clean ice should be used. Dirty ice should be discarded. Fish are chilled when the surrounding ice melts and heat is removed. Melting freshwater ice always stays at 0°C so it is not necessary to monitor the temperature of an ice

hold. It is important, however, to have proper drainage in the fish hold or fish box so that meltwater does not stay in contact with the fish. It is also important to have a cap layer of ice over the top of the fish so that they do not dehydrate. About 1 m<sup>3</sup> of fish hold will be enough for about 300 kg of fish on ice, depending on the size of the fish.

### Refrigerated seawater

RSW requires a refrigeration compressor to chill the seawater in a fish hold. Usually fresh water is added to the seawater to raise the temperature and keep the fish from freezing. It is important to keep the temperature of the refrigerated seawater at about -2 to 0°C. Therefore, it is critical to monitor and regulate the temperature. It is also important to have good circulation so that the water temperature is uniform. Baffles may be needed to prevent fish from moving around in the RSW hold. Some fishermen like to hang fish vertically in an RSW hold to prevent them from moving. Larger fish such as tuna can be put in cloth or plastic body bags to prevent damage. Each cubic metre of an RSW fish hold can chill about 500 kg of fish.

### Chilled seawater

CSW is made by mixing two parts of clean ice to one part of seawater. The resulting slurry will stay at about -2 to 0°C. It is not important to monitor the temperature of a CSW hold as it will always stay within this range as long as there is sufficient ice. As more fish are added more ice may be needed to maintain this temperature range. The slurry should be thick enough so that fish cannot move around. The slurry should have the consistency of wet cement. Each cubic metre of a slurry hold can chill about 500 kg of fish.

## Sanitation

Sanitation is important to reduce bacterial spoilage. The working deck of the boat should be rinsed clean after each catch. Blood, slime and scales should be rinsed away with clean seawater regularly while fishing. Gills and guts should be thrown overboard. The deck and fish hold and fish boxes should be cleaned and sanitised after every fishing trip. Good sanitation protects against bacterial spoilage and prevents contamination. All surfaces that come in contact with fish should be rinsed to remove blood, slime, scales and offal. They should then be scrubbed with a mixture of seawater and detergent, using a stiff nylon bristle brush. All detergent should be rinsed away with clean seawater. Then all surfaces should be sanitised with a mixture of seawater and household bleach in a ratio of about 20 to 1. This should be allowed to stand for about five to ten minutes before being rinsed away with clean seawater. All tools used for catching and processing fish should also be cleaned and sanitised, including gaffs, spikes, saws and knives. Gloves should be washed and sanitised as well. Household products containing phenols should never be used for sanitising.

## Fish handling and safety

### Be aware of hazards when fishing:

- Make sure that all crew members know the specific dangers of each fish species that you may catch, and the specific dangers of each piece of equipment and fishing gear on the boat.
- Make sure that all gaffs, spikes, meat hooks, saws and knives are clean and sharp.



- Always have a bolt cutter onboard so that if a fisherman becomes impaled by a hook, the tip and barb can be cut off. The hook is then removed by pulling it out the way it went in. If the tip has not pierced the skin it must be shoved through until it is exposed so it can be cut off. Never pull a hook out without first cutting off the tip and barb.
- Never wrap a leader line around your hand when pulling in a large fish.
- When pulling up a multiple hook-line with a fish still in the water, always remove empty hooks as they come up. Otherwise the fish could run and impale the fisherman with a hook.
- When standing by to gaff a fish, always hold the gaff so that the hook is up and not on the deck, otherwise someone could step on the gaff hook when the boat rolls and become seriously injured.
- When gaffing marlin or other billfish, always grab the bill when hauling the fish onboard so nobody gets injured.
- Always wear gloves when handling fish. This prevents injuries to your hands and fingers. Fish are coated with slime that contains millions of bacteria. Small cuts and scrapes on your hands can become infected easily.
- Wear protective clothing and gumboots when handling larger fish.
- Remove hooks by striking with a fish bat or by gripping the leader and turning the hook the opposite way that it went in. Avoid putting your hands in the fish's mouth as the sharp teeth and gill rakers can cut your fingers.
- Stun and then kill larger fish immediately before they have time to injure someone when they flop around on deck. Smaller fish can be stunned by immersing them directly into RSW or CSW.
- When lifting heavy fish, bend your knees and keep your back straight. Lift with the knees. You may need help from someone else to lift or move very large fish.
- Always rinse blood and slime from your hands and gloves after cleaning and handling a fish.
- Treat any cuts or scrapes on hands immediately by cleaning and disinfecting them.
- Never enter a fish hold that contains rancid fish or if it smells like rotten eggs.



*The bluespine unicornfish (Naso unicornis) has two razor-like spines on each side of its caudal peduncle.*

*Artwork: Les Hata.*

### *Be aware of hazards from handling fish:*

- Dorsal and anal fin spines
- Opercular spines
- Caudal spines
- Tail scutes
- Sharp teeth of wahoo, barracuda, moray eels and sharks
- Sharp beaks of needlefish and garfish
- Bills of marlin and swordfish
- Poisonous spines of scorpionfish
- Poisonous tail barbs of stingrays
- Poisonous barbs of some sharks
- Stinging tentacles of Portuguese-man-o-war and some jellyfish (often encountered while fishing)
- Poisonous gas given off by decomposing fish

### *Be aware of fish that are unsafe to eat*

Finally, there are some fish that are not safe to eat even if they are handled properly. These include fish that have accumulated ciguatera toxins in their flesh, fish that have accumulated high levels of mercury in their flesh, and some species of pufferfish that are naturally toxic. Ciguatera and mercury can both occur in fish that are normally safe to eat. Generally, larger fish in a group are more likely than smaller fish of the same species of being ciguatoxic. Larger fish are also more likely to have higher levels of mercury. Consult your local fisheries officer to find out what the ciguatera and mercury risks are in your area. It is best, however, to always avoid eating puffer fish, as a mistake could be fatal if the wrong species is consumed.

# Developing a database and relevant management indicators for monitoring commercial fisheries<sup>1</sup>

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## Background

New Caledonia's three provinces — Northern Province, Southern Province and Loyalty Islands Province — have jurisdiction over their respective coastal fisheries. Each province collects its own catch data, issues fisheries regulations, and establish public policies aimed at supporting the fisheries sector.

Each year, as part of its responsibility to ensure statistical monitoring of economic data, New Caledonia produces a summary of the provincial data it has received. Given the need to standardise data and procedures, the three provinces expressed a desire to draft a common set of terms of reference before establishing standardised provincial databases.

New Caledonia's ZoNeCo programme<sup>1</sup> assisted with this work and the Secretariat of the Pacific Community (SPC) played an active role by developing the terms of reference. It was on this basis that the provinces proceeded with developing their respective databases.

Although the data collected by the three provinces are similar, different software is used to process the data, and the lack of a common taxonomic reference system makes compiling these data difficult and very imprecise.

The goals of developing databases for each province were to:

- facilitate the annual data compilation work carried out by the Merchant Marine and Maritime Fisheries Service (SMMPM);
- allow non-nominal data (i.e. the name of the fishermen is not linked with the data) to be exchanged between provinces; and
- facilitate data analysis and the production of summary reports.

Each database's structure and interface make it possible to:

- enter and print out fishing permits;
- enter details on the characteristics of fishing campaigns and related catches; and
- import permits and safety inspections from SMMPM software.

Applications are currently being developed for the Northern and Loyalty Islands provinces. The Southern Province has completed the development of its computer application, which is now operational.

Once developed, the databases will:

- serve as a tool to store data over long periods of time;
- allow managers to gain a clear picture of the coastal fisheries sector's production levels and special characteristics;
- make it possible to produce reports for decision-makers;
- allow fishing statistics to be shared with professionals; and
- allow extraction of summary data about the sector for SMMPM, using a taxonomical reference system that is common to all three provinces.

## Objective

The large amount of data in the database (80,000 entries per year for the Southern Province) means that in-depth descriptive analyses of the coastal fisheries sector should be possible at several levels of detail (e.g. by species, group of species, season, geographic zone, gear, fisher, type of activity).

The goal of this pilot project is to 1) identify whether a database that is created from a common set of specifications can produce descriptive analyses of fisheries exploitation levels, and 2) analyse fisheries statistics so as to identify indicators of changes in reef and lagoon resources. The Southern Province's operational database was used for this study.

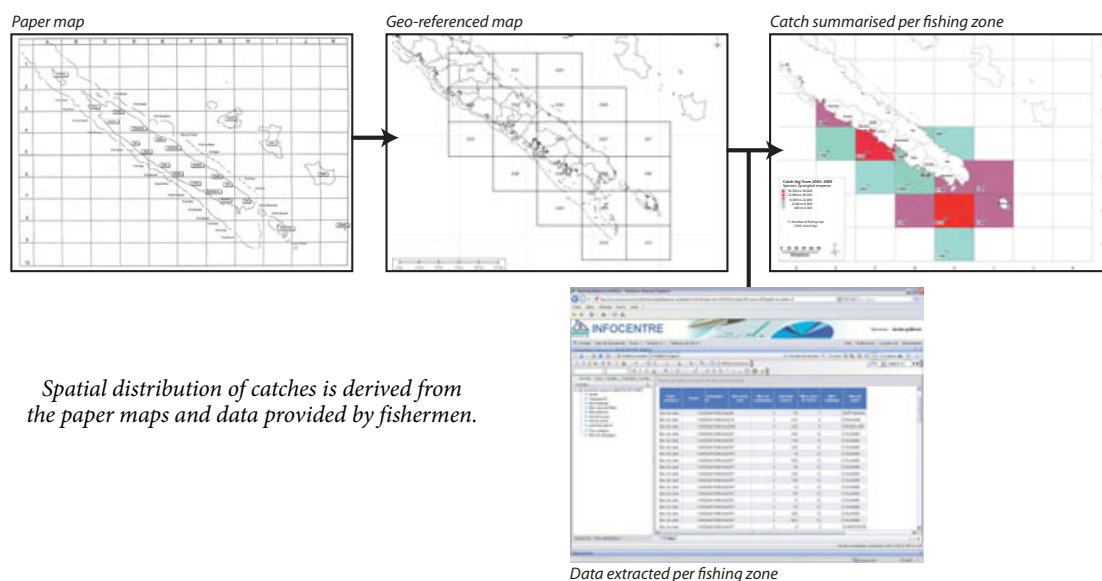
This approach involves technical support — in the form of additional information and statistical analyses — to provincial fisheries departments. It is important to note that this project does not, in any way, aim to replace the expertise and experience of fisheries managers who are vital for decision-making.

The ultimate goal is to provide decision-makers with a statistical picture of catch trends, which will allow them to enhance their perception of trends in the sector.

<sup>1</sup> This article is a summary by Manuel Ducrocq of Nicolas Guillemot's report (Guillemot N. 2011. Indicateurs d'évolution des ressources récifolagounaires pour la gestion et le suivi de la pêche professionnelle en Province Sud de Nouvelle-Calédonie. Rapport d'étude Zonéco (ADECAL), Nouméa, 50 p. + 91 p. annexes), which is available (in French) on the ZoNeCo website: <http://www.zoneco.nc>

<sup>2</sup> In 1990, New Caledonia and the Government of France set up a research programme called ZoNeCo (Zone Économique de Nouvelle-Calédonie) for the sustainable management of marine resources within New Caledonia's exclusive economic zone.





the status of exploited resources because catches are subject to many factors (e.g. socioeconomic, cyclical, regulatory).

Reduced catches do not necessarily mean that the stock is diminishing, if at the same time the number of fishermen or the time of their fishing campaigns has diminished. But, if effort has been constant and catches are diminishing, then it can be assumed that stocks are likewise diminishing.

## Spatial distribution of catch and CPUE

Reef and lagoon resource use levels cannot be described in any relevant way without examining spatial distribution. The reference grid that was used was digitised and georeferenced, and capture and CPUE data were extracted and then linked to geographic information from the fishing zone.

The maps show high variations in spatial distribution for both catches and CPUE, no matter what the resource is. The main interest in these graphics is to be able to get a more precise picture of the distribution of use and fishing pressure. In particular, when a general trend can be identified on a provincial scale, it can provide

information on which fishing zones are most likely to be affected by this trend and which zones are likely to need specific management measures for a given resource.

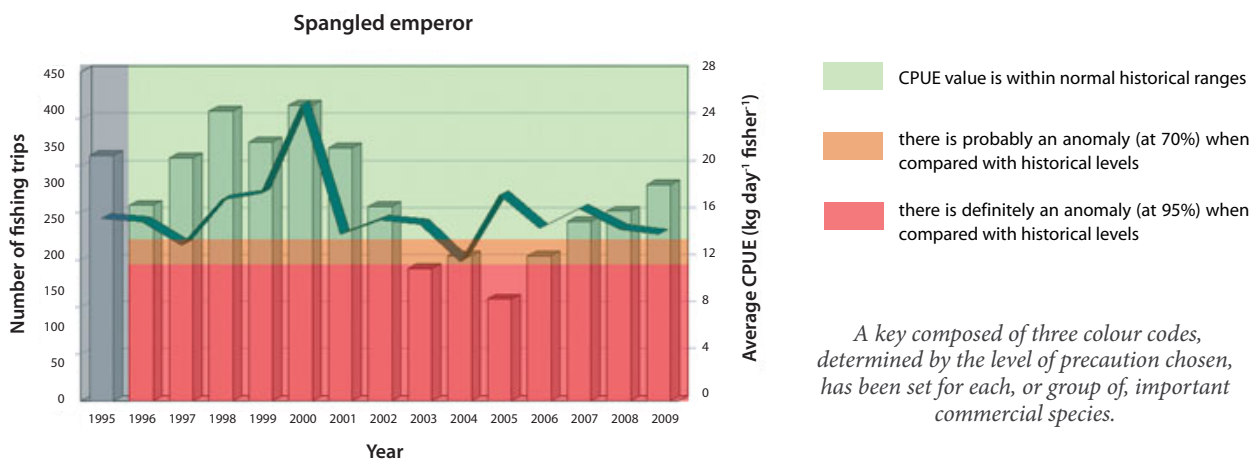
## Statistical analyses

Statistical analyses are designed to calculate warning thresholds (regarding changes to these parameters) that alert fisheries managers to abnormal situations in exploitation levels.

Because the biological data needed to determine the health status of resources in New Caledonia is based on exploitation levels (and so, do not provide enough information), warning thresholds for resource use were set on the basis of historical variations in CPUE.

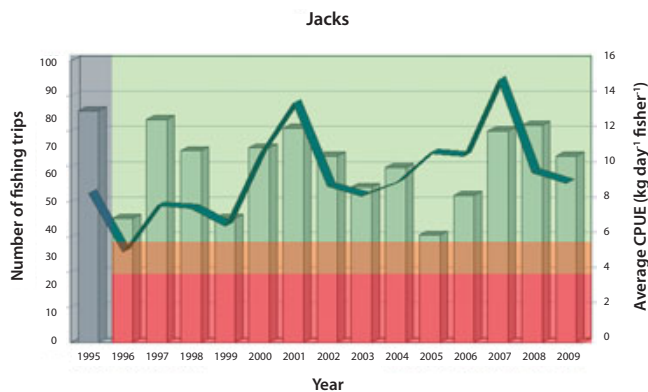
Thresholds calculated in this way for each exploited resource make it possible to detect variations in fishing levels as compared with historical levels.

*For a given resource, what range of variation observed makes it possible to state that one value is significantly different from the others?*

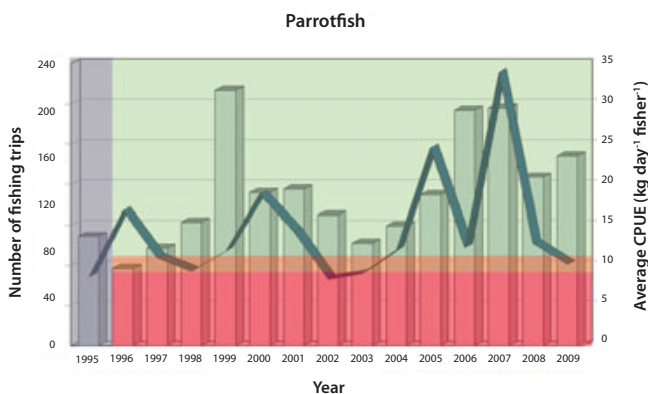


The desired range, which allows thresholds to be set, differs for each resource and depends on the number of years of available data, the number of yearly fishing trips, the average number of years considered, interannual variation, and the desired level of precaution.

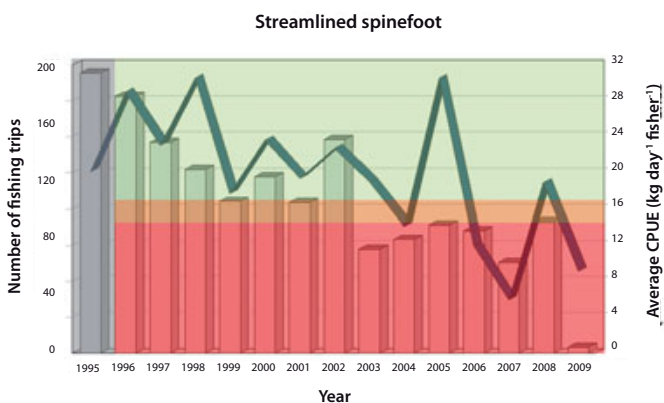
For each species or group of species involved, the sensitivity analysis carried out made it possible to produce a key composed of three colour codes determined by the level of precaution chosen. Some examples are given below.



An example of a resource whose 2009 CPUE value is within the normal historical range.



An example of a resource whose 2009 CPUE value shows a probable anomaly.



An example of a resource whose 2009 CPUE value shows a definite anomaly.

*Thresholds provide warnings that the CPUE value is significantly lower than historical levels but they do not necessarily correspond to stock overexploitation levels because they do not provide any information on the biological health status of the resource.*

Analyses of the main exploited resources in the Southern Province led to the identification of three levels of relevance for the proposed thresholds.

**Relevant:** The threshold values obtained are aligned with historical CPUE characteristics; they are within the tolerance of the historical interannual variability in the species concerned, and provide relevant warning levels. This relevance level covered 15 species caught in the Southern Province.

**Uncertain:** The threshold values obtained show a range that is clearly lower than the historically observed variation range. They are not very tolerant and these thresholds can be exceeded on a regular basis without this necessarily reflecting a downward trend or an abnormal situation. Such cases may appear with resources whose recruitment (and, therefore, abundance) varies greatly from one year to the next. The thresholds obtained can be used for information purposes. This relevance level covered two species caught in the Southern Province.

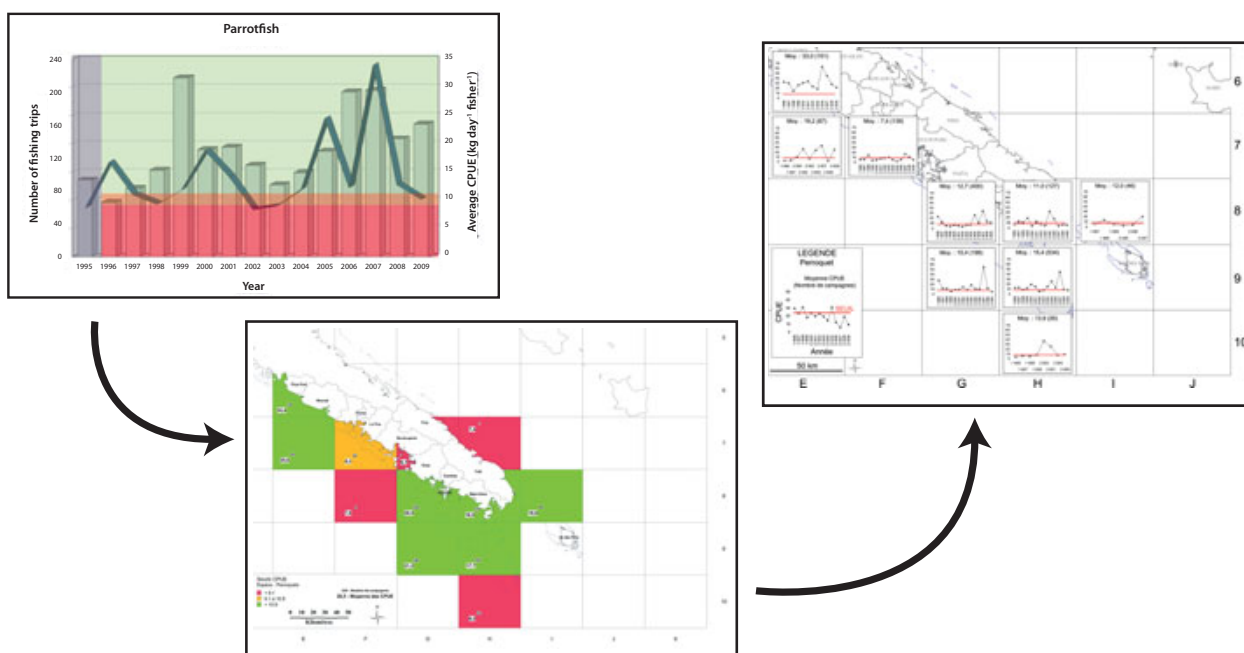
**Unusable:** The threshold values obtained show a range that is much greater than the historically observed range and is very far from average levels, which makes the thresholds too tolerant to be used in a relevant manner. This can be due to high intra-annual variability in data for such resources, which makes it impossible to calculate precise thresholds. This relevance level covers five species caught in the Southern Province.

*For exploited resources as a whole, 75% of catch volumes can be monitored in a statistically relevant way which includes variation thresholds and set warning levels.*

Sensitivity analyses were carried out for each category of resource in order to calculate the alert threshold using the statistical software G\*Power, based on the characteristics of historical data from extractions done with Business Object and Excel. The thresholds set during this study do not need to be updated annually. They can take into account the historical characteristics of fishing levels over a 16-year period, and can be considered to be reference thresholds; they only need to be revised when there are changes in technology or regulations.

### Spatial breakdown of thresholds and additional analyses

Once an alert threshold has been set, it is then possible to make a diagnostic of the presumed status of a resource on a province-wide scale. However, the spatial distribution of resources and fishing activities can vary greatly and so the spatial structure needs to be considered in order to formulate a relevant diagnostic.



*Spatial breakdown of thresholds and additional analyses make it possible to identify fishing zones that are the sources of CPUE variation anomalies, and provide managers with the high quality information they need to make decisions.*

Given that it was not possible to have specific thresholds for each fishing zone, CPUE spatial distribution was examined, particularly CPUE levels as compared with generic thresholds covering all of the Southern Province.

The maps make it possible to identify fishing zones that are the sources of CPUE variation anomalies, and provide managers with the high quality information they need to make decisions (a case of exceeding a threshold in a given zone does not lead to the same decisions as those made for broader trends).

Using generic thresholds to diagnose the CPUE level of a given fishing zone raises the issue of the zone's specific characteristics (particularly in terms of its productivity level). In fact, in the case of a zone where productivity is lower than the average for all zones, CPUE levels will probably be lower than the thresholds set for all zones. Therefore, historic CPUE levels for the fishing zone in question should be examined in order to determine if the recent values below the threshold are the result of a decrease in CPUE or from low natural productivity levels (historically low CPUE).

Mapping historical changes in CPUE makes it possible to 1) have a more accurate geographic definition of the diagnosis made using overall graphs, and 2) highlight those precise zones that are a problem in terms of abnormal CPUE variations.

## Practical use of this tool

The diagnostic for all resources is done on an annual basis after all fishing logsheets have been entered.

When a threshold is exceeded, a range of factors needs to be examined.

## External factors

Variations in CPUE can be influenced by outside factors that are independent of the resource's status, including:

- a significant change in the main operator(s);
- an unusual weather event;
- a change in regulations; and
- a change in technology.

If a major outside factor affects CPUE variations, it may be impossible to establish a reliable diagnostic because CPUE levels are not always comparable with historical levels, and thus, with the thresholds calculated from them.

If the change is significant and ongoing, the validity of the threshold may be compromised. Thresholds may have to be updated for the resources in question. Several years of data will then be needed to ensure that the new threshold is robust.

## Data entry

The first step to take when a threshold has been exceeded is to check the data. By targeting data on the resource in question and the related operators, it is possible to eliminate any entry errors or mistakes in data information that could be the source of the false CPUE value for the year involved in the diagnostic.

When a threshold is exceeded and data problems and external factors have been eliminated, the possibility

of a problem with the status of the resource can then be raised.

### Orange threshold, or pre-alert threshold

The purpose of this threshold is to ensure that the resource does not reach the red threshold. A suspected anomaly linked to an exceeded threshold should lead to a scientific study to determine the exact nature of the problem with the resource, and can lead, over the long term, to management measures designed to reverse the trend.

Conducting sampling protocols to analyse size spectrums and growth curves for the species in question should make it possible to compare the levels of the studied resource with biological references, and to deduce the study resource's health status.

### Red threshold, a proven anomaly

This level should immediately lead to a specific study designed to clearly identify the origin of the anomaly and to assess the health status of the resource in question, as well as define relevant management measures. While waiting for the results of the study, conservative management measures designed to limit the abnormal trend are highly recommended. At the very least, categorising the resource as excluded or subject to special authorisation should allow a decrease in fishing pressure.

*When a threshold has been exceeded, a detailed map-based analysis must be carried to clearly define the spatial scope of the anomaly by identifying those zones that caused the threshold to be exceeded and, within these zones, those that correspond to an actual downward trend (and not to a lower-than-average productivity level).*

The mapping component appears to be vital for defining adequate compensatory measures and/or ordering specific studies.

## Recommendations

For this pilot study, the data quality was sufficient for calculating thresholds for the species caught in the Southern Province. However, if data continued to improve in terms of quantity, quality and representation, this would significantly improve the precision of analyses, and better target their results, particularly in terms of calculating alert thresholds by geographic zone.

**Improving collected data** — Several points were noted where improvements could be made:

- **Standardising the basic observation unit (i.e. the fishing trip)** — Compiling data from several trips onto a single logsheet can lead to bias in statistical analysis and does not allow the locations of catch data to be shown;

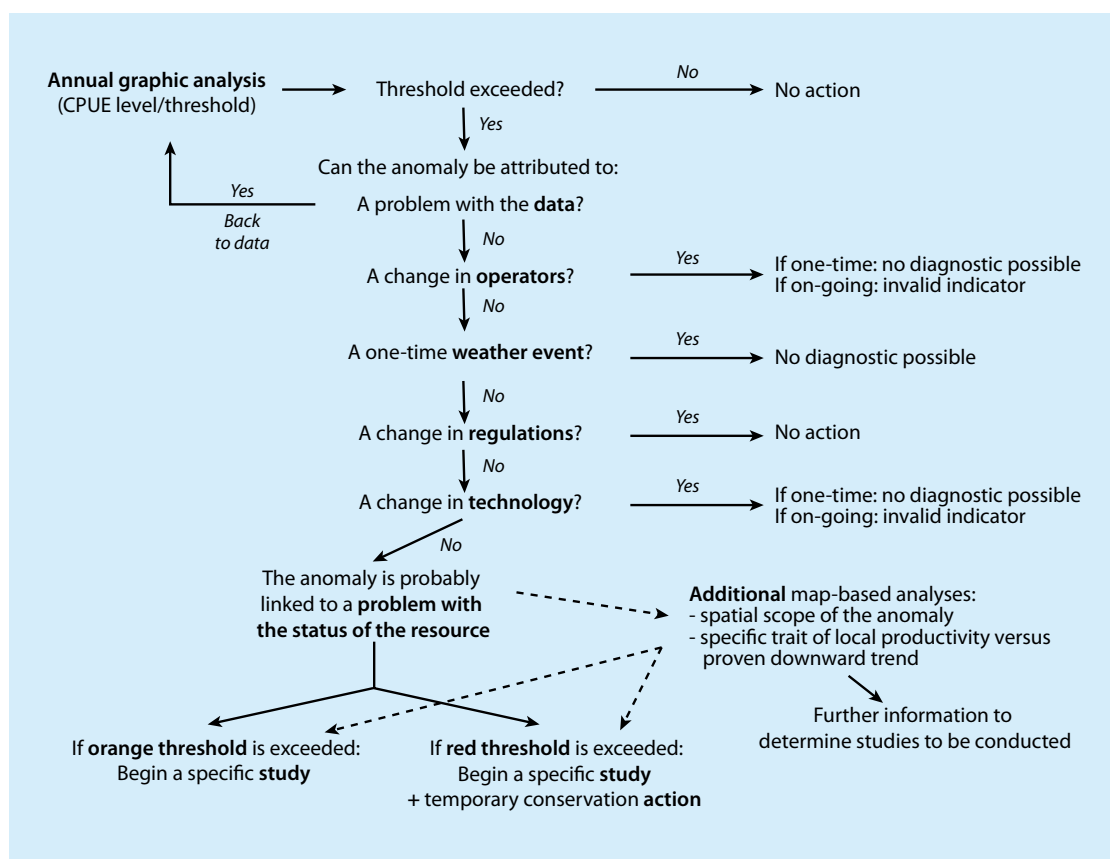


Chart of the priority actions to be taken when a threshold is exceeded.

- *Completing logsheets* — Some logsheets are only partially completed. However, if a variable needed to calculate CPUE is missing, the logsheet cannot be used, leading to a loss in data;
- *Fishing log coverage rates* — The higher the coverage rate, the more precise the analysis will be;
- *Refining data at the taxonomic species level* — The various species caught are grouped in categories. This clustering ensures that each category has enough data to carry out analysis but, more importantly, makes it possible to standardise fishers' reports, which vary greatly in terms of descriptions of species caught. Providing commercial fishers with an identification guide would allow analyses to be targeted to the species level, particularly in those categories that cover a large number of different species, whose interest for fisheries vary.

*Providing each fisher with a yearly report on his/her activity, as the Southern Province currently does, allows fishers to benefit from concrete feedback on their reports and should contribute significantly to the above-mentioned improvements.*

**Improving the spatial distribution of data:** Identifying fishing zones based on the grid currently used made it possible to examine the spatial distribution of exploitation levels, variations over time, and their situation in terms of alert thresholds. However, the size and layout of the squares used had some major disadvantages.

- *Zone size* is too large, so fishing activity can only be plotted very roughly. The size of the zones is not consistent with the small-scale diversity of habitats, resources and, consequently, practices;
- *Zone layout* does not take into account certain factors that provide natural structure to reef and lagoon populations, particularly the coast to offshore gradient.

Two options are possible for improving the spatial distribution of fisheries data.

- *Raw data collection:* Using a new grid layout is possible but there could be a problem with data continuity. In order to be able to analyse both older data and data from the new grid, the new fishing zones would need to be subcategories of the older ones. The grid's level of precision must be compatible with the level of detail fishers are likely to provide.
- *Further processing of data:* Linking maps that describe the main reef and/or lagoon habitats and geomorphic units to those that show species and/or fishing gear should make it possible to tie the data contained in the database to a limited number of habitats. Once CPUE data have been reassigned to corresponding habitats, they can then be mapped on existing geomorphologic or habitat charts. This approach has the advantage of not modifying the currently used grid.

It provides relevant cartographic outputs and allows for greater precision. However, this option entails significant requirements in terms geographic information system analysis.

### Towards new indicators

**Fishing distance:** The results of these analyses do not take into account the distance fishers must travel to ensure that they maintain their exploitation levels and the size of the fishing zones is too large to estimate any notable changes in this regard. This is likely to create a problem in interpreting the observed trends. In fact, observed catch and CPUE can remain stable over time, even when fishers must continually cover greater distances in order to maintain their exploitation levels. In such cases, an increase in resource scarcity would not be shown by the analyses. Therefore, it is important to know the distance the fisher travels during each fishing trip. Reducing the boundaries of the fishing zones could partly resolve this problem, and using fuel consumption data would make it possible to approximate the distance covered and to create a "quantity of fuel used" indicator. It would also be possible to directly consider CPUE corrected by the quantity of fuel used (in kg/litre of fuel/fisher).

**Monitoring landings/biomonitoring:** Recording biological factors (e.g. size, weight, gonad maturity) at the main landing sites would allow a comparison of these factors with referenced values for the concerned species; this would also make it possible to initiate a collection of biological data for each zone, as this is vital to evaluate stock health status.

**Including socioeconomic data:** The large amount of data entered into the database means it should be possible to expand descriptive analyses, and to identify socioeconomic indicators. Such an approach would allow us to focus on management aspects for both the sector and stakeholders in terms of economic performance. The added value of such an approach would double by implementing alert thresholds for abnormal changes in certain economic parameters for the sector, and by using factorial analyses that integrate various parameters from the sector. This would make it possible to create activity profiles, compare their performances and their impacts on resources, and provide managers and operators with precise information on relevant choices in terms of determining fleet typologies and project sizes, and better defining eligibility criteria for public aid.

### Acknowledgements

Outcomes of this operation were made possible through the active involvement of the Southern Province, particularly the Office of Finance for developing the BIP-BIP software, and the Department of Rural Development/Office of Fisheries for their involvement in the historical monitoring of this area.

# Cost-benefit analysis of community-based marine protected areas: Five case studies in Vanuatu

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## Introduction

### *Community-based marine protected areas in the Pacific*

In the Pacific, local populations, governments and other institutions are investing considerable effort into improving ways to sustainably manage coastal marine resources with inexpensive and strong performing tools (Bell et al. 2009; Mora et al. 2006).

For some stakeholders, community-based management of marine resources is proposed as one of the best options for securing the well being of both reefs and communities in the Pacific Islands (Johannes 2002; Johannes and Hickey 2004; Tawake and Aalbersberg 2002; UNEP 2004).

Community-based marine protected areas (MPAs) have experienced impressive development over the last decade (Aalbersberg et al. 2005). They usually form part of a larger management scheme referred to as a marine managed area (MMA), and more than 550 documented MMAs now exist in the Pacific (Govan 2009). Management is carried out primarily by the community through relevant user groups, and involves local and national institutions and private stakeholders.

Management rules such as fishing closures, temporary bans, size restrictions and gear controls can be diverse, and some are still based on traditional ecological knowledge (Cinner and Aswani 2007; Johannes 1998, 2002). In recognition of these characteristics, a regional term is used: locally managed marine area or LMMA.

### *From theory to reality: What do we really know about the benefits of MPAs to communities?*

The benefits and distribution patterns expected from community-managed MPAs in the Pacific are little studied, as highlighted by a recent bibliographic study on socioeconomic and ecological impacts of MPAs in Pacific Island countries (Cohen et al. 2008). Although, a good deal has been written about what MPAs could or should do, few empirical studies demonstrate what they actually do for people (Mumby and Steneck 2008).

### *MPAs and the bilateral agencies in the Pacific*

In the Pacific, development banks and bilateral agencies have used several intervention instruments for coral reef ecosystem management: direct support via a project grant approach, pilot programmes, trust funds, capacity building or alternative livelihood promotion. To illustrate, nearly 40 MMAs in 10 Pacific Island countries and territories have been directly supported in their start-up phase since 2005 (Oréade-Brèche 2008) by the Secretariat of the Pacific Community (SPC)–Coral Reef Initiative for the South Pacific (CRISP) project.

## Project objectives

From the perspective of bilateral agencies, financial investment in small MPAs must be analysed from a double bottom line perspective: 1) impacts on economic growth and poverty reduction, and 2) impacts on world biodiversity.

One important criterion of these investments is the continuity of the intervention. The existence of local benefits and their distribution patterns are often identified as a successful factor for continuity, and projects should be marketable not only to donors but also to stakeholders and governments (UNEP 2004).

To respond to previous requirements and, at the same time possibly increasing the “stewardship” of projects to local stakeholders, an investment appraisal was conducted in select community-based MPAs in Vanuatu.

The research was designed to focus on observed and proven impacts of the MMA, and results came from intensive field study.

## Methodology

### *General approach*

The study monitored selected MPA impacts through a control-impact protocol on fishery yields and tourism revenues, and conducted a cost-benefit analysis (CBA) for each MPA and for each stakeholder (village level, national and international level). CBA results were then

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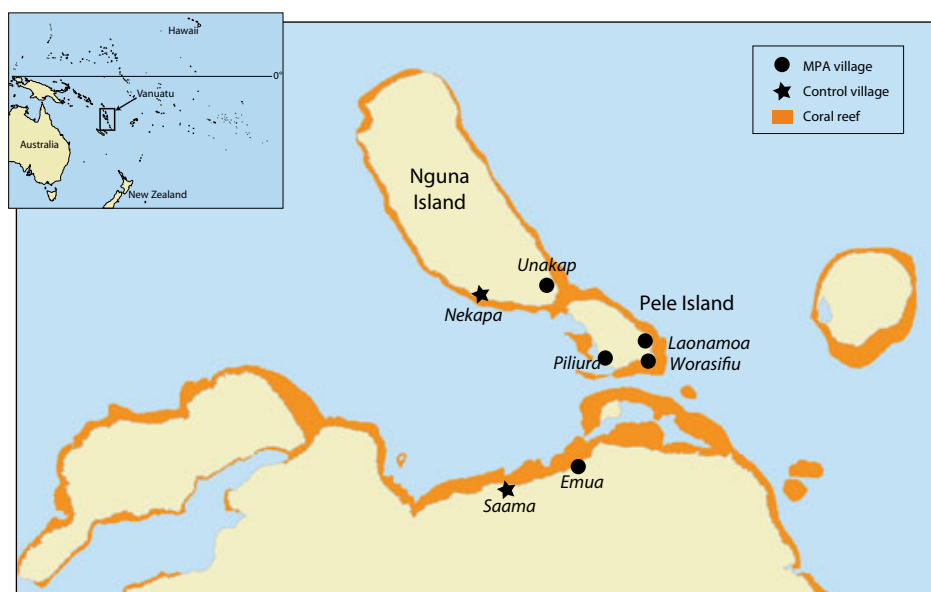


Figure 1. Location of villages, MPAs and control sites.

used to 1) compare the benefits of MPAs with the calculated annual village gross domestic product to give an idea of the relative importance of MPAs for villages, and 2) realise a financial analysis of MPA cash flows to present the internal rate of return and the return on investment for development banks.

### Selection of MPA sites

#### Criteria

Five villages — each with an MPA — and two villages — both without an MPA — were selected in North Efate (Fig. 1 and Table 1). Each MPA site met the three following criteria: 1) a fringing coral reef was the dominant ecosystem; 2) the MPA had been managed and adequately enforced by communities for at least five years, with the reserve covering at least 10% of the fishing ground area<sup>2</sup> and, 3) fulfilled at least three of the six key success factors identified for community-based MPA (Pollnac and Crawford 2000). The key success factors met by the selected sites were: 1) population size and the village area are relatively small, 2) there is a visible level of community participation in decision-making, and 3) there is a continuing presence of the implementing agency.

### Fishing activities

Each village has customary tenure of its fishing ground, from the shoreline to the end of the reef (Johannes 2002), and the size of the fishing ground varies from 0.5 km<sup>2</sup> to 1.5 km<sup>2</sup> (Table 1). Both subsistence and commercial fishing take place within the MPA, and fishing activity

is evenly distributed across the population. Nonetheless, as described by several authors (Amos 2007; Bartlett et al. 2009; Hickey 2008), the commercial fishery is not developed as a formal activity, and represents a supplemental and irregular income to agricultural activities for most households.

The two main gear types used are 25-metre-long gillnets (7.2 units km<sup>-2</sup>) and spearguns (6.4 units km<sup>-2</sup>). These gear types usually target species that benefit from the protection that marine reserves offer (Russ and Alcala 1996), and include species from the families Scaridae, Acanthuridae and Serranidae. Other gear types that are used less regularly include cast nets (depending on the migration timing of some species), handlines (used from the shore or a canoe), hand collecting (common at low tide for *Octopus* sp. and shells), as well as some other traditional gear types (e.g. hand spear).

### MPA and other fishery management rules

Every MMA is associated with a unique village. The size of an MPA within an MMA varies from 0.1 km<sup>2</sup> to 0.2 km<sup>2</sup>, which is similar to most small MPAs in the Pacific (Govan 2009), and which represents an average of 15% of the reef fishing ground. The MPAs are all actively managed by villagers through an MPA committee or environment committee consisting of village members. Some MPAs are non-permanent closures, where periodic harvesting can occur for specific village events.

Other fishery management rules are also in place (e.g. on trochus, sea turtles, night spearfishing, specific rules to some species migration).

<sup>2</sup> This corresponds to the minimal time period and fishing ground size that allow for the effects of an MPA to be visible with regard to fishery yields (Gell and Roberts 2003)

Table 1. Socioecological context of the villages

	MPA sites					Control sites	
	Emua	Piliura	Unakap	Laonamoa	Worasifiu	Nekapa	Saama
Resident population	240	110	90	250	50	110	130
Number of private electricity generators per household	0.15	0.05	0.06	0.06	0.11	0.05	0.12
Monthly average household expenses (monetary and non-monetary) (Euros)	479	373	388	420	420	438	455
Monthly average non-monetary incomes (% total expenses)	31%	40%	40%	36%	36%	36%	31%
Tourism infrastructure (number of beds)	5	-	8	14	5	-	-
Dominant reef geomorphology	Intra-seas exposed fringing, forereef	Intra-seas exposed fringing, forereef	Ocean exposed fringing, forereef	Ocean exposed fringing, forereef	Intra-seas exposed fringing, reef flat	Intra-seas exposed fringing, forereef	Intra-seas exposed fringing, forereef
Fishing ground size (in km <sup>2</sup> )	1.5	1.1	1.3	1.3	0.5	1.2	0.9
Demographic pressure on reef (inhabitants km <sup>-2</sup> )	157	102	71	188	104	92	144
Main fishing gear used	Net, speargun, handline	Net, speargun, handline	Speargun, handline	Speargun, handline	Speargun, handline	Net, speargun, handline	Net, speargun, handline
Fishing pressure index	3.1	3	1.35	3.75	3.65	3.05	3.25
MPA creation date	2005	2003	2003	2003	2003	-	-
MPA size (km <sup>2</sup> )	0.24	0.13	0.12	0.14	0.13	-	-

### Tourism activities

Small-scale rural tourism takes place in every village. Tourism activities include day tours, snorkel tours, scuba diving, staying in guesthouses, scientific tourism, and other activities associated with the previously named activities, such as restoration and the selling of handicrafts.

Guesthouses are small structures that cater to adventure and nature travelers. The houses are developed without external financing (except occasional aid) and can survive even with low occupancy rates because they do not borrow funds from banks and keep their costs very low. The majority of guesthouses are managed privately but some are owned and managed by the community.

Scientific tourism includes visits from researchers, non-governmental staff, or other professionals.

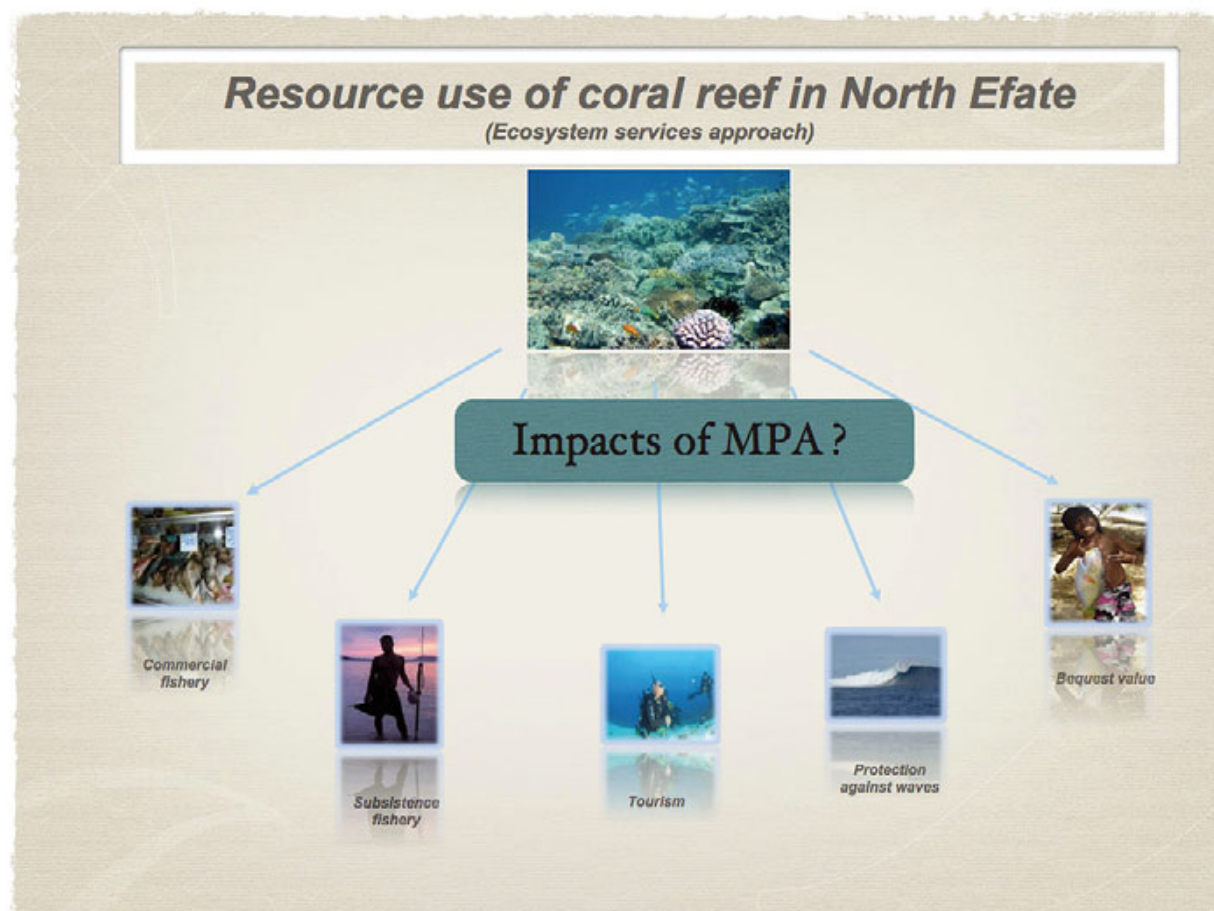
As confirmed by a study (Trip consultants 2008) that showed that around 8,000 international and domestic (non-affinity tourism)<sup>3</sup> visitors came to North Efate in 2007, this kind of tourism is in the start-up phase.

### Validation of control sites

The control-impact approach is proposed by several authors (Balmford et al. 2008; Underwood 1994) as a way to solve the difficulty of separating and identifying MPA effects from site or context effects.

Two villages acting as control sites were chosen to be compared with selected MPA villages. The control sites were similar to MPA sites with regard to ecological attributes, fishing effort, tourism, and their socioeconomic context in order to make it possible to compare the various sites and identify MPA effects. Specific methods were

<sup>3</sup> Non-affinity tourists: tourists who have no family or friendship ties with their hosts.



employed to validate the degree of similarity of these previous factors: 1) a medium-scale approach (Clua et al. 2006) to compare fish habitat attributes; 2) the use of a synthetic fishing effort index; and 3) a household income and expenditure survey.

Several statistical tests were applied to data to determine factors such as distance from an MPA, substrate type, fishing pressure index, and tide cycle; and to identify their effects on catch per unit of effort (CPUE) due to the existence of the MPA.

### Selected MPA impacts

An MPA can increase:

- subsistence food items, and commercial reef fisheries,
- underwater tourism and other tourism sectors,
- biodiversity,
- protection of coastlines from wave damage (due to the presence of a healthy coral reef), and
- social capital.

## Valuation methods

### Spatial perimeter of analysis

The spatial perimeter of MPA impacts took into account 1) spillover effects of an MPA,<sup>4</sup> 2) the area where use(s) take place (e.g. fishing grounds or dive sites), and 3) the residence of stakeholders (e.g. fishermen, tourism businesses).

Following the conclusions of different authors (Halpern 2003; Jennings et al. 2001; McClanahan and Graham 2005; Russ and Alcala 1998), and given the small size of the studied MPAs (less than 50 ha), it was assumed that the potential spillover area would cover a maximum of 1 km on either side of the MPA when the habitat was continuous. This spatial effect applies to the main local commercial reef fish species (Scaridae, Acanthuridae and Siganidae). Therefore, considering the size of the fishing grounds of the villages, it was found that most of the potential spillover effects from an MPA benefited mainly the village.

<sup>4</sup> Spillover effects refers to when marine resources are so plentiful within an MPA that they venture into surrounding areas where they can be caught by fishermen.

### *Quantification and valuation*

The valuation of impacts is based on a two-step, bio-economic approach. The first step is to quantify MPA benefits (e.g. volume of additional extracted biomass). The second step is to calculate the monetary value of the impacts. The valuation is focused on the financial value of the impacts.

### *Data collection approaches for quantitative valuations*

Data collection includes several techniques: interviews and questionnaires, focus group discussions, experimental fisheries, fishing logbooks and monitoring.

As reported on by several authors (Caddy 2000; Pickering et al. 2003), the impacts of an MPA on a fishery are usually small and their identification requires precise data. In this study, preference was given data collection through field observations and experiments instead of surveys when the objective was to gain quantitative data (e.g. fishery).

### *MPA impacts on fishery productivity (spillover effect)*

CPUE (e.g. kg of fish captured per hour of a standard fishing effort) was chosen as an indicator of fish productivity. CPUE has been collected and differentiated by gear types in order to cope with the complexity of fisheries and multi-species fisheries. CPUE for gillnetting and spearfishing are collected in both MPA and control sites. Experimental fishing is used for gillnet fishery and fishing logbooks for spearfishing.

### *MPAs and how they affect tourism*

For each type of tourism activity, the way in which an MPA affected visitation was assessed. During their stay in the village, most tourists can take advantage of several activities such as trekking, participating in cultural ceremonies, and relaxing on the beach.

Two methods were used to assess visitation: interviews with business owners to define the distribution of activities undertaken by tourists, and a tourism advertising images analysis (AIA) to estimate the weight that marine related activities had in their choice of destination.

AIA is a method that is based on the fact that tourists make their decision to come to a specific site on previous information received through advertising (Andersson 2007). AIA was realized through a counting of the number of images suggesting different activities or ecosystems.

### *Economic valuation*

Classic economic valuation techniques were applied in order to valorise MPA impacts on added values of commercial fishery and tourism. For subsistence fishing, the monetary valuation was done in two steps. First, the protein equivalent of catches for the most representative fish species was estimated and then transformed into the equivalent weight and price of a basic commercial food item (canned tuna in this case).

Economic valuation of impacts on coastal protection and on bequest value<sup>5</sup> is described in detail in the technical report.

### *Results*

The average investment per community-based MPA is EUR 2,400/ year (including amortising of setup costs). Investments for each of the five MPAs are in the range of EUR 5,000–19,000 for the initial investment phase (setup and assets), and EUR 900–4,000 for annual operational costs. Investment mainly comprised building capacity in villages (70% of operational costs).

Returns on investment are generally attractive, with a mean value of 1.8 after 5 years (SD = 0.9) and a potential of 5.4 (SD = 2.5) after 25 years.

MPAs have produced an average annual gross profit of around EUR 8,900 (SD = 3,000), which represent 7% of the total village gross domestic income. The previous result confirms the role of MPAs as a development tool for rural areas, and is a necessary (but not sufficient) condition to ensure their durability without external support.

Impacts on rural tourism and fisheries were the main sources of benefits (56% and 26% of annual benefits, respectively) and both sectors represent key sources of cash income and protein for villages (see Fig. 2).

Less visible in the economic valuation, MPAs have also had positive impacts on social capital, the protection against wave damage that a healthy ecosystem can provide, and the bequest value attached to the ecosystem.

Observed benefits of these small MPAs to the fishery sector included an increase in productivity for the principal gear types (estimated to vary from a 4% to a 33% increase in CPUE). Other observed effects included fish catches were more stable for each fishing trip, and the maximum fish size increased for villages with an MPA.

Benefits to tourism were evident for rural tourism (through guest house and day tours by family own-businesses). The importance of an MPA in the choice

<sup>5</sup> Bequest value: The current generation places value on ensuring the availability of biodiversity and ecosystem functioning to future generations. This is determined by a person's concern that future generations should have access to resources and opportunities. It indicates a perception of benefits from the knowledge that resources and opportunities are being passed to descendants. Source: [http://www.coastalwiki.org/coastalwiki/Non-use\\_value:\\_bequest\\_value\\_and\\_existence\\_value](http://www.coastalwiki.org/coastalwiki/Non-use_value:_bequest_value_and_existence_value)

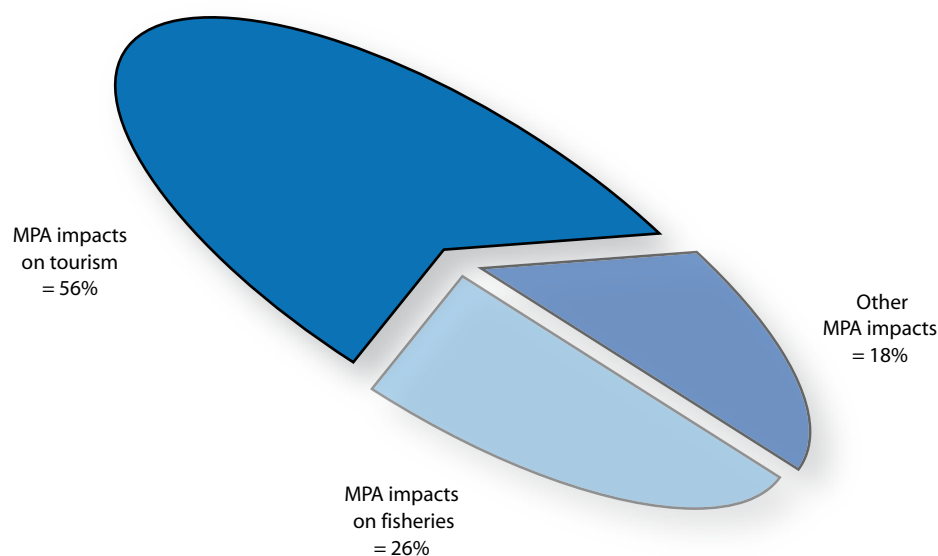


Figure 2.

*MPA annual economic benefit distribution based on average benefits from five MPAs, 2009.  
Mean benefit per MPA = EUR 8,900 per year.*

of tourism site was estimated to vary between 40% and 75%. In a similar way, it was observed that, on average, for 60% of visitors, at least one group member took part in some snorkeling activities.

On average, 70% of benefits were directed to the villages. The other 30% went to national stakeholders (mainly through tourism activities).

Nonetheless, the level of capital investment per MPA (equivalent to a mean annual of EUR 14,000 km<sup>-2</sup> of protected area) must be analysed carefully. Not all investments in MPAs have been recuperated after the first five years, and for some, there is no return on investments (i.e. breaks even), even after 25 years of projections. This reflects a differential between the potential of a fishery and tourism business development for some villages, and the investment amount.

Also, there is no evidences that indicates MPAs have an influence on the level of maximum sustainable yield for a fishery, or for the maximum carrying capacity for tourism. Therefore, the hypothesis that an MPA can ensure sustainable benefits (from fisheries and tourism) at the intergenerational scale remains uncertain.

Furthermore, in a context of increasing fishing effort and rapid introduction of a market economy, questions may arise on the resilience of community-based governance and the role of the MPA as the primary tool for maintaining sustainable catches.

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*The reefs at Nguna and Pele islands and the village of Unakap. Image: Nicolas Pascal.*



a. A meeting of the MPA or environment village committee.  
b. Cast net fishing at low tide in a zone opened to fishing.  
c. A traditional sign indicating a tabu zone (no fishing).

All images: Nicolas Pascal.

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Original text: English

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