Fisheries Newsletter

Pacific Community
Communauté du Pacifique

#150
(May–August 2016)

ISSN: 0248-076X

In this issue

Editorial

I am delighted to introduce the 150th edition of the SPC *Fisheries Newsletter*, a milestone marking 46 years since the first issue in 1970.

Our fisheries programme was established in 1954, two years after hosting the first Fisheries Conference in Noumea in 1952 and six years after SPC itself was founded in 1947. Since then, the development of both SPC's fisheries programmes and the *Fisheries Newsletter* has reflected the fundamental economic and cultural significance of this sector to Pacific Island people.

Today, the *Fisheries Newsletter* is read throughout the region and internationally, and is considered a primary source of scientific and technical information, advice and advocacy for a sustainable fisheries sector in the Pacific Islands region.

Two feature articles in this 150th edition trace the evolution of SPC's Coastal and Oceanic Fisheries Programmes, which are now the two main programmes of the Fisheries Aquaculture and Marine Ecosystems Division (FAME). Other articles highlight the continued importance of FAME's role in designing scientific bio-economic models, analytical methodologies and assessment techniques to provide the best scientific projections and advice to assist Pacific Island countries and territories in sustaining the ocean's health and harnessing its wealth sustainably.

The 150th SPC *Fisheries Newsletter* is dedicated to past and present SPC staff and to our colleagues and partners throughout the Pacific Island fisheries sector.

Moses Amos
Director, Fisheries, Aquaculture and Marine Ecosystems Division

Reef passage to Nukufetau village, Tuvalu (image: George Vann Temanaui).

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

Crossing the bridge between science and management: The 12th meeting of the Scientific Committee of the WCPFC

Representatives from countries across and beyond the Pacific met this past August in Bali for the 12th Regular Session of the Scientific Committee (SC) of the Western and Central Pacific Fishery Commission (WCPFC). In this meeting, delegates review the latest science relevant to the management of migratory species in the Western and Central Pacific Ocean (WCPO), and make formal recommendations to the WCPFC meeting, which is held in December every year. The SC meeting is the key and most exciting meeting for the scientists of the Oceanic Fisheries Programme (OFP) of the Pacific Community (SPC); as the WCPFC's science services provider, the OFP deliverables presented at this meeting (over 40 SC papers by OFP authors) provide the backbone for these important discussions – and it is the key pathway through which OFP's work translates into concrete outputs for Pacific communities. The OFP team was heavily involved in presentations and working groups for all of the four themes reviewed by the SC: data and statistics, stock status, management issues and ecosystems and bycatch mitigation.

One of the exciting developments on the data and statistics front this year was the first official annual provision of full operational data for all Japanese fleets. Japan now joins Korea and China, which both began providing such data last year, and the USA, which has provided data since 2007. Operational (set-by-set) data are available from all Pacific Island countries and territories but distant-water fishing nations have historically provided data aggregated at a much coarser level (in time and space). This contribution from Japan provides great opportunities for SPC scientists to better account for the impact of fleet dynamics in the management of complex, large-scale fisheries, and in particular to improve the indices of tuna abundance that are used to inform stock assessments.

In parallel, talks of electronic reporting (ER) and electronic monitoring (EM) occupied an important place both before the meeting (with a two-day working group on this topic), and on the floor, with several delegates mentioning ER and EM in their interventions. ER and EM gathered overwhelming support across member countries to move ahead with the development of data standards, trials and implementation. The growing and universal interest in applying these technologies to Pacific fleets is sure to lead to breakthroughs in fisheries data collection and management in the years to come.

In the ongoing quest to improve the quality of species and size composition data for the purse seine fleet, a new data source is being explored: cannery receipts data. Companies routinely document both species and size distribution when they purchase a vessel's catches, and this detailed information is gathered for all catches (compared with current observer-based methods which sample 0.2–0.5% of the catch). SPC verified that the sample of available data matched up with observer records and highlighted the potential for this unconventional source to transform the SPC's data collection toolbox for purse seine fisheries. It was also emphasised that, to realise this potential, the cannery data need to be available comprehensively so that all purse seine trips can be cross-checked in this way.

Assessments of stock status provided by both OFP and ISC[1] again drew lively discussions, with the stock status of Pacific bluefin and skipjack tuna keeping the delegates occupied for many hours. The two stock assessments on the SPC's to-do list for 2016 were skipjack tuna and South Pacific blue shark. Skipjack tuna is the most caught species of tuna in the Pacific (1.8 million tonnes in 2015) and the raison d'être for the extensive purse seine fishery in the tropics. This species is fast-growing and short-lived, and, accordingly, previous assessments by SPC have shown that it was above or close to the agreed management target reference point, reflecting the stock's ability to sustainably support high levels of fishing pressure. This year's assessment was no different except for the extra twist of the strong El Niño event that took place during 2014 and 2015, which resulted in increased fishing and relatively large catches in the Central Pacific, which was concurrent with improved recent recruitments and stock status. The dynamics of the stock and fishery over the next few years will be especially interesting to follow as we move away from El Niño conditions.

The stock assessment for the South Pacific blue shark was not such smooth sailing. Successful stock assessment models require good knowledge of the species' biology, together with a reliable and sufficiently long time-series of catches. In this first iteration of an assessment for this stock, the catches for this species, despite it being the most commonly observed shark bycatch in the longline fishery, had to be estimated since catches for sharks tend to be severely under-reported across fleets. As sharks live for so long, especially compared with tropical tunas (e.g. the blue shark lives for over 20 years compared with skipjack, which lives for 5 years), long time-series of catch data are especially important, but the further back in time the data go, the more challenging it becomes to reconstruct catches. Because of both data and modelling challenges, the OFP stock assessment team were unable to satisfactorily estimate the current status of the stock for this year's SC, but are working hard to identify potential approaches to improve this in the future.

[1] International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean

In addition to stock assessments, the OFP team also presented an update on planned management strategy evaluation (MSE) analyses for both skipjack and South Pacific albacore tuna. The MSE approach can directly model all of the practical steps that go into the management of a species, from data collection and assessment to the implementation of fishing regulations, and relies on extensive stakeholder participation for its success. The framework for this participation within WCPFC is still being agreed upon but will likely involve several preparatory workshops to be attended by country delegates.

Another initiative progressed by the OFP team is the development of bycatch data exchange protocol (BDEP) templates to summarise bycatch data. This project is currently focused on ensuring that bycatch data are properly summarised and available to WCPFC members. It will facilitate the exchange and sharing of these data so that this important source of information on the interactions between fisheries and ecosystems can be accessed by all interested stakeholders.

Continuing from the bycatch theme, three species groups were assessed this year for the designation under the 'key shark/elasmobranch species' status: devil rays, manta rays and pelagic stingrays. This designation was based on a review of eligibility criterion done by OFP. Traditionally when species get this designation, they have to be reported on vessel logsheets (not just by observers) and they become included in the Shark Research Plan, which can entail both formal updates on stock status and/or further research on the species' biology. The main outcome of this year's review process was that, for species where there are good catch estimates already (if, for instance, they are mostly caught on fleets with high observer coverage, as devil and manta rays are), the delegates needed to clarify the definition for 'assessment-only' species (i.e. those that only get considered in the Shark Research Plan). So far, no species have received this special designation.

From the scientists' perspective, a significant win this year was the recognition that tagging programmes should be an ongoing component of the SC's work, given their role as a critical input into tuna stock assessments. To support this, substantial new funding was recommended in the SC budget for the Pacific Tuna Tagging Programme. This research programme relies on extensive tagging trips across the Western and Central Pacific Ocean and delivers essential inputs into the movement and stock status of key tuna species. The resulting information is particularly important for the WCPO skipjack assessment, and hence the management of equatorial purse seine fisheries, for which indices of abundance are particularly hard to estimate using conventional approaches.

An important increase in funding was also allotted to the tissue bank, which collects and archives a reference collection of biological samples of marine organisms from the Pacific to allow innovative analyses to be conducted on a large geographical scale. For example, it has been used to look at mercury levels in tuna muscle at the scale of the Pacific, allowing us to identify areas of higher and lower levels of mercury content. With some samples as old as 20–30 years, it also provides the opportunity to analyse the effect of climate variability and climate change on this large and complex ecosystem on which tuna fisheries are so reliant.

In addition to SPC's work, excellent contributions were presented by our scientific colleagues who work across the Pacific, including assessments for Pacific bluefin tuna and blue marlin by ISC, seabirds by-catch mitigation measures by New Zealand and Japanese scientists, ongoing research on post-release mortality in sharks by NOAA[2], and new swordfish growth and maturity estimates by CSIRO[3], which will prove useful in next year's assessment for this species.

Back at the office, the team gears up for the next year's assessments for yellowfin tuna, bigeye tuna and swordfish (reflecting SC's recommendations), the meeting of WCPFC's Technical and Compliance Committee, and of course, the Commission meeting to be held in Fiji in a few months, where the SC's and TCC's recommendations are reviewed and translated into actual management measures and regulations.

For more information:
Laura Tremblay-Boyer
Fisheries Scientist (Stock Assessment), SPC
LauraT@spc.int

[2] National Oceanic and Atmospheric Administration of the US Department of Commerce
[3] Commonwealth Scientific and Industrial Research Organisation, Australia

Long time-series of catch data are essential for shark stock assessment.

12th Central Pacific tuna tagging cruise: research area shifts west

Since 2008, the tagging cruises organised by SPC have been designed to catch and tag tuna in areas where pole-and-line fishing gear is not efficient due to bait ground absence. Using special trolling gear developed in Hawaii, and targeting the National Oceanographic and Atmospheric Administration's Tropical Atmosphere Ocean (TAO) project buoys anchored between the 180° and the 140°W meridians (Figure 1), the Central Pacific (CP) tagging cruises have improved the overall spatial coverage of the Pacific Tuna Tagging Programme tag releases. Interestingly, they have also greatly increased the number of bigeye tuna tagged to nearly 38,000, which represents more than 92% of the fish captured during this research. Recapture data from tagged bigeye show large-scale movements from the Western and Central Pacific Ocean to the Eastern Pacific Ocean, suggesting that species stocks should be managed at the whole Pacific Ocean scale. The data recovered from archival tagged bigeye (125 fish from 651 releases to date) have provided considerable information on bigeye behaviour and habitat utilisation. This knowledge is important for estimating fish relative abundance and their catchability by type of fishing gear.

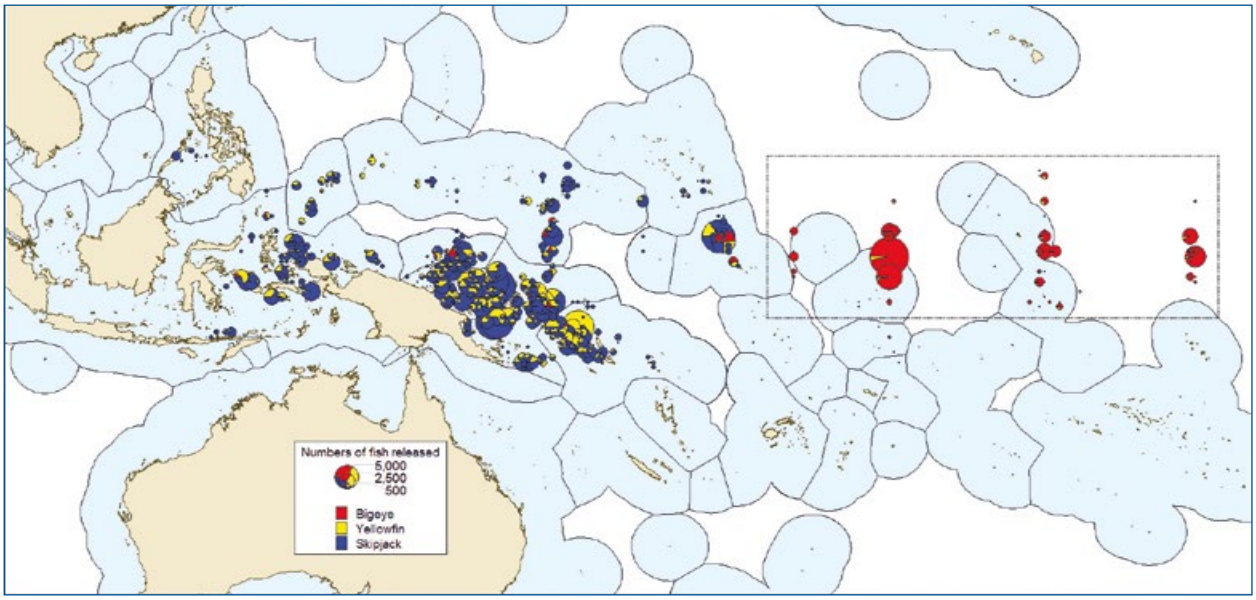


Figure 1. 2006–2015 Pacific Tuna Tagging Programme releases by species; the dotted square shows the Central Pacific releases.

The main goal of the 12th Central Pacific tuna tagging cruise (CP12) is to obtain similar information on the western side of the 180° meridian, where the number of tagged bigeye is considerably smaller than on the eastern side. The research area is along the 165°E meridian where TAO buoys are anchored and along the 5°S parrallel and the 170°E meridian (Figure 2). In addition to these TAO buoys, CP12 will have the opportunity to tag fish associated with drifting fish aggregating devices (dFADs) that two purse-seine companies, Tri Marine and South Pacific Tuna Corporation, have agreed to give us access to. Some of these dFADs will be equipped with acoustic receivers, and tuna and associated species captured around the FADs will be tagged with pressure-sensitive acoustic tags. The information obtained will give us a better understanding of how the dFADs affect these species. The Republic of Korea, the European Union, SPC, the Western and Central Pacific Fishery Commission and the International Seafood Sustainability Foundation (ISSF) are co-sponsoring the research.

FV *Gutsy Lady 4*, the same boat chartered in 2015 for CP11, will be our tagging platform for CP12 (Figure 3). Although its home port is a long way from the targeted fishing zone, the boat is considered to be the best option available in the region to meet the requirements of this type of cruise.

We plan to attach a minimum of 2000 conventional and 50 archival tags to bigeye tuna during the cruise (Figure 4). Depending on the species composition of tuna schools, yellowfin tuna will also be tagged. Five dFADs will be equipped with satellite acoustic listening stations that will each record and send data transmitted by 20 fish implanted with sonic transmitters.

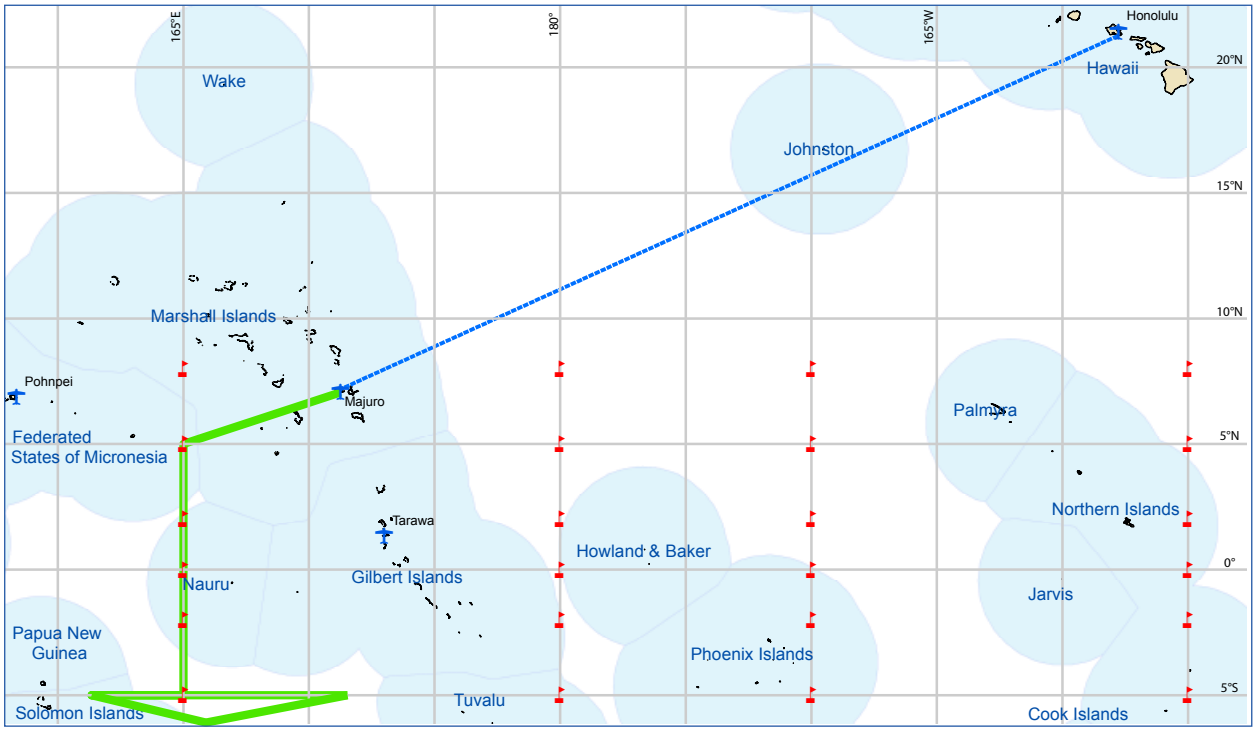


Figure 2. Approximate planned track of the 12th Central Pacific tuna tagging cruise (green line). The red flags are the anchored TAO buoys; the dotted blue line is the transit leg between the boat's home port (Honolulu) and Majuro, which is the departure point for the scientific research.

Figure 3. Seven pepole took part in the 12th Central Pacific tuna tagging cruise aboard FV *Gutsy Lady 4* (image: Fabien Forget).

Figure 4. A bigeye tuna implanted with an archival tag ready to be released (image: Fabien Forget).

For more information:
Bruno Leroy
Fisheries Scientist (Ecosystem Monitoring), SPC
BrunoL@spc.int

CSI: Noumea!
Can anyone identify this mysterious fish? Episode 1

Part of the fisheries laboratory work at the Pacific Community (SPC) focuses on the taxonomy of living pelagic organisms from all parts of the Pacific such as squid (Figure 1), crustaceans (Figure 2), gelatinous plankton (Figure 3) and fish (Figure 4).

What is taxonomy?

Taxonomy is the science of describing organisms and classifying them into units known as taxa (singular taxon), which makes the identification and naming process of organisms possible. A taxon or taxonomic group covers species that share specific criteria. Taxonomic classification is organised in the shape of a tree that starts at the broadest level (trunk) and separates into successive divisions (branches) followed by the most descriptively precise level (leaves). The broadest level is known as the 'kingdom' (e.g. the animal kingdom or the plant kingdom, which cover all animals and all plants, respectively). The species, together with its genus, is the most precise level. There are many taxonomic levels that lie between kingdom and species (see figure 5) – these are phylum, class, order, family and genus. These levels cover fewer and fewer species as the classification of an organism becomes more particular. All taxa are given names in Latin so that they can be recognised internationally (i.e. a species always carries the same scientific name, whether it is in Mexico or Fiji). Figure 5 shows two examples of marine species classification.

Taxonomy concentrates mainly on morphological and anatomical criteria but also distinguishes one species from all others due to a whole set of characteristics including anatomy, biology, physiology, and others. Certain reference documents condense and rank this type of information and offer a series of alternatives known as dichotomous keys that cover the morphological characteristics of a specimen.

In such keys, a very wide range of criteria are taken into consideration such as the position of the fins, the number of spines and rays, the shape of the jaw, the shape and number of teeth, the shape and number of scales, whether or not there are photophores, the shape of the gills and the number

Figure 1. *Liocranchia reinhardti.*

Figure 2. *Oplophorus spinosus.*

Figure 3. Anthomedusae.

Figure 4. *Bathysaurus ferox.*

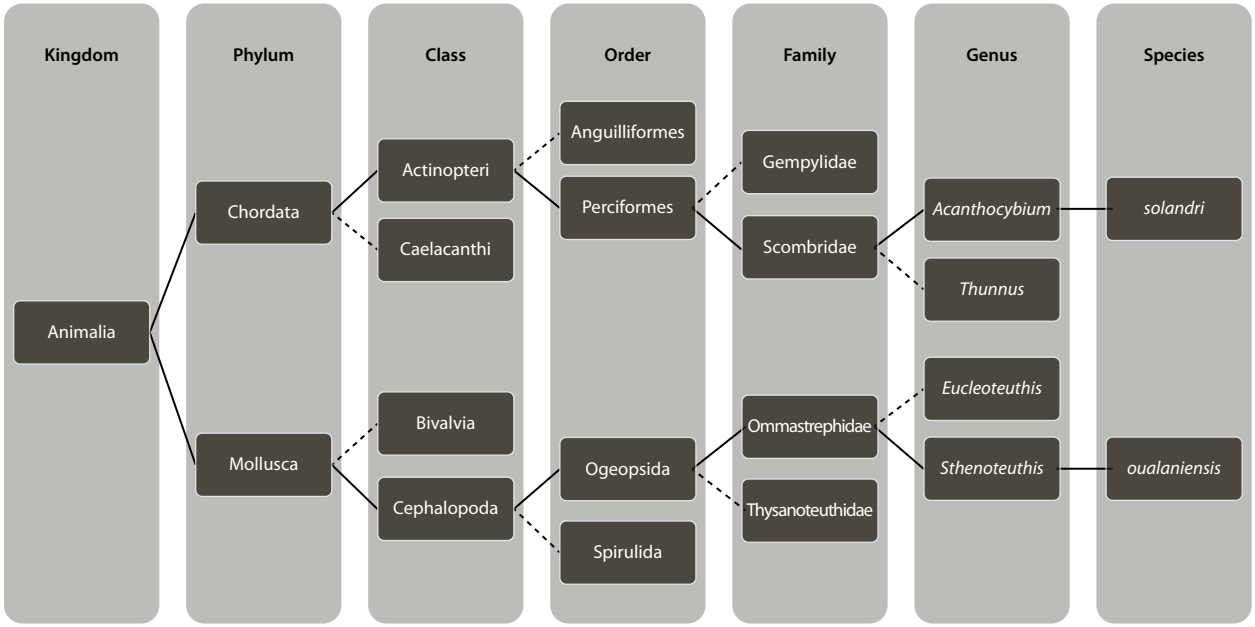


Figure 5. The pathways used to classify two marine species: *Acanthocybium solandri* (wahoo) and *Sthenoteuthis oualaniensis* (purpleback flying squid).

Figure 6. Sample NEC3018/M098/03 (length: 61.7mm SL).

of gill rakers (small spines located on the gill arches), the shape and number of vertebrae, etc. Very detailed observations of such criteria make this work rather complicated.

Most of the time, the specimens that are analysed in the laboratory are already known to science, but occasionally difficulties arise during identification and, therefore, classification.

In February 2016, as taxonomist for SPC's Oceanic Fisheries Programme, I was in charge of identifying a fish that came from a sea expedition in the waters off New Caledonia. This small fish, about 6 cm long, appeared to be a well-known fish but certain details raised questions.

So, an in-depth study was made of its morphology; i.e. all the visible parts of the fish were measured (total length of

Figure 7. Location of ventral fin.

Figure 8. Ventral fin.

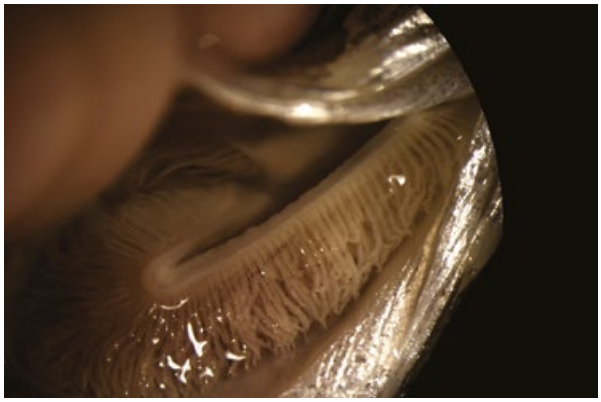


Figure 9. First gill arch.

Figure 10. Gill spines of the first gill arch.

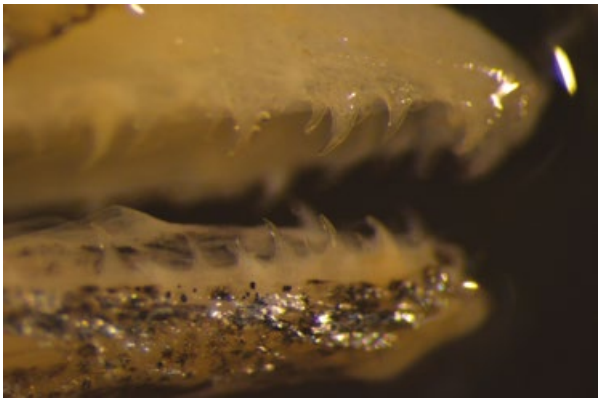


Figure 11. Upper and lower jaw.

the fish, size of its head, snout, all the fins, etc.) and all the fins' rays and spines were counted.

Special attention was paid to details so as to note specific features such as, for example, the shape of the jaw and the teeth. Photos were taken of all the external parts (see Figures 7–11).

However, even with all the information that was collected on the fish's external morphology and dichotomous keys, a precise species was unable to be identified.

Only a few species have dorsal-fin spine and ray counts similar to this specimen; i.e. Scombridae (tuna and wahoo family, among others) and Gempylidae (escolar family).

But the shape of the jaws, the lack of a lateral line, and the specimen's long canines are not characteristic of Gempylidae.

This fish did have a long snout and jaws that looked like a beak, its gill spines were small and its ventral fin was well-developed like the species *Acanthocybium solandri*. However, other criteria did not correspond to that species, such

Figure 12. X-ray of specimen NEC3018/M098/03.

as, for example, the existence of two anal spines whereas *A. solandri* doesn't have any. The shapes of its anal and dorsal spines were different, too.

This is probably a juvenile fish and certain characteristics can change as fish grow. It is very hard to find dichotomous keys or even studies relating to juvenile fish; most available keys only make it possible to identify fish at the larval or adult stages.

Therefore, another important criterion for identification was applied: the number of vertebrae. In order to get that information, fish are often dissected. In this precise case, it was impossible to carry out a dissection given that there was only a single specimen and so it was important to keep it intact and not to harm it in any way. For all those reasons, this strange fish specimen was taken to a radiology clinic to be x-rayed. Thanks to the very clear image obtained (see Figure 12), 64 vertebrae could be counted. Two Gempylidae species have the same number of vertebrae but they differ from the specimen on a lot of other points. *A. solandri* also has 64 vertebrae, but it was already know that it is not that species.

The x-ray helped round out the information about this mysterious fish. However, the combined internal and external morphological criteria still did not allow us to identify the fish. Therefore, world specialists were contacted and provided with this information along with questions about the initial morphological description that was obtained. They all had their doubts and none of them offered any possible names.

The decision was then made to continue the investigation through DNA testing, which could help us pinpoint a family, a genus or a species. Then by compiling all the information, it may be possible to connect this specimen to a known species ... or determine that an unknown species is involved, which would then need to be described and named.

The tests are currently being analysed and we are impatiently awaiting the results.

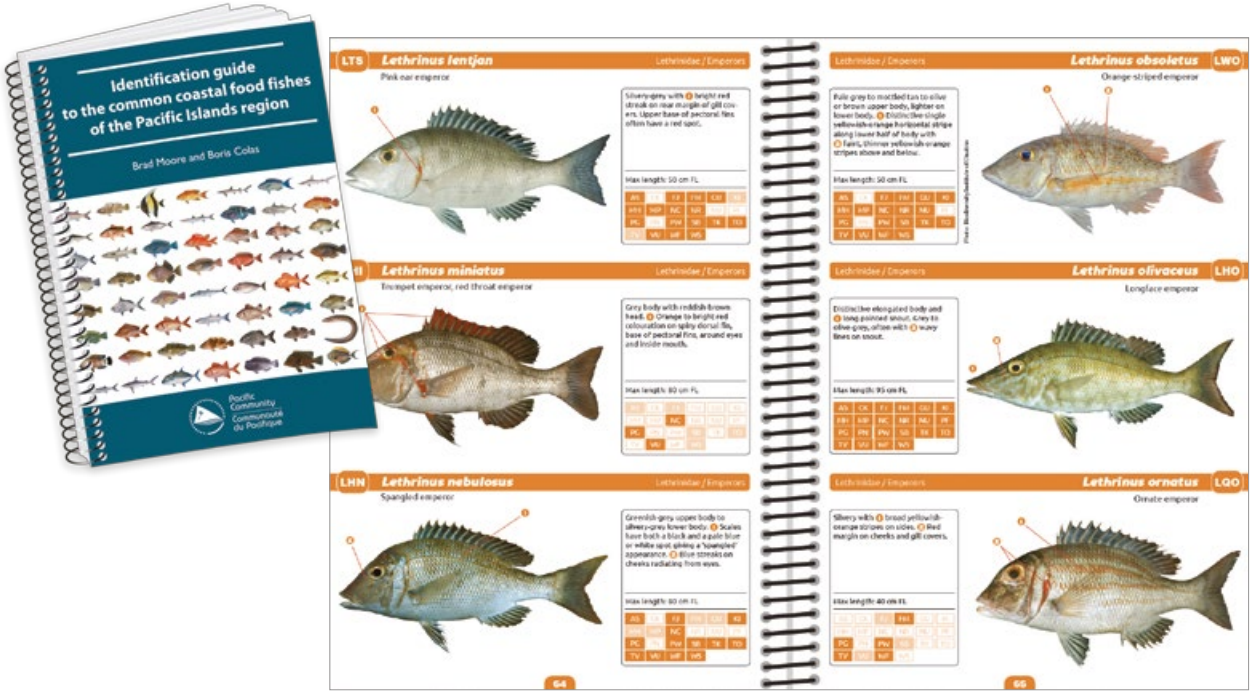
Acknowledgements

The author would like to acknowledge Dr Benjamin Marc and his colleagues Maïté Mauret and Anne Gibert, who performed the x-ray of this little unidentified specimen.

For more information:
Elodie Vourey
Laboratory Assistant (Taxonomy), SPC
Email: elodiev@spc.int

SPC releases new identification guide for coastal finfish

The new 'Identification guide to the common coastal food fishes of the Pacific Islands' by Brad Moore and Boris Colas has been produced by the Pacific Community (SPC) to assist fisheries officers in the identification of the common coastal food fishes that are encountered in catches or during market surveys.



Catches of coastal finfish in the Pacific Islands region are typically characterised by a wide variety of species from many different taxonomic families. Often closely-related species exhibit vastly different life histories – particularly with respect to growth rates, maturity schedules and longevities, and thus may have vastly different vulnerabilities to fishing pressure. The guide will assist in accurately identify harvested species, which will improve the reporting of catches, the monitoring of coastal fisheries in the region and ultimately lead to more effective management.

The information included for each species consists of a high-resolution photo, the scientific and common English names, a description of the key identifying features that are additionally linked to the photo, the species' likely presence or absence for each individual Pacific Island country and territory, and, where relevant, notes on similar species, and the key features that can be used to distinguish these from each other.

As the guide is intended to aid fisheries officers in the identification of species that are encountered during their catch or market surveys, it was considered important to include photos of dead fish (where possible) – rather than underwater images – as these would be similar to the states and colours of fishes that officers will encounter during their surveys. While the bulk of the photos of each species were provided by renowned ichthyologist and fish photographer John Randall, securing images for all species that are included in the guide proved to be major challenge; thereby, images were provided by researchers and amateur fish photographers from locations as far afield as Australia, Canada, Japan and the United States.

The guide has been produced with financial assistance from the Australian Government Department of Foreign Affairs and Trade, and the European Union through the 'Scientific Support for the Management of Coastal and Oceanic Fisheries in the Pacific Islands Region' ('SciCOFish') project.

Copies of the waterproof guide, which contains approximately 320 of the most commonly targeted coastal sharks, rays and bony fishes, will be distributed to fisheries agencies across the region.

For more information:

Dr Brad Moore
Coastal Fisheries Scientist, SPC
bradleym@spc.int

Boris Colas
Technical assistant (Graphic designer), SPC
borisc@spc.int

SPC FAME scientists participate in Japanese research cruise on tuna food webs, and on freshwater eel larval migrations

Hakuho Maru berthed in Noumea at the start of Leg 2 of its research voyage through the South Pacific.

During August 2016 two scientists from the Pacific Community's (SPC) Fisheries, Aquaculture and Marine Ecosystems (FAME) Division, Dr Tim Pickering and Elodie Vourey, participated in a South Pacific research expedition on board the University of Tokyo's oceanographic research vessel, Hakuho Maru.

Ms Vourey boarded the *Hakuho Maru* for the third leg of the voyage between Pago Pago in American Samoa and Papeete (French Polynesia) to work on micronekton (small organisms such as fish, squid, crustaceans and gelatinous organisms) that are consumed by tuna.

Ms Vourey said 'SPC's Oceanic Fisheries Programme took this opportunity to collect micronekton across the Pacific to acquire knowledge on the spatial distribution and species composition of the tuna forage. By increasing our understanding of the tuna forage, we are in a better position to forecast the tuna movements which are in permanent quest for food.' She added 'This is the second Japanese research cruise we are involved in, the previous one being in 2013, and by collecting micronekton in the region on a regular basis it gives us a tool to monitor the changes occurring in the ecosystem and to understand the impact of those changes on the tuna resource.'

During the voyage's second leg from Noumea, New Caledonia to Pago Pago, Dr Pickering joined an international team of expert scholars to help study South Pacific freshwater eels, which undergo long migrations between freshwater growth habitat and marine oceanic breeding habitat.

One of the objectives of this scientific exploration is to discover the spawning grounds of South Pacific freshwater eels, and to obtain genetic samples of eel larvae in an effort to better understand the genetic relationships and evolution of eels. Knowledge of breeding and life cycles is fundamental to science-based fisheries management but to date, there has not been any systematic research done on South Pacific eels.

Dr Pickering said 'The South Pacific is the last frontier of freshwater eel research. SPC member governments and administrations need scientific information or capacity to make policies for conservation and management of eels, so international collaboration is necessary.' and that 'SPC has been participating in a South Pacific eels research network of international experts and recently hosted the third meeting of this network in collaboration with the University of the South Pacific. Our involvement in this network and our facilitation of Pacific students to study in Japan on eel topics led to an invitation to join prominent eel experts and participate in this research.'

The eel researchers for Legs 2 and 3 included Katsumi Tsukamoto and Michael J Miller of Nihon University in Japan, Mari Kuroki of University of Tokyo, Noritaki Mochioka of Kyushu University, Robert Schabetsberger of Salzburg University, Yu-San Han from Taiwan, Pierre Sasal of CNRS CRIOBE Moorea, and Eric Feunteun and Anthony Acou of the Muséum National d'Histoire Naturelle in France. Among a group of post-graduate students working in eel projects on-board was a Fijian PhD candidate, Chinthaka Hewavitrarane, who is enrolled at Kyushu University.

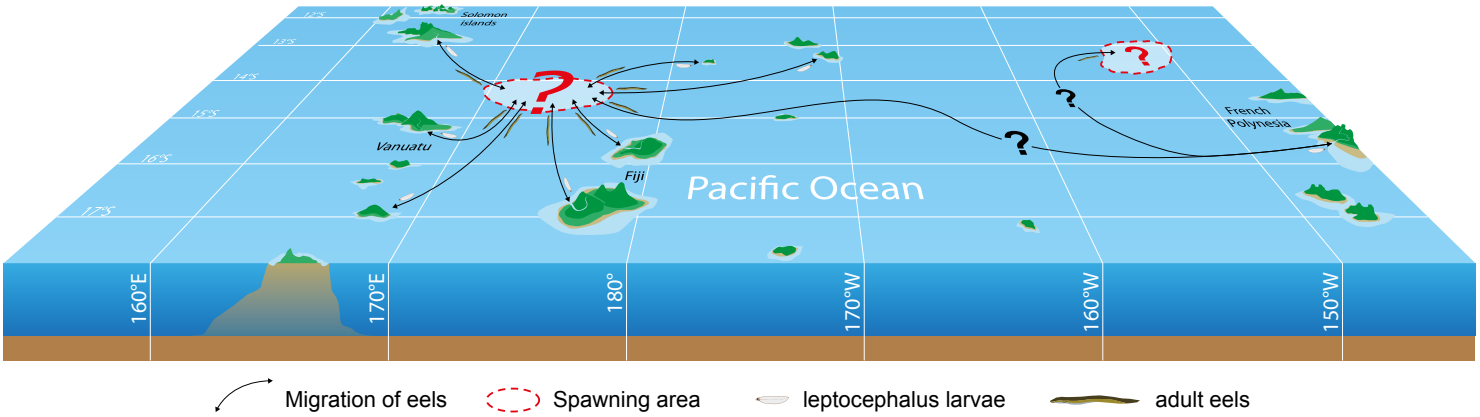
The search is being undertaken for the spawning areas of tropical South Pacific eels in order to better understand the spawning ecology and environment of the tropical eels, and

Leptocephalus larvae hunt. Each plankton haul has to be carefully examined by the scientific team to find the transparent, ribbon like eel leptocephalus larvae among all the other sea creatures in the plankton catch.

Work on deck to deploy the sampling gear continued day and night. This is the CTD with Nisken bottles, about to be lowered to 1000 m depth.

Freshwater eel leptocephalus larva caught in the oceanic waters north of Fiji.

Close-up of the head of a freshwater eel larva.



Adult eels migrate from island rivers to oceanic spawning areas; leptocephalus larvae swim from these spawning areas back to island rivers. The red question marks signify that the location of the spawning area(s) are not yet known. The black question marks signify that it's not known whether the eels of biogeographically remote French Polynesia spawn together with other eels of the tropical Pacific, or have a different spawning area (illustration: Boris Colas, SPC).

their migration ecology. A similar and successful search by *Hakuho Maru* for the spawning ground of the Japanese eel in the north Pacific during the 1990s had strong commercial motives behind it, because there are valuable industries based upon utilisation of eels in Japan and China.

By contrast, such a costly expedition by a Japanese vessel to study South Pacific eels is motivated mainly by scientific curiosity – particularly because the ecology of tropical eels appears to be quite different from temperate eels. For SPC members, the spin-off benefit is that this research will assist the understanding of the mechanisms of between-year resource size fluctuations and thus help the management of eel fisheries.

Life on board *Hakuho Maru* revolved around a four-hour watch system, with all scientists rostered to complete two of these watches per day. The vessel was thus operating around the clock, day and night. Everybody was expected to work alongside the ship's crew and perform every task related to the deployment of the sampling gear and processing of collected samples.

Eel leptocephalus larvae were caught by setting an Isaacs–Kidd midwater trawl (IKMT) net that was towed behind the vessel. This delivered a bucket-full of plankton on each haul that then needed to be carefully sorted piece-by-piece to find the eel larvae, which could be as small as 5 mm or as large as 200 mm. Most of the eel larvae found was not freshwater eels but rather of the marine eel families like morays or congers, which are themselves worthy topics for research. A vertical-tow North Pacific Standard (NORPAC) net collected nekton for the tuna food web analysis. A conductivity, temperature, and depth (CTD) recording instrument with Nisken sea water collection bottles was deployed at each sampling station to describe the oceanic conditions at each layer of the water column down to 1000 m depth.

The method that eel scientists use to locate eel spawning grounds is to first collect freshwater eel leptocephalus larvae across a wide area of ocean and look for the place where larvae are smallest and youngest. This box of sea area is next searched for newly spawned eel eggs. Finally, once the 'box' is better defined, techniques like underwater video can be used to confirm the presence of spawning adult eels. The August 2016 cruise of *Hakuho Maru* has commenced with the first of these steps for the South Pacific tropical eels.

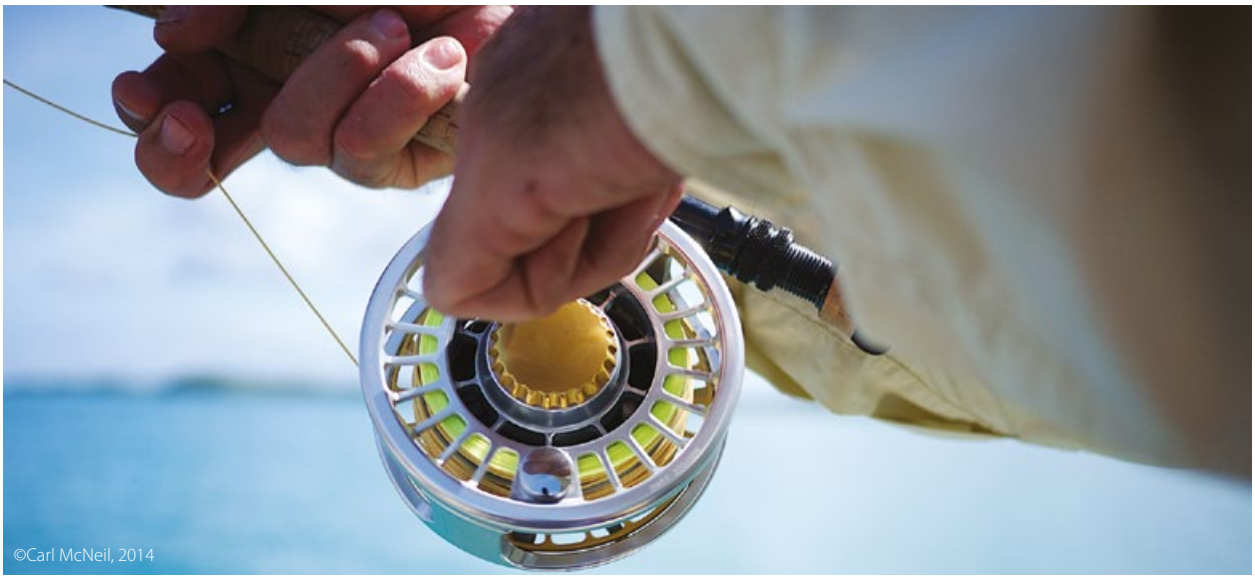
By the end of Leg 2 on 19 August 2016, the team had collected 7 freshwater eel larvae. A surprise was the collection of 4 larvae of the Australian shortfin eel *Anguilla australis*, which is a temperate eel species, in a sea area north-west of Fiji Islands. These larvae were only 10–12 mm long and therefore less than three weeks old. They were found moving westward in the Southern Equatorial current, so must have been spawned somewhere east of Fiji and north of Tonga.

This sets a new record for the smallest *A. australis* larvae ever collected (the previous record was 20 mm). This is a major discovery, with important implications for understanding the early life cycle ecology of the Australian shortfin eel. It raises more questions, such as: how do the adult eels find their way from Australia and reach the correct place in the vast ocean to aggregate for breeding?

All pictures in this article by Tim Pickering.

For more information:
Tim Pickering
Freshwater Aquaculture Adviser, SPC
TimP@spc.int

A preliminary economic valuation of the sport fishing industry of New Caledonia



This article reviews data from a sport fishing business in New Caledonia. It shows that the estimated direct economic value of this business alone is AUD 125,000 per year and the estimated indirect economic value generated is between AUD 113,000 and AUD 359,000 per year.[1] It is thought that New Caledonia could support up to 10 sport fishing businesses, which suggests an estimated potential direct economic value of sport fishing in New Caledonia of AUD 1.25 million and an indirect economic value of AUD 1.13 million to AUD 3.59 million per year. The analysis further suggests that for every AUD 51,000 of total economic value generated, one job is created or supported. The article demonstrates that sport fishing has the potential to add significant value to an economy as well as support local jobs not only within the sport fishing industry, but also in the wider economy.

Introduction

Sport fishing has huge global potential; the World Bank (2012) estimates that sport fishers spend over USD 190 billion per year globally, yet only 10% of sport fishers are outside OECD countries. In Costa Rica, for example, in 2008, foreign anglers contributed USD 279 million to the economy compared with USD 17 million from the commercial capture fishery. The report further suggests that sport fishing can achieve an impressive return on investment of more than 300%. Catch and release sport fishing[2] has the potential to provide some strong localised benefits and alternative livelihood options for communities across the Pacific and is already an active industry in a number of countries. The Pacific Community (SPC) assists member countries to develop tourist-focused sport fishing as an alternative livelihood and to help protect fish resources and ecosystems. SPC has been involved in feasibility studies in countries such as Cook Islands (Aitutaki), Papua New Guinea (PNG) (Kavieng) and Palau. The organisation promotes best fish-handling practices for sport fishing and has trained guides in Cook Islands, PNG, Niue and New Caledonia.

This article presents a summary of the analysis of data collected by a single operator in New Caledonia – Blue Calédonie Fishing Trips (BCFT). It provides an overview of the data collected through simple tourist questionnaires that are administered at the end of their visit to New Caledonia. It goes on to provide an estimate of the total economic value of BCFT and the target species.

Context: Tourism in New Caledonia

Data collected and published by the *Institut de la Statistique et des Études Économiques* (ISEE) in New Caledonia recently showed growth in visitor numbers: 107,000 visitors were recorded in 2014, increasing to 114,000 visitors in 2015.[3] Fifty-three per cent of the visitors came with the express reason of vacationing in New Caledonia, 23% came

[1] All figures expressed in AUD were converted from XPF at an exchange rate of 80 XPF = 1 AUD

[2] 'Catch and release fishing': fish are released almost immediately after capture, alive and unharmed.

[3] Data collected at Tontouta Airport and therefore excludes sail and cruise passengers. Detailed tables found at http://www.isee.nc/economie-entreprises/entreprises-secteurs-d-activites/tourisme

to visit friends and family, 13% to conduct business and 11% for unknown reasons.

While the visitor make-up varied from month to month in 2015, visitors arriving by plane to New Caledonia mostly came from France (33%), Australia (18%), Japan (18%) and New Zealand (7%).

In 2014, total tourist spending was estimated at AUD 275 million – 34% of which was the cost of international travel – meaning total domestic spending was approximately AUD 180 million. Six per cent of domestic spending, or AUD 11 million, was spent on 'hobbies' (including fishing), and the greatest spending categories were accommodation (42%) and food and drink (19%).

Detailed reasons for visiting and spending patterns are not published and therefore we cannot use this data to determine the size of the recreational fishing industry in New Caledonia. However, unpublished data from ISEE indicates that as of December 2015, there were about 200 employees working in the fishing industry, although most of these were likely to be in the commercial fishing industry and not the recreational or tourist-focused fishing industry. There are also unregistered fishing guides operating in New Caledonia that some tourists may use but we do not have data to provide an estimate of the size of this informal market.

Case study: Data description

Data were collected from 25 group sport fishing trips operated by Blue Calédonie Fishing Trips (BCFT) during the 2014–2015 period.[4] These trips involved a total of 59 fishers – 12% of which were New Caledonian locals and the rest from across the world. The clients spent a total of 348 nights in New Caledonia, with an average trip duration of just under six nights.

While this is a small sample of a single business and the data cannot be taken as representative or conclusive, it provides an indication of the potential income from sport fishing for small businesses.

A total of 11 different nationalities were represented in the data. Twenty four percent of visitors were from Australia, 15% from France, 13% New Zealand, 13% Russia and 12% were local to New Caledonia (see Figure 1). Notably, the business did not get any clients from the 20,000 Japanese visitors who come to New Caledonia annually; this could be for a range of reasons including language and cultural factors. However, more research should be done to identify if this could be a potential market.

Information was not collected on the primary purpose for visiting New Caledonia, but total nights in New Caledonia and number of days fishing were collected. We have therefore assumed that fishing was the primary purpose of a visit to New Caledonia if more than 50% of visitors' time in New

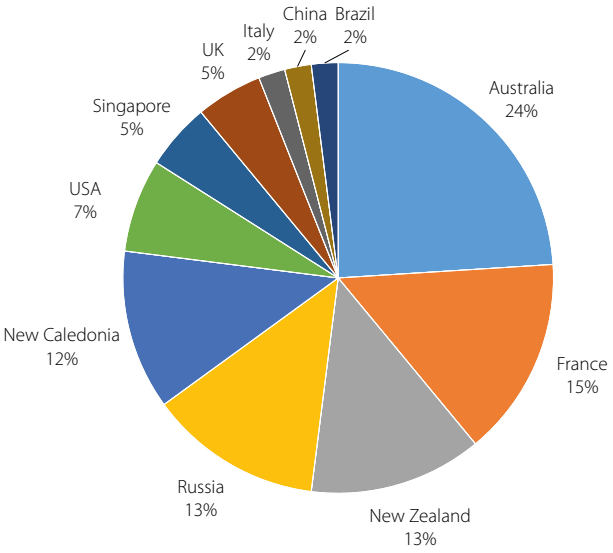


Figure 1. Nationality of Blue Calédonie Fishing Trips clients (n = 59).

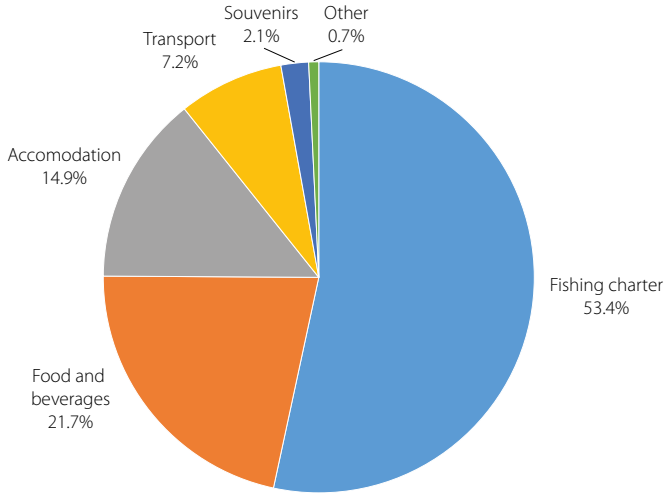


Figure 2. Breakdown of expenses by Blue Calédonie Fishing Trips clients (n = 59).

Caledonia was spent fishing. The data thus shows that 87% of foreigners who went fishing with BCFT visited New Caledonia for the express purpose of fishing.

Total spending in New Caledonia by the 25 groups was AUD 250,000, equating to an average outlay per person, per night of AUD 850. The break down on client spending was 53% on charter costs, 15% on accommodation and 22% on food and drink. Local transport and souvenir spending made up a small amount of spending (Figure 2).

The spending data from the 87% of the visitors primarily coming to New Caledonia because of the availability

[4] Ten trips occurred in 2015, 15 in 2014

of fishing-related activities indicate that for every AUD 1 spent directly on sport fishing, AUD 0.76 is spent on related expenses such as accommodation and food.

The clients targeted two species of fish for which New Caledonia is known – the bonefish (*Albula glossodonta*) and the giant trevally or GT (*Caranx ignobilis*). The 25 groups caught a total of 391 GT and 61 bonefish. GT was the most popular species, with 22 groups targeting it including four groups that targeted both GT and bonefish. Bonefish-only fishers accounted for just 3 groups or 6 people. Local clients targeted only GT and not bonefish, likely because bonefish can be shore caught, which is an activity they can eventually do by themselves. Seventy-four per cent of international clients targeted GT only. As a result, GT fishing led directly to 276 visitor nights and bonefish fishing to 80 visitor nights. The average nightly spend was AUD 810 for a GT fisher and AUD 720 for a bonefish fisher. Charter costs were substantially lower for bonefish fishers; however, on average they spent 50% more compared with GT fishers on food and beverage.

Economic impact

The economic impact of any activity can be divided into two categories: Direct effects and indirect effects. Together these effects make up the total economic effect of any activity. This is not strictly equivalent to national accounting for tourism and should not be taken as a measure of such.

Direct effects or direct economic value (DEV): Clients directly contribute to the economy through their spending on activities related to the activity of interest. In this case, it would cover charter costs, accommodation, food and beverage, souvenirs, and taxes among others.

Indirect effects or indirect economic value (IEV): Tourist spending allows businesses and employees to make expenses in other branches of the economy. For example, businesses will pay for other goods or services in support of their businesses such as suppliers, mechanics, accountants, outfitters, mariners, advertising and others. Individuals who are employed in the businesses will also spend their income on items such as food, housing, transport, clothing, entertainment and others.

In this study we assume that the total expenditure figures provided in the case study data represent the tourist consumption and as such approximate the DEV of BCFT as AUD 125,000 per year, or an average of AUD 850 per person night. The business also provides employment for one person plus ad hoc employment for others, depending on the number of people fishing. Data on the cost of international flights were not collected; however, tourist data from New Caledonia shows that international flights made up 34% of total spending. This suggests that BCFT clients paid AUD 66,000 for flights. This spending, however, is excluded from the headline calculations because much of this spending maybe outside New Caledonia – although AirCalin, the New Caledonia international airline company, can be expected to capture some, but not all, of this spending.

Estimating IEV using usual economic techniques is not an option because of the absence of detailed input–output tables, or econometric models for the New Caledonian tourist industry. In this situation, the best alternative is to use IEV figures from studies made in comparable countries. Given that most Pacific islands lack these detailed models, tables and studies, we had to rely on studies made in other parts of the world and transfer these values to the Pacific. These studies define the values that can be used to calculate the IEV and the employment impacts from an observed DEV. These values are termed 'multipliers', and a brief summary of some of the research literature is as follows:

- Ditton and Stoll (2003) use the assumption that indirect effects for the US billfish sport fishing industry are between 1.5 and 2.5 times that of the direct effects.
- A study in Belize on the economic impact of bonefish fishing (Fedler and Hayes 2008) showed that US studies returned higher multipliers than those from developing countries. The research that is quoted suggests that in the US, on average, indirect effects are 2.9 times those of the direct effects. However, it is suggested that this figure is likely to be lower in Belize, and Fedler and Hayes (2008) use a conservative figure of indirect effects being 1.22 times that of observed direct effects.
- The World Bank (2013) estimates that multipliers are far lower in developing countries compared with developed countries and estimate that for developing countries indirect effects are between 0.9 and 1.9 times that of direct effects.
- Seidel and Lal's (2010) study of the economic value of the Pacific Ocean to Pacific Island countries and territories (PICTs) estimates much higher IEVs for tourism in PICTs than suggested by the literature above. Seidel and Lal (2010) estimate that the indirect economic value created from tourism in the Pacific to be 2.62 times the direct effects for Vanuatu, 2.87 times for Fiji and 3.5 times for Kiribati.

The second indirect impact that we are interested in is the employment created elsewhere in the economy. The literature also provides some data to allow us to estimate the number of jobs created or supported by a tourist-focused business.

Fedler and Hayes (2008) estimate that in Belize for every USD 1 of IEV, 2.2×10^{-5} jobs are supported or created. This means that for every USD 40,000 (AUD 51,000) of IEV one job is created or supported in the wider economy.

The giant trevally is, as bonefish, an iconic species that draws anglers to New Caledonia (image: ©Carl McNeil, 2014).

Seidel and Lal (2010) take a slightly different approach to calculating the numbers of jobs created or supported. They estimate the number of people directly employed by the tourist business, and from this calculate the number of jobs that exist elsewhere in the economy. They conclude that for one person employed in the tourist industry approximately three jobs exist elsewhere in the economy, with an estimated economic multiplier that ranges between 2.59 and 3.80.

This is complicated further by the mix of accommodation and eating options associated with tourism in New Caledonia; for example, locally owned and run guest houses, camp sites, bars and restaurants are likely to have a far higher economic multiplier than those owned by foreigners, foreign companies or large corporations. Therefore, multipliers from sport fishing will certainly be much higher when guests stay in local accommodation and frequent locally owned and run establishments. These local factors are important considerations when designing sport fishing projects that have the objective of maximising the local economic benefits. Small economies, such as New Caledonia, may have smaller multipliers because they source many goods and raw materials from outside the country; therefore, more money ultimately flows out of the country.

The direct economic value of BCFT per year was calculated at AUD 125,000 per year or AUD 850 per night. Given the discussion above regarding the compilations associated with calculating indirect effect multipliers, to be conservative and with the acknowledgement that the multipliers presented are not perfectly applicable to New Caledonia, we have used the lower multiplier from the literature that has an IEV multiplier of 0.9. As a result, the IEV of BCFT is estimated at AUD 113,000 or AUD 765 per night. If we use the less conservative multiplier of 2.87 calculated by Seidel and Lal (2010) for the tourism industry in Fiji, the annual IEV of BCFT would be estimated at AUD 359,000.

To be conservative we estimate the number of jobs created or supported by BCFT in the wider economy by using the lower job multiplier suggested by Fedler and Hayes (2008) of AUD 51,000 per job created or supported. This suggests that because of BCFT, 2.2 jobs exist elsewhere in the economy. Full-time equivalent employment at BCFT is 1.02 people[5] and therefore using the average multipliers suggested by Seidel and Lal (2010), the business could support as many as 3.06 jobs in the wider economy. The total number of jobs created or supported by BCFT is thus between 3.22 and 4.08 full-time equivalent jobs.

[5] The business employs two people but on an ad-hoc basis. As such, the full time equivalent rate is calculated on the number of fishing days per year, which was an average of 118, scaled to a full year of 231 working days.

Potential of the sport fishing industry in New Caledonia

It is estimated that New Caledonia could support approximately ten charter fishing operators similar to the one used for this case study, while maintaining good environmental and resource standards (E. Picquel, personal communication, August 2016). Assuming that the figures above are transferable to these potential sport fishing businesses, sport fishing has a potential direct economic value to New Caledonia of AUD 1.25 million and an indirect economic value of between AUD 1.13 million and AUD 3.59 million. Furthermore, ten active sport fishing businesses can be expected to support between 32 and 41 jobs in New Caledonia.

As discussed above, for the vast majority (87%) of BCFT foreign clients, fishing was the primary reason to come to New Caledonia. It can therefore be expected that with no sport fishing activities on offer, these clients would not be coming to New Caledonia and most of the benefits from a developed sport fishing industry would not be captured by other sectors of the tourism industry.

These figures are given for illustrative purposes only as the business considered in this article may not be representative of the industry as a whole. Further investigation will be required to gather a comprehensive estimate of the economic contribution of sport fishing to the New Caledonian economy. The data does, however, demonstrate the potential for sport fishing as an alternative livelihood strategy and also suggest that the potential multiplier effects could be very high and provide wider economic benefits.

Value of a single fish

The average direct expenditure by GT and bonefish fishers is described above in the data section. We used this data to establish a direct economic value of each fish landed, we have no information regarding the number of fish that were lost before landing. However, from this data we can establish a value of each fish caught and released. We have established a direct economic value of AUD 790 per bonefish and of AUD 520 per GT. If applying the conservative 0.9 multiplier, the indirect economic values are AUD 710 per bonefish and AUD 460 per GT, which is well above the market value for these species if they were to be sold on the local market. This assumes each fish is caught and released just once; the value of each fish will obviously increase if the fish is caught and released several times. The data here corroborates the US National Oceanic and Atmospheric Administration's 2011 assessment of the US fisheries sector,[6] which estimated the economic value of a fish at USD 1370 per kg for recreational fisheries and USD 46 per kg for capture fisheries.

[6] Quoted in World Bank/IGFA 2013

Conclusion

This article uses data from just one operator and a limited number of trips in New Caledonia; therefore, it is by no means conclusive. However, figures could be considered indications of the potential economic contribution of sport fishing to local economies. Further extensive economic-based studies on sport fishing initiatives for economic development need to be done in the Pacific Islands to understand the cost-benefit of investment in the industry, by recognising that it is a niche industry.

Despite underestimating the economic impact of sport fishing by excluding international travel costs from the analysis, this article demonstrates that the direct economic contribution of sport fishing to an economy is only part of the story and the indirect benefits could be equal to or greater than the direct economic benefits.

References

Ditton R.B and Stoll J.R. 2003. Social and economic perspective on recreational billfish fisheries. Marine and Freshwater Research 54:545–554.

Fedler A.J. and Hayes C. 2008. Economic impact of recreational fishing for bonefish, permit and tarpon in Belize for 2007. Gainesville: Friends of Turneffe Atoll. 26 p.

Seidel H. and Lal P.N. 2010. Economic value of the Pacific Ocean to the Pacific Islands Countries and Territories. Gland, Switzerland: IUCN. 74 p.

World Bank. 2012. Hidden harvest: the global contribution of capture fisheries. Report 66469-GLB, Washington DC. 69 p.

World Bank/IGFA. 2013. Recreational fishing for poverty alleviation and conservation. 4 p.

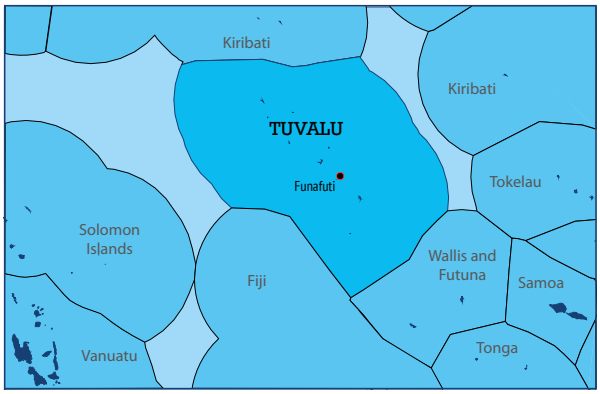
For more information:
Philip James
Economic Officer (Fisheries), SPC
philipj@spc.int

Tuvalu Fisheries: Moving into the 21st century

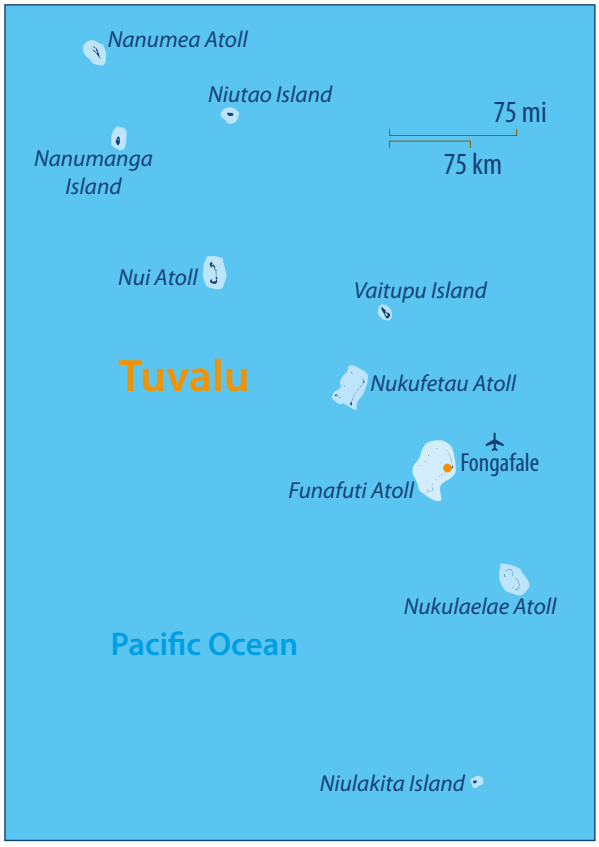
Garry Preston,[1] Matelina Stuart[2] and Sam Finikaso[3]

Fisheries in Tuvalu

The importance of fisheries to Tuvalu cannot be overstated: indeed, Tuvalu is often characterised as one of a handful of 'fishery-dependent small island states' whose economy, livelihoods, food security and dietary health depend largely on marine resources. Since 2013 fishery access and licence fees paid by industrial fishing vessels catching tuna in Tuvalu's exclusive economic zone (EEZ) have been the primary source of non-aid revenue to the Government. Seafood is a major source of protein to Tuvaluans, especially in the outer islands, where fish consumption may exceed 80 kg per person per year (five times the global average).



Tuvalu's exclusive economic zone.



Tuvalu's nine islands.

Commercial fishing in Tuvalu primarily comprises the industrial purse-seine and longline tuna fisheries. Fishing is generally undertaken by foreign vessels operating under access agreements, and skipjack tuna make up the bulk of the catch, which in 2015 was around 90,000 tonnes (50% more than usual due to El Niño). Fishery access is a major source of government revenue: in 2015, licence and access fees were AUD 31.4 million, 58% of non-aid revenues and 43% of the national budget. As well as generating revenues, the fishing industry provides employment to Tuvaluan observers and fishing vessel crew.

Domestic fishing is dominated by subsistence activities. A wide variety of techniques are used throughout the group to collect fish, crabs and shellfish, which are consumed, shared, bartered or sold. Fisheries centres have been established on all outer islands in order to provide fishers with income earning opportunities, although not all are functioning. On the main island, Funafuti, artisanal fishing is carried out by a fleet of 4–5 meter outboard powered skiffs, which mostly fish by trolling (tuna) and handline (reef fish).

About 75% of the fish landed in Tuvalu are ocean species, predominantly skipjack and yellowfin tuna. The rest are reef and lagoon species, with smaller amounts of bottom fish from deep slope areas. Census data indicated that 74% of households participate in reef fishing and 63% in ocean fishing. Studies in fish consumption over the past decade have estimated annual per capita fish consumption of between 85 and 146 kilograms. Current annual domestic fishery

[1] Advisor, Tuvalu Fisheries Department.
[2] Information Officer, Tuvalu Fisheries Department.
[3] Director, Tuvalu Fisheries Department.

production of approximately 1100 tonnes suggests that per capita fresh fish consumption is around 100 kg per person, per year.

Transforming the Tuvalu Fisheries Department

The Tuvalu Fisheries Department (TFD) is one of three departments in the Ministry of Natural Resources (along with Agriculture and Lands). In 2012, the Department was reviewed by two consultants (Tom McClurg and Grant Carnie) as part of the Institutional Strengthening Programme Inception Phase, generously funded by the Government of New Zealand via its Ministry of Foreign Affairs and Trade. The review concluded that:

- In regard to coastal fisheries, TFD had for too long been focusing on small research and development projects, especially in aquaculture, that had delivered no visible economic or social benefits to Tuvalu.
- In regard to oceanic fisheries, Tuvalu had been a passive player in regional fishery management and access negotiations, 'standing on the sidelines' and following the consensus instead of promoting its own national interests for greater economic benefit.
- Organisationally, the Department was 'about the right size, but the wrong shape', with too many staff focusing on issues that were not very important, and insufficient attention being paid to 'big-ticket' items.

The reviewers recommended that the Department be reorganised into three separate divisions (Oceanic, Coastal and Operations & Development), overseen by an Administration group comprising the Director, Deputy Director, and several staff with cross-cutting duties (Legal Officer, Information Officer and Economist).

The review recommendations were formally accepted by the Tuvalu Cabinet in late 2013, for implementation in 2014. The Cabinet also approved the Department's first-ever Corporate Plan, covering the period 2014–2016. The Plan provided a clear statement of the TFDs vision, mission and objectives. Importantly, the Plan specified a number of key performance indicators by which the Department's performance would be monitored over the three-year period.

TFD's revised organisational structure

2014 thus became a transitional year for the Department. Several 'frozen' positions were unfrozen and re-designated, a couple of new positions were created, some staff members were moved around, job descriptions rewritten, and the new structure was implemented by the end of the year. However as some positions were filled by internal promotion or transfer, there were still several vacancies at the end of 2014 that were not filled until the following year.

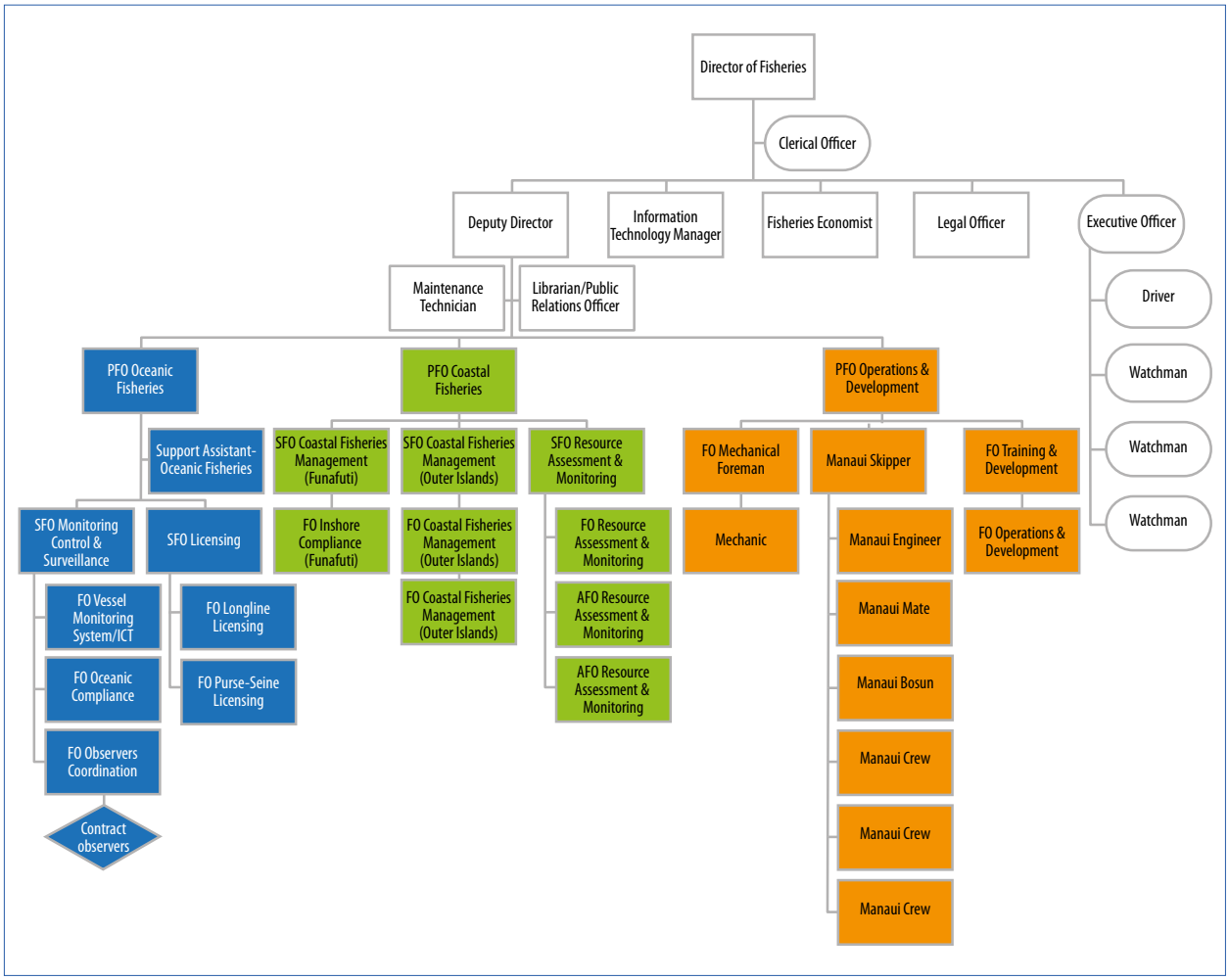
At the same time work began on reforming the Department's work programme to align with the Corporate Plan approved by Cabinet. TFD's work is now aligned along two major axes:

- The promotion of food security, livelihoods and economic development based on sustainable management and utilisation of coastal and inshore resources, primarily through working with the Kaupule (island councils), communities and fishers associations on each island.
- The generation of revenue and economic growth from the industrial tuna fishery, through collection of licence and access revenues, joint ventures, and the employment of Tuvaluan seafarers on fishing vessels.

Tuvalu's isolation, lack of water and labour, high cost of fuel and electricity, unavailability of materials, supplies and equipment, poor telecommunications and infrequent air and sea transportation make it difficult to envisage onshore development such as canneries or loining plants. There may, nevertheless, be smaller-scale development opportunities that can be leveraged through concessionary resource access arrangements, and these are also being investigated and pursued by the Department.

Simultaneously with these transitional changes, the Department began to address one of its major constraints: insufficient funding. During the period 2013–2015 the fisheries sector became by far the largest contributor to the Tuvalu economy, but as the organisation responsible for generating and managing this revenue stream, TFD remained seriously under-funded by the Government of Tuvalu. As a result of the limited recurrent budget allocation, many TFD core functions essentially could not be carried out. In recognition of this situation, in 2013 the Department began to seek support from several major development partners, which has resulted in substantial amounts of additional funding now being available:

- The New Zealand-Tuvalu Fishery Support Programme (TFSP) is providing NZD 1,036,800 in operational funding over the five-year period which commenced on 31 May 2014. TFSP is also providing two technical advisors to TFD, and will also support the construction of new office facilities for the Department, now expected to be completed in 2017.
- The World Bank Pacific Regional Oceanscape Programme (PROP), approved in December 2014, is providing a total of USD 7,910,000 over a six-year period that commenced on 9 June 2015. These funds will support internal capacity development and training, the procurement of equipment and supplies, consultancy services in technical areas, increased surface patrols within the Tuvalu EEZ, and other activities.
- The Global Environment Facility-funded NAPA2 (National Adaptation Plan of Action for Climate



TFD's revised organisational structure

Change, Phase 2) project is providing approximately USD 2.1 million to support fisheries development and food security activities in Tuvalu's outer islands over a four-year period from early 2015. In early 2016 the NAPA2 project also procured a project vessel, the *Tala Moana*, which is being operated by the Department, and which is used to support a range of TFD activities.

- The GEF-funded Ridge-to-Reef project was approved in mid-2015 and supports aquatic biodiversity conservation and establishment of marine protected areas in selected outer islands.

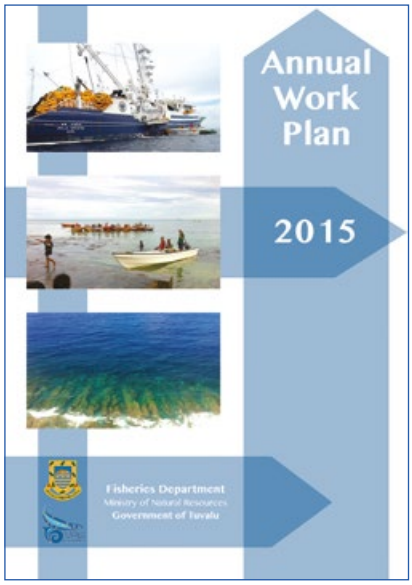
Together these programmes support a wide range of activities by the Fisheries Department by working in close collaboration with other partner agencies, including the Maritime Wing of the Tuvalu Police Department, the Tuvalu Maritime Training Institute (TMTI), and the Kaupule on each of Tuvalu's islands. Activities to be supported by all four programmes are fully integrated into the Department's Work Programme, and in many cases will be funded by a combination of both donor and recurrent budget allocations.

RV *Tala Moana* (image: George Vann Temanaui).

Work planning and monitoring

The TFD Corporate Plan provides an overall framework that guides the Department's activities over a three-year period (the first Corporate Plan will expire at the end of 2016, and a new Plan is currently being prepared).

The planning framework has been further refined through the production of annual work plans (AWP), the first of which covered the calendar year 2015 and which was formally published with SPC's assistance. Producing an AWP is a useful process because it provides a permanent reminder to all TFD staff of the tasks to be achieve during the year, as well as a basis for assessing performance and rectifying problems. The document also serves as a valuable handout for the numerous visiting consultants, donor representatives, regional organisations staff and others who want information on the Department's work programme. Instead of having to go through long question-and-answer sessions over and over again, TFD staff can simply provide a copy of the AWP and invite visitors to read it and then come back with any further questions. The AWP also makes the Department's priorities clear in the event that donor representatives are trying to promote projects and activities that are not pressing concerns for the Department – which happens a lot more than we would like. Finally, the AWP provides a basis for monitoring and reporting. The Department's 2015 Annual Report will be finalised shortly, and will for the first time be reporting against the objectives and tasks set in the AWP.



TFD's 2015 Annual Work Plan

The reality is that the 2015 AWP turned out to be too ambitious. The goals and objectives that the Department set itself were quite high, and we failed to achieve some of them for a variety of reasons, including lack of technical capacity, insufficient recurrent budget allocations, delays in several donor-funded projects, lengthy bureaucratic processes within the Government, the impacts of severe weather events on TFD facilities and infrastructure, and unexpected developments in the fisheries sector (including Tuvalu's being issued with a 'yellow card' by the European Commission). The 2016 AWP, which is being followed but has not yet been formally published, is essentially a continuation of the 2015 AWP, in which tasks that should have been completed in 2015 will now, hopefully, be done in 2016. The difference is that some of the equipment, facilities and arrangements that we expected to have in 2015 are now in place, and the delivery of AWP activities is accelerating. By 2017 TFD expects to be able to set a realistic AWP that is fully equipped for and capable of carrying out.

TFD work areas

In line with the important social and economic role of fisheries in Tuvalu, and the provisions of the MRA and other legislation, the Department's work falls into a broad range of areas:

- Sustainable management of the tuna fishery in Tuvalu waters, through:
  - ensuring compliance with the provisions of international fishery treaties to which Tuvalu is a party, including UNCLOS, FSA, PA and WCPFC;[4]
  - actively promoting Tuvalu's national interests through regional tuna fishery management arrangements, including WCPFC, FFA, PNA, TKA and other mechanisms;[5]
  - maintaining fishery licensing and data collection systems for vessels fishing in Tuvalu waters, and monitoring their activities through data collection programmes;
  - monitoring, control and surveillance (MCS) of fishing activities in the Tuvalu waters to ensure compliance with licence conditions, and to deter, detect and penalise illegal, unregulated and unreported (IUU) fishing; and
  - responding to the requirements of major market states in regard to IUU fishing and fishery product food safety.
- Increasing sustainable economic benefits from the tuna fishery, through:
  - effective negotiation of favourable fishery access conditions with foreign interests;
  - development of joint-venture arrangements between the Government of Tuvalu and selected foreign fishing companies with emphasis on shore-based development;
  - promotion of the employment of Tuvaluans as crew on board fishing vessel operating in Tuvalu waters, through training and licence conditions; and

[4] United Nations Convention on the Law of the Sea, United Nations Fish Stocks Agreement, Palau Arrangement for the Management of Fisheries of Common Interest, and Western Central Pacific Fisheries Management Convention.

[5] Western and Central Pacific Fisheries Management Commission, South Pacific Forum Fisheries Agency, Parties to the Nauru Agreement, and Tokelau Arrangement for the Management of South Pacific Albacore.

  - reform of the National Fishing Corporation of Tuvalu (NAFICOT) as a vehicle for the Government's commercial fishery interests.
- Improved management of coastal fisheries in order to maintain livelihoods, food security and dietary health. This involves:
  - working closely with Kaupule, who are responsible for by-laws and other regulations controlling local fishery management;
  - strengthening relationships between TFD, fishers and other stakeholders;
  - fishery resource assessment and monitoring, to provide the information needed for management;
  - supporting the establishment and enforcement of local conservation areas and other management mechanisms;
  - formulation of management plans for beche-de-mer, sharks and other resources that are prone to extreme overfishing; and
  - environmental monitoring to assess and mitigate adverse environmental impacts, including waste management, coastal development and ciguatera fish poisoning.
- Supporting the sustainable economic development of Tuvalu's small-scale fisheries, through:
  - provision of technical assistance, training and material support to small-scale fishers and fish processors, including for sea safety; and
  - deployment and maintenance of fish aggregation devices in all of Tuvalu's islands.
- Public awareness and education in all the above areas.

This list is not exhaustive, but provides an indication of the diversity of tasks TFD is (or may be) required to perform.

The Tuvalu fisheries sector is dynamic and fast-evolving, especially in regard to tuna fishery management and international trade in tuna products. Since Cabinet's approval of the first TFD Corporate Plan in September 2013 there have been new developments that required a response by the Department. These include increasing international fishery compliance obligations resulting from Tuvalu's membership of the WCPFC, changes to aspects of the PNA Vessel Day Scheme that could affect Tuvalu's fishery revenues, the EU's identification of Tuvalu as a possible non-cooperating country in regard to IUU fishing, and the establishment of the Tokelau Arrangement for the Management of South Pacific Albacore. All these issues required Departmental action, sometimes substantial, which was not anticipated and thus not fully planned for. This emphasises the need for the Department to remain responsive and flexible irrespective of the planning framework adopted.

Recent achievements

The last couple of years have seen the Department gain momentum and strength in most its work areas. Notable achievements and outcomes have included:

- establishment of fishery data collection programmes in Funafuti and the outer islands to provide the basis on which to provide management and development advice to Kaupule (which in Tuvalu have the legal mandate to manage fisheries within 12 miles of the shore);
- conduct of field surveys and assessments in selected outer islands, to gather additional information that will complement the data collection programme;

The creel survey team at work (image: Semese Alefaiao).

- successfully promoting several amendments to PNA fishery management arrangements that were in Tuvalu's interests, including changes to the FSM Arrangement, vessel-day pooling trials, and a charging regime for FAD-fishing by industrial purse-seine vessels;
- deployment of fish aggregation devices on all Tuvalu's islands, as a means of improving safety and productivity for small-scale fishermen, as well as diverting fishing pressure away from reef resources;

Deploying a FAD (image: Semese Alefaiao).

- establishment of the Community Vessel-Day Scheme, under which a proportion of Tuvalu's tuna fishery revenues are returned direct to the communities in each island;
- completion of the Tuna Fishery Management and Development Plan, and initial work on Shark and Beche-de-Mer Fishery Management Plans;
- establishment of a safety training programme at the Tuvalu Maritime Training Institute for Tuvaluan seafarers who want to work in the fishing industry. About 100 seafarers have now been trained at the Institute. Following the failure, for three years in a row, of PNA to agree to Tuvalu's proposal for regional mandatory minimum crewing requirements on foreign purse-seiners, Tuvalu will implement this as a national licence condition in 2017;
- expansion of the Tuvalu Fishery Observer Programme, which has increased since 2013 from 12 to 68 PIRFO-certified observers (some of whom are also MSC-certified, or qualified as debriefers), with further expansion planned. Tuvaluan observers have a good reputation in the fishing industry and are in high demand, and the Programme provides jobs that are very well-paid by Tuvaluan standards; and
- revision and updating of the Marine Resources Act (MRA) to respond to concerns raised by the EU and to ensure consistency with the changing provisions of international fishery treaties and agreements. The revised MRA is now in draft form and expected to be submitted for Parliamentary approval in November 2016.

Observer training (image: Onosai Takataka).

This is just a handful of the Department's recent outputs – there are many more. Some of these are documented on TFD's new website, www.tuvalufisheries.tv. The website is a work in progress – some areas are still to be completed and most will require regular updating.

Most of the above outcomes (including the website) were only possible because of the funding support available from

TFD's website homepage: www.tuvalufisheries.tv

New Zealand, the World Bank, and GEF via UNDP, and several relied on technical assistance from FFA, SPC, PNA and WCPFC. The Department is very grateful for this support, which will continue to be essential in the future.

Future plans

Despite the Department's recent achievements, we have only begun to scratch the surface and there remains a huge amount of work to be done, including:

- Complete field survey work in each island and use this information, plus that from the fishery data collection programmes and from other sources, to establish island-by-island fishery management and development plans.
- Strengthen the management of the Funafuti lagoon fishery, especially through working the Funafuti Kaupule and Fishermen's Association to enforce the prohibition on fishing in the Funafuti Conservation Area.
- Further work through PNA and WCPFC to find alternatives to the current three-month FAD closure for the purse-seine fishery, which places a heavy disproportionate burden on Tuvalu.
- Establish IUU and Fishery Product Food Safety Competent Authorities, to satisfy the requirements of the EU and other key market states.
- Reform of NAFICOT (the National Fishing Corporation of Tuvalu) to comply with the requirements of the Public Enterprises (Accountability) act and to act as an effective vehicle for joint ventures or other fishing enterprises in which the Government of Tuvalu has an interest.
- Fulfil Tuvalu's commitment to implement the PNA Longline Vessel-Day Scheme as of 1 January 2017.

Some of these upcoming tasks will be technically demanding and will require significant investments of time and money, but the Tuvalu Fisheries Department will rise to the challenge!

Samoa villagers celebrate first fish harvest from tilapia floating-cage aquaculture system

Tim Pickering[1]

The first ever harvest of cage-cultured tilapia fish in Samoa took place on 25 August 2016, from a floating-cage culture system that is being trialled at Lake Satoalepai in Savaii. The fish were raised with daily feeding and care by the Satoalepai Village fish farm committee that is led by mayor Matai'a Kereta, under the guidance of the Ministry of Agriculture and Fisheries staff who work in collaboration with the Aquaculture Section of the Pacific Community (SPC).

The tilapia harvest event was attended by Samoa's Minister of Agriculture and Fisheries Hon. La'aulialemalietoa Leuatea Schmidt, several Members of Parliament, ACEO Fisheries Division Magele Etuati Ropeti, and other dignitaries. The village of Satoalepai showed its appreciation in a Samoan traditional way or *faa-Samoa* in the presentation of fine mats (*ietoga*), kava (*'ava*) and food to the Minister and other guests. Fish from the harvest were distributed throughout the village, with a portion distributed to other ministers of Samoa's Cabinet in Apia so they could also experience the taste of cage-cultured tilapia.

The harvested tilapia also featured in a lunch that was served after the harvest ceremony. Comments about the eating qualities of these lake-cultured fish were very complimentary. This can be attributed in part to the clear and slightly brackish waters of Lake Satoalepai. Another factor is the use of formulated fish-feed pellets imported from Fiji. This appears to have improved their fatness and taste, compared with other tilapia fish stocks in Samoa, which are mainly raised in ponds or cement tanks using locally grown vegetable leaves such as cassava and *pele* as feed.

The sheer quantity of fish from the trial also made a big impression. From two 3 x 3 m floating cages, and one 3 x 3 m hapa net attached to stakes,[2] the first culture cycle of this project delivered about 1800 fish. This produced a total of 380 kg of tilapia, which represents an average weight of 210 g each (but ranging in sizes up to 500 g) and an 80 per cent survival rate of the fingerlings that were initially stocked. Along this stretch of coast in Samoa, it is only on rare occasions that people see 1800 fish being landed in the same place at the same time.

The trial is part of a four-year project on improving community-based aquaculture in Samoa, which is funded by the Australian Government through the Australian Centre for International Agricultural Research (ACIAR). This is in response to the Samoa Fisheries Division's current Aquaculture Management and Development Plan 2013–2018, which has accorded priority to tilapia aquaculture for food security and livelihood development due to the increasing demand for this fish in the local markets including hotels and restaurants.

Fish were apportioned and placed into baskets for each household in Satoalepai village (image: Tim Pickering).

[1] Freshwater Aquaculture Adviser, SPC. Email: TimP@spc.int

[2] See article in issue #148 of this Newsletter: http://www.spc.int/DigitalLibrary/Doc/FAME/InfoBull/FishNews/148/FishNews148_06_Bermudes.pdf

Solomon Islands' tuna fishery achieves MSC certification

Francisco Blaha[1]

In July 2016, the Solomon Islands skipjack and yellowfin purse seine and pole-and-line fishery achieved Marine Stewardship Council (MSC) certification.

The certification firm that conducted the assessment (MRAG Americas) found sufficient guarantees that the Solomon Islands (SI) fishery will continue to be managed in a way that ensures healthy stocks, minimises environmental impacts and promotes good management under the existing regulatory structure for the fishery. This structure includes overlapping national and regional regulations, including the Solomon Islands Tuna Management and Development Plan that was established by the SI Ministry of Fisheries and Marine Resources, the Parties to the Nauru Agreement Vessel Day Scheme, and a framework set by the Western and Central Pacific Fisheries Commission – all of which encourage sound management of the tuna resources in the country

The certification covers five purse seiners and three pole-and-line vessels owned by National Fisheries Developments LTD (NFD), which fish at Noro within Solomon Islands' archipelagic waters and exclusive economic zone (EEZ). Around 25,000–30,000 tonnes per year of the skipjack and yellowfin tuna that is caught by NFD fleet from free schools, anchored fish aggregating devices (FADs) or pole-and-line, could potentially qualify as MSC-certified if caught under all the certification conditions.

The majority of NFD catch is used by the Noro-based tuna processing facility Soltuna, which is covered by the certification's Chain of Custody.

Early morning on a pole-and-line fishing boat, Solomon Islands (image: ©Francisco Blaha).

[1] Fisheries Adviser, Consultant. Email: franciscoblaha@mac.com

Soltuna sells canned tuna locally and to other Pacific Island markets where its premium product, chilli tuna, is well known and appreciated. It also exports pre-cooked frozen loins of tuna to Europe.

NFD and Soltuna are locally managed and collectively employ over 2000 Solomon Islanders, which together makes them one of the country's largest private sector employers.

The certification is not a one-off event; to maintain it, NFD must continue to adhere to several conditions, such as the inclusion of observers on fishing trips to ensure regulatory compliance; this is something that NFD has done for years.

NFD must also continue to follow an action plan that implements harvest control rules and adheres to documentation and evaluation standards. Also, NFD and Soltuna must continue to ensure that the certified tuna is kept separate from non-certified product at all stages along the supply chain.

The MSC is one of the most highly regarded ecolabels in the world, hence, fisheries that achieve this certification are in an advantageous position to respond to the growing demand for certified sustainable sources of tuna.

What is an ecolabel?

Many governments have introduced diverse policies and mechanisms at national, regional and international levels (with different degrees of success and capacity), to ensure the sustainability of fish stocks. In addition to the official measures, the private sector has also introduced market-based initiatives to support the same objective.

Ecolabels are one of these initiatives; for marine products, they are designed to influence the purchasing decisions of consumers and the procurement policies of retailers, in order to reward producers that are involved in responsible fishing practices that lead the way in sustainable use of natural resources.

Ecolabels are seals of approval given to products that are considered to have a lesser impact on the environment than other products in the same market segment.

An ecolabel is a logo or label that is placed directly on a product and provides information that links the product to the production process, thereby instantly influencing the buying decision of the consumer or retailer.

An organisation that is developing and managing an ecolabel – such as MSC – sets a series of standards that must be adhered to by hopeful applicants. If applicants are found to be in compliance with these standards after being assessed by the ecolabelling organisation, they are then certified in due course.

Assessments are done by certifiers and auditors, who must be accredited as being competent to carry out the assessments and certification against the standards that are specific to each ecolabel.

The organisation that delivers the certification also promotes the significance of the label to consumers in order to ensure appreciation and demand for the certified products.

Four examples of ecolabels

Quantifying benefits from Pacific Island fisheries

Robert Gillett[1]

In July 2016, the Pacific Community (SPC) launched the book 'Fisheries in the Economies of Pacific Island Countries and Territories',[2] *which attempts to quantify the various types of benefits produced by fisheries in the region. The document contains a fisheries-oriented discussion of macroeconomics, country information on specific topics (fisheries production, contribution to GDP, etc.), a discussion of important topics across all countries (e.g. the regional significance of access and exports of fishery products), some important features of the benefits from fisheries that have emerged from this study, and recommendations on improving the measurement of fisheries benefits and assuring the continuity of those benefits. This short article is a summary of the major features of the book.*

Recent annual harvests (values and volumes) in the 22 Pacific Island countries and territories (PICTs) are given in various fishery categories for the year 2014: (1) coastal commercial fishing, (2) coastal subsistence fishing, (3) locally-based offshore fishing, (4) foreign-based offshore fishing, (5) freshwater fishing, and (6) aquaculture. Figure 1 below gives the relative values of these six categories in the region. The national volumes and values are given in Tables 1 and 2.

The coastal and offshore information given in Tables 1 and 2 is graphed in Figures 2 and 3.

The regional fish production in 2014 is estimated to be 2,013,742 t, worth USD 3,248,224,638. In comparing these figures with estimates by other studies, it is important to note carefully what the 'region' is and where the value is estimated on the value chain. The present study defines the region as the PICTs and their 200-mile zones, and the values used reflect the prices paid to the producer or (for offshore fisheries) in-zone prices.

The unit price of coastal commercial fisheries across the region in 2014 (USD 4,047 per t) is greater than that of any of the other four fishery categories, and 2.5 times the unit value of offshore fisheries.

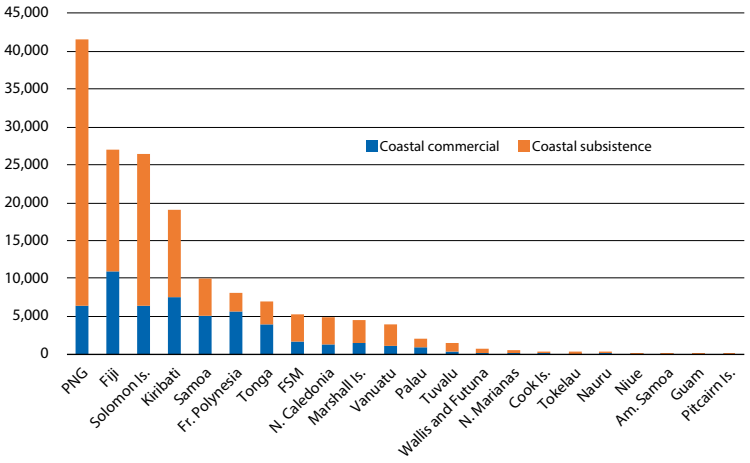


Figure 2. Volume of coastal fisheries production (tonnes).

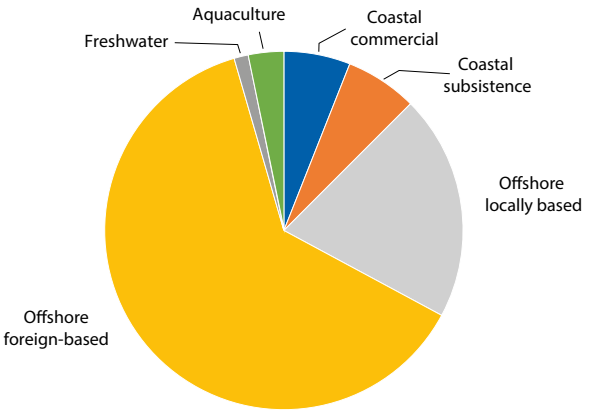


Figure 1. Relative values of the various fishery categories summed across the Pacific Islands region.

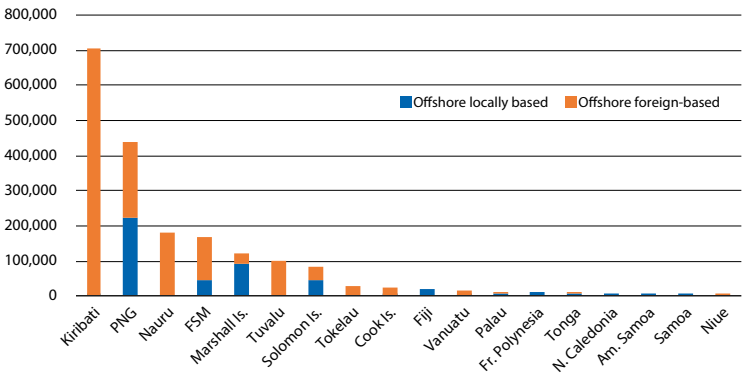


Figure 3. Volume of offshore fisheries production (tonnes).

[1] Director, Gillett, Preston and Associates. Email: gillett@connect.com.fj
[2] http://www.spc.int/coastfish/en/component/content/article/462-benefish-study-2016.html

Table 1. Volume of fisheries production (tonnes) and aquaculture production (tonnes and pieces), 2014.

	Fisheries (tonnes)						Aquaculture	
	Coastal commercial	Coastal subsistence	Offshore locally based	Offshore foreign-based	Freshwater	Total	Tonnes	Pieces
Kiribati	7,600	11,400	510	701,067	0	720,577	255	8,642
Papua New Guinea	6,500	35,000	216,896	217,871	20,000	496,267	145	160,000
Nauru	163	210	0	177,315	0	177,688	0	0
FSM[3]	1,725	3,555	40,838	124,481	1	170,600	8	37,400
Marshall Islands	1,500	3,000	85,918	29,754	0	120,172	0	10,000
Solomon Islands	6,468	20,000	41,523	36,573	2,300	106,864	1,530	20,000
Tuvalu	300	1,135	0	96,898	2	98,335	1	0
Fiji	11,000	16,000	17,079	0	3,731	47,810	205	85,236
Tokelau	40	360	0	24,286	0	24,686	0	0
Cook Islands	150	276	194	20,342	5	20,967	12	52,000
Vanuatu	1,106	2,800	568	10,942	80	15,496	43	27,300
French Polynesia	5,666	2,350	5,390	0	100	13,506	101	8,361,500
Samoa	5,000	5,000	1,254	0	10	11,264	12	0
Tonga	3,900	3,000	1,363	1,891	1	10,155	0	1,291
Palau	865	1,250	3,987	4,017	1	10,120	22	343,800
New Caledonia	1,350	3,500	2,876	0	10	7,736	1,733	0
American Samoa	42	120	2,154	0	1	2,317	9	0
Wallis & Futuna	150	675	0	0	0	825	0	0
Niue	11	154	0	547	0	712	0	0
Northern Marianas	142	350	0	0	0	492	41	15,000
Guam	72	42	0	0	3	117	100	0
Pitcairn Islands	3	6	0	0	0	9	0	0

Table 2. Value of fisheries and aquaculture production (USD), 2014.

	Coastal commercial	Coastal subsistence	Offshore locally-based	Offshore foreign-based	Freshwater	Aquaculture	Total
Kiribati	15,459,836	16,259,016	3,606,557	1,111,106,457	0	237,506	1,146,669,373
Papua New Guinea	50,583,658	66,731,518	312,719,079	311,048,127	38,132,296	1,228,288	780,442,964
FSM[3]	5,000,000	8,800,000	85,342,200	228,148,080	8,000	164,800	327,463,080
Nauru	1,071,275	965,438	0	231,229,508	0	0	233,266,220
Solomon Islands	12,848,296	33,027,523	57,520,263	79,228,378	3,800,786	773,263	187,198,510
Marshall Islands	4,350,000	6,000,000	133,530,000	38,700,638	0	50,000	182,630,638
French Polynesia	31,107,594	11,466,127	28,829,104	0	487,920	89,771,222	161,661,967
Tuvalu	747,951	1,120,287	0	131,951,751	1,639	820	133,822,448
Fiji	37,878,788	29,292,929	54,364,955	0	3,741,414	1,452,307	126,730,392
Cook Islands	1,328,125	1,562,500	2,265,625	57,153,854	29,297	855,469	63,194,870
New Caledonia	9,324,366	16,916,335	13,416,896	0	48,334	18,786,304	58,492,235
Palau	3,200,000	3,300,000	31,471,000	18,555,070	10,000	285,000	56,821,070
Vanuatu	5,584,821	7,429,519	1,474,009	26,402,602	232,875	383,377	41,507,203
Tonga	18,064,516	10,053,763	4,177,419	5,058,065	3,226	15,054	37,372,043
Samoa	17,782,427	12,447,699	4,666,309	0	22,703	27,615	34,946,752
Tokelau	109,375	689,063	0	33,203,125	0	0	34,001,563
Wallis and Futuna	1,528,585	6,534,699	0	0	0	0	8,063,283
American Samoa	244,000	487,000	5,113,395	0	4,000	44,500	5,892,895
Northern Marianas	821,356	1,400,000	0	0	0	1,130,000	3,351,356
Niue	116,016	1,136,953	0	1,519,487	0	0	2,772,455
Guam	388,996	158,358	0	0	11,000	800,000	1,358,354
Pitcairn	14,063	9,375	0	0	0	0	23,438

[3] Federated States of Micronesia

The higher unit value of offshore locally-based production, relative to offshore foreign-based production reflects a higher proportion of locally-based longlining. The lower value of freshwater production, relative to coastal subsistence reflects the low imputed value of the production in PNG's inland fisheries.

In the present study the total production by volume from the offshore fisheries of the region, is almost nine times that of coastal fisheries. By value, it is only about 5.6 times as great – due the high unit value of coastal fisheries production.

Some of the other notable features of the over-all fisheries production of the region are as follows:

- The total production from the region in 2014 (2,013,742 t) divided by the population of the region in 2014 (10,776,937 people) equates to 187 kg of fish per person.
- Fiji and French Polynesia are the only two countries among the top producing countries whose production is not strongly tuna-oriented.
- The production from Fiji's coastal commercial fisheries is greater than than of any other PICT, even that of PNG, which has a population that is almost nine times greater.
- The value of offshore fishing in the Kiribati zone in 2014 (USD 1.1 billion) approaches the combined value of offshore fishing of all other PICTs except PNG (USD 1.3 billion).
- Three countries in an area of relatively good tuna fishing had no locally-based offshore fishery production in 2014: Nauru, Tuvalu and Tokelau. A fourth country, Kiribati, had just a tiny amount of locally-based offshore fishery production.
- In about one-third of the countries that are significantly involved in offshore fisheries, the fleet is locally-based, in another third it is a mixture of locally- and foreign-based, and in the another third it is all foreign-based.
- In only six countries of the region is aquaculture significant (i.e. production value is greater than 5% of that of coastal fisheries) – all but one of those countries are territories (Cook Islands).
- Two French Territories were responsible for over 93% of the value of all aquaculture production in the region in 2014 (Figure 4).

The study used fishery production information to estimate the contribution of fishing to gross domestic product – and then compared those estimates to estimates made by the statistics departments of the region. The official contributions of fishing to GDP are compared to the re-estimates in Figure 5.

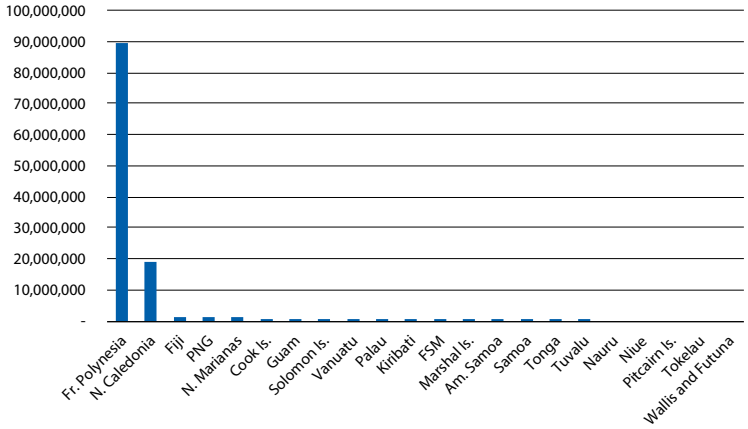


Figure 4. Value of aquaculture production in the Pacific Islands region in 2014 (USD).

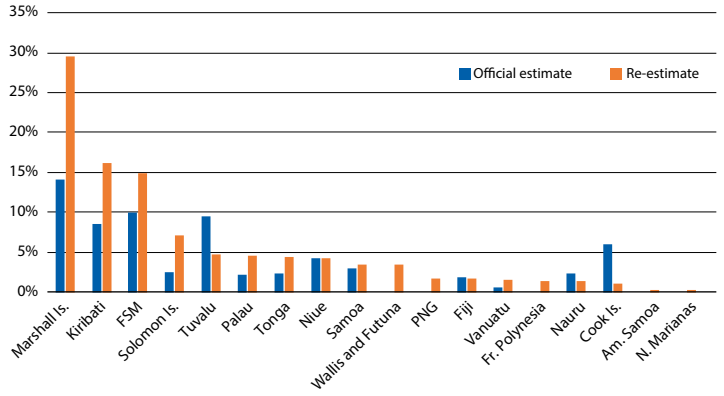


Figure 5. Official vs re-estimated fishing contributions to GDP (2014 or latest year available).

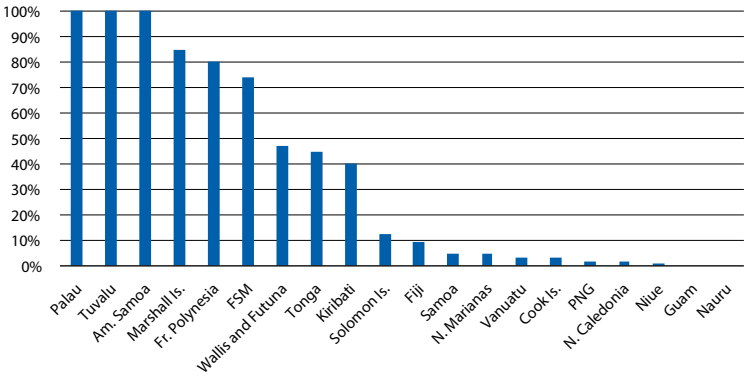


Figure 6. The relative importance of fishery exports.

Fishery exports are very important to the countries of the region. Figure 6 shows that in about half of the countries, fishery exports represent over 40% of all exports. Where they represent less than 40% of the value of national exports, several are quite large in nominal terms: PNG (USD 136 million), Fiji (USD 58 million), Solomon Islands (USD 54 million), and New Caledonia (USD 22 million).

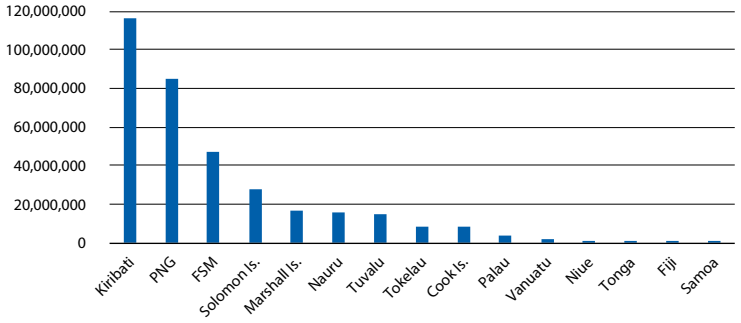


Figure 7. Access fees for foreign fishing (USD; 2014 or most recent year).

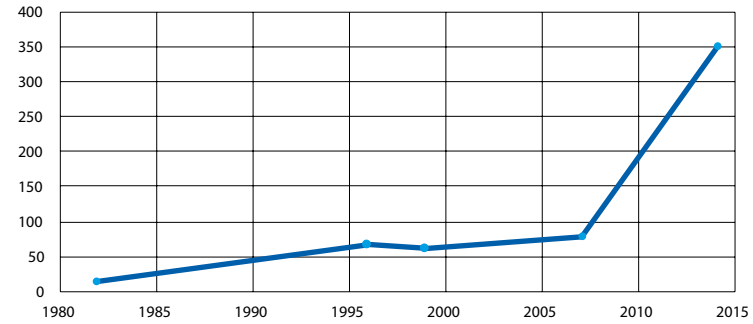


Figure 8. Change in access fees 1982–2014 (USD million).

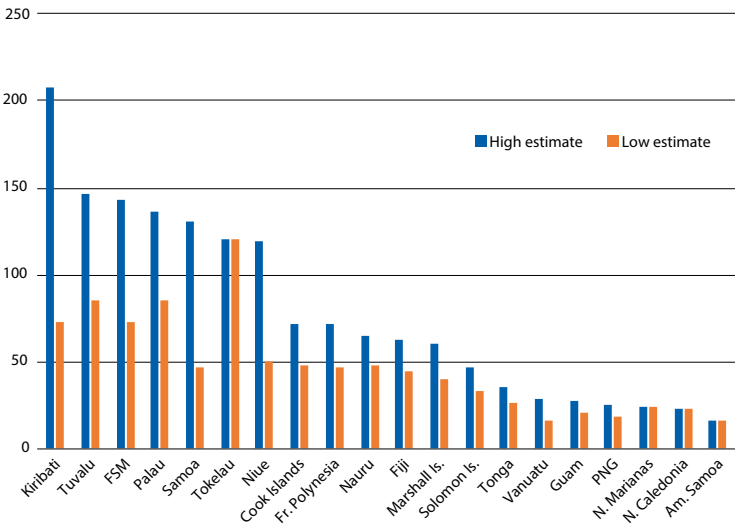


Figure 9. The range in estimates of annual per capita fish consumption estimates (kg person^{-1} year^{-1}).

Information is provided in the book on access fees received for foreign fishing. Figure 7 summarises access fees paid for the most recent annual period for which data is available.

Access fees have changed considerably over the years. The evolution in the level of the fees is shown in Figure 8. It should be noted that the amounts in this figure are nominal access fees (i.e. not converted to 2014 prices).

The book gives the readily available information on the consumption of fish and other fishery resources from a large number of studies. The results (minus the outliers) are summarised in Figure 9.

One of the major conclusions of the book is that in the work of the government fisheries agencies of the region, there should be a shift in the thinking, from efforts to extract more benefits from coastal fisheries (coastal fisheries development) to efforts to maintain the existing flow of benefits (coastal fisheries management). Similarly, the assistance that regional/international development partners provide to the fisheries sector at the national level needs to focus more on coastal fisheries management. The recent trends in coastal fisheries also indicate that there has already been a dietary impact due to the changes in coastal fisheries production – which further strengthens the argument for increased attention to coastal fisheries management.

Acknowledgements

The book on which this article is based was produced by SPC with support for the Forum Fisheries Agency and financial assistance from the Australian Department of Foreign Affairs and Trade.

Pacific region capacity building for CITES sharks and rays

Dr Cassandra Rigby[1] and Prof. Colin Simpfendorfer[1]

*Sharks are a significant by-product of Pacific fisheries, especially for tuna and billfish. Five shark and two manta ray species were listed on the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) Appendix II on 14 September 2014: oceanic whitetip shark (*Carcharhinus longimanus*), porbeagle (*Lamna nasus*), scalloped hammerhead (*Sphyrna lewini*), great hammerhead (*S. mokarran*), smooth hammerhead (*S. zygaena*), giant manta ray (*Manta birostris*) and reef Manta Ray (*M. alfredi*). An Appendix II listing is for species in which trade must be controlled to avoid utilisation that is not compatible with the survival of the species.*

Background

The CITES listing requires member countries to develop non-detriment findings (NDFs) if exports are to occur. Countries that are not CITES members that wish to trade in CITES-listed shark species with CITES members must provide documentation comparable to NDFs. The NDFs are intended to ensure that the export of the species (or parts of the species, such as fins) will not be detrimental to the survival of the species. In the Pacific region there are six countries that are CITES members: Fiji, Palau, Papua New Guinea, Samoa, Solomon Islands and Vanuatu. Two workshops have previously been held to assist CITES Parties in the Pacific region to understand their obligations and requirements associated with the implementations of the listings. These workshops were held in Wollongong, Australia on 9–11 December 2013 and in Nadi, Fiji on 11–12 February 2014. The outcomes of the second meeting in Nadi 2014 led to the implementation of this Pacific CITES Shark project. This project aimed to build capacity in the Pacific region to assist countries to implement the NDF processes if they wish to trade in the CITES Appendix II shark and ray species. This project was funded by CITES through the European Union-CITES capacity building project and led by James Cook University.

This project focused on the three hammerhead and two manta ray species mentioned above, and not the oceanic whitetip shark as it has a Western Central and Pacific Fisheries Commission (WCPFC) ban on their retention, transhipping, storing or landing; and not the porbeagle shark as it is a temperate species that rarely occurs in the tropical Pacific waters. There is no defined process for how an NDF is undertaken, thus to assist the NDF process for the shark and ray Appendix II listings, in 2014 the *CITES Non-Detriment Findings Guidance for Shark Species* was produced (Mundy-Taylor et al. 2014). The CITES shark guide outlines a six-step process to carrying out an NDF for sharks and rays, illustrated by a flow chart (Figure 1). For each of the six steps, there are worksheets in the guide that clearly set out the information needed for an NDF. These worksheets were proposed to form the basis of a common regional NDF template, which could be used by the Pacific Island countries to assist with the production of NDFs. The Pacific countries share stocks of the CITES Appendix II shark and ray species that need to be considered in NDF development and a regional NDF approach can address this issue. A common NDF template provides a consistent format, language and terminology, and is well supported by the CITES shark guide with detailed explanations on the required information.

The suitability of such an approach to NDFs in the Pacific was informally discussed with representatives from Pacific management organisations – that is, Pacific Community (SPC), Forum Fisheries Agency (FFA) and Western Central Pacific Fisheries Commission (WCPFC); NGOs active in shark conservation and CITES efforts in the Pacific – that is, TRAFFIC, World Wildlife Fund (WWF) and Secretariat of the Pacific Regional Environment Programme (SPREP); and people that had completed shark NDFs for Australia and New Zealand from the Australian Department of the Environment and New Zealand Department of Conservation.

Workshop

A workshop for this Pacific CITES Shark project was held in Nadi, Fiji on 11–13 April 2016 to discuss the proposed regional NDF template, the information needed for an NDF, and the need to develop a regionally co-ordinated approach to sustainable management of shared stocks of CITES listed sharks and rays. To achieve these outcomes, the workshop was designed to be relatively informal to encourage participation by all delegates in round-table discussions. Each country was invited to nominate two persons to attend – ideally one each from the designated CITES Management Authority and CITES Scientific Authority, respectively – who would be most closely involved with the development of NDFs within the country. Representatives

[1] Centre for Sustainable Tropical Fisheries and Aquaculture, College of Science and Engineering, James Cook University, Townsville QLD 4811, Australia.

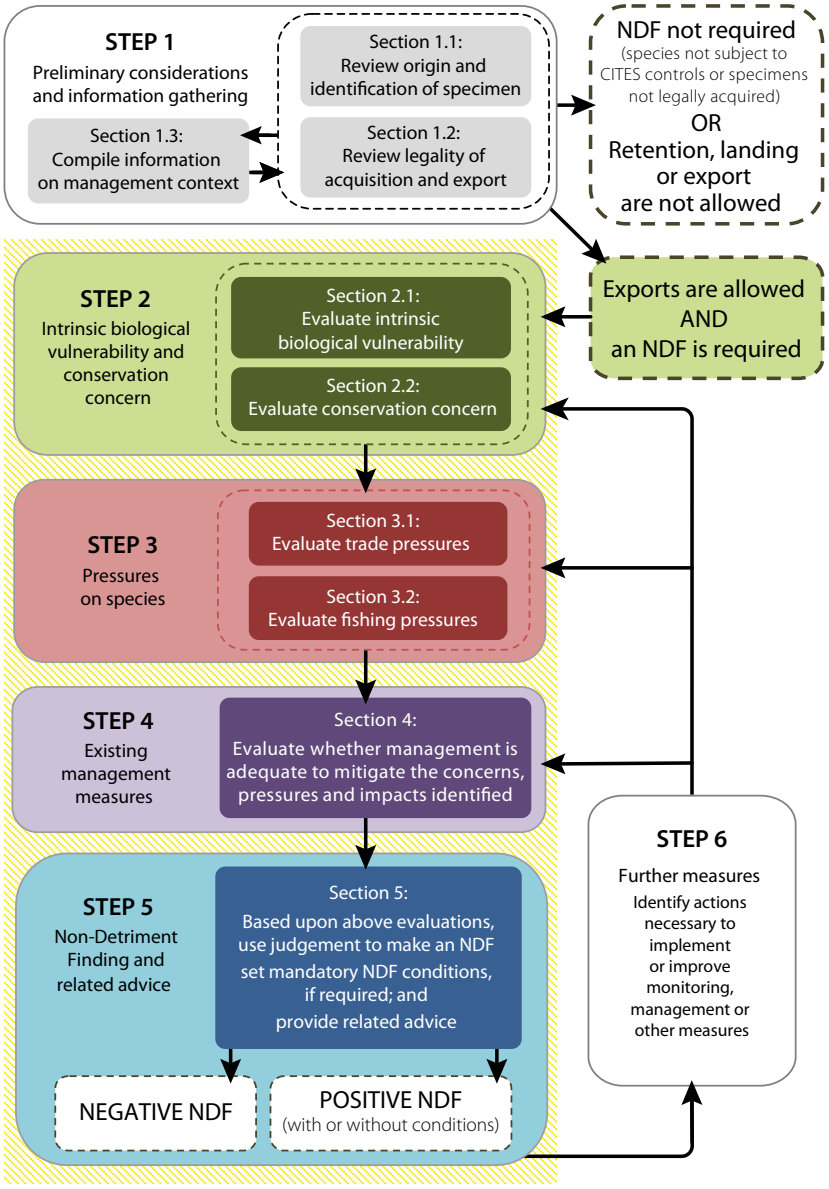


Figure 1. Flow chart showing non-detriment finding (NDF) process.
Source: Mundy-Taylor et al. 2014.

attended from Fiji (2), Palau (1), Papua New Guinea (1), Samoa (2) and Solomon Islands (2). A delegate from each of FFA, Pew Charitable Trust (PEW), SPREP and WWF also attended (Figure 2).

Project outcomes

All delegates at the Fiji 2016 workshop agreed on the format and content of the regional NDF template and that templates pre-populated with common information for each of the three hammerhead and two manta ray species would be very beneficial in starting the shark and ray NDF process in the Pacific region. This was undertaken and the common information was provided for the NDF templates; that is, global catches, conservation status, biological vulnerability and regional management measures. A summary document that presented the detailed background information for the NDF templates was also compiled. This included a review of existing pelagic and coastal catch data for the three hammerheads and two manta rays in the Pacific region that was available from the literature, WCPFC reports, and the summary of WCPFC observer data provided by SPC. A potential framework for regional co-operation to produce NDFs

Figure 2. Participants of the Fiji 2016 workshop from governments of Fiji, Palau, Papua New Guinea, Samoa and Solomon Islands, along with representatives from the Forum Fisheries Agency (FFA), Secretariat of the Pacific Regional Environment Programme (SPREP), Pew Charitable Trust (PEW), World Wildlife Fund (WWF), and James Cook University (JCU) (image: Cassandra Rigby).

on shared hammerhead and manta ray stocks, was also outlined (Figure 3). The development of a regional NDF in the long-term would be useful because of the shared stocks and limited capacity within in-country agencies; however, in the short-term individual countries need to consider NDF production.

There are two major challenges to the NDF process: the lack of species-specific catch data that hinders the ability to do stock assessments for the hammerheads and manta rays, and communication issues among in-country agencies that can slow down the flow of data and other information that is required to undertake an NDF. Fiji has a CITES Scientific Council that provides a good model for implementing CITES procedures as it aids communication among agencies and supports an efficient whole of government approach to NDFs. There are some existing and commencing projects that have synergies with the information needs of NDFs and this may assist in collecting better data on hammerheads and manta rays, and improve communication among tuna Regional Fisheries Management Organisations and the understanding of the stocks of hammerheads in the Pacific region; that is: Rapid Assessment Toolkit (http://wwf.panda.org/wwf_news/); Global Shark and Ray Initiative (http://wwf.panda.org/sharks/global_shark_and_ray_initiative/); Areas Beyond National Jurisdiction (http://www.commonoceans.org/home/en/); WCPFC Research Plan (Brouwer and Harley 2015); NESP Hammerheads Project (Australia) (http://www.nespmarine.edu.au/project/hammerhead-sharks); and Sustainable management of the shark resources of Papua New Guinea (ACIAR project) (http://aciar.gov.au/project/fis/2012/102).

Recommendations

Participants at the workshop identified that the most critical step required for moving the shark NDF process forward is one-on-one in-country assistance. It would be regionally beneficial if this assistance is one person or a small group of people, as this will provide a more regionally consistent set of NDFs that could eventually transform into a single regional NDF. There is the need for an entity to drive and co-ordinate the shark NDF process among the Pacific countries. Without this, progress is likely to be very slow due to capacity and resource restraints. One of the Pacific management organisations may be best placed to do this in the longer term. A number of organisations are committed to providing assistance; that is, SPREP, FFA, PEW and WWF. Detailed distribution maps of each of the CITES listed shark and ray species on the CITES shark website would be helpful to enable countries to determine whether the species occur in their waters (a small project to provide these maps has commenced through James Cook University). A continuous improvement approach should be applied to NDFs; the recommendations associated with the NDF can be used to drive improvements in data collection, assessment and management. Capacity building in

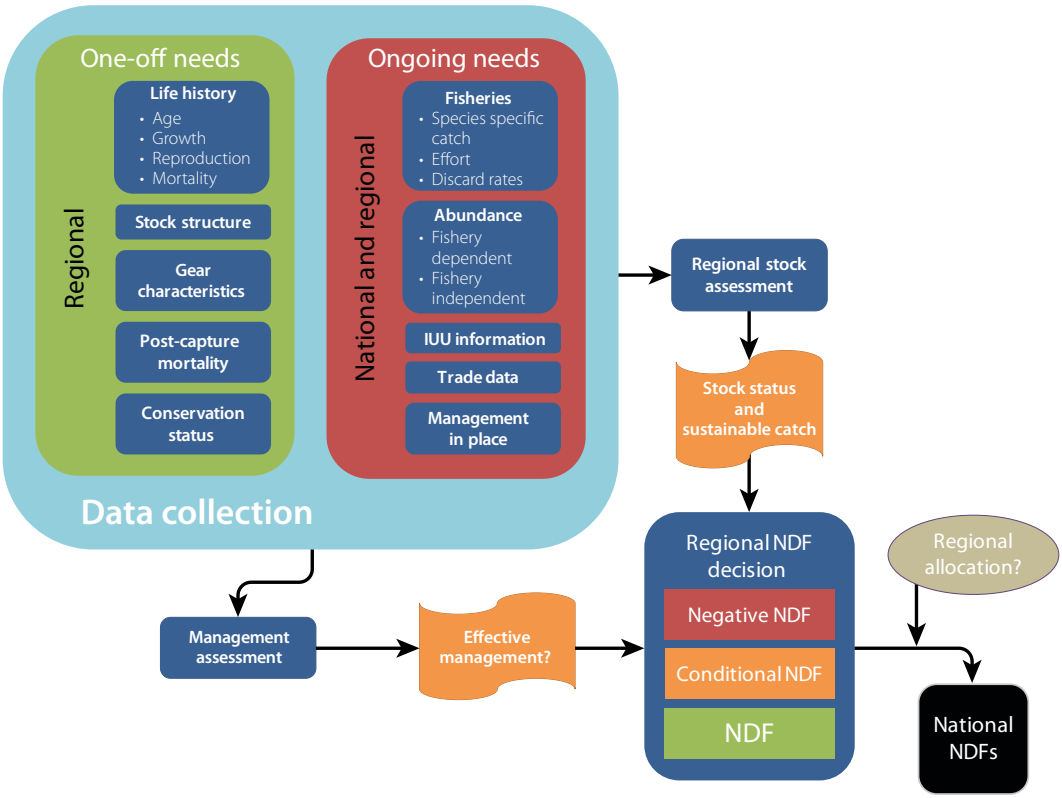


Figure 3. Model for the development and ongoing maintenance of NDFs in the Pacific region. Source: Simpfendorfer 2014.

identification of shark fins for customs, quarantine and fisheries officers would be beneficial for enforcement efforts, and capacity building with legislation will better enable countries to link their fisheries and environment legislation to CITES requirements.

The CITES shark and ray website (https://cites.org/eng/prog/shark/index.php) provides information resources for NDFs and the latest news, meetings and highlights relevant to CITES listings of sharks and rays. More detailed information on this Pacific CITES Shark project will be available on this website; that is, the NDF templates for each of the hammerhead and manta ray species, the summary of information document and the Fiji 2016 workshop report, which includes the presentations given at the workshop.

For more information:
Colin Simpfendorfer
Director, Centre for Sustainable Tropical Fisheries and Aquaculture, James Cook University
colin.simpfendorfer@jcu.edu.au

References

Brouwer S. and Harley S. 2015. Draft Shark Research Plan: 2016-2020. Scientific Committee Eleventh Regular Session. WCPFC-SC11-2015/EB-WP-01 rev1. https://www.wcpfc.int/node/21717

Mundy-Taylor, V., Crook. V., Foster, S., Fowler, S., Sant, G. and Rice, J. (2014). CITES Non-detriment findings guidance for shark species (2nd, revised version). A Framework to assist authorities in making non-detriment findings (NDFs) for species listed in CITES Appendix II. Report prepared for the Germany Federal Agency for Nature Conservation (Bundesamt für Naturschutz, BfN). https://cites.org/eng/prog/shark/Information_resources_from_Parties_and_other_stakeholders

Simpfendorfer C. 2014. Information for the development of Non Detriment Findings for CITES listed sharks. Report to the Department of the Environment, Australia. https://www.environment.gov.au/system/files/resources/39c06695-8436-49c2-b24f-c647b4672ca2/files/cites-listed-sharks.docx

Update on beche-de-mer market prices in China

Unlike fish, beche-de-mer (dried sea cucumber) is a luxury seafood that is eaten at banquets and often for its medicinal properties. Five years ago, a project by the Pacific Agribusiness Research for Development Initiative (PARDI) of the Australian Centre for Agricultural Research (ACIAR) revealed the prices of exported sea cucumbers from Pacific Islands and the attributes of beche-de-mer that affect sale prices (Purcell 2014). Prices commonly ranged from USD 15–400 depending on the species and product size. Since then the Chinese government has discouraged 'conspicuous consumption' of luxury food items, including beche-de-mer, thereby affecting demand (Eriksson and Clarke 2015). On the other hand, some fisheries (e.g. Kiribati and Tonga) have closed recently, thereby affecting supply.

Most of the beche-de-mer that is harvested and processed in the Pacific Islands is exported to Hong Kong, and then much of it is redistributed to mainland China, via Guangzhou (Canton city). In most cases, market prices in China reflect export prices from the Pacific Islands. Knowledge on beche-de-mer prices can help to substantiate the value reported by exporters from the Pacific Islands and inform economic valuations of fisheries and aquaculture.

A recent study commissioned by the Pacific Community (SPC) believed that 'prices are rising' for Pacific Island beche-de-mer (Carleton et al. 2013), but the extent of such rises in recent years is uncertain. A regional workshop in Nadi in 2012 listed 'better information on markets and prices' as one of the five key needs for sea cucumber fisheries in the Pacific Islands (Anon. 2012). Likewise, delegates, on several occasions at a 2015 regional technical meeting on beche-de-mer in Tonga, raised the need for 'market information' in order to improve sea cucumber fisheries in the region (Shelley 2015).

In order to address the regional priority for updated information on market prices of beche-de-mer, an ACIAR-funded project will again collect and analyse data on market prices in November 2016. The study will collect data from Hong Kong and Guangzhou. The trip will allow for reporting on the changes in the market over the five-year period since the last study, and the publication of an up-to-date list of prices of beche-de-mer for various species of sea cucumbers that are harvested in Pacific Islands.

Tropical sea cucumbers in jars in Hong Kong (image: Steve Purcell).

It is hoped that the upcoming study will enable improved decision-making by Pacific Island fishery managers on certain regulatory measures and validation of the reported export value of beche-de-mer. The study could also underpin cost-benefit analyses and production strategies for sea cucumber aquaculture.

References

Anon. 2012. A proposed regional approach to improved management of sea cucumber fisheries: working Paper 2. Noumea, New Caledonia: Secretariat of the Pacific Community. Informal Consultation with Heads of Fisheries, Noumea, New Caledonia, 4 June 2012. 3 p. [www.spc.int/DigitalLibrary/Doc/FAME/Meetings/HOF/Informal_HOF_Consultations/Inf_HOF_2012_WP2.pdf]

Carleton C., Hambrey J., Govan H., Medley P. and Kinch J. 2013. Effective management of sea cucumber fisheries and the beche-de-mer trade in Melanesia. SPC Fisheries Newsletter 140:24–42. [www.spc.int/DigitalLibrary/Doc/FAME/InfoBull/FishNews/140/FishNews140_24_Carleton.pdf]

Eriksson H. and Clarke S. 2015. Chinese market responses to overexploitation of sharks and sea cucumbers. Biological Conservation 184:163–173.

Purcell S.W. 2014. Value, market preferences and trade of beche-de-mer from Pacific Island sea cucumbers. PLoS One 9: e95075 [http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0095075]

Shelley C. 2015. Outcomes of a Regional Technical Bêche-de-mer (BdM) Meeting Nuku'alofa, Tonga 29 September – 1 October 2015. IUCN, Suva. 29 p. [www.iucn.org/sites/dev/files/import/downloads/bdm_tech_meeting_tonga_oct15_report_1dec.pdf]

For more information:
Steven W. Purcell
National Marine Science Centre,
Southern Cross University, Australia
steven.purcell@scu.edu.au

Sharing Pacific nearshore FAD expertise

Nearshore fish aggregating devices (FADs) are gaining momentum in the Pacific region as a tool to enhance food security and income for fishers and communities, and to reduce pressure on the resources of lagoons and reef fisheries. A lot of experience has been gained by countries across the Pacific. There have been, however, limited opportunities for nearshore FAD practitioners to come together to share this experience in order to advance the implementation and use of nearshore FADs in the Pacific.

In June 2016, twelve experts from the Pacific region came together at the Vanuatu Maritime College in Santo, Vanuatu, to share knowledge and experiences in the design, planning and implementation of nearshore FAD programmes. Countries and territories represented at this first regional Expert Consultation on nearshore FADs were American Samoa, Cook Islands, Fiji, French Polynesia, Kiribati, Papua New Guinea (PNG), Samoa, Solomon Islands, Tuvalu and Vanuatu. These FAD practitioners were identified based on their experience and complimentary knowledge covering the full life-cycle of a nearshore FAD programme. The purpose of the consultation was to gather lessons learnt and to identify the best practice principles to guide future nearshore FAD programmes across the region.

The Expert Consultation included countries' innovations in FAD design and the full cycle of a nearshore FAD programme, including site selection, community engagement, rigging, deployment, fisher training, maintenance, and monitoring and evaluation. Overall programme management and funding models for sustaining long-term national FAD programmes were also discussed.

This article provides an overview of the lessons learnt from the experts' experiences as well as the knowledge and research gaps that need to be addressed. Further feedback from other countries, experts, non-governmental organisations (NGOs) and others in the region would be very much appreciated.

These lessons and the information gathered through this consultation will be used by the Pacific Community (SPC) and partners to develop an updated nearshore FAD manual for the Pacific – anticipated for release in 2017.

Lessons learnt

FAD design and innovation

FAD design is one of the most technical elements of nearshore FADs. Different types, designs and components of FADs have evolved over the years through research and innovation by countries, and regional and national non-government organisations. This has resulted in several nearshore FAD designs now being used in the region – the most popular of which are the SPC modified Indian-Ocean FAD (renamed 'Indo-Pacific' FAD by the regional experts to account for the modifications to the original design), Vanuatu's Vatu-Ika FAD, and the SPC sub-surface FAD. Other designs and innovations discussed at the Expert Consultation included bamboo FADs, spar and catamaran buoys, lagoon FADs and a Tahitian FAD design.

Across the region, the two most common issues identified by regional experts were the loss of nearshore FADs due to vandalism and the difficulty in deploying FADs from small vessels. In essence, these two issues have been largely resolved through technological advances and innovations. In areas of high vandalism, the SPC sub-surface FAD or designs that are based on locally available and less targeted materials (such as bamboos) are the best options. Advances in FAD deployment systems, either through the use of small purpose-built barges, or by using modified anchors (e.g. multiple cement blocks or sand bags) enable the safe deployment of nearshore FADs from small (6–7 m) community boats, even in remote locations.

Detailed discussions were had on most of the nearshore FAD designs that are currently used in the region. For brevity the remainder of the design and innovation section concentrates on the key lessons gathered for surface FADs (e.g. the Indo-Pacific and Vatu-Ika designs).

Surface components (floatation system)

Surface hardware such as swivels and shackles should be avoided as these components become the underlying structural weaknesses within the FAD structure.

Large floats cause greater stress on the mooring system; however, using the hard plastic 30G (or similar) floats provide a good durable floatation device. The 30G type is preferable to Polystyrene (PS) foam floats. A major problem identified with the PS foam floats is that when they plunge repeatedly they become hard and acts as a weight rather than a float and affect the integrity of the system.

Between each surface float a 'buffer' rope should be tied. This reduces both the wear on the system but also acts as a blocker to secure each float individually. This avoids the loss of the whole FAD should one or two floats come loose and float away.

In addition, the mooring rope through the surface buoys should be protected with insulation material (PVC or hose) to protect the rope from chafing that is associated with the

Whipping the end of the buoy line to secure the knot and protect the rope from chafing (image: Joelle Albert).

joining seams on buoys (especially the 30G buoy). The ends of the insulation material should be peeled back and whipped to protect the rope from potential sharp edges.

Mooring rope

Braided multi-strand rope is currently the best mooring rope available as it does not kink and thus avoids the need to use surface and mid-water swivels (which as identified above can result in structural weaknesses). If, due to budget constraints, three-strand rope is used, a swivel will be required. When this is the case, it will be important to ensure the connection is covered with protective hose or rubber and then whipped with rope for added protection.

A steel-reinforced mooring rope means that the rope and the FAD is more resilient to being snagged by fishing gear or shark bites, which extends the life of the FAD.

Aggregator components

Where possible, biodegradable aggregators should be used (e.g. cotton mussel spat rope and coconut fronds). Biodegradable aggregators will not last as long as plastic aggregators; however, the use of biodegradable materials reduces the impact on the environment. Let's keep thinking 'reduce – reuse – recycle!'

Anchor system

The anchoring system most commonly used across the region is a heavy cement block. When deploying from small boats, a series of smaller cement blocks or sand bags can be used as an alternative to heavy blocks in order to reduce risks associated with deployment. Sand bags are an appealing and cheap option – especially in remote areas with limited access to cement, but the bags need to be able to withstand high pressures and abrasion. Vanuatu, which uses sand bags for the Vatu-Ika FADs, orders bags from Japan to ensure they are sufficiently durable.

When deploying the anchor system on steep slopes, it should be complemented with a Danforth anchor or a grapnel made of rebar to prevent the anchor from sliding down the slope.

Site selection and community engagement

The discussions regarding nearshore FAD site selection, highlighted that it can often be driven by external factors including local agendas and donor preferences. It is recommended that national-level frameworks are developed to guide the nearshore FAD site selection process in order to retain transparency and to ensure that FADs are deployed for genuine purposes and for the relevant end users.

Across the Pacific region, nearshore FADs are becoming increasingly used as a component of community-based fisheries management (CBFM) to 'shift' fishing pressure from lagoons and reefs to more sustainable oceanic fish resources. There is a set of regional guidelines and principles for site selection and community engagement for CBFM, and these may help FAD practitioners select appropriate FAD sites and develop community engagement frameworks.

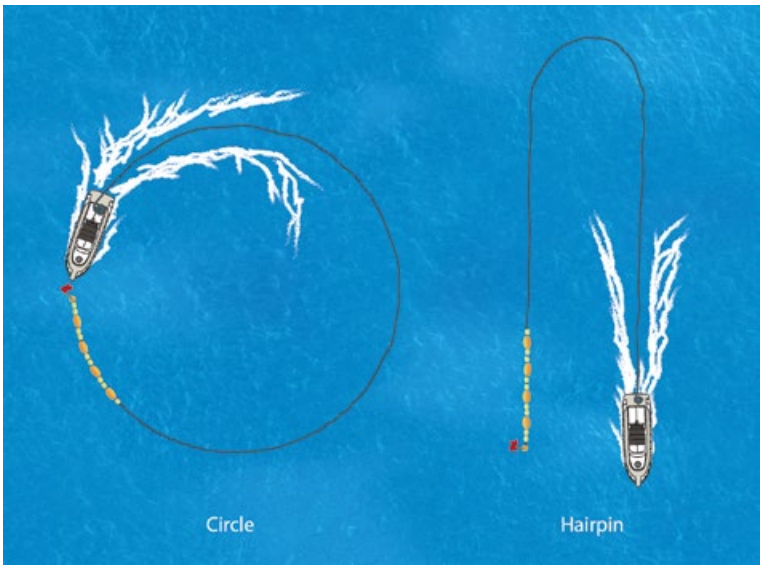
Regional experience highlights that engagement processes need to be consistent with local customs and traditions. Ownership needs to be clearly defined to ensure responsibility for nearshore FADs being successfully transferred to the target

groups. In particular, involving local fishers and fisher associations in the site selection process is important. This local knowledge can also increase the effectiveness of the FAD by locating it at known productive fishing ground. Through the community engagement process, mechanisms are also required to enable conflict and dispute resolution. The process should also identify possible access to funds or materials to enable replacement, repair and maintenance of the FADs for long-term benefits to the concerned communities.

FAD deployment methods

Safety should be the number one priority when deploying nearshore FADs. Nearshore FADs can be successfully and safely deployed from small boats; however, deployment procedures need to be in place and trained personnel are required for deployments to ensure safety considerations are fully accounted for and evaluated.

Deployment methods should follow the 'hairpin' or circle formation (where the floatation system is put in the water near the allocated deployment location then the rope is released and the vessel returns to the deployment location where the anchor is finally dropped overboard). Both techniques are far more accurate than a straight line deployment method and reduce the risks of entanglement and stress on the mooring rope.



The circle and hairpin techniques that are recommended to set FADs (illustration: Boris Colas, SPC).

The use of an echo-sounder and GPS is essential for safe and accurate deployments. On the other hand, detailed bathymetric charts like those produced by the SPC Geoscience Division will ease and streamline the deployment procedures as pre-deployment surveys of the seabed are no longer required – however the availability of such charts is still limited across the Pacific region.

Fisher training

Fishers training is important, especially for communities without prior FAD experience, as specific fishing methods are required to fish FADs efficiently and FADs are usually located further offshore than usual fishing grounds – this places small-scale fishers out of their comfort zone. Fisher training is, however, labour intensive and can be costly. Given these constraints, it is not always possible to train fishers on FAD deployments, particularly in countries with a large FAD programme that covers a wide geographical area.

SPC and countries have developed courses that address the key training needs of FAD fishers, including FAD fishing skills, small boat safety and catch handling. A possible approach to this training is to conduct 'train the trainer' workshops to enable a wider transfer of knowledge with limited funding through the training of key community fishers and national fisheries instructors. This approach could utilise existing networks like fisher organisations to strengthen these bodies and provide a greater reach to other fishers.

Two key lessons from past fisher training initiatives were identified by the regional experts. Firstly, it is essential to show local fishers how to be innovative by using locally available fishing gear; however, the training itself usually utilises the best available gear, which is ordered from overseas if necessary. Secondly, it is recommended to conduct the training at a productive FAD to show that the techniques and practices being demonstrated 'actually work'.

FAD maintenance

The life-span of FADs is impacted by the maintenance schedule. Maintenance of nearshore FADs including the removal of entangled fishing gear, removal of fouling materials (e.g. coral growth) and replacement of degraded structural materials can increase the time that FADs remain in the water.

Maintenance of submerged hardware can be difficult and often requires expensive, well-trained and experienced dive teams, which many countries do not have. While experience demonstrates that joint collaborations in maintenance programmes (e.g. between scuba divers, fisher associations and government) can help reduce maintenance costs, this may not be an option in all countries and locations. Therefore, most countries only maintain surface hardware at best. A number of countries are exploring programmes to delegate surface hardware maintenance and even FAD replacement to communities and fisher associations.

Monitoring and evaluation

Across the Pacific region there is a dearth of coastal fisheries data generally and even more so for the impacts of nearshore FADs. This lack of data is attributed to the remoteness of most Pacific Islands, the costs involved in implementing

extensive monitoring programmes, the lack of appropriate data collection methodologies and the shear difficulty in collecting the data required.

Within the region there has been some success in developing community-based monitoring programmes through a network of trained community resource people in order to enable monitoring at remote locations that are inaccessible by fisheries officers on a regular basis. Community-based monitoring requires a robust design, the 'right' community resource persons with the knowledge and skills to undertake the data collection required, along with an extensive training programme that includes a mechanism to feed-back information (in an appropriate form) to the communities involved. The expansion of computer assisted data collection is expected to improve the feedback of data to communities as it reduces data entry time.

Monitoring and evaluation is required to assess the effectiveness of nearshore FADs and to 'prove' the value of these – the measure of which depends on the objectives of the national FAD programme or of a particular FAD project. Although it is recognised that 'forever monitoring' is not necessary, and that monitoring and evaluation should be carefully targeted. A key recommendation, therefore, is to develop clear objectives at a national or project level to guide the collection of data that is fit for purpose. Sufficient funds are then required to implement an effective and directed FAD monitoring and evaluation programme.

Programme management and funding

First and foremost, it was recognised that there have been successes in the region in developing longer-term nearshore FAD programmes through partnerships with fisher associations, NGOs, other ministries and stakeholders. It was highlighted that by placing FADs as part of the broader community development planning process, FADs can become more than a fisheries management tool.

This said, a number of management issues surfaced through the experts' discussions including limited capacity at national level. Even where capacity does exist, a lack of planning means that when FAD-competent staff members change to another work area, or retire, their knowledge and technical skills are lost with them. The management and capacity issues are related to national fisheries administrations being unable to secure recurring funds in support of long-term nearshore FAD programmes. The lack of monitoring and evaluation data to 'prove' the impacts of FADs was identified as a major weakness in being able to secure this support.

When discussing the elements that are required for governments to develop long-term, sustainable national nearshore FAD programmes, four key elements were highlighted. These were as follows:

1. **Funding**: ongoing funds must be available to support dedicated FAD staff, materials, deployments, maintenance and monitoring. This may be through government, donors or cost-sharing arrangements with end users.
2. **Capacity**: countries must have competent personnel and the necessary equipment (e.g. deployment vessel equipped with suitable echo-sounder and GPS) to undertake FAD-related activities.
3. **End-user engagement**: countries must have national awareness and community engagement processes in place and partnerships that are developed between governments and end-users.
4. **Management**: countries must have a national FAD plan (or similar) in place, supported by legislation and corporate/strategic plans that showcase nearshore FADs as a priority.

Further work will be undertaken by SPC in coordination with member countries to determine the main characteristics of a sustainable FAD programme, which will enable regional and national organisations to better target support to Pacific Island countries and territories to achieve sustainability in their nearshore FAD programmes. These will be summarised in a policy brief or similar product aimed at senior fisheries personnel and policy makers, planned for release in 2017.

Research and knowledge gaps

There have been substantial advances in nearshore FADs programmes in the Pacific region in recent years, in particular around the technological aspects of FAD designs and deployments. Advances in technology have enabled safer and easier deployments in remote locations, even when using small vessels.

FAD monitoring and evaluation efforts are still limited in the region. Consequently, there remain a number of knowledge gaps for which sound research and experiments are required. Five priority questions were formulated by the experts to guide relevant nearshore FAD research to assist practitioners in developing sustainable nearshore FAD programmes. These were (not in order of priority):

1. Do nearshore FADs contribute to food security and income generation?

   This includes a better understanding of catch rates (CPUE) and catch utilisation at both FAD and non-FAD fishing locations as well as understanding the end use of fish caught in different locations.

2. How useful are nearshore FADs in support of coastal fisheries management?

This research question relates, in particular, to community-based fisheries management. Data is required to determine whether fishers change their practices as a result of the presence of nearshore FADs and shift fishing effort away from lagoons and reefs.

3. What are the underlying factors that influence the longevity of nearshore FADs?

   These underlying factors include both the structural weaknesses in the FAD itself as well as social components such as the root causes of vandalism and conflicts between users.

4. What are the social impacts of nearshore FADs?

   Across the region we need a greater understanding on the social impacts of nearshore FADs programmes on the recipient communities. This will require an understanding of the governance and ownership structures that impede or facilitate success and how the presence of nearshore FADs influence the trade-offs that communities make in terms of livelihoods (e.g. shifting from farming to fishing and the influence of a new income source). Such research will enable the development of mechanisms to mitigate conflicts between different users (e.g. subsistence and artisanal fishers).

5. How do oceanic and coastal fish interact with earshore FADs and what is the seasonality in aggregations around nearshore FADs across the region?

   To aid both site selection and fishers use of nearshore FADs, greater understanding is required on the seasonality and interactions between coastal and oceanic fish. While this will be different across the region, this knowledge will help inform both national and regional tuna fishery management decisions to ensure that coastal communities do share the benefits of their countries' tuna resources.

Without further research and evaluation, the ability to prove the effectiveness and value of FADs in achieving the objectives of a country will be limited. This will severely impact the ability of national fisheries departments to secure recurring budgets and ensure food security and alternative livelihoods of their communities.

Acknowledgements

The first Expert Consultation on nearshore FADs in the Pacific was a joint initiative between SPC and WorldFish. We would like to thank all the regional experts that were able to come and share their knowledge and expertise. The consultation would not have been possible without the financial contributions from the French Pacific Fund, the ACIAR PacFish Project of the Australian Government, SPC and the in-country support from the Vanuatu Fisheries Department and Vanuatu Maritime College.

A flagpole buoy indicates the location of a subsurface FAD set during the workshop (image: Philip James, SPC)

Contributions

These lessons learnt and knowledge gaps on nearshore FADs summarised in this article are an output from this joint initiative. They result from contributions from the following FAD experts: George Amos, Kairaoi Ientumoa, Lotokufaki Paka Kaitu, Samol Kanawi, TeeJay Letalie, Lionel Luda, Graham Nimoho, Babitu Rarawa, Kori Raumea, Mainui Tanetoa, Sapeti Tiitii, Regon Warren; and the consultation organising committee: Joelle Albert, Michel Blanc, Brooke Campbell, Philip James, Etuati Ropeti, and William Sokimi.

For more information:

Joelle Albert
Scientist, WorldFish Solomon Islands
J.Albert@cgiar.org

William Sokimi
Fisheries Development Officer, SPC
WilliamS@spc.int

Update on ciguatera research in French Polynesia

Mireille Chinain[1], H. Taiana Darius[1], Clémence M. Gatti[1] and Mélanie Roué[2]

Seafood is a source of both basic nutrition and significant income for many communities in the Pacific region. Unfortunately, many cases of food poisoning occur every year after eating seafood, including fish, shellfish and bivalve molluscs. This is because the seafood involved contains toxins produced by phytoplankton, which are then bio-accumulated in marine food webs. The rise in the number of cases of food poisoning and their spread to previously unaffected areas of the world, clearly indicate that seafood safety is a growing public health concern and economic challenge, not only regionally but globally as well.

Of the six major poisoning syndromes recorded in French Polynesia, ciguatera is the main, if not only, cause of seafood poisoning [1]. It is usually caused by eating edible reef fish that has been naturally contaminated by ciguatoxins (CTXs). Ciguatera is highly dynamic and can spread endemically or sporadically in outbreaks. CTXs are produced by the unicellular microalga *Gambierdiscus*, which proliferates episodically in highly degraded coral ecosystems (Figure 1).

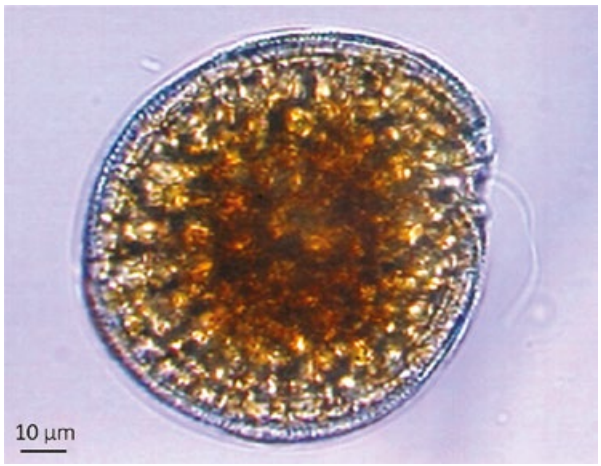


Figure 1. *Gambierdiscus* spp., the ciguatera-causing dinoflagellate, seen through an optical microscope. © ILM

Intense *Gambierdiscus* colonisation in reef ecosystems is what triggers reef-food-chain contamination. The toxins produced by the microalgae gradually accumulate in herbivorous fish as they graze on micro-algal turfs covering dead coral. The toxins then accumulate in carnivorous fish that prey on the toxic herbivorous fish. As the toxins accumulate along the food chain, they eventually reach consumers at the pyramid's summit (Figure 2). Thereby, natural disturbances in coral ecosystems such as cyclones, tsunamis, coral bleaching and *Acanthaster planci* infestation, as well as man-made causes like dynamiting, landfill and coral aggregate quarrying, are factors that should be considered likely to lead to ciguatera outbreaks. Because CTXs are very stable, they stay active even after fish is frozen, cooked, salted or smoked. In all, some 400 lagoon species are thought to be potential poison vectors. In a ciguatera-affected area, however, not all species are necessarily toxic for humans, and the same is true for even very closely related species. Also, only some fish of a particular species may prove to be toxic and, those that do vary from one island to another, making risk management in the most ciguatera-prone lagoons more difficult.

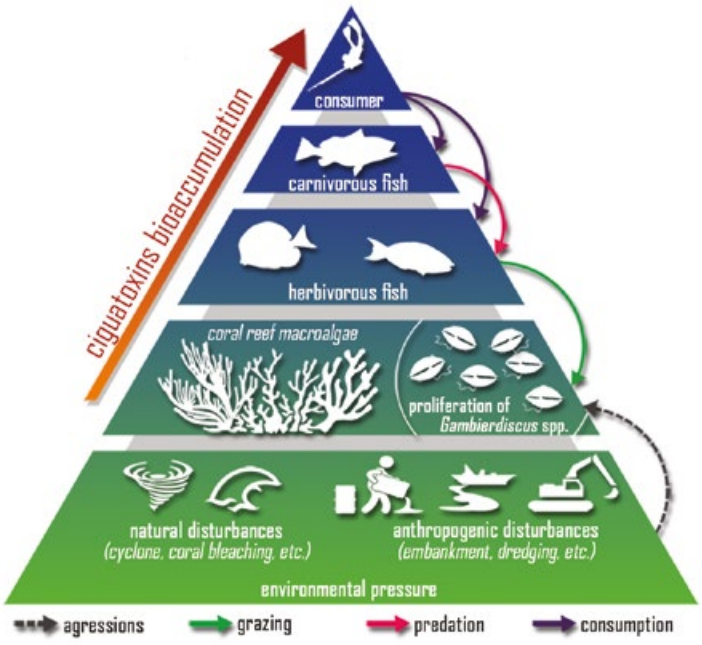


Figure 2. Diagram showing how ciguatera toxins travel up through the food pyramid. © ILM

[1] Laboratory of Toxic Microalgae, Louis Malardé Institute, UMR 241-EIO, BP 30 98713 Papeete, Tahiti, French Polynesia
[2] IRD (French Research Institute for Development), UMR 241-EIO, BP 529, 98713 Papeete, Tahiti, French Polynesia

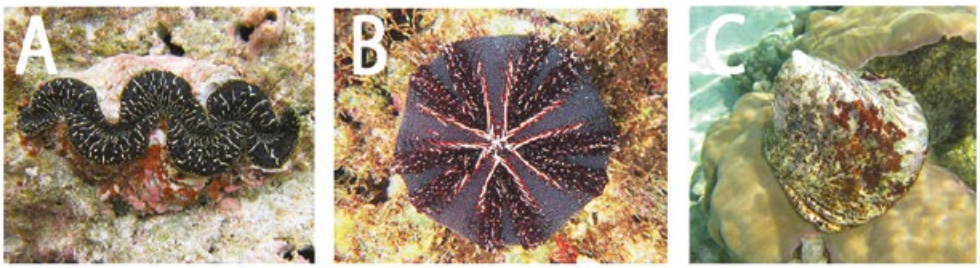


Figure 3. Examples of marine invertebrates that cause atypical ciguatera food poisoning in French Polynesia: A) giant clam or *pahua* (*Tridacna maxima*); B) sea urchin or *hava'e* (*Tripneustes gratilla*); C) trochus (*Tectus niloticus*). © ILM

While lagoon fish were long thought to be the only ciguatera vectors, recent research demonstrates that some marine invertebrates such as giant clams (*Tridacna maxima*), sea urchins (*Tripneustes gratilla*) and gastropods (*Tectus niloticus*) (Figure 3) can also contribute to atypical and sometimes more severe forms of ciguatera, also known as ciguatera shellfish poisoning. These forms have so far been reported in French Polynesia, New Caledonia, Vanuatu and the Cook Islands [2, 3].

Essentially, the seafood-related toxic hazard in French Polynesia is now a persistent public health issue with concrete social and economic fallout. Two of the main hurdles standing in the way of sustainable marine resource use in Pacific Island countries and territories (PICTs) are: (i) no internationally-approved reference detection test; and (ii) the limited availability of pure ciguatoxins required for the calibration of current detection tests, which is a definite obstacle to implementing large-scale monitoring programmes (cf. section on 'molecular detection of *Gambierdiscus*').

Early ciguatera research in the Pacific by pioneering American, Japanese and French Polynesian teams started in the early 1960s. In French Polynesia, it all began with an outbreak of 33 severe poisoning cases after eating giant clams on Bora Bora, Society Islands, between April and July 1964 and resulted in three deaths. The local authorities commissioned a consultancy to the island by two American experts, Profs Banner and Helfrich, from the University of Hawaii. It was not until 1976, however, when Prof. T Yasumoto and Dr R Bagnis conducted research in the Gambier Islands during an unprecedented toxicity outbreak, that the agent causing ciguatera, i.e. *Gambierdiscus* microalga, was at last formally identified [4]. That historic discovery would pave the way for several decades of research in French Polynesia, the only Pacific Island country that currently has a permanent ciguatera research unit, i.e. the Toxic Microalgae Laboratory (LMT) based within the Louis Malardé Institute (ILM) in Tahiti. Since 2012, the LMT has been conducting research in close partnership with the French Institute for Development Research (IRD) in French Polynesia, as part of the ESSENTIA[3] Pacific Island Ecosystem joint research unit (UMR 241-EIO).

The strategy adopted by French Polynesia in ciguatera control is an integrated approach that tackles the issue from various angles, namely epidemiology, the environment, biology, toxicology and medicine (Figure 4). On the sidelines of the research *per se*, the LMT also carries out community education, and awareness work and training for development or skill transfer purposes as part of technical co-operation with countries in the Asia-Pacific region.

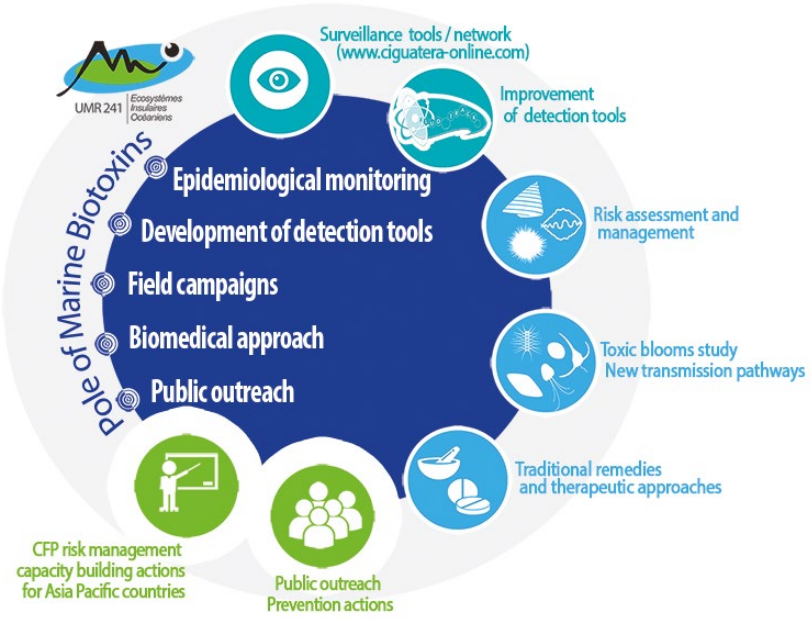


Figure 4. Integrated approach used in French Polynesia for ciguatera research.

[3] http://wwz.ifremer.fr/umr_eio/Equipes/Equipe-3-ESSENTIA

1. Epidemiological surveillance of marine biotoxin poisoning cases

French Polynesia is one of the few Pacific countries to have a country-wide ciguatera epidemiological surveillance programme. It is implemented in collaboration with the public health staff of all 61 healthcare facilities located throughout the country, including outlying hospitals, clinics, medical centres and dispensaries, and aims at narrowing down the aetiology of the various forms of marine biotoxin poisoning and monitoring the yearly incidence both on each island and country-wide [5]. Under the programme, a standard form is completed by the relevant facility's public health staff for each reported patient. Information is gathered on age, gender, island of residence, symptoms, number of previous ciguatera poisonings and details of the seafood eaten, e.g. whether it was fish or not, the species, part eaten and fishing area. Case reporting by practitioners is, however, optional. Since 2007, all notification forms have been filed centrally at ILM, which issues a yearly summary report. The general trend observed in French Polynesia as a whole since 2007 points towards a stable annual incidence rate (IR), although rates can differ considerably from one island to another, ranging from 2 to 1,500 cases per 10,000 inhabitants, depending on the island or island group. These figures are, however, heavily distorted by a high under-reporting rate and could quite possibly be at least doubled, as in more than half the reported cases patients stated they had shared the toxic food with others at table who had also gone on to develop symptoms, but only one form had been completed [5] (Figure 5). For this reason, major efforts are being made to broaden the current reporting programme's reach, mainly by building a dedicated ciguatera website that went on line in late 2014 (www.ciguatera.pf; www.ciguatera-online.com). In addition to opening up the notification programme to private practitioners and the general public, the site also provides web users with access to participatory and dynamic, real-time mapping of toxic-hazard areas and the marine species involved in any poisoning cases. Extending the website to the Asia-Pacific region is currently being explored with two international agencies, i.e. the International Atomic Energy Agency (IAEA) and the UNESCO Intergovernmental Oceanographic Commission (IOC), with additional funding from the French Pacific Fund (CiguaWatch project).

As a result, the surveillance programme identified both the scarce areas that are still ciguatera-free and, in contrast, a number of ciguatera hotspots [5, 6] that are ideal for research or where ecotoxicology investigations combined with preventive work could be carried out. A distance gradient has generally been observed in the IRs with the island groups furthest from Tahiti showing the highest IRs, due mainly to dietary differences observed between island groups. Also, based on the significant number of people who reported poisoning after eating only fish heads and/or viscera, it would appear vital to maintain or even reinforce the public health message that strongly warns against eating such fish parts, which are known to store more toxins than other parts do [5].

The surveillance also highlighted the fact that new forms of poisoning similar to ciguatera were emerging or re-emerging after popular marine invertebrates in French Polynesia, particularly giant clams, had been eaten [2], with the latest being a collective food-borne disease incident involving nine tourists who had eaten gastropod molluscs (*Tectus niloticus* or trochus) in 2014 on Nuku-Hiva in the Marquesas Islands [7]. These atypical poisoning forms, referred to by the generic term 'ciguatera shellfish poisoning' or CSP, were researched in depth under the ARISTOCYA programme (2009-2012) funded by the French National Research Agency (ANR). This investigation showed that such poisoning, which had been reported elsewhere in the Pacific, e.g. Lifou, New Caledonia, Vanuatu and Cook Islands, was probably caused by a proliferation of marine cyanobacteria in the Oscillatoriales family (*Oscillatoria*, *Hydrocoleum*, *Trichodesmium),* which are able to produce several toxin families that would also require surveillance [8, 9, 10].

More recently, research has shown that giant clams (*Tridacna maxima*) are also capable of metabolising *Gambierdiscus*

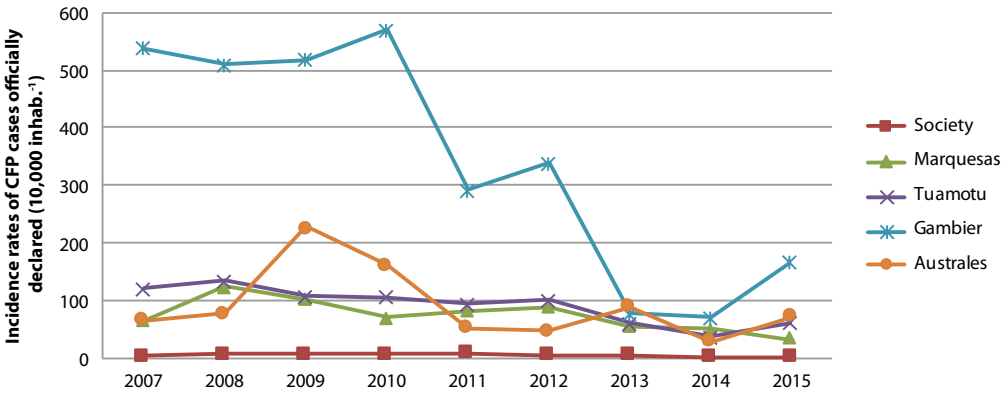


Figure 5. Incidence rate of reported ciguatera cases in French Polynesia's five archipelagos from 2007 to 2015 (www.ciguatera-online.com).

toxins in their tissues and organs after being exposed *ex situ* to highly-toxic cultures of this microalga [11]. Experiments to identify CTX depuration pathways and kinetics in this locally-popular bivalve are on-going.

2. Detection methods and technology watch

At the moment, health-hazard surveillance in terms of phycotoxins in French Polynesian waters and marine products focuses exclusively on *Gambierdiscus* and ciguatoxins. Aside from this now efficient surveillance process, there is also the issue of the possible health impact of other microalgal species that have already been reported in our waters and are behind emerging events in other parts of the world. There is considerable potential for new, emerging health hazards related to the toxicity of certain algae, as shown by recently-identified palytoxin-producing *Ostreopsis* strains on Rapa Island in the Austral Islands or the unprecedented report of the dinoflagellate *Azadinium* sp. on Nuku-Hiva in the Marquesas in 2015 [12], some species of which produce azaspiracids: cyclic imines that cause diarrheic food-poisoning in coastal Europe. As a result, the laboratory's strategy for developing *ad hoc* analytical methods is firmly based on an approach that combines surveillance (using tests that are able to detect substances that have so far not been included in the current monitoring system, or only inadequately) and a 'technology watch', i.e. constantly improving current tools. In order to meet this dual objective, several innovative microalgae and/or phycotoxin detection methods have been introduced into the current surveillance framework.

Passive monitoring devices (window-screens and SPATT filters)

Window-screens (WS) are artificial substrates for assessing microalgal species abundance in the marine phytobenthos. [13]. They are rectangular, artificial substrates made up of fibreglass screen-pieces submerged in the natural environment for short periods of less than 24 hours (Figure 6). This novel technique has a major advantage over standard natural substrate-based methods, which involve sampling the macrophytic algae that are benthic microalgae's natural substrate, because WS samples contain less debris and contaminating micro-organisms and can thus be directly tested using molecular biology techniques (e.g. qPCR, cf. section entitled 'Molecular detection of *Gambierdiscus*') and so, provide valuable information on the structure and genetic diversity of benthic communities closely associated with ciguatera-producing biotopes. By using this technique, it was shown, for example, that up to six *Gambierdiscus* species could co-exist on a single site on Mangareva Island, a historical ciguatera hotspot in the Gambier group. The artificial substrate technique also lends itself very well to monitoring other dinoflagellates often associated with *Gambierdiscus* in ciguatera-generating biotopes, including *Ostreopsis*, *Prorocentrum*, *Amphidinium* and *Coolia* [14, 15].

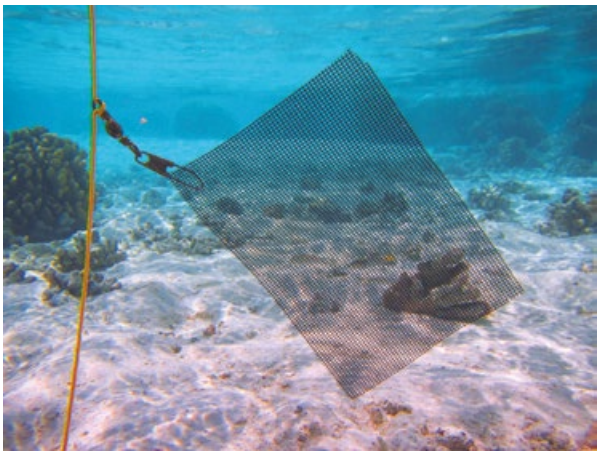


Figure 6. In situ view of window-screen artificial substrates for monitoring *Gambierdiscus* populations. © ILM

SPATT (solid-phase adsorption toxin tracking) filters are tools for concentrating toxins and consist of a resin formed by microbeads that can trap a broad range of lipophilic toxins produced and spread through the water during algal blooms [16]. When combined with high-resolution testing techniques, such as liquid chromatography coupled with tandem mass spectrometry (LC-MS/MS), the method can prove to be an excellent toxic-bloom early-warning system. The usefulness of such cheap, easily-designed systems, which are also well-suited to French Polynesia's widely scattered islands, is currently being assessed as part of collection campaigns in several at-risk lagoons in French Polynesia (Figure 7).

Figure 7. Deploying toxin-concentration devices (SPATT filters) in the wild. © ILM

Preliminary studies show that SPATT filters are useful in the time-integrated sampling of a large array of toxins including CTXs, maitotoxin, okadaic acid and azaspiracids that already inhabit our waters [17, 18].

Molecular detection of the ciguatera-causing Gambierdiscus *microalga*

Monitoring *Gambierdiscus* populations on specific fishing grounds is a key aspect of ciguatera assessment and management campaigns. The genus displays a remarkable morphological and genetic diversity with no fewer than 13 currently-known distinct species and three related globular species (*Fukuyoa* spp.), each of which is widely-distributed geographically and has a different toxicity level [19, 20, 21]. Differences in toxicity can also be observed between the strains of the same species [22]. Such genetic diversity and, more importantly, varying and unpredictable toxin production in dinoflagellates mean that *Gambierdiscus* blooms can prove dangerous at any given time and must be viewed as suspect. Our ability to detect and quantify the different species in natural microalga populations will have profound implications for the ciguatera-risk surveillance and early-warning system's performance and reliability. Following collaboration with the Centre for Coastal Fisheries and Habitat Research (NOAA, North Carolina) team, qPCR tests targeting specific Caribbean and French Polynesian *Gambierdiscus* species are now available [23]. This technology is a major step forward in hazard management, as it allows for prior monitoring of *Gambierdiscus* blooms in both qualitative and quantitative terms before significant amounts of CTXs accumulate in the lagoon food web. It also paves the way for cross-regional research into the microalga's bio-geography in the hope of better understanding the variations observed in ciguatera outbreak severity between the regions of the world.

By systematically carrying out toxin screening on the 100 *Gambierdiscus* strains in ILM's algal collection (Figure 8), several 'super-productive' ciguatoxic strains have been identified and are prime material for several innovative research areas:

(i) mass production and purification of algal CTXs, which have enabled us to acquire a unique bank of standards. Having the pure toxins required as standards for detecting CTXs is a major development asset for the laboratory against a backdrop of globalised ciguatera outbreaks and the heightened demand for standards of CTXs from laboratories seeking to acquire *ad hoc* testing capacity;

(ii) experiments to explain and mimic algal CTX biotransformation pathways *in vitro* and *in silico* towards the more oxidised (and more toxic) metabolic forms found most often in higher trophic levels;

(iii) experimental contamination of popular local fish species through gavage so as to more clearly understand CTX toxin kinetics and the metabolic processes that govern CTX transfer to and bio-accumulation in marine food webs. Early results suggest that algal CTX retention in fish tissue is closely tied to CTX chemical composition (e.g. polarity and lipophilic nature) [24]. This approach, if used on several representative fish species for different trophic levels such as herbivorous and carnivorous, will explain why some fish families such as surgeon fish, giant grouper and bluefin trevally are more of a poisoning hazard than others.

Figure 8. Maintaining the algal collection containing approximately 100 *Gambierdiscus* strains at the Louis Malardé Institute Toxic Microalgae Laboratory. © ILM

Marine biotoxin detection tests

A succession of CTX-detection methods have been explored at ILM. Historically, the mouse bioassay was the earliest method used at the laboratory and it led to progress in toxin research spanning several decades. It was based on observing symptom severity and nature and - standardised (age, sex and weight) animal survival rates and used to assess a sample's overall toxicity, but its main drawback was its limited sensitivity. It was finally discarded in 2008, due to difficulties in implementing it and increasingly stringent legislation on live-animal experiments. Other, more precise methods were subsequently explored based on physical, chemical, pharmacological and immunological processes, though with varying degrees of success [25].

The approach currently favoured in the laboratory to provide the most reliable possible testing services to consumers and commercial fisheries is to use a combination of two functional tests, namely a neuroblastoma cell-based assay (CBA-N2a) and a radioactive receptor binding assay (rRBA) that have roughly the same advantages in that specificity and sensitivity are high with a detection limit ranging from 10^{-10} to 10^{-12} M based on the FDA-recommended safety threshold; applicability to a wide range of sometimes complex biological matrices (including algal or cyanobacterial cell extracts, fish or giant clam flesh and blood); and a high sample processing capacity, as testing can easily be automated. CBA-N2a is additionally a good alternative to the mouse bioassay for assessing a samples' overall toxicity and is remarkably flexible in detecting a wide range of toxins (e.g. ciguatoxins, palytoxin, maitotoxins, brevetoxins and saxitoxins), and so is perfectly suited to the monitoring requirement referred to in the introduction to this chapter. That is why the test is currently being used routinely for fishing-ground monitoring and lagoon seafood safety checks in French Polynesia [6], with rRBA only being used for confirming specific instances of CTXs in suspect matrices. That test requires using a radioactive marker, is difficult to operate and strictly regulated, making it very costly and financially unviable. As part of the laboratory's technology watch, collaboration has begun with the University of North Carolina at Wilmington (UNCW) to migrate rRBA towards a high-throughput format using a fluorescent marker or FRBA [26]. The clear advantages of FRBA (easy deployment, shorter testing time and nearly 25 % cost reduction per test) should contribute to making the test more readily accessible across the Pacific, which would be a major step forward for Pacific communities in managing this global hazard.

3. Ciguatera risk management and prevention in French Polynesian lagoons

In remote island groups, where lagoon seafood is a basic staple, people who have had severe seafood poisoning sometimes need to limit their consumption of fish for several months, making them more dependent on consistently more expensive and generally less nourishing imported food for their protein intake. In the long run, the situation can lead to a forced dietary transition with its array of so-called 'lifestyle diseases' [27] signalling that the ciguatera hazard also needs to be approached from a sociological and anthropological angle and not just through public health. As such, any operations promoting lagoon fisheries not only have a positive impact on the relevant communities' living standards, but can also help improve their income by developing small-scale export industries.

Several field campaigns to help communities effectively manage the toxic hazard have been conducted under our research programmes [6, 28]. They have mainly involved mapping ciguatera risk in the affected lagoons based on ciguatera-causing phytoplankton species distribution and abundance and toxic fish prevalence. Such campaigns also provide an opportunity to hold information, communication and awareness sessions for public health staff, communities and schools (Figure 9). Overall, such sessions have had a clearly positive impact on community lifestyles, as borne out by the significant fall in the annual IRs over the ensuing years [5, 6].

Figure 9. Awareness training for A) communities; and B) public schools. © ILM

These large-scale campaigns were also an opportunity to gradually compile a unique biobank containing more than 2000 fish samples taken from 84 representative species from 10 French Polynesian islands and whose toxicity has been fully described. The database is currently being analysed to attempt to create a predictive model for French Polynesian lagoon fish toxicity based, for instance, on the size of the specimen tested. Results show that there is no significant relationship between fish size and toxicity [29], belying the popular belief that the largest specimens are also the most dangerous. This raises the question of just how effective current local-community practices are, as they tend to require eating only small fish to lessen the risk of poisoning [30]. Another study into links between toxicity and fish age and/or growth-rate estimated by otolithometry has just been completed. The study results are still being analysed, but the research will eventually lead to the first-ever growth-curve models for several South Pacific species including parrotfish, grouper and unicorn fish.

Finally, these campaigns were also an opportunity to examine certain widespread traditional ciguatera-control practices in French Polynesia such as various traditional tests to detect fish that are unfit for human consumption [30]. If communities in isolated or remote archipelagos can use validated homemade tests that are cheaper and can be carried out on the spot, they would be definite everyday assets to ciguatera hazard management. Avoidance strategies developed by local communities rely on a whole host of methods that vary from one island or archipelago to another and range from live animal testing on cats, dogs, ants and flies to using coins, through to detailed examinations of certain characteristics of dead fish several hours after they are caught. The literature offers fairly little information, however, on whether all or part of such methods have been scientifically validated, so we have attempted to assess how reliable two of them were, i.e. the *rigor mortis* and bleeding tests, by comparing the diagnoses of local fishers for approximately 100 fish to laboratory toxicology data (Figure 10). The most accurate test (bleeding) scored a little short of 70 % predictability. It is, however, likely that when the test is combined with the local communities' in-depth knowledge of species and areas to avoid, it significantly reduces their poisoning risk [30].

4. Medical approach

Research on chronic forms

Ciguatera is characterised by a complex set of symptoms, such as digestive, neurological, cardiovascular and respiratory complaints that vary in severity and are often complicated by the onset of chronic neurological disorders in 20% of cases and the patent lack of antidotes [22]. In practice, 175 different symptoms have been recorded in the disease's acute and chronic phases [31]. During the chronic phase, after an initial occurrence of poisoning residual hypersensitivity triggered by eating even non-toxic seafood and its by-products, animal protein such as pork or chicken, vegetable proteins like soya or lentils, alcohol, coffee or peanuts can revive neuro-digestive attacks with or without general signs [32]. While the acute forms of ciguatera are now well-documented, the exact cause of this unusual disease's chronic residual and/or sporadic manifestations still remain unexplained. In order to estimate ciguatera prevalence and better describe the chronic symptoms in a hospital population, a study has recently been launched in conjunction with the French Polynesia general hospital (CHPF) to accurately describe those symptoms and explain the biological mechanisms behind them [33]. Ultimately, it is hoped that solutions, such as special diets, will be recommended to provide relief to patients.

Biological sample bank and biomedical research

Although ciguatera has been studied for five decades now, biomedical research resulting in better care for patients has been scarce, if not incidental. Biomedical studies are still seen as the poor cousin of ciguatera research, due mainly to the short supply of human biological samples from ciguatera patients. Because ILM is closely involved in surveillance networks, it has ready access to patients in addition to a team of doctors, pharmacists and pathologists and a pathology laboratory capable of taking samples. So the LMT is working on setting up an unprecedented human biological sample collection, which will pave the way for developing and promoting biomedical ciguatera research both locally

Figure 10. Traditional toxic-fish screening tests used by local fishers: A) rigor mortis test (limp fish are considered toxic); and B) bleeding test (a fish showing signs of heavy bleeding is considered toxic). © ILM

and internationally. Some of the research avenues currently being explored are the identification of immunogenetic factors predisposing certain people to severe forms of ciguatera and chronic side-effects, improving the description of the physiopathological mechanisms behind the chronic/severe forms which could lead to suitable treatment options and the development of diagnostic tools.

Assessing the effectiveness of traditional remedies for ciguatera

Allopathic medicine has as yet failed to develop a truly effective and specific treatment for ciguatera and is based mainly on a symptom-based palliative approach to seafood poisoning. Many South Pacific communities, however, use traditional remedies as a matter of course, particularly on remote islands and atolls where no healthcare services are available. Ethnobotanical research by IRD has produced an inventory of nearly 100 plants used in traditional medicine for ciguatera treatment or prevention [34]. Brews, teas or extracts are prepared from roots, leaves, bark and fruit, whether pure or mixed in varying proportions and dosages based on household recipes handed down through the generations. Further research narrowed the work down to a single plant, *Heliotropium foertherianum* (velvetleaf soldierbush or octopus bush) (Figure 11), and identified its main active ingredient, rosmarinic acid, isolated from the plant's leaves [35]. As a result, a patent was registered in 2010 relating to the use of rosmarinic acid and its related derivatives in treating ciguatera. The next step was to examine the potential for industrially marketing the complete remedy based on an *H. foertherianum* concentrate. As the results confirm that the remedy has neuroprotective properties against CTX toxic activity, the prospect of treating ciguatera appears promising. The treatment now requires confirmation and development through clinical trials [36, 37].

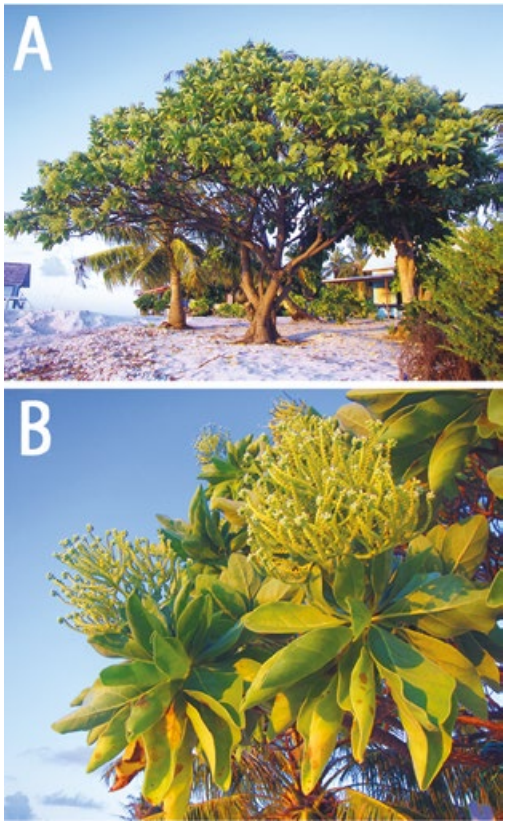


Figure 11. Velvetleaf soldierbush/octopus bush *tahinu* (*Heliotropium foertherianum* Diane & Hilger), a ubiquitous plant in coral atoll landscapes in the Tuamotu Group;
A) some specimens can grow very tall; and
B) detail of *H. foertherianum* flowers. © ILM

5. Regional co-operation on marine biotoxin research

ILM and IRD both wish to help broaden national and regional co-operation on marine biotoxin research, particularly regarding ciguatera, based on two considerations, namely (i) the extremely high ciguatera prevalence in the Pacific region [38]; and (ii) repeated requests from many PICTs for scientific and technical support from the region's leading ciguatera research centres in the form of capacity building training, advice and expert opinions, etc. The advantages of increased regional co-operation around marine biotoxins are major. In addition to setting up joint, harmonised ciguatera management at a regional level, such a network will pave the way for launching cross-disciplinary projects that would be in a position to receive considerable funding for issues that the region's countries and territories view as priorities. We have contributed towards this goal by participating in two community and international initiatives for promoting pooled research efforts at the Pacific level:

1. Pace-Net+, which aims at stimulating dialogue between Europe and the Pacific in science, technology and innovation in areas relating to major societal challenges such as health and food security (http://plus.pacenet.eu/events/pacenetplus-noumea-2014). In July 2016, a workshop attended by the representatives of seven PICTs (Fiji, Cook Islands, Marshall Islands, New Caledonia, French Polynesia, Tonga and Wallis & Futuna) was held in Noumea with a view to improving ciguatoxin risk surveillance and management, in particular by setting up a common database.

2. the IAEA RAS 7/026 programme, one of whose specific objectives is to build ciguatera surveillance capacities in the Asia-Pacific region. A regional ciguatera workshop held on Tahiti in March 2015 trained 17 participants in the various standard techniques for monitoring ciguatera (field-sampling methods, identifying the main species under the optical microscope, culturing, chemical extraction and toxicology tests).

The drastic fluctuations observed in the world's island ecosystems as a result of climate change and Pacific communities' heavy dependence on fishery resources for subsistence purposes make it urgent that ciguatera research and relevant scientific resource effort pooling be accelerated. This is the only way to increase control over the health hazards related to marine resource-use by those communities so as to achieve sustainable, quality food production.

Acknowledgments

The information presented in this newsletter was obtained from several research programmes funded under 'Contrats de Projets État-Pays' (contracts between the French central government and regions), ANR (French National Research Agency), the French Pacific Fund and the French Overseas Ministry. The authors are indebted to the French Government and the Government of French Polynesia for their financial support. They also wish to acknowledge all their scientific partners, the staff of French Polynesia's health facilities and the local communities for their valuable contributions.

References

1. Gatti C, Oelher E, Legrand AM. 2008. Severe seafood poisoning in French Polynesia: A retrospective analysis of 129 medical files. *Toxicon*, 51:746–753.
2. Laurent D, Kerbrat AS, Darius HT, Rossi F, Yeeting B, Haddad M, Golubic S, Pauillac S, Chinain M. 2011. Ciguatera Shellfish Poisoning, a new ecotoxicological phenomenon from cyanobacteria to human via giant clams. In: *Food Chain*: *New Research*, Jensen MA & Muller DW (Eds.), Nova Publishers 1:1–44.
3. Rongo T, van Woesik R. 2011. Ciguatera poisoning in Rarotonga, southern Cook Islands. *Harmful Algae*, 10: 345–355.
4. Yasumoto T, Nakajima I, Bagnis R, Adachi R. 1977. Finding of a dinoflagellate as a likely culprit of ciguatera. *Bull. Jap. Soc. Fish.*, 43: 1021–1026.
5. Hossen, V, Velge P, Turquet J, Chinain M, Laurent D, Krys S. 2013. La ciguatéra en France : une intoxication alimentaire dans les départements et régions d'outre-mer aux portes de la métropole ? *Bulletin Epidémiologique ANSES*, 56: 3–8.
6. Pawlowiez R, Darius HT, Cruchet P, Rossi F, Caillaud A, Laurent D, Chinain M. 2013. Evaluation of seafood toxicity in the Australes archipelago (French Polynesia), using the neuroblastoma cell-based assay. *Food Additives and Contaminants, Part A*, 30(3): 567–586.
7. Gatti C, Darius HT, Chinain M, Lonati D. 2015. First report of a mass-poisoning outbreak following the consumption of *Tectus niloticus* (Gastropod) in French Polynesia: a novel pathway of Ciguatera Fish Poisoning? IOC newsletter on Toxic Algae and Algal Blooms, n°50, January 2015, http://www.e-pages.dk/ku/1086/
8. Méjean A, Peyraud-Thomas C, Kerbrat AS, Golubic S, Pauillac S, Chinain M, Laurent D. (2010). First identification of the neurotoxins anatoxin-a and homoanatoxin-a from *Hydrocoleum* spp. marine cyanobacterium. *Toxicon* 56: 829–835.
9. Kerbrat AS, Amzil Z, Pawlowiez R, Golubic S, Sibat M, Darius HT, Chinain M, Laurent D. (2011) First evidence of palytoxin and 42-hydroxy-palytoxin in the marine cyanobacterium *Trichodesmium*. *Marine Drugs*, 9: 543–560.
10. Roué M, Gugger M, Golubic S, Amzil Z, Araoz R, Turquet J, Chinain M, Laurent D. 2014. Marine cyanotoxins potentially harmful to human health. In: Labarre S & Kornprobst JM (Eds.) *Outstanding marine molecules - from natural history to human welfare*, Labarre S. and Kornprobst J.M. Eds., Wiley, pp. 3–22.
11. Roué M, Darius HT, Picot S, Ung A, Viallon J, Gaertner-Mazouni N, Sibat M, Amzil Z, Chinain M. 2016. First evidence of the bioaccumulation of ciguatoxins in giant clams (*Tridacna maxima*) exposed to *Gambierdiscus* spp. cells. *Harmful Algae*, 57: 78–87.
12. Tillmann U, Krock B, Trefault N, Gu H, Clarke D, Gottschling M, Nézan E, Jaen D, Fernandez L, Kilkoyne J, Akselman R, Smith K, Sanchez S, Guinder V, Gatti C, Roué M, Kaufmann M, Biszel N, Carbonell-Moore C. 2016. Amphidomataceae, the dinophycean source of azaspiracid toxins: new records, new species, new toxins. 1rst Annual MERHAB Azaspiracid project meeting, 16–17 mars 2016, Seattle, WS, USA.
13. Tester PA, Kibler SR, Holland WC, Usup G, Vandersea MW, Leaw CP, Teen LP, Larsen J, Mohammad-Noor N, Faust, MA, Litaker RW. 2014. Sampling harmful benthic dinoflagellates: comparison of artificial and natural substrate methods. *Harmful Algae*, 39: 8–2.
14. Tan TH, Lim PT, Mujahid A, Usup G, Leaw CP. 2013. Benthic harmful dinoflagellate assemblages in a fringing reef of Sampadi Island, Sarawak, Malaysia. *Marine Research Indonesia* 38:11–21.
15. Jauzein C, Fricke A, Mangialajo L, Lemée R. 2016. Sampling of Ostreopsis cf. ovata using artificial substrates: Optimization of methods for the monitoring of benthic harmful algal blooms. *Mar Pollut Bull* 107(1):300–304.
16. MacKenzie LA. 2010. *In situ* passive solid-phase adsorption of micro-algal biotoxins as a monitoring tool. *Current Opinion in Biotechnology*, 31: 326–331.
17. Caillaud A, de La Iglesia P, Barber E, Eixarch H, Mohammad-Noor N, Yasumoto T, Diogene J. 2011. Monitoring of dissolved ciguatoxin and maitotoxin usinf solid-phase adsorption toxin tracking devices: Application to *Gambierdiscus pacificus* in culture. *Harmful Algae*, 10: 433–446.

18. Roué M, Ung A, Darius HT, Harwood T, Chinain M. 2014. Evaluation of Solid-Phase Adsorption Toxin Tracking devices for the monitoring of Ciguatera. Proceedings of the 16th International Conference on Harmful Algae, 27–31 Octobre 2014, Wellington, New-Zealand.

19. Litaker RW, Vandersea MW, Faust MA, Kibler SR, Chinain M, Holmes MJ, Holland WC, Tester PA. 2009. Taxonomy of *Gambierdiscus* including four new species, *Gambierdiscus caribaeus*, *Gambierdiscus carolinianus, Gambierdiscus carpenteri* and *Gambierdiscus ruetzleri* (Gonyaulacales, Dinophyceae). *Phycologia*, 48(5): 344–390.

20. Gómez F, Qiu D, Lopes RM, Lin S. 2015. *Fukuyoa paulensis* gen. et sp. nov., a new genus for the globular species of the dinoflagellate *Gambierdiscus* (Dinophyceae). *PLoS ONE*, 10(4): e0119676. doi:10.1371/journal.pone.0119676.

21. Fraga S, Rodriguez F, Riobo P, Bravo I. 2016. *Gambierdiscus balechii* sp. nov (Dinophyceae), a new benthic toxic dinoflagellate from the Celebes Sea (SW Pacific Ocean). *Hamrful Algae*, doi:10.1016/j.hal.2016.06.004.

22. Chinain M, Gatti C, Roué M, Laurent D, Darius.HT. 2014. Ciguatéra: aspects écologiques, biologiques et toxicologiques. *Revue Francophone des Laboratoires* 460: 27–39.

23. Vandersea MW, Kibler SR, Holland WC, Tester PA, Schultz TF, Faust MA, Holmes MJ, Chinain M, Litaker RW. 2012. Development of semi quantitative PCR assays for the detection and enumeration of *Gambierdiscus* species (Gonyaulacales, Dinophyceae). *J. Phycol*, 48(4): 902–915.

24. Ledreux A, Brand H, Chinain M, Dechraoui Bottein MY, Ramsdell JS. 2014. Dynamics of ciguatoxins from *Gambierdiscus polynesiensis* in the benthic herbivore *Mugil cephalus*: Trophic transfer implications. *Harmful Algae*, 39: 165–174.

25. Caillaud A, de la Iglesia P, Darius HT, Pauillac S, Aligizaki K, Fraga S, Chinain M, Diogène J. 2010. Update on methodologies available for ciguatoxin determination. Perspectives to confront the onset of Ciguatera Fish Poisoning in Europe. *Marine Drugs*, 8(6): 1838–1907.

26. Hardison DR, Holland WC, McCall JR, Bourdelais AJ, Baden DG, Darius HT, Chinain M, Tester PA, Shea D, Flores Quintana HA, Morris Jr. JA, Litaker RW. 2016. Fluorescent Receptor Binding Assay for detecting ciguatoxins in fish. *PLoS ONE,* 11(4): e0153348, doi:10.1371/journal.pone.0153348.

27. Gatti CM, Suhas E, Côté S, Laouan-Sidi EA, Dewailly E, Lucas M. 2015. Obesity and metabolic parameters in adolescents: a school-based intervention program in French Polynesia. *Journal of Adolescent Health,* 56(2):174–180.

28. Chinain M, Darius HT, Ung A, Tchou Fouc M, Revel T, Cruchet P, Pauillac S, Laurent D. (2010) Ciguatera Risk Management in French Polynesia: the case study of Raivavae Island (Australes Archipelago). *Toxicon,* 56: 674–690.

29. Gaboriau M, Ponton D, Darius HT, Chinain M. 2014. Ciguatera fish toxicity in French Polynesia: size does not always matter. *Toxicon*, 84: 41–50.

30. Darius HT, Drescher O, Ponton D, Pawlowiez R, Laurent D, Dewailly E, Chinain M. 2013. The use of folk tests to detect ciguateric fish: a scientific evaluation of their effectiveness in Raivavae Island (Australes, French Polynesia). *Food Additives and Contaminants, Part A*, 30(3): 550556.

31. Wang DZ. 2008. Neurotoxins from marine dinoflagellates: a brief review, *Marine Drugs*, 6(2): 349–371.

32. Château Degat ML, Huin-Blondey MO, Chinain M, Darius HT, Legrand AM, Nguyen NL, Laudon F, Chansin R, Dewailly E. 2007. Prevalence of chronic symptoms of ciguatera disease in French Polynesian adults. *Am J Trop Med Hyg*, 77(5): 842–846.

33. Chung K, Gatti C, Oehler E, Chinain M. 2016. Characterization of Ciguatera poisoning chronic manifestations: A retrospective study on a hospitalized patient cohort of French Polynesia. *17th International Conference on Harmful Algae, 9-14th October 2016, Florianopolis, Brazil.*

34. Bourdy G, Cabalion P, Amade P, Laurent D. 1992. Traditional remedies used in the Western Pacific for the treatment of ciguatera poisoning. *J Ethnopharmacol*, 36: 163–174.

35. Kumar-Roiné S. 2009. Valorisation de remèdes traditionnels utilisés dans le traitement de la ciguatéra dans le Pacifique. Thèse Université de la Nouvelle-Calédonie, 193 pp.

36. Rossi F, Jullian V, Pawlowiez R, Kumar-Roiné S, Haddad M, Darius HT, Gaertner-Mazouni N, Chinain M, Laurent D. 2012. Protective effect of *Heliotropium foertherianum* (Boraginaceae) folk remedy and its active compound, rosmarinic acid, against a Pacific ciguatoxin. *J Ethnopharmacol,* 143: 33–40.

37. Braidy N, Matin A, Rossi F, Chinain M, Laurent D, Guillemin G. 2014. Neuroprotective effects of rosmarinic acid on ciguatoxin in primary human neurons. *Neurotoxicity Research,* 25: 226–234.

38. Skinner MP, Brewer TD, Johnstone R, Fleming LE, Lewis RJ. 2011. Ciguatera Fish Poisoning in the Pacific Islands (1998 to 2008). *PLoS Negl Trop Dis*, 5(12): e1416.

The history of SPC's involvement in fisheries development in the Pacific

Part 1: the 20th century

Lindsay Chapman[1]

SPC's fisheries programme: How did it start and evolve (1947 to 1969)?

The Pacific Community (SPC), formerly known as the South Pacific Commission (SPC), was established in 1947 when the six countries (Australia, France, United Kingdom, the Netherlands, New Zealand and the United States of America) that were administering non-self-governing territories in the Pacific signed the 'Canberra Agreement'. At that time, the dependent territories covered by SPC were Papua, New Guinea, Nauru, Norfolk Island, the French establishments in Oceania (consisting of the Society, Tuamotu, Austral and Marquesas groups), New Caledonia, Wallis and Futuna, Netherlands (or Dutch New Guinea), Western Samoa, Cook Islands, Niue, Tokelau Islands, Fiji, British Solomon Islands, Gilbert and Ellis Islands, Pitcairn, American Samoa and the New Hebrides. In 1949, Papua and New Guinea were combined (PNG). In 1951, Guam and the USA Trust Territories of the Pacific were included. In 1962, Norfolk Island and Dutch New Guinea (now Irian Jaya and part of Indonesia) were removed. As Pacific countries gained their independence, they became full members in their own right, with the current Pacific Island membership covering the 14 independent countries and 8 territories (3 French, 3 US, 1 British and 1 New Zealand).

Appended to the 'Canberra Agreement' was a list of 'projects' to which the SPC should give early consideration due to their great importance for the economic and social welfare of Pacific Islanders. Fisheries was mentioned as one of the 'projects': fisheries research, including surveys and the testing of methods of catching and processing fish and other marine products with the special aim of improving the nutrition of local Pacific Islanders. Furthermore, this was considered a project that called for early action and showed promise of early results, and information was to be collected on the various fisheries in the region. In support of this, the first 'Fisheries Conference' was held in 1952 in Noumea. The underlying theme of this meeting was to increase the availability of protein from marine resources for Pacific Islanders. The objectives of the meeting were to work out a practical method of bringing together all relevant fisheries information; suggest the best way of investigating the problems of catching, processing, transporting and marketing; make constructive suggestions for fisheries development in the region; and consider and advise what role SPC could play in the development of fisheries in the region.

As a result of this first 'Fisheries Conference', a fisheries programme was established, and in 1954 SPC founded a Technical Advisory Committee on Fisheries (TACF) to support the implementation of recommendations from the meeting. Mr Hubertus (Bert) van Pel was recruited as SPC's first Fisheries Officer. From 1954 to 1961, the Fisheries Office undertook a range of fisheries and aquaculture assignments across the region. Some of the assignments included: an evaluation of the fisheries industry in Fiji, Dutch New Guinea, Tonga, Cook Islands, French Polynesia, and Norfolk Island; an assessment of the possibility of fish culture in ponds, and sea fisheries, in Western Samoa; a survey of the fisheries in the New Hebrides, British Solomon Islands and Tokelau; an assessment of possibilities for improving fisheries in American Samoa and the territory of PNG; a fisheries development plan for the Caroline Islands; an assessment of fisheries development in the South Pacific; and an assessment of a 25-foot motor fishing boat for Pacific waters.

In addition to the in-country assessment work on fisheries and development potential, two major trainings were undertaken. The first was from November 1956 to February 1957 in Noumea, where 24 participants were funded to undertake training in boat building, engine operation and maintenance, elementary navigation and chart reading, fishing equipment and methods, fish breeding, oyster culture, fish preservation, fisheries management and conservation of marine resources. As a result of this training, almost all participants gained employment in fisheries in their own country. A second boat building course was undertaken in the Solomon Islands, which lasted 15 months and had 24 participants in 1960/1961. The result of this training was the construction of three diesel-powered boats. Using these boats, a training course was undertaken in the Solomon Islands on the use of fish traps and the use of small powered vessels. A second boat building course was then conducted over two years in Noumea, and this commenced in 1963.

In 1962, a 'Fisheries Technical Meeting' brought together members of SPC's TACF and representatives of territorial fisheries departments and research institutions. This meeting

[1] Deputy Director, Fisheries, Aquaculture and Ecosystems Division (Coastal Fisheries), Pacific Community. LindsayC@spc.int

The SPC *Boatbuilding Guide* by Mr Arthur N. Swinfield, a leading Australian naval architect, was the instruction manual for the 15-month boatbuilding course that took place at Auki, Solomon Islands (1961/1962) (images: SPC).

was requested to study SPC's activities in the fisheries field and to make recommendations on future activities. The meeting also needed to consider the progress made since 1952, the organisation by some territories of their own fisheries departments, the interest shown by some territories in the development of commercial fisheries, and the question of technical training in the fisheries field. At this meeting, recommendations were made to establish a project to develop more efficient fishing gears and methods – especially to exploit deep-water bottom species in depths to 400 m – and to gather further information on surface-schooling tunas, deep-swimming tunas, and baitfish resources.

In 1963, it was decided that the SPC Fisheries Officer position would not be maintained, however, several years later, this decision was reversed and in late 1967, Mr Val Hinds was appointed to the position. One of his first tasks was to prepare a Fisheries Technical Meeting for June 1968 in Noumea. At this meeting, mainly coastal fisheries topics were discussed, with concerns expressed on over fishing of the reef and lagoon resources. A recommendation of this meeting was to establish a South Pacific Islands Fisheries Development Agency (SPIFDA). The aim of the SPIFDA was to coordinate programmes designed to develop and utilise aquatic resources, with a specific reference to reef and lagoon resources; to advise and assist individual territories in the formulation and implementation of development projects; to find funding and expertise to implement projects; and to establish and operate a service through which information relevant to the fisheries of the area may be collected, collated, analysed and disseminated in the region. The SPIFDA was established in 1969 and came into operation in 1970.

Training was also highlighted in the 1968 meeting as an area needing assistance from SPC. This should cover both vocational training for adults, and broader-based training for youths. Some of the topics for training included: outboard and diesel engine operation, maintenance and repair; fish handling and processing; and the operation of cooperatives including accounting skills. It was also highlighted that the countries preferred the visit of specialists to the territories to teach by demonstration on-site, rather than transporting trainees to a set location.

It was during the late 1960s that more interest was being generated by the territories in development of the offshore tuna fishery, more at an industrial level, as well as coastal fisheries, and there became a split in the focus between the two very different fisheries. The tuna fishery and its development and history is covered in a separate 'story',[2] so the rest of this article will remain focused on coastal fisheries and aquaculture.

[2] See article by Paul Judd on page 61 of this Newsletter.

SPC's coastal fisheries and aquaculture activities in the 1970s

There were eight Fisheries Technical Meetings convened in the 1970s, most held in Noumea, with Fiji and Tonga both hosting a meeting. The main focus of the 1970 meeting was on suitable small-scale fishing vessel designs to be used for fisheries development by the different territories. Both monohull and catamaran designs were discussed as well as construction materials, including ferro-cement.

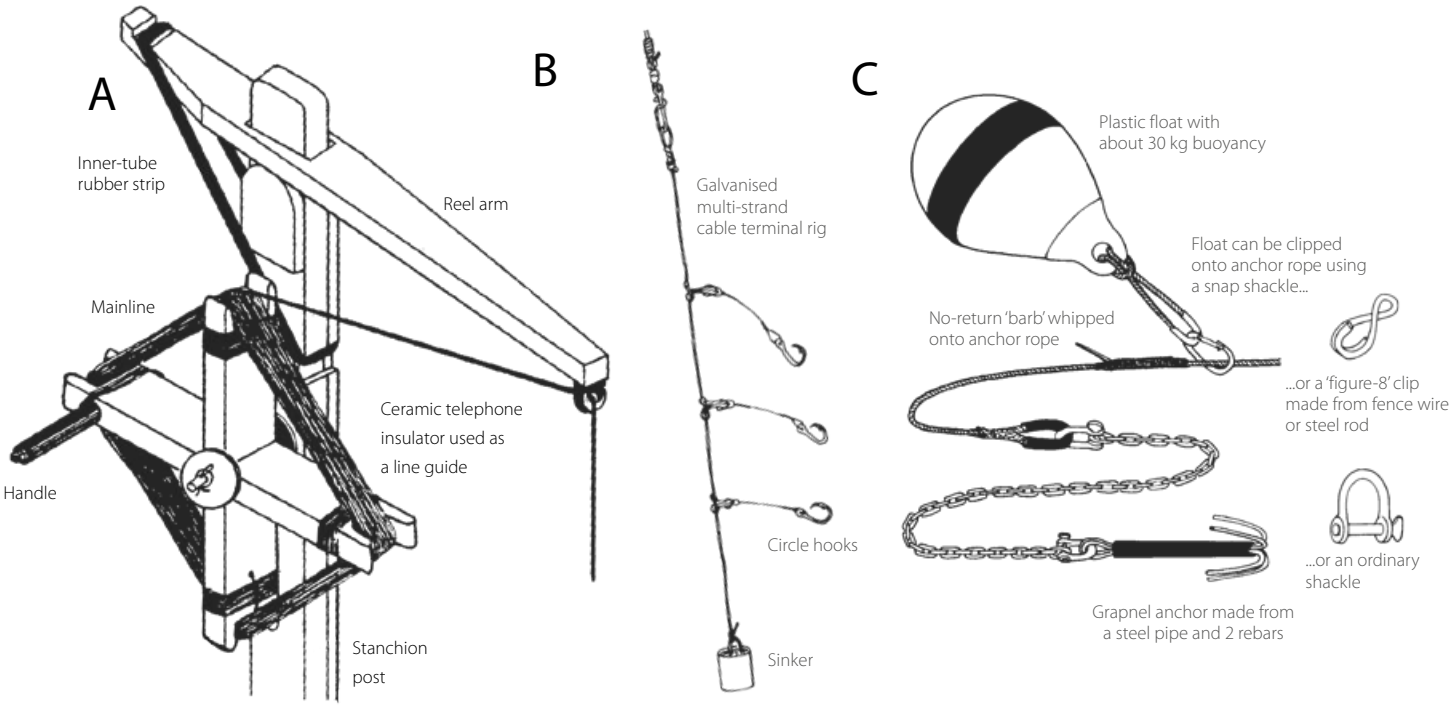
The role of the SPC Fisheries Officer in the early 1970s was one of being a clearing house for information and sharing this amongst the territories, and training on organising the location, cost requirements and data of all training programmes in the region, in addition to locating funding to allow the territories to participate in these trainings. In support of sharing information, the 'South Pacific Islands Fisheries Newsletter' was established with its first issue published in April 1970. This was a collaboration with SPIFDA, UNDP[3] and FAO[4] as the executing agencies, and SPC as the cooperating agency on behalf of participating governments. The SPC Fisheries Officer was also involved in arranging consultant services in 1970, which covered marine turtles, spiny lobsters, boat building, mollusc culture, and reef and lagoon ecology. The success of the Newsletter would depend on fisheries staff from the territories sharing their experiences and development activities, by providing this information to the SPC Fisheries Officer.

In 1971, issue 2 of the Fisheries Newsletter was published, issues 3 to 7 were published in 1972, and issues 8 to 10 in 1973, using the same standard format and layout. However, in 1972 there was some disagreement over the SPIFDA's usefulness, it was therefore terminated in 1973 and the Fisheries Newsletter for its 11th issue became the 'SPC Fisheries Newsletter', a name that still stands today. At the 1972 Fisheries Technical Meeting, it was recommended that adequate financial and other support be given to the SPC Fisheries Officer so he could coordinate ongoing projects and disseminate information, such as through the Newsletter, and that funding be included in the SPC budget for ongoing training and funding participants to different training. Several proposals were also being considered for developing outer reef fisheries, and in 1974, several projects continued to be supervised by SPC (such as the lobster and beche-de-mer projects in the Solomon Islands and turtle farming in Fiji).

Also in 1974, the first main project implemented by SPC for coastal fisheries development, the 'Outer Reef Artisanal Fisheries Project (ORAFP)' commenced. The project had

Preparing wild oyster spat collectors, Fiji, May1971 (image SPC).

[3] United Nations Development Programme (UNDP).
[4] Food and Agriculture Organization of the United Nations (FAO).



The 'Western Samoan handreel' (A), was adapted from a model developed by FAO. It allowed fishers to target deep bottom snappers from small crafts and canoes. The fishing line terminal rig (B) was often made of galvanised wire. The anchor buoy system developed by SPC (C) allowed fishers to easily retrieve the mooring from depths (illustrations: Steven J. Belew, ©SPC).[5]

four vessels that were purpose built for trialling; two with petrol engines and two with diesel engines, with three having jet propulsion system and one having a conventional shaft and propeller drive. The project had a manager, a master fisherman, and four volunteers with different skills and backgrounds. The project ran from late 1974 to the end of 1977, targeting the untapped deep-water snapper resource with some trolling for tuna for bait and food. The objectives of the projects were to survey local resources and assess the economic feasibility of commercial fishing in each location, to determine and demonstrate fishing techniques suitable for the area, and to train local fishers. The project worked in the New Hebrides (Vanuatu), Western Samoa, Cook Islands, Tuvalu and the Solomon Islands.

Many problems were encountered with the boats built for the project, such as the jet drives not being suited to the conditions, and mechanical problems with the engines, resulting in lost fishing time. Good catches of fish were taken from 100–400 metres with line fishing, although in some locations up to a quarter of the catch was considered poisonous (ciguatoxic species). Many sharks were also caught and released as there was no market for shark flesh in most locations.

In the mid-1970s, the Fisheries Officer position was promoted to Fisheries Adviser, and in 1978, a second position was created – a Fisheries Officer. By the end of 1979, a total of 19 issues of the Fisheries Newsletter had been published with the format evolving over the years, and territories started to provide articles to be included. The roles of the adviser and officer continued with the focus on information sharing, and some assignments were undertaken in the territories and reported in the Newsletter. Other activities included some assessment work on the production of 'fish silage' from fish waste, mainly for stock feed. SPC also convened a specialist group to research ciguatera fish poisoning, and this included researchers and laboratory assistance from France, the USA and Japan.

In March 1978, the Deep Sea Fisheries Development Project (DSFDP) superseded the ORAFP. The focus of the DSFDP was also on the development of the region's deep-water snapper fishery in depths of 100–400 metres, through in-country training and assessments using local fishing boats. The two master fishermen also used wooden handreels that were developed in Western Samoa by FAO, which made fishing in deeper waters more viable and less strenuous. In 1978 and 1979, 10 projects were undertaken in eight countries. Over this time the gear used for deep-water snapper fishing was improved and standardised; it became the famous 'Western Samoan handreel'. Given most of the fishing was undertaken with the boat anchored using a grapnel anchor, an anchor retrieval system was also developed.

[5] See, for more details: http://www.spc.int/DigitalLibrary/Doc/FAME/Manuals/Preston_99_DBFTforPI.pdf.

Another important feature of the 1970s was the development and expansion of fisheries departments in the countries and territories, with the University of the South Pacific (USP) providing a 'Diploma in Tropical Fisheries' course to equip new 'fisheries officers and technicians' with the skills needed to work in fisheries development. Several countries, including American Samoa, Western Samoa, Fiji, Tonga, the US Trust territories and the Solomon Islands had commenced boat building projects to provide fishers with suitable boats to fish in lagoons and outside reefs, with a focus on deep-water snapper fishing. There were also a lot of aquaculture projects underway, mainly in Fiji, the Solomon Islands, PNG, the US Trust Territories and Western Samoa, where research was the main focus. Most of these activities were geared towards increasing fish production, while focusing on reducing fishing pressure on reef and lagoon resources that were (already) considered fully exploited in many countries.

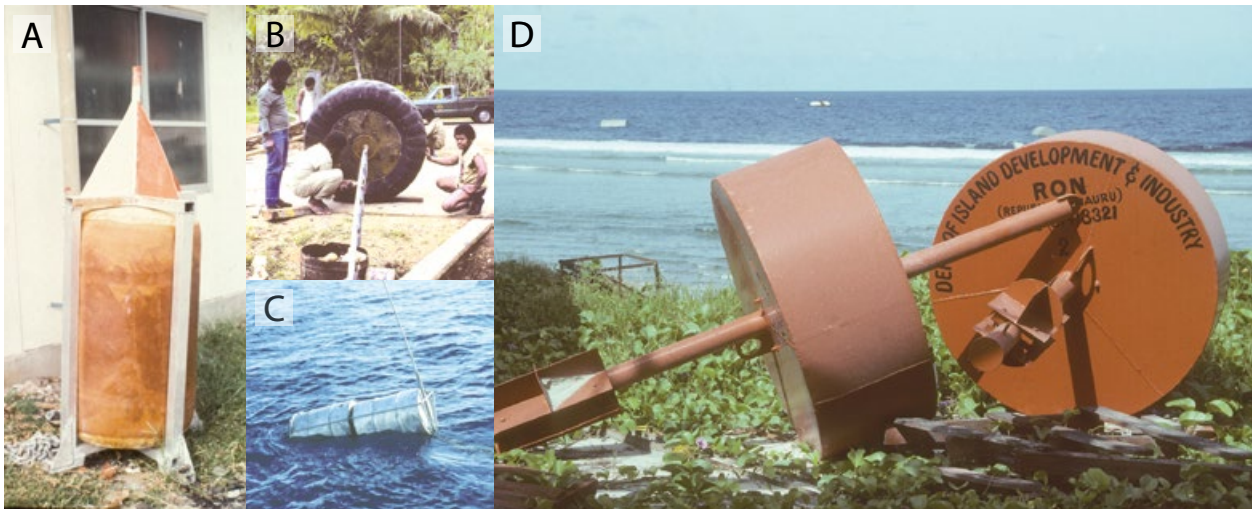
SPC's coastal fisheries activities in the 1980s

A regional training programme was established in 1979 in New Zealand and called 'the Nelson Polytechnic fishing cadet course for Pacific Islanders', which ran for 18 weeks. It combined lectures with practical work at the Polytechnic, with periods of sea time on a variety of fishing boats. The training was also modified to suit the Pacific requirements, so sea time covered the use of lines and nets rather than trawlers, and in the engineering section, outboard motor operation and maintenance were stressed. Other subjects included practical netting and seamanship, welding, navigation and chart-work, safety at sea, first aid, electronic aids (echo sounders, radar, etc.) and marine science. This very successful course ran annually through the 1980s with class sizes of 8 to 14 students, with slight changes to the curriculum to meet changing needs of the Pacific countries.

The format of the Fisheries Newsletter changed in 1981, with a new approach that involved less time and labour in the preparation and printing, which would allow quarterly issues to be produced. The aim continued to showcase the work of the SPC, and the work of national fisheries officers and researchers who provided information for the Newsletter. This also included many articles on tuna fishery development, both with SPC's activities and those of others donors and countries in the region. In the first half of the 1980s, 11 issues (numbers 20 to 31) were produced, and in the second half of the 1980s a further 20 issues (numbers 32 to 51) were produced.

The DSFDP continued its operations in the 1980s, further promoting the gears and methods developed for targeting the deep-water snapper resource. Assignments were usually for 4 to 6 month, with three master fishermen. Catch rates varied between locations, ciguatoxic species were caught in most locations as well as sharks, which were discarded, alive if possible. Atoll locations or steep reef slopes, with little area in the 100–400 metre depth range, had lower catch rates in general than locations with a more-gentle gradient, which increased the 'fishing area'. From 1980 to 1984 the project undertook 19 assignments in 14 countries and territories.

Successful use of the 'Western Samoa handreel', Santo, Vanuatu, 1982 (images: SPC).



All kind of floating devices were used for the first series of FADs set in the Pacific Islands region (A–C). In 1984, SPC recommended the use of a steel spar buoy (D) designed by Lieutenant R. Boy from the US Coast Guard, which helped increasing FADs lifespan (images: SPC).

In 1983/1984, the focus of the DSFDP started to change, as catch rates for the deep-water snappers remained constant or started to decline, indicating this to be a fragile resource that could only sustain limited fishing pressure. So the focus changed towards harvesting the tuna resource through small-scale fishing methods and the use of Fish Aggregating Devices (FADs). A FAD is a floating buoy system on the sea surface that is moored, usually by rope, to the ocean floor with concrete blocks or other anchor systems, in depths of 500–2,000 metres. FADs 'attract' and hold schools of tunas and other pelagic species, and allow fishers to go to these locations and have a much better chance of a good catch.

The use of FADs was increasing in the Pacific, both in the industrial tuna fishery and the small-scale sector. While the SPC master fishermen were experimenting with designs that had been used in other locations, a study was also funded by SPC, with Lieutenant R. Boy from the US Coast Guard, which resulted in a report on FADs 'An improved FAD mooring line design for general use in Pacific island countries: a report of the SPC design study on fish aggregation devices', in 1984.[6] This added to the range of information available, including the results from the SPC master fishermen's trials in different countries. Coupled with this was the trialling of different mid-water fishing methods to target the larger, deeper swimming tunas that were aggregated at times around FADs. These methods were being developed to reduce the fishing costs, as trolling used a lot of fuel, but was still the most used and favoured fishing method.

There were many other changes in the mid-to-late 1980s, with new funding made available to expand SPC's activities in coastal fisheries, and a 'Coastal Fisheries Programme' was established as new staff were recruited into new positions. The first was a Fisheries Training Adviser, who commenced in 1986, and focused on supporting the fisheries officer's course in Nelson, New Zealand, as well as looking at other training opportunities in the region for Pacific Islanders. This included the development of some specific vocational workshops on topics such as refrigeration and outboard repairs. The second was a Fisheries Post-Harvest Adviser, who commenced in 1987. The aim of this position was to look at value adding to the existing catch, including tuna products as shown by the workshop on alternative products to fresh and canned tuna that was conducted in 1989.

The Inshore Fisheries Research Project (IFRP) was also established in 1988, with funding support from multiple sources. As an inaugural activity, a major workshop on 'Pacific Inshore Fishery Resources' was organised and run in Noumea, with over 100 fisheries scientists and marine resource specialists attending and sharing their experience and scientific results on coastal fisheries resources. This also gave the IFRP some guidance for future areas of assistance to provide to countries, with work undertaken in Palmerston Island in Cook Islands by doing a resource survey and training local fisheries scientists; beche-de-mer surveys in Vanua Levu in Fiji; some analysis of the deep-water snapper data collected over the years from the DFSDP; training on ciguatera sampling protocols in the Federated States of Micronesia (FSM); and a survey of pearl oyster resources in Kiritimati Island in Kiribati. Also, in support of producing the Fisheries Newsletter, a Fisheries Information Adviser was recruited in 1989 to relieve the workload of the Coastal Fisheries Manager and Coastal Fisheries Coordinator. All of this expansion was in response to the direction set through the Regional Fisheries Technical Meetings (RTMF), which were held annually in the 1980s (RTMFs 12–21).

The DSFDP also continued during the rest of the 1980s, with another 18 assignments undertaken by the three master fishermen. Again, these projects moved away from

[6] http://www.spc.int/DigitalLibrary/Doc/FAME/Manuals/Boy_84_FADs.pdf.

deep-water snapper fishing, although this was undertaken on some occasions. The focus on small-scale tuna fishing activities around FADs became prominent. This also included the trialling of gillnets around FADs, which was not considered successful, with mainly sharks taken. Bait fishing for scads and small mackerel with gillnets and small jigs were also used to provide suitable bait for mid-water fishing techniques that were under trial, such as vertical longlining and 'palu-ahi' or mid-water handlining. Trolling was also a main fishing method and a manual was developed by the master fishermen and published in 1987 'Trolling techniques for the Pacific Islands – a manual for fishermen', with technical information for fishers to improve their trolling techniques, and hopefully catches.[7]

Fisheries departments in Pacific Island countries and territories (PICTs) continued to expand in the 1980s, as new graduates from USP with the desired skills became available for employment. The focus was still on fisheries development, and many countries continued their boat building programmes as well as training programmes to support new fishers with the equipment and skills to earn a living from fishing. Some countries like Fiji and Western Samoa had extension services that would assist fishers in the field with their fishing operations. Government operated ice plants were also being established as well as rural fishing centres to spread the fishing pressure, with some countries having fish collection vessels to bring the catch from the rural centres to urban centres for marketing. Many donors were also involved in bilateral small-scale fisheries development projects, some focusing on the deep-water snapper resource and others more on tuna and the use of moored FADs. Aquaculture activities, again with more of a research focus, continued with invertebrate species and some fish, such as tilapia, however, actual production was very low.

Among other fishing techniques promoted by SPC in the 1980s, the use of the *palu-ahi* and vertical longlines around FADs allowed to access the bigger deep-swimming tuna. Note the sea anchor used to fish while slowly drifting, facing wind and swell. Fiji, 1984 (image: SPC).

SPC's coastal fisheries activities in the 1990s

The steady expansion of the SPC's Coastal Fisheries Programme at the end of the 1980s continued into the 1990s. It reflected the importance that Pacific Island governments placed on the domestic exploitation of their marine resources, and the assistance they needed from SPC. In 1990, the 'Coastal Fisheries Programme' consisted of the DSFDP with a coordinator and three master fishermen, the Fish Handling and Processing Project (FHPP) with one adviser, the IFRP with two scientists, the Regional Fisheries Training Project (RFTP) with an adviser and an officer, and the Information Adviser, with an overall manager for the programme and a project assistant. However, more expansion occurred during the 1990s as new project funding became available. The first project addressed information, with the establishment of 'special interest groups' and information bulletins were produced, with the first covering pearl oysters in 1990, the second on ciguatera and the third covering beche-de-mer in 1991, while *Traditional marine resource management and knowledge* and *Trochus* bulletins were added in 1992.

The DSFDP's activities continued to change in the early 1990s, and entirely moved away from deep-water snapper fishing, with the continuing focus on the design, rigging and deployment of FADs, and small-scale tuna fishing around FADs, with eight countries visited. The RFTP continued with a range of regional and national training activities in the 1990s, including the annual Nelson course as the main activity. In 1991, the RFTP organised a workshop in collaboration with the Western Pacific Fisheries Consultative Committee, CIDA and the French Government. The workshop also included a number of ASEAN[8] training and education institutions, which focused on promoting greater cooperation between the two regions in fisheries training and education.

The FHPP project undertook activities in: PNG and Solomon Islands on assisting women's groups with fish processing and marketing; the development of tuna jerky as a small-scale processing facility in Kivela in Tokelau, mainly for export;

[7] http://www.spc.int/DigitalLibrary/Doc/FAME/Manuals/Preston_87_Trolling.pdf.
[8] Association of Southeast Asian Nations (ASEAN).


Conducting scientific assessments to get a better understanding of reef species stock status (Aitutaki, Cook Islands, 1995; image: Tim Adams) and organising training workshops for fisherwomen (Futuna, Wallis and Futuna,1997; image: Lyn Lambeth) were some of the activities run by SPC's Costal Fisheries Programme in the 1990s.

and the coordination of a post-harvest fisheries study tour in the Pacific Latin American countries of Mexico, Ecuador, Peru and Chile. In late 1991, a Woman's Fisheries Programme commenced within the FHPP, to develop, coordinate and enhance post-harvest activities for women throughout the Pacific. The first activity was a workshop on fish processing and marketing held in Kavieng, PNG in 1992.

IFRP was also very busy as national fisheries departments focused more on conducting scientific assessments to get a better understanding of stock status, which could then be used for management purposes. Some of the main activities included: a survey of the pearl oyster resources in Nukulaelae in Tuvalu; improved ciguatera case history reporting; the holding of a workshop on trochus resource planning; a survey of beche-de-mer resources in Ha'apai, Tonga; and shallow reef fish stock assessment in the outer islands of Yap State, FSM. In April 1992, a new senior fisheries scientist was recruited for the IFRP.

The Coastal Fisheries Programme was reorganised in 1993, with a specific manager for the programme. The DSFDP was renamed the Capture Section; the other sections were Post-Harvest, Training, Information, and the IFRP became the Inshore Resource Assessment and Management Section (IRA&MS), thus combining both science and management given that they are closely linked. The programme also started to produce more information on post-harvest, and training aids and handbooks to get information out to fisheries departments and fishers in the region.

The post-harvest section continued different activities, and there was an increasing focus on the harvesting and processing of sea cucumbers into beche-de-mer, with the production in 1994 of 'Sea cucumbers and beche-de-mer of the tropical Pacific: A handbook for fishers'.[9] Other activities included a fish drying workshop. In the following year the women in fisheries positions moved more into the IRA&MS area, and the post-harvest activities in the mid-to-late 1990s moved more into food safety with training and assessments conducted on Hazard Analysis and Critical Control Points (HACCP), as a requirement of the USA for exports of fresh chilled tunas from the Pacific. Unfortunately, funding for the post-harvest area came to an end in 1998, and SPC ceased activities in this area, but kept hiring consultants to provide HACCP training in the following years.

The Capture Section with additional funding, started branching out into small- to medium-scale tuna longlining, and in 1996, a new master fisherman was recruited with the skills to provide technical assistance in this area. A lot of FAD work also continued, but the new interest of PICTs was in developing domestic tuna longlining, with FSM, PNG, Fiji, Cook Islands, Tonga, Western Samoa and others promoting this in the late 1990s. The Capture Section also produced a range of technical manuals: 'Deep-bottom fishing techniques for the Pacific Islands – a manual for fishermen';[10] 'Vertical longlining and other methods of fishing around FADs – a manual for fishermen'[11] in 1998. There were also several manuals produced on FAD materials, rigging and deploying, and planning an FAD programme including maintenance of FADs.[12]

The Information Section added a staff person in the mid-1990s, to keep up with the 3-monthly production of the Fisheries Newsletter, the different Special Interest Group bulletins, and a range of other publications being produced for other sections within the Coastal Fisheries and Oceanic Fisheries Programmes, as well as some countries. The Section also started the annual production of the SPC version

[9] http://www.spc.int/DigitalLibrary/Doc/FAME/Manuals/Handbook18_94_BDM.pdf.
[10] http://www.spc.int/DigitalLibrary/Doc/FAME/Manuals/Preston_99_DBFTforPI.pdf.
[11] http://www.spc.int/DigitalLibrary/Doc/FAME/Manuals/Preston_98_VLL.pdf.
[12] http://www.spc.int/coastfish/en/publications/technical-manuals/fads.html.

of the 'Fisheries Address Book'[13] in the early 1990s. This has been an invaluable resource or networking tool, as it provides the names and contact details for fisheries officers in the region, researchers and consultants, gear manufactures and suppliers, fishing companies and many others. It is continually being expanded and updated, to maintain its usefulness for the region.

The Training Section also continued with the annual Nelson course and a range of other vocational training during the mid-to-late 1990s. Staffing levels remained at two. There were regional workshops, and national training was undertaken in Samoa, PNG and French Polynesia. In addition, a sea safety campaign was undertaken with various materials produced to encourage fishers to be safe when they head out to sea on fishing boats.

The IRA&MS became the Resource Assessment Section in 1996, with a new funding source. The main project under this section was the Integrated Coastal Fisheries Management Project (ICFMP), which continued with fish and invertebrate stock assessment work and turning this into management advice. Two fisheries research associates joined the project for a year to gain work experience and assist with assessment work in-country. In 1998, the section added a Reef Fisheries Management Adviser, to strengthen advice on sustainable resource management plans for the reef environment. Activities were undertaken in many countries covering stock assessment of species, establishing monitoring protocols, the use of non-destructive fishing methods, and many other assignments looking at better management of natural resources, which was all based on the best available science.

A new section was established in 1997, the 'Women's Fisheries Development Section', which was a mix of fisheries development and fisheries management, as well as post-harvest activities, with the focus on women. The new section had two staff members – an adviser and an officer. Some of the activities undertaken included: a study on the participation of women in fisheries in Nauru; a workshop in Nauru on alternative harvesting and processing techniques for women; a gender analysis of the tuna industry in the Solomon Islands; a workshop on seafood processing and marketing techniques in the Marshall Islands; a workshop on the production and marketing of shell craft in Niue; and many other related activities.

For the PICTs in general, the 1990s was a time for further expansion of their development aspirations and reliance on fisheries for food security and small-scale livelihoods. Governments continued with rural fishing centres and the establishment of ice plants in rural areas to support small scale fishers. There was a slow-down in the boat building programmes, with some fishers preferring the imported fibreglass or aluminium skiffs for fishing. FAD programmes were established, although these relied heavily on donors providing the FAD materials and SPC to provide assistance in training on rigging and deployment, including site selection and survey methods. Aquaculture was also promoted and run by governments, with many subsidies. Fisheries management was still overshadowed but the drive for development of coastal resources, and the overharvesting of sea cucumbers and other commercial invertebrates was becoming apparent in some countries.

The Regional Technical Meeting on Fisheries (RTMF) continued to provide the priority setting for SPC's Coastal Fisheries Programme during the 1990s, even though the number of meeting was reduced, mainly due to available funding. Five RTMFs were held from 1990 to 1996, and then the focus of these meetings changed from the technical to more management and decision making. In 1998 a trial 'Heads of Fisheries' meeting was held, and this was followed by the First full Heads of Fisheries meeting being held in August 1999. Although the format was a little different, it was still the main meeting used by SPC to get the input of PICTs to the work plan of the Coastal Fisheries Programme, to meet the PICTs priority needs.

In the Pacific Islands region, the tendency for coastal fisheries programmes to move away from technical activities that are linked to fisheries development and toward activities related to the management of fragile coastal marine resources is essential for the subsistence of most coastal communities, as well as the development of aquaculture related activities, and will slowly become more apparent, as will be shown in a follow-up article that will be published in the next issue (#151) of this Newsletter, under the title: 'A new millennium: SPC's Coastal Fisheries Programme and activities in the 21st century'.

Acknowledgements

The author would like to acknowledge the input provided by SPC fisheries staff, past and present, the fisheries officers of the Pacific Island countries and territories and all others who provided written materials, which are hosted in the SPC Fisheries Digital Library[14], where most of the information in the 'story' has come from. Some of these writings date back to the early trip report of the first SPC Fisheries Officer in the mid-1950s, and a few general documents prior to this are from the late 1940s. Additional information was gleaned from the SPC publication 'Meeting House of the Pacific – the story of SPC: 1947-2007'[15], many of the 149 issues of the Fisheries Newsletter[16], and other regional reports from organisations, such as FAO and UNDP, especially from the early years of fisheries development in the Pacific.

[13] www.spc.int/coastfish/doc/coastfish_docs/Address_book.pdf
[14] www.spc.int/fame/en/publications/digital-library
[15] www.spc.int/en/featured-publications.html
[16] www.spc.int/coastfish/en/publications/bulletins/fisheries-newsletter.html

A short history of the Skipjack Survey and Assessment Programme (SSAP) [Part 1]

Paul Judd[1]

For over 20 years the Oceanic Fisheries Programme (OFP) has been arguably both the best known and the most highly regarded programme within the Pacific Community (SPC). Its reputation for excellence in data capture, science provision and resource management advice has fuelled its ability to attract funding for its continued core function and for many large-scale projects over the years. All of this has contributed to the high profile of OFP within the member countries of SPC, but also on a much wider scale within the scientific and fisheries management communities world-wide. OFP is the successor to the Tuna and Billfish Assessment Programme (TBAP), which ran from October 1981 to early 1994. TBAP, itself, had evolved from the Skipjack Survey and Assessment Programme (SSAP), which ran from September 1977 to September 1981.

Overview

The Skipjack Programme carried out tuna surveys and assessments that enabled the first estimates of the skipjack resources of the whole central and western Pacific, and evaluation of the ability of these resources to support sustainable fisheries. Over a period of three years, which began in the late seventies, the ground-breaking Skipjack Programme team tagged 160,276 skipjack and other tuna. Of these, 6,889 (4.3%) were reported as recaptured with the associated data forming the basis of vital understanding of the migratory nature of the species, the magnitude of the stocks and the variability in their genetic structure and distributions. In the process the Programme greatly expanded world knowledge of the biology of skipjack and other tuna species. In addition, the baitfish resources of SPC member countries and territories were assessed.

In 1989, OFP undertook a second major tagging programme within the region – the Regional Tuna Tagging Project (RTTP). Since then a third major tagging programme has also been completed – the Pacific Tuna Tagging Programme (PTTP), which ran from 2006 to 2013. In total, nearly 800,000 tunas have been tagged in the Western and Central Pacific Ocean (WCPO), with the three large-scale tagging projects conducted by SPC contributing about 83% of this total. Each of the large-scale projects tagged tunas throughout the equatorial WCPO, and recoveries have correspondingly been reported from across the equatorial WCPO and beyond.

Tagging data have been included in WCPO stock assessments since 1982 for skipjack tuna, since 1992 for yellowfin tuna, and since 1996 for South Pacific albacore and bigeye tuna. Since 2001, tagging data have been included routinely in WCPO tuna stock assessments using the integrated assessment model MULTIFAN-CL[2].

Today, neither the feasibility nor the usefulness of such large scale tagging programmes are questioned – the biggest obstacle remains the raising of the necessary funding to conduct them. But back in 1974, the concept of tagging on such a large scale, and over such a large area of relatively remote ocean, was revolutionary – it had never been attempted, and for most people, including most fisheries scientists, it was unthinkable. There were no arrangements for any regional tuna research, let alone region-wide survey and tagging studies and as for most significant scientific endeavours, gaining support for proving the concept was a major obstacle.

Therefore, there were many reasons why SSAP was a ground-breaking project. Upon its completion it was hailed as an outstanding success. Yet it almost never happened.

Notable achievements of the Programme include:

- proving that tagging could be done on a grand scale, numerically and geographically, such that sufficient tuna could be tagged and adequately distributed in both time and space over the 30 million square kilometres of the region, and that adequate recoveries would be recorded to enable region-wide resource assessments;
- quantifying for the first time the large size of the skipjack resource in the Western and Central Pacific (estimated by SSAP at around 3 million tonnes), as well as its dynamic nature (extremely rapid turnover) and associated ability to withstand fishing pressure. It is most significant from the perspective of confirmation of the quality of a truly scientific experiment (being able to repeat an experiment and confirm results) that more recent repeats by the OFP of the Skipjack Programme's original tagging experiment have confirmed the 3 million tonne estimate;

[1] Finance and Administration Officer (SPC's Oceanic Fisheries Programme).

[2] MULTIFAN-CL is a computer programme that implements a statistical, length-based, age-structured model for use in fisheries stock assessment.

Action during the inaugural SSAP tagging cruise in late 1977 (Bob Kearney bottom left). Note the large backpack containing the voice recorder, and the long microphone hanging on the chest. The material used these days for voice recording is MUCH more compact (image: Bob Gillett).

- documenting the migratory nature of the resource, but the relatively limited interaction between well-separated national fisheries;
- generating estimates of biological parameters (age, growth, fecundity, mortality and feeding behaviour) for skipjack, of which little was known at the time, and in the process correcting much of what had previously been postulated and/or believed;
- becoming the first extra-budgetary (XB) project managed under the auspices of SPC;
- increasing the overall budget of SPC by approximately 33% (from AUD 2.8 million in 1977);
- purchasing the first ever computer at SPC (in April 1979 at an initial cost of approximately USD 100,000), thus propelling SPC into the computer era;
- elevating the perception and profile of SPC to one of scientific and technical excellence;
- providing scientific support and insight for Pacific Island nations in the development of their individual and collective strategies in the lead up to the declaration of their 200-mile Exclusive Economic Zones under the United Nations Law of the Sea. In so doing the Programme provided conceptual strategies and baseline analyses that underpinned the development of cooperative regional fisheries policies. This cooperation was essential for the creation of the Forum Fisheries Agency and eventually the Western and Central Pacific Fisheries Commission.

Background

In 1970, the total tuna catch in the SPC area was less than 100,000 tonnes, and was nearly all taken by foreign longline fleets. These longline catches and related catch-rates had, however, levelled out after peaking in the mid-1960s. With the development of joint-venture pole-and-line operations, first in Papua New Guinea (PNG) (1970), then the Solomon Islands (1971), interest in the skipjack resource, as one with potential to support considerable expansion of catches, intensified.

In early 1971 Dr Robert (Bob) Kearney, a young Australian with a driving interest in fisheries research, who had just graduated from the University of Queensland (UQ) with a PhD in Marine Biology, accepted a job with the Papua New Guinea (PNG) Department of Agriculture, Stock and Fisheries (DASF) as the Principal Biologist in charge of tuna

research. Two other young Australians who had also been studying at UQ accepted jobs in the DASF tuna research team within months of Dr Kearney's appointment – Bernard (Barney) Smith and Antony (Tony) Lewis (who both were later to make extremely important contributions at the most senior levels of SPC fisheries programmes).

In the development of his tuna research programme, Dr Kearney made inquiries of relevant fisheries research institutions including the Commonwealth Scientific and Industrial Research Organisation (CSIRO, Australia's national science agency) and the Inter-American Tropical Tuna Commission (IATTC, based in San Diego, California). Tagging was clearly the best option around for basing a comprehensive research effort that was to include aerial surveys and intensive biological sampling. Over the next two years, techniques specific for tagging skipjack and other tropical tunas, were developed and perfected by the team in DASF. Several thousand fish were then tagged in PNG waters.

At the time, the four tuna fishing companies in PNG were all Japanese joint-ventures, operating Okinawan pole-and-line boats out of bases in Rabaul, Kavieng and Madang. The catches by these fleets were impressive by the international standards of that era. At that time, according to Dr Kearney, the best boats caught up to 400 tonnes in a month, which for pole-and-line boats represented excellent returns. By world standards the fishery was considered to be one with great potential and its progress began to be keenly monitored by most Pacific nations.

The DASF team tagged sufficient fish and set in place tag-recovery systems to quickly generate impressive numbers of recoveries. Data from these releases and recoveries, together with daily catch information from each individual vessel operating in the PNG tuna fishery, were then computerised and subsequently analysed. Dr Kearney and his team were among the first in any discipline in PNG to computerise scientific research – a practice that is taken for granted today.

To quote Dr Kearney:

> The country had an impressive Computer Centre but few excellent data sets, so if you made a case that included appropriate Departmental support, they were keen to facilitate your access to the computer. The operators of the Centre were visionary and they wanted to see their computer used to best effect for PNG. They would actually do all of the data entry and software development for you. And so I made a case, with very strong support from the Director of DASF (Bill Conroy). The fact that the tuna fishery represented an exciting development opportunity for the country at that time was clearly a major factor influencing the strength of the support we received. Senior staff of the Computer Centre took our research really seriously, and within – oh, I don't know exactly, about a year of commencing our research we had fully computerised catch and effort data from each and every tuna boat. These data were compiled and presented in such a way that we could cross-reference all catches with our scientific sampling. The Computer Centre would deliver me monthly printouts of the daily catch by every boat, aggregated by area and any other classification I specified, combined with summaries of size-sampling of skipjack from every boat and area. So we had a very, very good handle on the tuna fishery which we could correlate with the tag return information that was also being computerised and analysed.

However, as more tag returns came in, and more analysis was done, Dr Kearney soon saw that he and his team were not able to get all the information necessary to comprehensively address the assessment of PNG's skipjack resources. The tagging techniques that had been developed were good – the fish were clearly surviving and they were being recaptured – particularly in PNG, and even in the fisheries further to the east. It was possible to determine where many of the tuna in PNG were going to, but it was impossible to determine where they were coming from, or to estimate the size of the

Bob Kearney, Papua New Guinea, early 1970s (image: Barney Smith collection).

total resource and the degree of mixing of the stocks that were being fished.

It was obvious the research team was dealing with a PNG fishery that was virtually isolated at that time. But what was the extent of the total resource that these fish were part of, and how would fisheries that might develop elsewhere impact PNG? The area-coverage of the tagging may have been impressive within PNG but it was manifestly inadequate for the analyses that were necessary, even for the assessments of only the stocks exploited in the PNG fishery. Dr Kearney realised that if the big questions were to be answered, even if only to the extent of the answers that PNG needed, it was necessary to try to expand their efforts geographically, beyond PNG's waters. There was not much point in tagging many more fish in PNG alone.

During 1973 he developed the idea of a tagging programme that was to be done on a much wider, regional scale. The initial concept was to have tagging done simultaneously in a number of other countries, such as the Solomon Islands, which was developing its own joint-venture pole-and-line fishery similar to PNG. The gaps in distribution of tags in the waters of countries that did not have pole-and-line fisheries could then be best covered by sharing a common research vessel to traverse the whole region and provide the capacity to tag reasonable numbers of skipjack, in at least, most of the other Pacific Island countries. He wrote a one-page summary of this concept. He showed it to a few of his colleagues who initially thought it idealistic to the point of being unrealistically optimistic. He put it on hold.

In mid-1973 Dr Kearney received an unheralded visit in his office in Port Moresby from Roy (Dick) Baird. Dick was the Fisheries Officer at SPC at that time. Dr Kearney knew very little of SPC and he had a busy schedule that day, which did not include a meeting with 'a Dick Baird': they spoke for less than 30 minutes. However, this short meeting was sufficient for Dick to be most impressed with the quality of PNG's skipjack research programme, including the data printouts on the joint-venture fisheries, the tag recoveries and the results of the baitfish surveys. It also provided the opportunity for a brief discussion on the much more ambitious tagging project. Dr Kearney thought little more of their encounter, until he received a letter from Dick two or three months later together with an air ticket for travel to Tahiti to attend a meeting to discuss skipjack assessment. It was with much enthusiasm and optimism that he accepted the invitation. He attended his first truly international meeting a few months later with this optimism clearly evident.

The 'Expert Committee on Tropical Skipjack' meeting convened by Dick Baird was held in Papeete, in French Polynesia, from 25 February to 1 March 1974 under the

It was always important to raise awareness on the Skipjack programme, to make sure it would receive support from all stakeholders involved. Tony Lewis providing technical information to Fisheries College students and Fisheries Department staff. Kavieng, PNG, October 1977 (image: Bob Gillett).

chairmanship of Richard Shomura, the Director of the Hawaii office of US Government National Marine Fisheries Service. The members of the Expert Committee were easily convinced of the usefulness and appropriateness of the tagging programme mooted by Dr Kearney, the need for which they endorsed as a high priority. The introduction on page 1 of the report for the meeting states that 'After considering all available alternatives for the study of skipjack in the area, the Expert Committee strongly recommended a regional tagging programme in which approximately 100,000 skipjack would be tagged and released over a three year period (Appendix 2).' Of particular note from the SPC perspective is the comment on page 11 of the proposal that constituted that Appendix: 'The international sponsorship of the project through the South Pacific Commission enables the vessel to catch both skipjack and baitfish in areas not accessible to a vessel of a single nationality.'

At Dick Baird's invitation, Dr Kearney agreed to stay on in Papeete a few more days after the meeting to expand his original one-page 'concept note' into more of a proposal, including a very preliminary estimate of possible costs. Over the next month or so, after further discussions with Dick Baird, Richard Shomura, Jim Joseph (then the Director of IATTC) and others, it was decided that it would be useful to get the Food and Agriculture Organization of the United Nations (FAO) and the affiliated Indo-Pacific Fisheries Council involved.

The SPC's Seventh Technical Meeting on Fisheries, held at Nuku'alofa, Tonga in July 1974, endorsed the Expert Committee's proposal as a 'project of the highest priority and urgency'; an endorsement that was seconded by the Indo-Pacific Fisheries Council Sixteenth Session, Jakarta, Indonesia, in November 1974.

Dr Kearney spoke to Dr John Gulland at FAO in Rome about furthering the development of the project. Gulland responded with the offer of a month's consultancy at FAO in Rome, and sent him an air ticket to that effect. Dr Kearney spent five weeks in Rome in November/December 1974, working with Gulland and other senior FAO staff, including Dr Sidney Holt and Fred Popper (the Director of the FAO Fisheries Department), on an expanded proposal. When it was published, it still did not include a detailed budget, but rather the comment: 'No attempt has been made to cost the services of a suitable vessel and crew for a two or three year period as more accurate estimates would be available from the appropriate fishing nations.' However, the proposal had expanded the project to include eleven full-time scientific staff members plus a part-time computer programmer; a major development from the four scientific staff cited in the proposal presented in February of 1974. The operational and fishing crew for the research vessel were to be additional. They were assumed to number approximately 20 but the costs of their employment would be included in the vessel charter arrangement, which remained to be determined.

The active quest for funding

With a refined proposal now endorsed by multiple bodies the search for funding could be undertaken in earnest. The first recommendation of the SPC's Seventh Technical Meeting on Fisheries, held in Tonga in July 1974, had not only stated that: 'The meeting recommends that the Tagging Programme as outlined by the Expert Committee on Tropical Skipjack be accepted as a project of the highest priority and urgency.', it went on to state that: 'The need for such a programme has been accepted, and the Meeting recommends that the South Pacific Commission make every possible effort to obtain funding for the programme from any possible sources. **It was appreciated that such funding should not interfere with the existing funding structure for South Pacific Commission projects** (emphasis added).'

The last sentence clearly reflected the reality that the SPC budget – entirely funded from core contributions at that time – could not possibly support such a large-scale project. There was considerable concern, including among the SPC Executives, that if donor country funds were directed towards this project that the outcome could have a negative influence on the quantum of funds available for SPC core support. Dick Baird and Dr Kearney, therefore, had no alternative but to seek funding totally from extra-budgetary sources. Obvious possibilities included most of the 'colonial' countries that had created SPC in 1947 – specifically Australia, France, New Zealand, the United Kingdom and the United States of America (listed in alphabetical order) – but they also included Japan. At that time, Japan was the dominant tuna fishing nation in the SPC region. Logically Japan would be the source of a great deal of the catch and effort information that would be an essential component of the assessment process and also many of the tag returns, if a tagging programme did eventuate. However, while Japan had expressed interest in increasing its support for Pacific Island nations, not only was it not a member of SPC, but it had never made a major contribution to an international organisation of which it was not a member: some kind of umbrella arrangement needed to be created to facilitate Japanese participation in the project.

Coincidentally, in 1974 the Rockefeller Foundation decided to create a new non-governmental organisation (NGO) to assist in fisheries management in the Asia-Pacific region. The new organisation would be called the International Centre for Living Aquatic Resources Management (ICLARM). Dick Baird was contacted by the Rockefeller Foundation to help with the establishment of ICLARM, and although he eventually turned down an offer to play a major role in this process he did suggest to Dr Kearney that he contact the Foundation as a possible funding source for the Skipjack Programme. This obviously bore fruit, as the Technical Advisory Committee of ICLARM met in Honolulu in February 1975, and just five days later the ICLARM Programme Coordinator sent a memo to Dr Phil

Helfrich, the Director of ICLARM, concerning the 'Skipjack Resource Assessment Project'. In it he stated:

> After working out the initial details with Dick Baird (DB) ... this is where we stand at the moment. The Project Manager for this programme will be hired directly through the SPC in a staff capacity. Dick will develop a job description for the position in line with SPC requirements (even though he already intends to hire Bob Kearney) and will also handle the transfer of grant funds on the SPC end... The SPC will provide office space, housing, support personnel, and medical services. ICLARM funds will go for salary, additional expatriation allowance, and travel expenses. DB has assured me that no percentage of ICLARM funds will be deducted for administrative overhead.

In the interim, Dr Kearney had been offered another consultancy by FAO, for a period of three months working on Indian Ocean tuna fisheries, which he had accepted. With the injection of funds from Rockefeller Foundation/ICLARM, Dick Baird was eventually able to offer him an initial contract of six months with SPC, with a mission to raise the money to fund the Skipjack Survey and Assessment Programme. Dr Kearney accepted the challenge. He commenced work at SPC on 13 September 1975.

The context for obtaining commitments

It is very easy to forget just how different a place the Pacific was in the early nineteen seventies. Many people today have little or no knowledge of the major political changes that took place in the region between 1970 and 1980. During that short time-span, no less than seven South Pacific States (SPS) – Tonga, Fiji, Papua New Guinea, the Solomon Islands, Tuvalu, Kiribati and Vanuatu – obtained their independence from, or severed their voluntary ties with, various colonial powers. During the same decade, three other Pacific Island states entered voluntarily into new agreements of free association with metropolitan powers – Niue, the Northern Mariana Islands, and the Marshall Islands.

As a result, by the end of the seventies the majority of the member countries of the SPC were either independent or self-governing. During the same period, many discussions and meetings were held in the region to develop national and regional strategies and policies to protect sovereignty over, and the use of, the region's fisheries and other oceanic resources. These meetings were part of the region's preparations for the changing law of the sea. Dr Kearney, and subsequently other members of the Skipjack Programme team, were to play a major role in the preparation of discussion documents and analyses, including the first detailed proposal for a regional organisation specifically for fisheries research and management, drawing of the first maps of the 200-mile zones of all countries and territories in the SPC region, and the first analyses of tuna catches by distant water fishing nations in the waters of each Island State. These negotiations culminated in the signature in December 1982 of the UNCLOS agreement. This convention formalised the notion of EEZs (exclusive economic zones of 200 nautical miles) around each coastal nation. UNCLOS enabled the countries to exercise sovereign rights over the living and non-living resources, particularly highly migratory species (HMS) such as tuna, within their EEZs. The tremendous importance to Pacific Island nations of sovereignty over their very substantial tuna resources is now obvious and accepted. For many countries therefore 'the concept of self-government and extended maritime jurisdiction was intrinsically interwoven virtually from the outset of nationhood' (Quote from a 1990 thesis by Transform Aqorau entitled 'Tuna Management and UNCLOS: Implementation of UNCLOS through the Forum Fisheries Agency).

SPC was the first major regional organisation of significance that was created in the Pacific. It was formed in 1947 by the six metropolitan powers of the period, namely Australia, France, New Zealand, the Netherlands, the United Kingdom and the United States of America, all of which had administrative and colonial responsibility over one or more island territory or state. The mandate of SPC was to promote the 'economic and social welfare and advancement of the peoples of the non-self-governing territories in the South Pacific Region administered by them'.

However, by 1975, SPC had major budgetary problems, as evidenced by the General Review presented to the 15th SPC conference by the Secretary-General, in which he stated:

> As you are all well aware, the Commission in 1975 has been plagued with budgetary problems caused by inflation and currency fluctuations. Other organisations, and indeed Governments, have suffered from similar problems, but this does not decrease their repercussions on the Commission and its Work Programme. Although the expenditure made in 1975 and that proposed for 1976 are in excess of sums spent in previous years, the Commission's actual activities have not appreciably increased. In December last year, the Programme Directors and I made a thorough examination of the approved 1975 Work Programme and Budget; in an attempt to meet the budgetary deficit which was already looming clearly on the horizon, we 'froze' a long list of items in the administrative section of the Budget, the regular Work Programme, and the Special Projects. . . Despite our efforts to prune expenditure, inflationary trends and devaluation have given rise to still further demands on our Budget, and we are faced with a deficit for 1975 of some seventy-five thousand dollars. . . The outlook for 1976 is still more depressing...

> On present indications, it is perfectly possible that the expenditure proposed in the draft Work Programme and Budget for 1976 will exceed available income to an alarming extent.

It was in this very difficult budgetary context that Dr Kearney commenced work at SPC in September 1975. His official title was 'Pacific Skipjack Stock Assessment Project Co-ordinator', and thanks to the Rockefeller Foundation and ICLARM, he had funding for six months – including a reasonable travel budget – to try and secure the necessary funding for a very ambitious three-year project.

After his arrival at SPC, Dr Kearney worked very closely with Dick Baird. They were both well aware that things were going to be very difficult, given that the budget they would be seeking was more than a million dollars a year, or about 33% of the total SPC budget, at a time when funding for international initiatives was extremely tight; global finances were being impacted by uncertainty following 'the oil crisis' and, closer to home, the SPC itself had admitted to serious budgetary difficulties (outlined above).

The likely possible donors for the Skipjack Programme were largely the same ones as those that funded the SPC core budget and, as was evident from the Secretary General's letter, they were clearly reluctant to give the SPC considerably more funds. There was also open expression by several emerging Pacific Island nations that SPC was more 'colonial' in its operation than they now wished. There was a ground-swell of suggestion that any major new regional undertakings should be under the auspices of organisations over which Island states had greater authority, such as the emerging South Pacific Forum, which was seen to have less 'colonial domination'.

It is also important to note that at that time SPC still did not have a single extra-budgetary project on their books – all were paid for out of consolidated revenue, known as core funding. Extra-budgetary projects had been talked about, and indeed actively sought, but at that point in time it had not been possible to obtain funding for a single one of them – not even for a few thousand dollars. If funding was to be obtained for a new multi-million-dollar project, optimism would be essential.

Figure 3. Some of the participants at the 8th Regional Technical Meeting on Fisheries, which was held in Noumea in October 1975, just one month after Dr Kearney started work at SPC.

From left to right: Mr R.H. (Dick) Baird - SPC Fisheries Adviser; Mr Luata Toatasi - Acting Chief Officer, Fisheries Division, Western Samoa; Mr B.R. (Barney) Smith - Acting Principal Bilogist, Department of Agriculture, Stock and Fisheries, PNG; Mr Richard Shomura - Director, Honolulu Laboratory, Sothwest Fisheries Center, Hawaii; Dr R. (Bob) Kearney - Skipjack Stock Assessment Coordinator (SPC)

[3] http://www.spc.int/fame/en/publications/digital-library

End of part 1

The second part of this 'short history of the Skipjack Survey and Assessment Programme (SSAP)' will be published in the next issue (#151) of this Newsletter.

Acknowledgements

The author wishes to acknowledge the input and participation of the following people, for without their assistance this article could not have been written:

- Dr Bob Kearney – Emeritus Professor of Fisheries, Institute for Applied Ecology, University of Canberra;
- the two other former OFP Programme Directors: Dr John Sibert and Dr Antony Lewis;
- the current OFP Programme Director: Dr William John Hampton;
- the staff from SPC's registry and library sections who assisted me in locating documentation, much of it from over 40 years ago: Veronique Fayard, Nathalie Desprez, Mary-Clare Ame, Stephanie Watt;
- the SPC staff responsible for designing and putting together the 'FAME Digital Library' (http://www.spc.int/fame/en/publications/digital-library): Franck Magron and Aymeric Desurmont; and
- many other past and current members of the OFP team, too numerous to mention individually within the limited confines of this short article.

From left to right: Barney Smith, Tony Lewis and Bob Kearney at a meeting in Cronulla in 1973, whilst all three were working for the PNG Department of Agriculture, Stock and Fisheries (image: Barney Smith collection).

Original text: English

Pacific Community, Fisheries Information Section, BP D5, 98848 Noumea Cedex, New Caledonia
Telephone: +687 262000; Fax: +687 263818; spc@spc.int; http://www.spc.int