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In this issue

Editorial

Participants of the SPC Heads of Fisheries Meeting in March, highlighted the need to raise the profile of coastal fisheries, given their importance for food security in the Pacific Islands region, and concluded that coastal fisheries should find a higher place in the list of priorities of their governments and donor agencies. I'm not sure if it is already a side effect of this call, but the list of articles we received for this issue certainly highlights the importance and diversity of coastal fisheries-related work being done in our region.

The fishery sector includes some of the most dangerous jobs in the world, globally causing over 20,000 deaths per year. But, in the public's mind, this danger is more associated with industrial fishing in extreme weather conditions than with artisanal fishing in relatively benign tropical waters. Nevertheless, anyone who has ventured outside the reef on a small outboard-powered boat is well aware that disaster is never far away. Engine failure combined with offshore winds can make for a very long and possibly fatal drift.

In Tuvalu, three drifting fishermen were saved by the activation of personal locator beacons, devices they had received from their government as part of a safety "grab bag" (see articles on p. 19 and 20). Each grab bag cost USD 1,200 – a very minor investment when compared to the cost of air search and rescue, or the loss of a life. The Tuvaluan government decided that the safety of artisanal fishers was a high priority. Three fishermen and their families will be forever thankful for this wise decision.

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Rabaul, Papua New Guinea (image: Francisco Blaha).

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

Towards participatory management of lagoon fisheries in French Polynesia

Lagoon fishing is one of the leading sources of income for half of all Pacific Island households. Fish accounts for 50–90% of animal protein intake in Pacific Island diets (SPC 2015). Regionally, coastal fisheries are particularly important in cultural and economic terms (SPC 2015). They are estimated to supply 49% of the fishing industry's contribution to gross domestic product, reflecting how central they are to the Pacific Island lifestyles (SPC 2015). The population of many Pacific Island countries and territories is increasing steeply while coastal fisheries resources are dwindling, and population pressure is widening the gap between the amount of fish required for Pacific Island food security and the volume that can be caught without jeopardising coastal fish stocks (SPC 2015).

The Polynesian region has the lowest reef fish catches in the Pacific at 28,338 t in 2014 – a 12% increase over 2007 – while catches in Melanesia have reached approximately 100,000 t. Lagoon fishing in Polynesia is practised for both subsistence and commercial purposes, whereas it is essentially a subsistence occupation in the other Pacific regions. Polynesians take the prize, however, for eating seafood, particularly in Tuvalu and Tokelau, where they eat 142–150 kg per person per year: nearly twice as much as the overall Pacific yearly rate estimated at 75 kg per person (Pinca et al. 2010). The status of lagoon resources in Polynesia is difficult to gauge because there are more than a thousand islands, and gathering information on such a scale is no small task. Research conducted to date on a small number of islands, particularly under the Pacific Community's PROCFish project, shows that Polynesian countries' lagoon resources are being overfished. PROCFish findings point to fish biomasses below the regional average of 118 t/km^2 on 65% of sites examined in Polynesia (Pinca et al. 2010). Some islands, such as Tutuila in American Samoa, would require a 40-year outright fishing ban to restore stocks to their original level (McNeil et al. 2015). The main causes of the lagoon resource stock depletion are related to watershed mismanagement (particularly the failure to involve stakeholders in development), and overfishing, destructive fishing methods, increased seafood demand to meet household needs, and changing values in the fishing industry. While former generations used environmentally sound fishing methods, younger people appear to be gradually losing their regard for nature and are adopting a more utilitarian approach to resources as a means of purchasing consumer goods. They also appear less knowledgeable about managing resources. The fact that communities do not own lagoon resources, which the public therefore has access to, is also seen as one of the causes leading to the resource damage. Urban sprawl along coastal areas and, more generally, public policy driven more by development than management are yet additional factors contributing to lagoon resource depletion. Climate change, however, is at the top of the list of dangers thought to be the most serious for Polynesian countries.

In order to deal with these trends – spanning many years now – Polynesian countries have adopted a variety of coastal resource management strategies, and the most conclusive so far have been those that fully involve fishers. The term "conclusive" refers less to scientific evidence that stocks are statistically on the rise than to a perceived improvement in resource status according to local managers, after developing local management measures and effective implementation by the communities involved. Legal frameworks for the co-management of resources have been developed in Samoa, Tuvalu, American Samoa, Tonga and New Zealand. Samoa has introduced a community fisheries management programme that currently involves some one hundred villages. Tonga has set up 27 special management areas, while Tuvalu has introduced locally managed marine areas on four different islands, and New Zealand has set up mataitai (customary fishing) reserves. Management in all cases is exercised under a partnership between the governments and communities, with governments adjusting their legal frameworks so that local communities can manage their resources, take part in enforcing the rules they have agreed to, and sometimes, as in the case of Tonga, even restrict access by neighbouring communities to managed areas. In French Polynesia, Hawaii and the Cook Islands, community management is still highly informal and practised on remote islands, such as Rapa in French Polynesia or Mangaia and Pukapuka in the Cook Islands, where the traditional resource management method, *rahui*, is used outside any legal framework.

Against a backdrop of increasing pressure and the declining influence of traditional leaders near urban and other developing areas, countries such as French Polynesia are searching for management methods that are relevant to the country's development context and are manageable by its administrative resources. French Polynesia, to a greater extent than its neighbours, has inherited a highly-centralised management system that does offers little opportunity for non-government players to take part in managing lagoon resources. Because French Polynesia does not have the staff required to implement such a centralised policy, with the Department of Marine and Mining

Resources having fewer than five dedicated lagoon management officers for a territory comprising 118 islands and 15,000 km² of lagoon, the country is lagging behind in terms introducing lagoon resource management measures at a time when resources are becoming increasingly scarce near areas under population pressure. During a regional workshop held on Tahiti from 10–13 April this year under INTEGRE,[1] French Polynesia learned from lagoon fisheries participatory management experience spanning the last 20 years in some parts of Polynesia, including American Samoa, Cook Islands, Hawai'i, New Zealand, Rapa Nui, Samoa, Tonga and Tuvalu, as well as in Chile, Fiji, and New Caledonia.[2] The meeting was attended by 60 participants who provided a broad outline for implementing management that was more inclusive of fishers across French Polynesia.

Overall, French Polynesia needs to decentralise management as much as possible, formalise the community management approach to make it more accessible and attractive to fishers and community members, and overhaul regulations. In terms of implementing participatory fisheries management on the ground, four major stages were outlined, each with its own challenges, and requiring the most pragmatic solutions possible.

1. *Defining stakeholders or the community*

   The crux of good resource management is managing communities, which raises two subsets of challenges: first, managing activity-, gender- and age-representativeness and authority; and, second, the "community's" connectedness to the environment it wishes to preserve or protect, as traditional social structures give way to modern lifestyles. It would appear necessary – in terms of influence and community involvement, reaching beyond the bounds of fisheries – to use existing structures such as associations and churches and to rely on local government authorities, to opt for a volunteer approach, and, finally, to identify other incentives.

2. *Planning*

   This challenge involves defining the objectives and actions by using the right method and the right tools. Simplicity and repeatable models should be aimed for, drawing inspiration from what has been done elsewhere. Thought should be given to the cost of participatory management in terms of people and time. Local culture and traditional knowledge must be integrated into the selected management options. French Polynesia's Department of Marine and Mining Resources must build capacity, both quantitatively (number of positions) and qualitatively (social science skills for consultation and awareness). The role of local government must also be formalised and strengthened for the consultation process. Whether work needs to be contracted out, at least in the early stages, with help from regional bodies or non-governmental organisations, must also be discussed.

Fakarava Atoll, Tuamotu Islands, French Polynesia (image: © Julien Girardot)

3. *Implementation*

   The main challenge is setting a limit – based on community commitment and skills and on the government's human, financial and regulatory resources. The sine qua non of successfully implementing

[1] INTEGRE (Pacific Territories Initiative for Regional Management of the Environment) is a joint sustainable development project involving four European Pacific overseas countries and territories (OCTs): New Caledonia, Pitcairn, French Polynesia, and Wallis and Futuna. It is funded under the 10th Regional European Development Fund and implemented by the Pacific Community.

[2] The workshop was also co-funded by the French government through the Pacific Fund.

participatory integrated management is to take a pragmatic approach based on the progress made in acquiring capacities ("start small"). Implementation must be based on representative management committees with accepted terms of reference to ensure that decisions are transparent, information is passed on, and local stakeholders are involved in the monitoring work. Participatory management implementation must go hand in hand with awareness training, which can become easier as success stories emerge that can generate enthusiasm for duplicating them.

4. *Monitoring, assessment and adaptation*

Here, the key is keeping to essentials and not trying to cover everything. The challenge is involving local stakeholders and being effective and transparent through participatory monitoring that is neither time-consuming nor a drain on resources, but based on assessing governance and on the perception of the state of resources and benefits, using Fiji's Locally Managed Marine Area network model. More elaborate forms of monitoring are also relevant, but cannot be developed on a large scale.

5. *Networking*

The challenge here is to change the scale. The network does not matter much if there are not many sites, but as more are managed, networking becomes a solution for improving information flow, peer-to-peer training of managers, creating positive emulation for better resource management, and even having a greater influence on fisheries management policies. This has been demonstrated by the Locally Managed Marine Area network in Fiji that now covers more than 300 partner-villages working together towards food security for the community and future generations.

By implementing these solutions drawn from the experience of their Polynesian neighbours, French Polynesian authorities will be required to delegate some of their powers to local stakeholders in a relationship based on trust that must be developed. This is no minor change, but it has been made by neighbouring countries and has resulted in highly significant improvements in lagoon resource management. It should support local communities in the management options they choose to pursue by fostering local initiative, adapting to local practices and organisation methods, and involving stakeholders in producing regulatory frameworks. It should also create opportunities by introducing adaptive legal frameworks and fostering discussion and decision-making forums. Also, all stakeholders' facilitation, consultation and information sharing capacities must be strengthened.

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Training in coastal fisheries monitoring

In the Pacific Islands region, the need for nearshore fish aggregating devices (FADs) to facilitate access to tuna and other oceanic fish resources is particularly important where coral reef areas are damaged or do not have the capacity to provide enough food for a rapidly growing population. The Public Health Division of the Pacific Community (SPC) recommends 35 kg of fish per person per year. This need has been recognised by the Government of Fiji for several years, and a national FAD programme has been put in place.

A data collector is using Tails[1] to record catch data from a fishing trip (image: Phil James, SPC).

A fisheries project, funded by the Asian Development Bank, is being implemented in Fiji's Ra Province in the Western Division, jointly by SPC and Conservation International. The project has a significant monitoring component, the purpose of which is to understand the impacts of FADs in facilitating access to new fisheries resource for Ra Province, including identifying any impacts on household consumption and livelihood activities.

In April 2017, SPC's Fisheries Economist, Phil James, and Data Analyst/Trainer, Andrew Hunt, trained seven community data collectors, two fisheries officers and one regional officer in using Tails[1] – a web application developed by SPC for smartphones and tablets – to facilitate the recording and transfer of coastal fisheries catch data and in household survey techniques. Monitoring will continue until December 2017.

Six of the major fishing villages in Ra Province were selected for monitoring, plus the main landing site. In February 2016, coastal reefs throughout the path of Cyclone Winston were severely impacted by the rough sea conditions generated. Climate change is expected to result in more cyclones, and warming ocean temperatures will negatively impact coastal reef health and fish stocks. Current fishing activities in Ra Province target coastal resources such as reef fish and sea cucumbers. The deployment of FADs offers an opportunity to access pelagic fish species, such as tuna, and provide a wider range of options to fishers in Ra.

Fish catch and effort data will be recorded using the Tails application for artisanal tuna collection and, as far as possible, species level data will be collected. Data will be reported back monthly to the communities via tablets and printed posters, thereby helping to empower communities to make informed decisions about the use of their resources. Data will also contribute to the regional understanding of the impact of FADs on coastal fisheries and livelihoods.

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[1] See: www.spc.int/DigitalLibrary/Doc/FAME/InfoBull/FishNews/149/FNL149.pdf)

Raising the profile of coastal fisheries and aquaculture governance in the Pacific

In the Pacific Islands region, coastal fisheries provide the main source of protein (50–90%) for coastal communities and the primary or secondary source of income for up to 50% of households. Coastal resources, however, are finite and there is growing evidence that overfishing is occurring, especially for finfish around main urban centres, and many countries have closed their sea cucumber fisheries due to overexploitation. In addition, a major concern for the region is the growing human population, which is expected to increase 50% by 2030, and the associated added pressures on already heavily fished coastal resources.

In March 2015, SPC hosted a major workshop on the "Future of coastal/inshore fisheries management", which produced "A New Song for Coastal Fisheries – Pathways to Change".[1] The New Song highlights eight key outcome areas, all focused on strengthening coastal fisheries management, policies, legislation and availability of information. The New Song was endorsed by the Heads of Fisheries in March 2015, the Forum Fisheries Officials in May 2015, and the Forum Fisheries Ministers meeting in July 2015. The New Song sets the direction for SPC, donors and other partners to deliver on priorities agreed on by Pacific Island countries and territories (PICTs).

In addition, "A Regional Roadmap for Sustainable Pacific Fisheries" has been developed by FFA and SPC with input from PICTs. The Roadmap sets out a range of goals, indicators and strategies for both oceanic and coastal fisheries, with the coastal component well aligned to the New Song. The Roadmap was endorsed by Forum Fisheries Officials (May 2015), Forum Fisheries Ministers (July 2015), and Pacific Island Forum Leaders (September 2015).

To assist PICTs with responding to and achieving the outcomes in the New Song and the Roadmap for Sustainable Pacific Fisheries, the Coastal Fisheries Programme (CFP) within SPC's Division of Fisheries, Aquaculture and Marine Ecosystems (FAME), through extensive stakeholder consultations with key partners such as the Food and Agriculture Organization (FAO) the Pacific Islands Forum Fisheries Agency (FFA), the New Zealand Ministry for Primary Industries (MPI) and SPC member countries, developed a project to address coastal fisheries governance priorities. The project is funded by New Zealand's Ministry of Foreign Affairs and Trade (MFAT) and focuses on strengthening governance structures and processes, specifically legislation, policy and monitoring, control, surveillance and enforcement (MCS&E), which are very weak for coastal fisheries and aquaculture. In strengthening governance, the project will contribute to the enhancement of food security and sustainable livelihoods for the future. This is a milestone project in that for the first time since its establishment, SPC's FAME can offer technical capacity to its member countries in coastal fisheries and aquaculture legal advice, and MCS&E-related assistance.

Three staff members were recruited under the coastal fisheries governance project: 1) a Coastal Fisheries and Aquaculture Management and Policy Specialist, 2) a Coastal Fisheries and Aquaculture Legal Adviser, and 3) a Coastal Fisheries and Aquaculture MCS&E Specialist.

Ian Freeman joined SPC in January 2017 as the MCS&E Specialist after spending the last six years at FFA in Honiara, Solomon Islands. He worked at FFA as a Fisheries Management Adviser on offshore tuna fisheries and this involved development and implementation of tuna plans and policies for most of SPC's Pacific Island members. This experience has provided Ian with a fundamental understanding of the cultural importance of fisheries and its critical role in the community.

In his role as the MCS&E Specialist, he will work with the other project team members and regional partners (FFA and MPI) to provide technical support and MCS&E advice to fisheries departments at the national and subnational level. This will involve working within government processes, including stakeholder input, to develop resources and capacity in coastal fisheries and aquaculture MCS&E at the national and subnational level in collaboration with FFA, MPI and other stakeholders.

The initial focus of his work will be overseeing the development of regional training modules specific to coastal fisheries and aquaculture MCS&E, in collaboration with FFA and MPI, to complement the training modules they have developed for tuna fisheries. When finalised, Ian will work with staff from FFA and University of the South Pacific to have the course and its materials accredited as a recognised training course.

Ian will also develop specific training materials for individual countries based on their needs through stakeholder consultations, taking into account gender, culture and human rights needs in the country. Activities will be coordinated with other partners, such as MPI and FFA, to ensure collaboration and prevent duplication.

[1] The New Song is a policy document that calls for an enhanced focus on coastal fisheries management and related development activities in the Pacific Islands region. See: http://www.spc.int/DigitalLibrary/Doc/FAME/Reports/Anon_2015_New_song_for_coastal_fisheries.pdf

Ian Freeman (image: Jipé Le-Bars, SPC)

Ariella D'Andrea (image: Jipé Le-Bars)

Jason Raubani (image: Jipé Le-Bars)

In January 2017, Ariella D'Andrea joined SPC as the Coastal Fisheries and Aquaculture Legal Adviser in support of the governance team. Her main role is to assist national and subnational governments in reviewing and updating coastal fisheries and aquaculture legislation, in line with national and regional policies and international commitments. She will be able to provide assistance in both English and French.

Ariella has extensive experience in reviewing and drafting legislation in support of sustainable fisheries, aquaculture and water resources management. A member of the Rome Bar, she has been providing legal assistance to governments in 54 countries worldwide over the past 15 years. Ariella has worked for many years with FAO and, more recently, with other organisations and firms at the regional and international level.

As legal adviser at SPC, Ariella will offer her expertise to PICT governments in developing national and subnational laws and regulations aimed at countering illegal, unreported and unregulated fishing activities in coastal waters, particularly by enhancing community-based fisheries management, as set out in the objectives of the New Song. The focus taken will be reflective of an ecosystem approach, cognizant of the main human rights and gender issues involved.

Active support from national and subnational authorities, and participation of all relevant stakeholders in the normative process, are crucial to the success of any legal reform. For this reason, the assistance provided will include a prior review of the existing legal and institutional framework, stakeholder consultations to discuss and validate the proposed texts, and legal training where needed. Her assignments will be carried out in collaboration with all relevant partners in the region, including FFA, FAO and MPI.

Jason Raubani is the Coastal Fisheries and Aquaculture Management and Policy Specialist. Before joining the project team in October of 2016, Jason was Director of the Vanuatu Department of Environmental Protection and Conservation, and long-time Vanuatu Fisheries Department Policy Officer.

In Vanuatu, Jason accumulated a wealth of experience in policy review and development at both the national and subnational level, including reviewing and drafting several community and fisheries management plans, the Vanuatu national fisheries sector policy and implementation plan, and the Vanuatu national environmental policy.

Jason will lead the implementation the project output related to the review, update and development of fisheries policies and management plans. This output links directly to one of the short-term outcomes of the project, which is for PICTs to have improved and robust policies and management plans at the national and subnational level.

One of the key goals of the project is to ensure long-term continuity of its benefits at the national and subnational level. Jason's role will, therefore, also focus on capacity development, training and mentoring in policy and management plans. The review, update and development of policies and management plans will be driven by national authorities.

As a regional organisation, SPC will provide through this MFAT project the technical and expert inputs and assistance to support government action at the forefront of sustainable management of coastal fisheries and aquaculture in the Pacific.

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What is aquatic biosecurity, and what is its relevance for the Pacific Islands region?

Nile tilapia being fed in Papua New Guinea. Nile tilapia (*Oreochromis niloticus*) is an exotic species that has become an important commodity of the aquaculture sector in the Pacific Islands region, contributing to food security in several countries and territories. Nevertheless, new imports of Nile tilapia strains should be carried out following basic biosecurity measures to minimise biosecurity risks (image: Ruth Garcia Gomez).

The Aquaculture Section of SPC's Fisheries, Aquaculture and Marine Ecosystem Division of has recently launched a new aquaculture-related project funded by New Zealand called "Sustainable Pacific aquaculture development for food security and economic growth". As a novelty for the Aquaculture Section, this project has a component dedicated to "aquatic biosecurity", which sounds like a very abstract word, but which has very practical and real implications for the Pacific Islands region. Aquatic biosecurity could be defined as a set of standardised protocols and measures to deal with biological risks in aquatic environments, such as the risk of pathogens (causal agents of animal diseases and plant pests) and the risk of invasive species. Appropriate aquatic biosecurity measures and protocols should minimise the introduction, spread and impact of the aforementioned biological risks.

Some of the better-known aquatic biosecurity measures are quarantine, health certification, import and export requirements, disease prevention and surveillance. Aquatic biosecurity requires a holistic and very proactive approach by different institutions, agencies and other key stakeholders at the national, regional and international levels (e.g. including quarantine, biosecurity, customs, agriculture, fisheries, aquaculture, farmers, exporters).

Because the aquaculture sector in the Pacific Islands region is growing, the need to streamline aquatic biosecurity measures is becoming more important for countries. Actually, since the beginning of the project in July 2016, SPC's Aquaculture Section has received official requests for the provision of technical assistance on aquatic biosecurity from 12 countries and territories, which indicates the current interest on the topic, and highlights the existing needs of the region.

It should be noted that, while the aquaculture sector contributes to improving food and nutrition security, and increasing livelihoods within the region, most aquatic animals successfully cultured in the region are introduced or are exotics (e.g. Nile tilapia, common carp and blue shrimp), and new species introductions are being pursued for further aquaculture development. Furthermore, aquatic animal diseases are a significant threat to the sustainability and productivity of aquaculture in the region, which is known for its high aquatic animal health standards.

As a first step to improving the capacities of countries and territories on aquatic biosecurity and to develop a common understanding of the term, the Aquaculture Section has conducted a subregional training workshop on aquatic biosecurity planning for a number of Pacific Island countries at SPC's headquarters in Noumea. The workshop was held from 24 to 28 April, and included a visit to the New Caledonian Technical Aquaculture Centre based in Boulouparis, and a visit to the National Veterinary Laboratory in Port Laguerre.

Nineteen quarantine, biosecurity and aquaculture officers from Cook Islands, Fiji, Federated States of Micronesia, Marshall Islands, Papua New Guinea, Samoa, Solomon Islands, Tonga and Vanuatu attended the training workshop. The training placed special emphasis on the following topics: import risk analysis for live aquatic organisms; import requirements for live aquatic organisms; quarantine operations and facilities for live aquatic organisms; guidelines for certification and inspection of quarantine facilities for live aquatic organisms; health certification; and emergency preparedness.

Furthermore, a full day of the workshop was devoted to building the capacities of participants on the official reporting to the World Organisation for Animal Health (OIE) on the national status of aquatic animal diseases – diagnosis, surveillance and official reporting – in order to raise awareness of the requirements covering all matters under the OIE.

During this subregional training workshop, country delegates also had the chance to exchange ideas about aquatic animal health management, and assess the components that could be part of their respective national aquatic biosecurity strategies. Moreover, steps for implementing these strategic components were assessed and defined.

Post-larvae of white-leg shrimp (*Penaeus vannamei*) imported from Thailand to Vanuatu being quarantined to minimise biosecurity risks. (image: Ruth Garcia Gomez, SPC).

The training was also used to identify key gaps in aquatic biosecurity implementation in island countries. While gaps are many and varied, workshop delegates identified opportunities to address them and improve aquatic biosecurity management strategies, taking into account the diversity and complexity of the region.

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Participants to the SPC Aquatic Biosecurity Planning Workshop came from nine different Pacific Island countries (image: Jipé Le-Bars, SPC).

A young scientist studies marine biodiversity of the open ocean

A few months ago, Aurore Receveur began work on her doctoral thesis, which was designed to study the biodiversity of pelagic ecosystems in the southwestern Pacific. She is carrying out her study within the Fisheries and Ecosystem Monitoring and Analysis Section of the Pacific Community's (SPC) Oceanic Fisheries Programme, and the French National Research Institute for Sustainable Development (IRD) in Noumea, New Caledonia, as part of the Biopelagos Project. This work supports SPC's commitment to encouraging young people, particularly young women, to engage in careers in science and technology. This article, written by Aurore, explains her work's background and the various avenues of research being developed.

Biopelagos Project

Pressures on pelagic ecosystems caused by human activities (e.g. resource overuse, global warming, pollution, biodiversity erosion) are rapidly increasing. They affect the composition of marine organism communities and, via trophic interactions between species, the dynamics and functioning of marine ecosystems (González Carman et al. 2016; Irigoien et al. 2014). Analysing the various biological components of such food webs would provide a better understanding of how marine communities are organised and their dynamics and, in that way, make it possible to study responses to the threats and disturbances that those ecosystems are facing.

This realisation gave rise to the Biopelagos Project, whose overall goal is to gain a better understanding of the diversity and structure of the pelagic ecosystems in New Caledonia and Wallis and Futuna. This European-Union-funded project (BEST 2.0 programme) is designed to provide decision-making support to both territories, with a view to ensuring better biodiversity and pelagic ecosystem management. The project, which began in June 2016, has been implemented through a partnership between SPC and IRD-Noumea, and is scheduled to end in June 2019. The project includes a section on acquiring new knowledge via surveys at sea, tagging marine birds, and genetics; a capacity-building component with, in particular, student training, including my thesis; and a knowledge summary and feedback component. This article explains the work to be done over the next three years as part of my thesis.

Micronekton

Micronekton are a vital part of marine ecosystems because they serve as food for top-level predators and, in that way, form the link between the physical environment and higher-level organisms in the food chain, such as tuna and seabirds (Fig. 1) (Bertrand et al. 2002). Micronekton are composed of organisms that can swim (e.g. small fish, crustaceans and molluscs) and are less than 20 cm long.

Currently, very little information exists about micronekton and their interactions with predators. So, it is vital to study the role these organisms play in open-ocean marine ecosystems so as to understand the distribution of top-level marine predators such as mammals (whales, dolphins), seabirds and tunas.

Given the key role this trophic group plays in the food chain, it is necessary to increase our knowledge about it, first by better describing micronekton distribution and diversity. The second part of this study will focus on the link between micronekton distribution and that of top-level predators (e.g. tuna, seabirds and whales). The final part will be spent producing decision-making tools to assist governments; for example, biodiversity maps that could help identify zones where priority should be given to management and protection efforts.

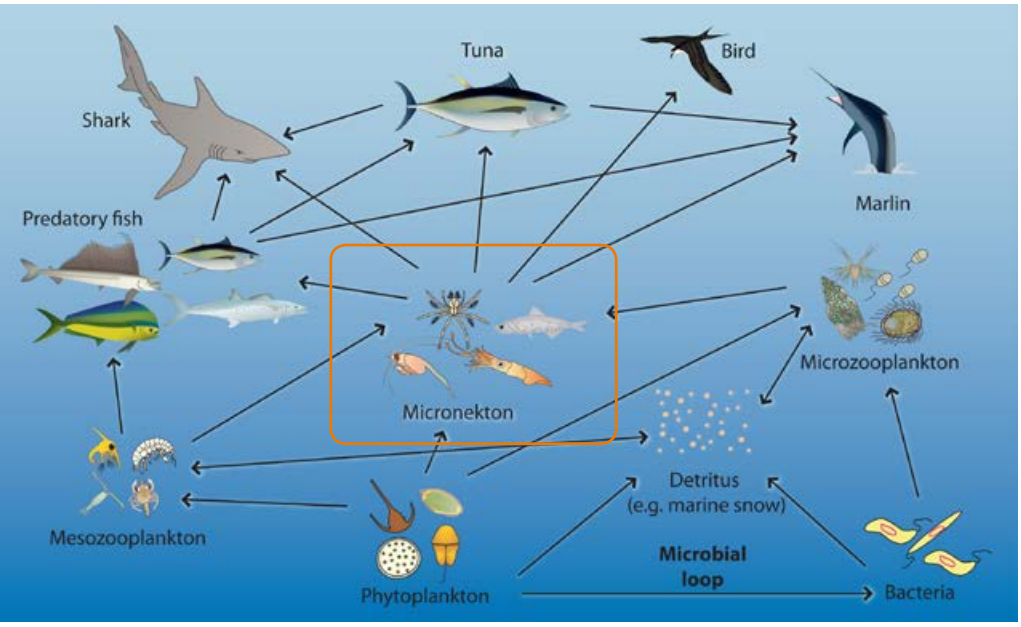

Figure 1. Diagram of the pelagic ecosystem with the micronekton compartment in the orange box (illustration: Jipé LeBars, SPC).

Compiling existing data on pelagic ecosystems

Since 2011, IRD and SPC have been conducting surveys at sea in New Caledonia's exclusive economic zone (EEZ) in order to study micronekton. These surveys have already been reported on in previous issues of the *SPC Fisheries Newsletter* (Allain 2011; Allain and Menkes 2015; Allain and Vourey 2017), but presently, no overall examination of all the surveys has been done. So, my first job will be to compare all of the data gathered since 2011.

The survey routes and periods were selected to optimise grid-wise searches of the EEZ and to cover the various seasons (hot and cool) (Fig. 2). In 2018, a survey at sea will also be carried out in Wallis and Futuna. All of these surveys will be conducted onboard the F/V Alis, IRD's research vessel (Fig. 2 – top), and will collect a wide range of data on micronekton and local oceanographic conditions.

1. Micronekton diversity and distribution

Because this trophic level is still poorly known, the goal is to characterise both micronekton distribution and its diversity. In order to study micronekton diversity, organisms need to be sampled using a pelagic trawl (Fig. 3 – left). The net is positioned at a certain depth in the water column and dragged behind the ship for about 30 minutes. The net is then brought back onboard and the specimens caught are collected and identified (Fig. 3 – right). Figure 3 shows a diverse range of organisms brought up by a trawl net.

An echo sounder is used to characterise micronekton distribution. The echo sounder is located under the ship's hull and sends sound waves into the water column (Fig. 4). Those waves reflect all objects whose density differs from the water's (e.g. living organisms or the seafloor). Through the time needed for the wave to come back to the boat and the reflected acoustic intensity, the position of the

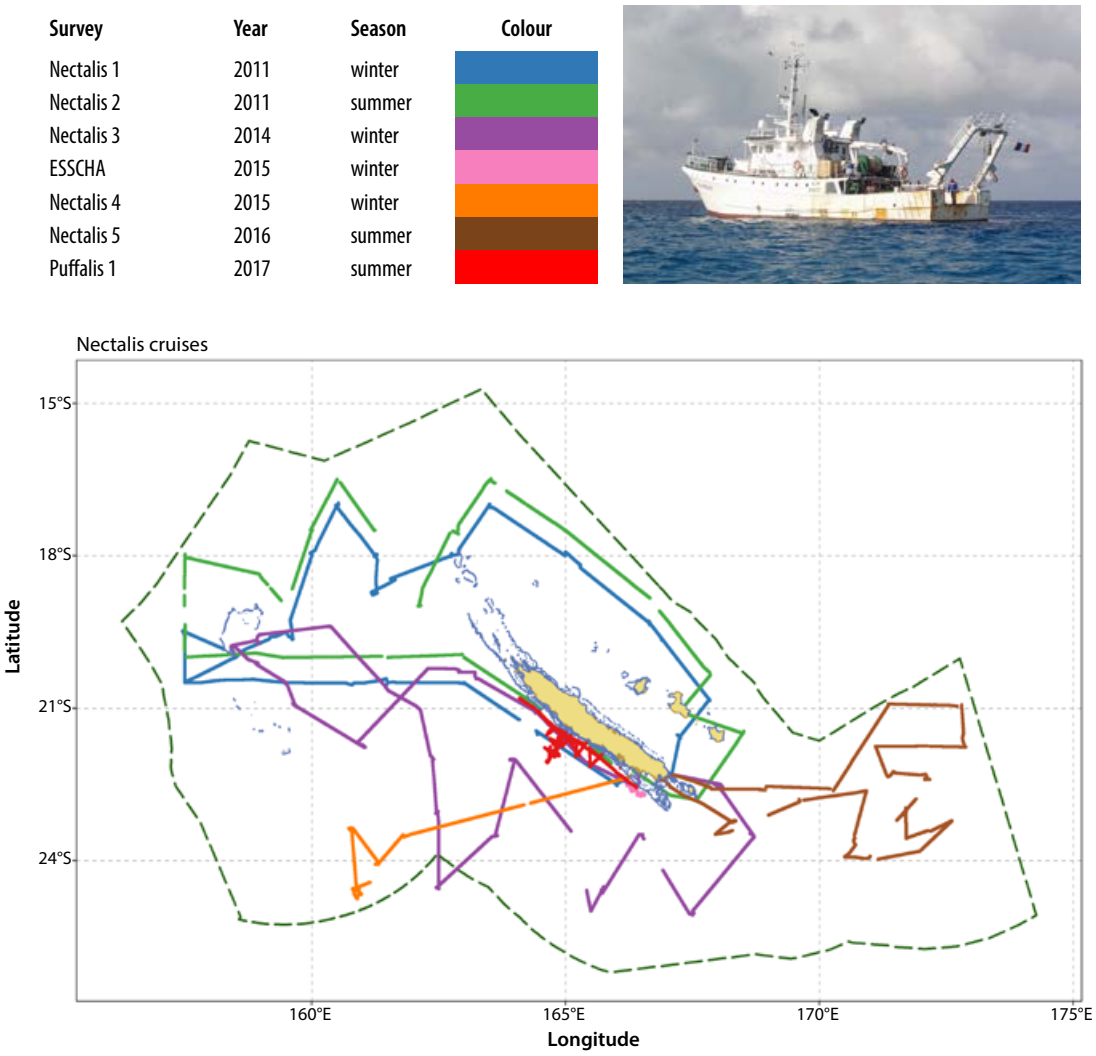

Figure 2. Sampling campaigns with, on the top left, a summary chart; on the top right a photo of RV *Alis*, IRD's research vessel; and below a map of the routes within New Caledonia's exclusive economic zone.

Figure 3. Micronekton sampling with, at left, the pelagic trawl used on the RV *Alis* and, at right, a micronekton sample with deep-sea fish, shrimp and a squid (images: Valérie Allain, SPC).

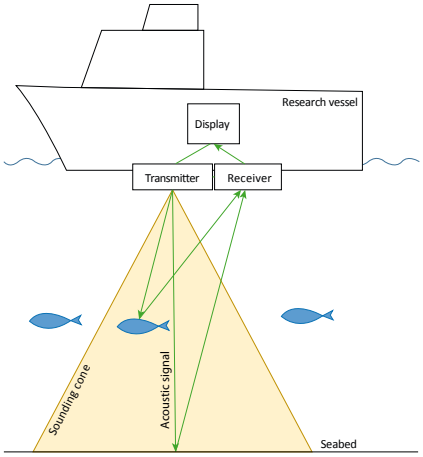

Figure 4. Illustration of an echo sounder and its search cone in the water column (illustration: Aurore Receveur, SPC).

object detected in the water column can be determined and its volume estimated. By choosing the frequency sent out by the echo sounder, it is possible to target organisms that correspond to micronekton. The data are shown on the echogram, which displays the intensity of the objects detected by sound, based on depth and time (Fig. 5). The echogram shows higher acoustic intensity at the surface (0–100 m) at night, and higher acoustic intensity deeper down (500–700 m) during the day. During the day–night transitions, the layers of high acoustic intensity move vertically in the water column. These vertical day–night migrations have been reported and described in the literature. One of the objectives of my thesis is to study the vertical migrations more in-depth, by calculating, for example, the speed of ascent or descent of these migrations, and characterising the layers in comparison to the data from the trawl net.

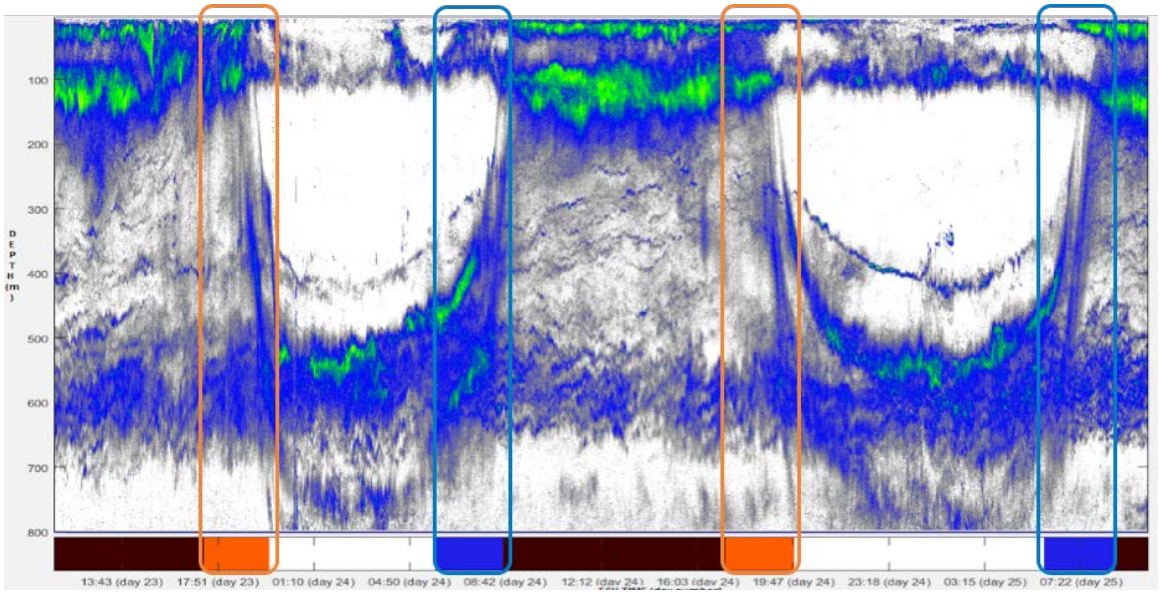

Figure 5. Two days of acoustic recordings called an echogram. On this echogram, the horizontal axis stands for time and the vertical one for depth from the surface (top) to 800 metres (bottom). The colours on the echogram show the acoustic intensity: green for very high acoustic intensity, blue for medium acoustic intensity and white for very low acoustic intensity. And the colour bar underneath the echogram shows the time of day: black for night, orange for sunrise, white for day and blue for sunset. Transition phases are encircled by their respective colours (image: Aurore Receveur, SPC).

After looking at the vertical distribution of the micronekton, I will look at its horizontal distribution. To do that, I will average the acoustic intensity over the water column and look at how that average is distributed over the EEZ (Fig. 6 – top). It is possible to extrapolate that figure over a regular grid to gain an understanding of micronekton distribution throughout the EEZ (Fig. 6 – bottom). Initial observations have already clearly shown a north–south difference with, on average, more micronekton in the south. It will be interesting to see if there are micronekton concentrations around seamounts (Morato et al. 2010) or if distribution changes according to season. In order to be able to more accurately predict distribution in the EEZ, it will have to be studied in relation to environmental factors.

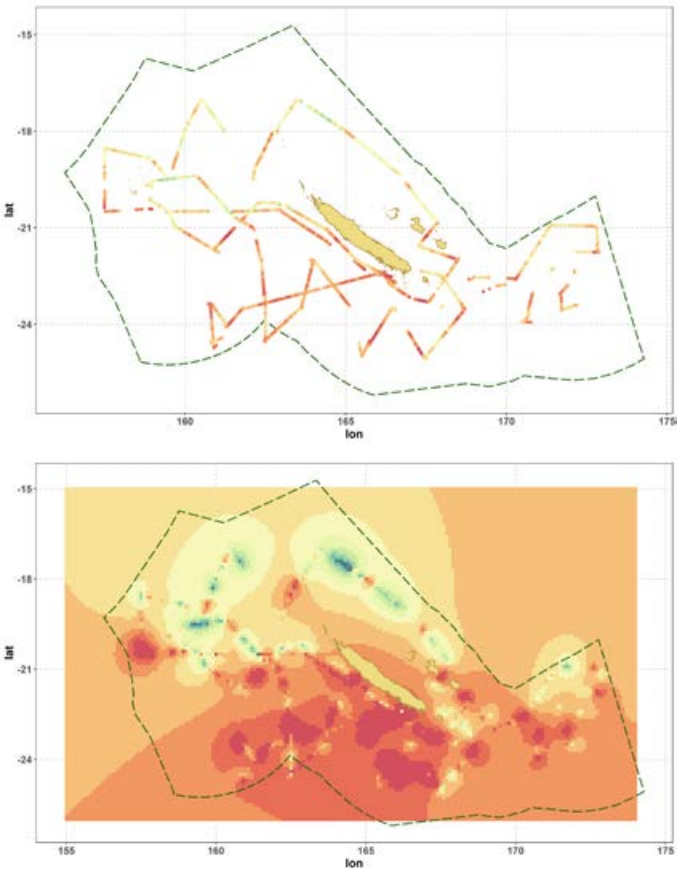

Figure 6. Average acoustic intensity of micronekton in the water column along the routes of all the surveys in New Caledonia's EEZ (top) and extrapolation over a regular grid for the EEZ as a whole (bottom). Blue shows low quantities of micronekton and red high quantities.

2. Physical oceanography

The surveys' second objective is to link acoustical information to oceanographic data. The main interest of establishing a relationship between micronekton and its physical environment is to be able to extrapolate micronekton distribution in those zones for which we only have data on the environment. If we could correlate mikronekton abundance to environmental factors, then we should be able to predict mikronekton abundance using oceanographic data that is available via models or satellite imagery. During the surveys at sea, oceanographic data are collected via probes on a rosette – a device used for water sampling in deep water (Fig. 7). The rosette also collects water at different depths when it descends into the water column in order to describe water chemistry and phytoplankton. Those data provide information on the vertical oceanographic structure, such as temperature, salinity, oxygen levels or fluorescence profile. By comparing those physical oceanographic profiles to the vertical profiles for micronekton, it will be possible to learn which environmental variables control the vertical distribution of micronekton. We also have access to model and satellite data, which have the advantage of covering the entire zone evenly and so, will be useful for extrapolation.

Figure 7. The rosette used on the RV *Alis* for water sampling (image: Florian de Boissieu, IRD).

3. Top-level predators

The third section of the project will involve joint analysis of prey distribution together with the distribution of top-level predators that come to feed on those prey. The ultimate goal is to quantify the degree to which food availability affects the distribution of three groups of predators: tunas, whales and seabirds. The information available for each group differs.

For tuna, I will use catch-per-unit-effort data as an abundance index. Onboard observer data will also be used for the bycatch diversity aspect. In those zones where fisheries data are limited, such as Wallis and Futuna's EEZ, I will use the SEAPODYM model (Lehodey et al. 2008; Receveur et al. 2016), which makes it possible to predict tuna abundance in a given zone based on the environment.

For whales, in 2014 the French Marine Protected Areas Agency (now called the French Biodiversity Agency) funded a flyover of the two EEZs (Fig. 8) in order to do a marine mammal census (Laran et al. 2016) conducted by the PELAGIS Observatory, under the umbrella of the French National Center for Scientific Research (CNRS) and the University of La Rochelle. That campaign (REMMOA) led to the production of maps showing relative abundance in both EEZs (Fig. 9) that I will use.

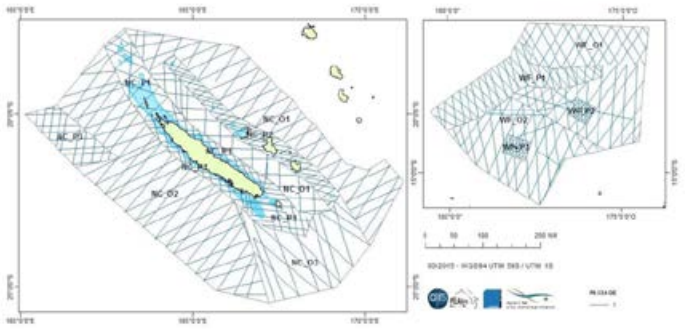

Figure 8. Sampling plan of the flyover for the REMMOA expedition (2014) in New Caledonia (left) and Wallis and Futuna (right) for observing whales, large pelagic organisms and seabirds (figure reproduced from Laran et al. 2016).

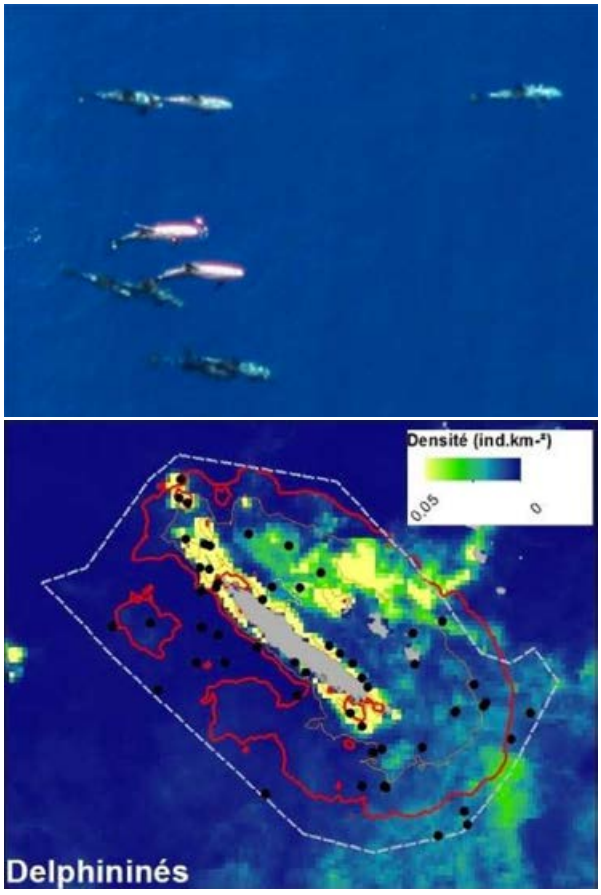

Figure 9. An example of a Risso's dolphin observation recorded during the REMMOA expedition (top) and an abundance map produced with all the observations made for Delphininae (bottom), with heavy abundances in yellow and low ones in blue (figure reproduced from Laran et al. 2016).

Finally, seabirds also eat micronekton. Given that their way of getting around and their feeding strategies differ greatly from other marine predators, it is supposed that the distribution of their prey has a different effect on seabirds. It is more complicated to make abundance estimates for seabirds; therefore, their behaviour will be studied via a GPS tracking unit. For the moment, efforts are focused on the wedge-tailed shearwater (*Ardenna pacifica*), and a team of IRD scientists have attached GPS units to these birds (Fig. 10).

During their breeding period, seabirds return to land on a regular basis (every one to five days) to feed their chicks. So, it is quite simple to find the birds that have been equipped with the GPS units and recover the equipment units and valuable data recorded on them (e.g. the bird's position, altitude and speed). Initial data indicate that some seabirds stay close to their colonies (Fig. 11, orange route), while other seabirds leave for several days to travel to the west and northeast of New Caledonia (Fig. 11, blue and green routes). Currently, about 50 seabirds have been been fitted with GPS units.

Figure 10. Photos of a shearwater and the GPS unit glued to the animal in the Pindai colony in New Caledonia (images: Karen Bourgeois)

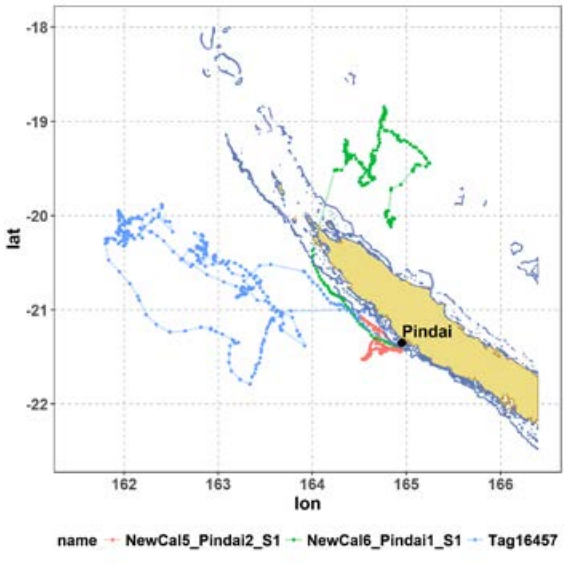

Figure 11. Example of three shearwater flight paths over New Caledonia's EEZ.

Micronekton abundance maps (Fig. 6 – bottom) will be compared to the distributions of top-level predators or with seabird feeding zones. Among other things, this will make it possible to identify biodiversity hotspots, which could assist in selecting new marine protected areas or to better manage fishing boats in those areas.

Finally, the goal is to describe the vertical and horizontal distributions of micronekton in the pelagic ecosystem, and to describe its interactions with other key trophic groups. This study will provide a better picture of the pelagic ecosystem as a whole. The data used and the interactions studied during the project are shown in Figure 12.

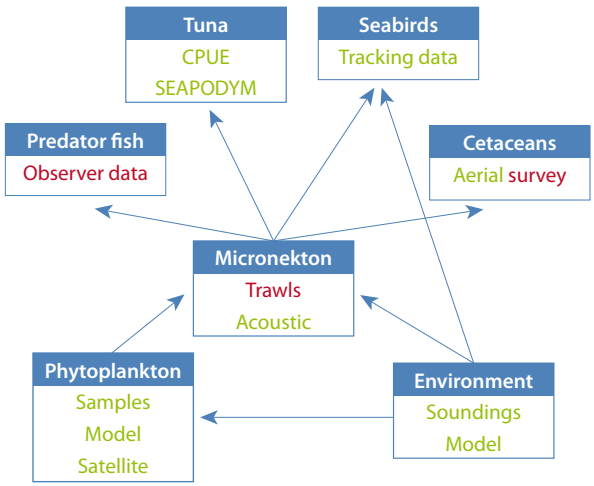

Figure 12. Summary of the data available for the New Caledonia exclusive economic zone study and some of the interactions that will be studied. Data in red will be used to study diversity and data, while those in green will be used to study the distribution and dynamics aspects (note: aerial survey data will serve both purposes).

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Outcomes of the 10th SPC Heads of Fisheries Meeting

The 10th Heads of Fisheries (HoF) Meeting took place at SPC Headquarters in Noumea, New Caledonia, from 14 to 17 March 2017. It was chaired by Luisa Naseri-Sale, Senior Policy Advisor at the Department of Economic Development, Natural Resources and Environment in Tokelau.

Fishing for dinner in the Solomon Islands. As noted by HoF10 participants, the importance of coastal fisheries resources to Pacific Island people is often underestimated (image: ©Francisco Blaha).

HoF is a regional meeting of the heads of SPC member country and territory fishery agencies, or their appointed deputies, covering the entire range of interests for which they have responsibility and on which the SPC Division of Fisheries, Aquaculture and Marine Ecosystems (FAME) provides advice and assistance. Other participants include representatives from other Council of Regional Organisations in the Pacific agencies, non-governmental organisations, research institutions and development partners. The HoF meeting plays a unique role in providing strategic guidance to FAME's director's office, Coastal Fisheries Programme (CFP) and Oceanic Fisheries Programme (OFP).

The following outcomes[1] constitute some the main points of consensus among delegates that the meeting felt necessary to document, in order to guide the management of the FAME work programme, draw the attention of other regional agencies and development partners, and signal agreement on issues that require attention by members themselves.

During the opening session, members noted the challenges and opportunities in considering the FAME review and progress against HoF 9 outcomes, and stressed the need to elevate the coastal fisheries profile of its various members by increasing awareness among PICT governments and funding agencies of the importance of coastal fisheries resources to Pacific Island people. Members also reaffirmed concerns over the recent recurring of "blue boat" poaching incidents occurring in the Pacific,[2] and inadequate coastal fisheries regulations and monitoring, control and surveillance (MCS) and enforcement in many coastal sectors.

Coastal fisheries

HoF recognised the importance of coastal fisheries to members, and supported enhancing the profile of CFP's work. Members recognised and encouraged CFP's ongoing focus on cross-cutting themes such as capacity building, gender, youth, human rights and climate change adaptation. They also recognised the immediate need to maintain the food security and livelihoods of coastal communities through the development of aquaculture and other sustainable marine-based alternatives.

The meeting also provided heads of fisheries with the opportunity to highlight their own needs in the area of coastal fisheries, including:

- requesting assistance in reviewing legislation to ensure improved coastal fisheries governance and MCS&E, particularly at the local and national levels;

[1] The complete list of HoF 10 outcomes, as well as all documents presented during the meeting, are available at: http://www.spc.int/fame/en/meetings/239

[2] See: http://www.spc.int/DigitalLibrary/Doc/FAME/InfoBull/FishNews/151/FishNews151_21_Blaha.pdf

- concerns with increasing incidents of coral beaching, and the broader effects of climate change (and other cross-cutting issues) in the region, and called for ongoing scientific advice and monitoring to assist with this, including re-surveying the climate change monitoring sites established in 2011–2012;
- thanking CFP for its "safety grab bag" initiative, and calling for donor assistance to expand this programme, and requesting training in the use of the equipment;
- requesting assistance with the development of policies and management plans for the aquaculture sector and in cage culture trials; and
- calling for CFP to embrace new developments and technologies to better address member concerns, specifically: 1) low-cost fish aggregation device development, 2) data collection and e-recording for small-scale fisheries, and 3) coastal MCS&E.

Oceanic fisheries

HoF participants reaffirmed their support for OFP's work in oceanic fisheries, including pelagic species stock assessments, data management, and fisheries and ecosystem monitoring and analysis, and OFP's role at the regional, subregional and national levels. They also reaffirmed OFP's role as the premier scientific advisory body for oceanic fisheries in the region.

When listing their own priorities in relation to OFP's work, HoF participants:

- supported the ongoing work of OFP in electronic data collection including electronic monitoring (EM) and electronic reporting (ER) and called for continued development of relevant tools, especially for mobile technologies, and support for on-site implementation and training in these areas;
- acknowledged the importance of the work done by observers and called for OFP to work with members to increase the quality and quantity of longline observer coverage to meet the 5% agreed coverage;
- supported the Stock Assessment and Modelling Section's move to undertaking economic analyses and modelling of tuna fisheries;
- acknowledged the transition from national tuna status reports to regularly updated national webpages, and called for further information on the national consequences of oceanographic influences and climate change on tuna fisheries;
- supported OFP's recent and on-going tagging work and requested that where feasible, tagging studies also be conducted on non-tuna species (e.g. sharks);
- called for ongoing research into the interactions between the industrial and artisanal sectors; and
- called for increased emphasis on ecosystem science.

Regional strategies

HoF members noted the process to develop draft indicators for reporting of progress to achieve the outcomes of the New Song for coastal fisheries, and the need to streamline and harmonise these with other international, regional and national reporting requirements that have fisheries components, such as the Regional Roadmap for Fisheries, and the Framework for a Pacific Oceanscape. They recommended that HoF feedback regarding fisheries indicators and data sources be fed directly into the discussions simultaneously taking place at the Pacific Regional Preparatory Meeting towards the UN Ocean Conference held in Suva, Fiji Islands.

The New Song: Progress to date, future plans, and challenges to implementation

Heads of Fisheries noted progress on the New Song and the 2015 and 2016 Coastal Fisheries Report Cards. To coordinate implementation of the Pacific Islands Forum Leaders' decision on coastal fisheries they endorsed, in principle, FAME's suggestion of establishing a regional coastal fisheries working group. In addition, SPC was encouraged to seek funding to support further work on community engagement activities, and to establish mechanisms to support skill sharing among communities and participation in coastal fisheries management.

As a strategy to engage the attention of Forum leaders, HoF members encouraged SPC to work with the Pacific Islands Forum Fisheries Agency (FFA) to share bi-annually as host of the annual officials fisheries meeting so that HoF recommendations can be more directly transmitted to the fisheries ministerial fora.

Sea cucumber fisheries

Heads of Fisheries endorsed the work being undertaken on sea cucumber fisheries by CFP's Coastal Fisheries Science and Management Section towards Component 2 of the Pacific Islands Regional Oceanscape Program: Sustainable management of coastal fisheries.

The session dedicated to sea cucumber fisheries allowed participants to:

- support recent undertakings on sea cucumber governance and value-chain analysis in Papua New Guinea by the University of Technology Sydney and partners, and recognised the applicability of the results to other Pacific Island countries and territories (PICTs);

- highlight the importance of carefully considering how to best translate the fast cash inflow brought about by sea cucumber fisheries into long-term development opportunities for coastal communities;
- express appreciation for the recent analyses of Pacific Island sea cucumber export data undertaken by WorldFish, SPC and the Australian Institute of Marine Science, and noted with interest the correlation between PICT fishery size and land area;
- note the lack of biological and economic data in most PICTs to inform the management of sea cucumber fisheries, and called for SPC's ongoing assistance with sea cucumber assessment and management, including in-water assessments, development of management plans, MCS and economic analysis;
- underscore the need for proactive regional initiatives and collaboration in addressing these issues, particularly in light of the boom-and-bust nature of the fishery, recent increases in the prevalence of "blue boat" sightings and interceptions across the region, domestic illegal, unreported and unregulated fishing and export activities, and high socioeconomic costs associated with diving accidents;
- recognise the importance of MCS&E in coastal fisheries, and in particular sea cucumber fisheries, and the need to raise this in upcoming MCS meetings; and
- highlight the need to better understand the ecosystem role of sea cucumbers in mitigating against urban sources of pollution, for example sewage associated with coastal development.

Other expressions of concern and support

HoF members:

- noted and supported the progress made by SPC's Statistics for Development Division in the development of Pacific Strategic Plan for Agricultural and Fisheries Statistics (P-SPAFS), and the increased recognition of the importance of collection of fisheries-related statistics;
- supported the move by FAME to attempt to proceed with regional harmonisation of collection of small-scale domestic fisheries data, specifically its artisanal tuna and coastal creel survey programmes, including the maintenance of minimum data standards, but called on SPC to undertake a greater examination of the positive and negative aspects involved in the initial stages of the harmonisation process;
- expressed concern that some historical data are no longer available to them and the importance of these data for future management of coastal fisheries. Therefore, they authorised SPC to look for this historical data on their behalf and supported the use of CFP for data holdings and as a repository for all forms of coastal fisheries and aquaculture data as a back-up to national systems, and supported CFP in seeking funding to undertake this activity in a full and thorough manner to recover as much historical data as possible and convert this into a useable format for PICTs in the future;
- expressed strong support for the proposal of SPC to host an expanded regional marine specimen bank, including coastal and oceanic specimens. They recommended that such a facility be used to address urgent scientific information needs around the life history of coastal and nearshore species and the region's ecosystems; and
- reaffirmed interest and commitment to a fisheries economic (coastal and oceanic) analysis for management and policy decisions, acknowledging that these decisions have wider management, livelihood and food security implications. Members also reaffirmed that fisheries economics is a priority area of work, and tasked FAME in collaboration with other regional agencies as appropriate, to seek additional funding to expand future work in and across priority activities.

The last session of the main HoF meeting was reserved for presentations made by "other organisations", including, in alphabetical order: Conservation International, the Food and Agriculture Organization of the United Nations, FFA, the International Maritime Institute of New Zealand, the Korean Maritime Institute, the Western and Central Pacific Fisheries Commission, and World Wildlife Fund.

Friday, 17 March was used to introduce new projects that had either begun in the previous six months, or likely to start in 2017. This allowed members to provide input to the work plans for these project. Several concept notes were also discussed for possible future projects so members could provide their input and support for those projects that interested them.

For more information, visit the meeting webpage at: http://www.spc.int/fame/en/meetings/239

Emergency "grab bags" save lives at sea

The successful rescue of three fishermen at sea in Tuvalu, after they set off the personal locator beacon from their emergency "grab bags", demonstrates how a relatively simple gesture and small investment in proper equipment and training can save lives.[1]

This was shared by Pacific Community's (SPC) Director-General, Dr Colin Tukuitonga and European Union (EU) Head of Cooperation to Solomon Islands and Vanuatu, Ioannis-Pavlos Evangelidis. The emergency grab bags were provided under the Development of Tuna Fisheries in the Pacific Project (DevFish2), an EU project which was implemented regionally by SPC and the Forum Fisheries Agency (FFA).

This follows a recent report by the Government of Tuvalu[2] about how the two fishermen were able to utilise their emergency grab bag equipment and training to successfully signal for help after drifting several hours at sea.

Each bag is fully kitted with a personal locater beacon (PLB), strobe light, compact medical kit, a signalling mirror and whistle, a rescue laser and sea rescue streamer, a marine handheld VHF radio, a sea anchor, three manual inflatable lifejackets, a directional compass and two emergency thermal blankets (see picture).

The DevFish2 initiative has focused on assisting small-scale fisheries development in the Pacific in recognition of the significant role of the fisheries sector for local rural community livelihoods and sustenance.

In 2015, the project supplied 30 bags to Funafuti fishers, including the one used by the two fishermen, and conducted training on the proper use and maintenance of the equipment.

Following this initial distribution of bags, UNDP through the NAPA II project and the New Zealand government through a post-cyclone Pam recovery project supported the further distribution of 128 additional bags to Funafuti and outer island fishermen.

"Small-scale fisheries are a lifeline for many Pacific Island communities and it is vital that safety at sea is observed. With the committed support of the European Union and other donors, SPC has been able to meet the practical needs of fishers to safeguard lives and livelihoods," Dr Tukuitonga said.

"The price of one fully equipped emergency bag is around USD 1,200 but its value is priceless in comparison with the cost of mobilising an air search and rescue and indeed in its ability to save a life which is what has been demonstrated here," Dr Tukuitonga added.

The emergency grab bag (image: Jipé Le-Bars, SPC).

According to SPC Fisheries Development Adviser, Michel Blanc, "The facilitation role played by the Tuvalu Fisheries Department needs to be highlighted as they ensured a fair distribution of bags between islands and importantly provided training to the bag recipients on how to be safe at sea and efficiently use the grab bag items in case of an emergency."

The emergency grab bag concept ensures that fishers and small craft operators have convenient access to basic sea safety equipment that is easy to carry and transport onto small vessels.

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[1] See a more detailed account of the rescue operations on page 20 of this issue.
[2] http://www.tuvalufisheries.tv/2017/03/fishermen-adrift-for-15-hours-and-the-convenience-of-grab-bags/

At-sea rescue made possible by the activation of a personal locator beacon

Earlier this year, two local fishing boats with failed engines were rescued by the Tuvaluan authorities on two separate occasions. Both rescues were made possible by the successful use of a personal locator beacon (PLB) – a device provided to local fishermen as part of a "safety grab bag", which includes life-saving equipment distributed by the Tuvalu Fisheries Department (TFD). The first incident occurred on Nukufetau Island on 27 February, while the second took place on 28 February on Funafuti Island.

In both instances, the boats were trolling for tuna when problems arose. In the first incident, the lone fisherman (Lonese Natano) from the island of Nukufetau drifted for more than 24 hours. In an interview with fisheries officers, Lonese, who was a sailor in his younger years, stated that the problem began on his way back to the island. The propeller on his outboard engine had become disengaged, most likely due to wear and tear, and this subsequently lead to the loss of propulsion. At this point, he was a mere 100 meters from the breakers and the sun was setting quickly.

Lonese admitted to being well aware of what the problem was but nightfall prevented any useful attempt to fix it. Realising there was little he could do other than wait until daylight, he began tying together all of the fishing lines on board together to make one very long line. He weighted the end of this line with a piece of metal that he carried onboard before dropping the line into the water. The piece of metal and fishing line acted together as an anchor and anchor rode, which was extremely helpful because it allowed him to take the time to fix his engine. With the island still within sight in the early hours of the next day, he pulled in his makeshift anchor and anchor rode and started heading back to land at a very slow speed.

But his problems were not over yet. About midday, all his fuel reserves were exhausted and the island was still at some great distance away. Without panicking, the improvised anchor and line was dropped once again. He waited patiently until 16:00, but with no luck, he decided it was time to activate the PLB that was part of the safety grab bag equipment he carried onboard. He activated it for only 15 minutes, but it was enough time for the New Zealand Maritime Surveillance Authority to receive the distress signal, and to issue an alert and warn the Tuvalu Police Department about the situation.

The Police Department requested the assistance of a local passenger boat, *Nivaga 2*, which was directed to the location of the distress signal. At 18:00, only a couple of hours after the distress signal had been activated, *Nivaga 2* found and picked up Lonese who was about three to four miles from shore.

In both incidents, the propeller was the faulty part. This picture of Lonese Natano's propeller was taken after the boat was rescued (image: Semese Alefaio, TFD).

The second incident involved two Funafuti fishermen. Semi Saaga and Foe Taalava went trolling offshore of Fuafatu, one of the Funafuti Islets, at 08:00 on 28 February 2017.

The incident began at 16:00 when they left the fishing grounds to head back home. Their outboard motor propeller broke down because their fishing line had become wrapped around the prop when they started the engine. They tried contacting help using their walkie talkie until 18:00, but got no response. They then activated the PLB from their safety grab bag. The two men agreed to take turns keeping a lookout for help while their boat drifted.

The two fishermen's families reported their failure to return to the police in the hope that the police would look for the two fishermen late that evening. By then, however, the Tuvalu Search and Rescue team had already received a message from New Zealand and was taking action. The *Te Mataili* (Tuvalu's Patrol Boat) found the two fishermen 7.5 miles away from the island at 23:00.

Safely on land, one of the fishermen described the incident and explained how handy the grab bag had been. He recommended that every fisherman should have

[1] See a more detailed account of the rescue operations on page 20 of this issue.
[2] http://www.tuvalufisheries.tv/2017/03/fishermen-adrift-for-15-hours-and-the-convenience-of-grab-bags/

Sea safety training session for fishers from Vaitupu Island, Tuvalu (image: Semese Alefaio, TFD).

These grab bags have been distributed to fishers from Nukulaelae Island, Tuvalu, after a sea safety training session (image: Tupulaga Poulasi, TFD)

one and carry it for every fishing trip, just in case of the unexpected.

For some islands, it is mandatory that a grab bag be onboard for every fishing trip, and this is being strictly enforced through the appointment of a fisheries warden in charge of regular checks.

One problem is that there are not enough grab bags for every fishing boat operator in Tuvalu. TFD, the agency responsible for the fisheries Sea Safety Program (SSP), reported that the current number of grab bags already procured and distributed to local fishermen is 168. This number represents about 44% of the total number of fishing vessels (boats and canoes) in 2016. Current grab bag donations were received from the Pacific Community (30), the National Adaptation Programme of Action (NAPA) II of the United Nations Development Programme (82), and the New Zealand Aid Programme (56).

TFD was extremely grateful for the donations, and disclosed that such donations have been a great boost to its SSP, both in terms of delivery and the positive impacts they have had in relation to search and rescue operations, as demonstrated by these two recent rescues.

Traditionally, SSP is executed through radio outreach programmes but this has changed since the introduction of grab bags, for which more practical training has been introduced. The focus of practical trainings has been on the correct use of all life-saving devices, including the grab bag, as well as basic sea safety and at-sea survival training. SSP trainings are carried out by local fisheries officers on an island-by-island basis.

In addition to addressing the issue of insufficient numbers of grab bags, TFD is hoping to improve communication between local fishing vessels and the islands. All of these efforts have direct bearing on the national search and rescue plan, which has been in draft form since November 2016 and should be finalised soon.

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New report urges management reforms to save Fiji's sea cucumber fishery

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Introduction

Sea cucumbers are one of the oldest traded commodities in Fiji, dating back 200 years (Ram et al. 2016). Due to their high economic value in China, sea cucumbers have been heavily exploited in Fiji over the past two decades (Mangubhai et al. 2017a), as they have in many other Pacific Island countries. Between 1998 and 2012, Fiji was the second largest exporter of sea cucumbers in the Pacific, and sea cucumber was the second-most valuable commodity, after tuna (Carleton et al. 2013).

In the past 10 years, Fiji's sea cucumber fishery has been evaluated in three major reports; a study made by the PROCFish project of the Pacific Community (Friedman et al. 2010), a study on the status of sea cucumber resources and fisheries management (Pakoa et al. 2013a), and a study on the economic value of sea cucumbers in Papua New Guinea, Solomon Islands, Vanuatu, Fiji and Tonga (Carleton et al. 2013). All three concluded that Fiji's sea cucumber fishery is overexploited and called for urgent management actions. Pakoa et al. (2013a) further recommended the finalisation and implementation of the national sea cucumber management plan to address depleted stocks. However, no management actions were taken in Fiji and the national sea cucumber management plan was drafted but is still not enacted.

Fiji's Ministry of Fisheries together with the Wildlife Conservation Society compiled a comprehensive report to summarise the latest science on the sea cucumber fishery in Fiji since 2013, and recommended key management measures.

Here, we summarise the eight studies in the recently published report, *Fiji's sea cucumber fishery: Advances in science for improved management*[3] (Mangubhai et al. 2017a), and highlight key findings and recommendations that are relevant and applicable to sea cucumber fisheries in other Pacific Island countries.

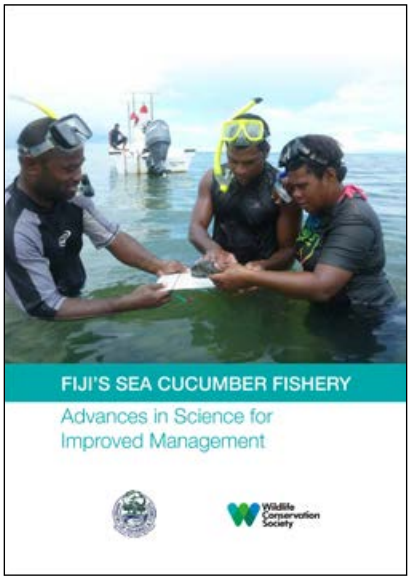

Figure 1. The 2017 report *Fiji's sea cucumber fishery: Advances in science for improved management.*

Findings

Stock status

Underwater surveys in Fiji by Lalavanua et al. (2017) found 17 out of the 27 commercially exploited species reported by Pakoa et al. (2013a). Densities of sea cucumbers in the eight locally managed marine areas were critically low, including in *tabu* areas, and most sea cucumber densities were low compared with theoretical regional reference densities.[4] Fishing should, therefore, only be permitted on a short list of species with healthy abundance. Despite a national ban on the exportation of sandfish (locally called *dairo*, *Holothuria scabra*) since 1988, the low abundance of this species and the presence of mainly immature individuals, indicates overexploitation. Apart from sandfish, all of the dragonfish (*Stichopus horrens*) found on transects were below the regional common body size (32 cm).

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[3] Available to download at: https://fiji.wcs.org/Resources/Reports.aspx
[4] Assessments conducted by SPC in 2002-2012, generated threshold densities for 17 species of sea cucumbers by averaging the 25% highest densities from the Pacific. These can be used as a baseline for comparison or as a reference in the case that a site has no specific site density data available.

Figure 2. Soni (left) and Steve (center) conducting a questionnaire-based interview of a fisher (image: ©Steven Purcell).

Fisher perceptions

Purcell et al. (2017) demonstrated that socioeconomic surveys of fisher knowledge and perceptions were cost-effective for diagnosing changes in sea cucumber stocks. Within eight study locations in Fiji, 78% of the 235 fishers surveyed believed that sea cucumber stocks were in decline. Fishers believed that stock declines were mainly the result of too many fishers targeting sea cucumbers (i.e. excessive fishing capacity). Fishers caught, on average, 3.5 times more sea cucumbers per day 10 or more years ago than they do currently. The socioeconomic surveys reinforced underwater visual censuses by Lalavanua et al. (2017), showing that sea cucumber stocks are overexploited across Fiji.

Value chain analysis

A value chain analysis of the sea cucumber fishery showed sea cucumbers passing through various actors as either raw or fully processed product (Mangubhai et al. 2017b). The majority of Fijian fishers sold their sea cucumber raw, with only a few fishers investing in partial or fully processed to fully dried form. There was also great variation in price per species received by fishers, which is likely a result of poor bargaining power and variation in the quality of product by fishers.

Postharvest processing by fishers

A study funded by the Australian Centre for International Agricultural Research showed that fishers processed sea cucumbers to various stages and standards across Fiji (Purcell and Lalavanua 2017). Over half (59%) of fishers had never received information or training on processing methods. In addressing this issue, a year-long programme provided workshops, a manual[5] and training video[6] to fishers to help them understand best practices of processing sea cucumbers. Of the 353 fishers trained in 24 villages, the majority found the village-based workshops more useful than the training manual and video. More than 95% of workshop participants reported gaining new knowledge on processing, and our recent follow-up interviews show that 79% of participants later change their methods. After applying the new methods, both women (92%) and men (93%) believed their products are better quality. Training is still needed, however, on postharvest processing methods for fishers in other coastal villages.

Pre-export size

A study by Tabunakawai-Vakalalabure et al. (2017a) on pre-export sizes of sea cucumbers showed that immature sea cucumbers are being harvested and exported from Fiji. Of the 7,497 sea cucumbers measured, 31% were below the

[5] http://aciar.gov.au/publication/cop026

[6] Online version: www.youtube.com/watch?v=KH6u0oZoclk
Downloadable files: http://scu.edu.au/environment-science-engineering/index.php/125

minimum legal size limit of 7.6 cm. Fiji's current size limit is unlikely to be effective for a multi-species fishery where different sea cucumber species reach sexual maturity at different sizes. Monitoring of export consignments prior to export is a cost-effective way of assessing the state of the fishery over time, compared to in-water field surveys. This study also reinforced that different size limits are needed for different species groups.

Impact of underwater breathing apparatus

An economic study by the Ministry of Fisheries and SPC demonstrated that the use of UBA (underwater breathing apparatus) in the sea cucumber fishery had a large socio-economic cost to rural communities, as well as a financial cost to the government and wider society (Tabunakawai-Vakalalabure et al. 2017b). UBA exemptions had an estimated cost to Fijian society of FJD 5.8 million over three years. A total of 37 injured sea cucumber divers were admitted at the hyperbaric unit in Suva for treatment of decompression sickness between 2012 and 2014. Three-quarters of those admitted were young divers between the ages of 18 and 28.

Ecological impact

An experimental field study by Lee at al. (2017) showed that the removal of sandfish (*H. scabra*) from reef flats negatively impacted reef sediments (sand and mud). Because sea cucumbers eat large quantities of sediments and turn over sediment layers through daily burying (Fig. 4), the removal of sea cucumbers impacts the efficiency of reef sediments to function as a filter system. Sediment oxygen consumption rates were consistently lower in enclosures with high densities of sea cucumbers than in enclosures where they had been removed. Oxygen penetration into the sediments decreased significantly where sea cucumbers had been removed. Excessive reductions in sea cucumber abundances through fishing, therefore, appears to negatively affect the function and productivity on inshore reef ecosystems, potentially impacting other fisheries.

Genetic connectivity

A genetic study of lollyfish (*Holothuria atra*) showed that there is an overall connectivity among populations at four locations in Fiji, with gene flow moving from east to west

Figure 3. Sea cucumber fishers ready for a fishing trip with scuba tanks (image: ©Watisoni Lalavanua).

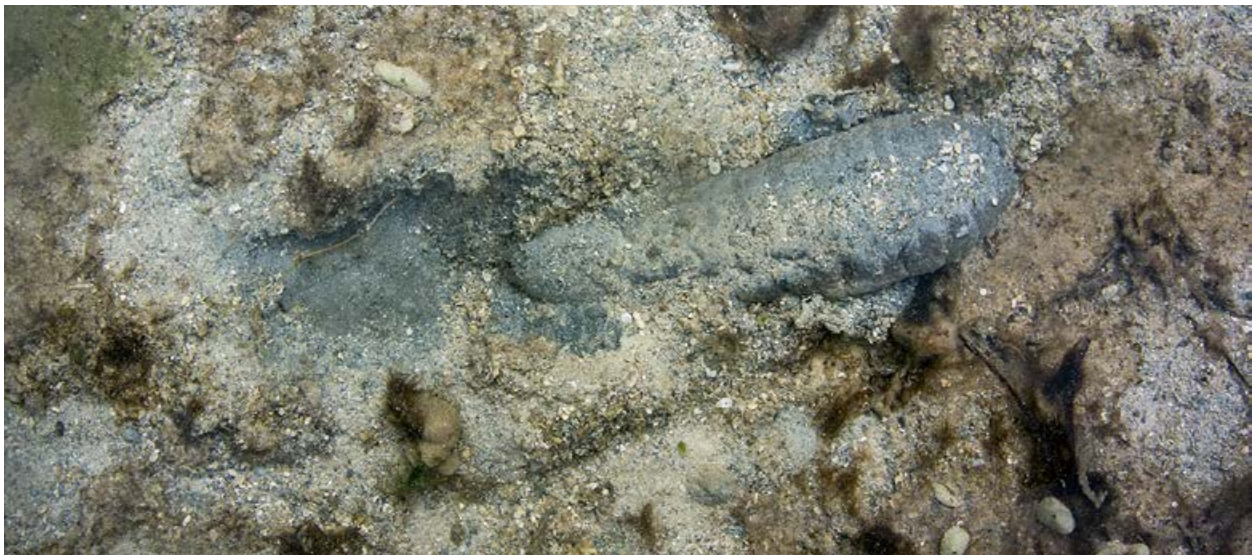

Figure 4. Sandfish (*dairo, Holothuria scabra*) turning over sediment layers through daily burrowing (image: ©Steven Lee).

between Vanua Levu and Viti Levu (López et al. 2017). This means that in order to safeguard Fiji's sea cucumber fishery, sea cucumbers in the eastern islands (Lau and Lomaiviti groups) need to be sustainably harvested because they might act as source of population replenishment and gene flow for stocks in western Fiji. It is, therefore, important for management plans to consider the fishery as a network of reefs.

Implications for the management of sea cucumber fisheries

Overexploitation of sea cucumbers in the Pacific has prompted national moratoria in Papua New Guinea, Solomon Islands, Vanuatu (Purcell et al. 2013) and Tonga (Pakoa et al. 2013b). Because a ban does not manage exploitation but only stops the fishery, the recent report suggests a shift in the management strategy of the sea cucumber fishery in Fiji to avoid moratoriums (Purcell and Pomeroy 2015).

A shift in management strategy includes a number of urgent actions needed immediately:

1. Impose a shortlist of permissible species that can be harvested;
2. Reduce fishing capacity by employing limited-entry rules or very short fishing seasons;
3. Develop and adopt nation-wide standards for the pricing of raw and dried sea cucumbers;
4. Impose minimum size limits for different species groups for fresh and dried products;
5. Continue the recent complete ban on the issuance of exemptions on the use of scuba; and
6. Strengthen enforcement of all regulations, especially the size limits and permissible species at the exit point of products out of the country.

If the above recommendations cannot be adopted promptly, the Ministry of Fisheries should consider imposing a 10-year moratorium on harvesting and exporting sea cucumbers in Fiji. The fishery should only be reopened after this period of time and if underwater assessments show that populations to be harvested are well above the regional reference densities recommended by SPC (Pakoa et al. 2013a), and if most animals are above the size at maturity.

Fiji, therefore, must swiftly choose between significant management reforms or a fishery moratorium. Failure to act promptly in either case will result in increasing local extinctions and the eventual loss of this critical livelihood from Fiji. It would be a pity to resort to a moratorium, which has been the fall-back for other Pacific Island fisheries because this measure fails to improve the management system to regulate fishing within sustainable harvest rates.

Clearly, as has been the case in other Pacific Island countries, harvesting by small-scale artisanal fishers can lead to depletion of wild populations, loss of biodiversity and potential flow-on effects to ecosystems.

Numerous scientific studies now make it clear that sea cucumbers do not replenish their populations quickly, and so should only be fished at light rates of exploitation. Fishery managers must, therefore, focus on stricter controls on fishing effort and to species at risk if sea cucumbers are to endure as an economic resource for coastal livelihoods.

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Private investors commit to mariculture development in Vanuatu

Aquaculture Solutions Vanuatu (ASV) opened its first hatchery in Port Havannah, Efate, on 28 February 2017. The brainchild of Derek French and Jonathan Delaney, ASV initially intends to produce sandfish seed for the restocking of locally depleted populations in collaboration with the Vanuatu Fisheries Department (VFD). In developing the concept, ASV targeted a commodity that is in need of rebuilding, has a known market potential for eventually generating income, and can involve local communities to look after the resource and to participate in harvesting activities. With assistance from VFD and the Aquaculture Section of SPC, the first step for ASV was to develop hatchery technology that is low-tech and low-cost, and can be replicated in other places.

A common problem

As in many countries where sea cucumbers were once abundant, overexploitation has led to severe stock depletion and the eventual harvest ban that is now in place in Vanuatu since 2008. This ban has been lifted in specific areas and on a temporary basis, as was the case in 2014 and 2015.

The global overexploitation of sea cucumbers is well documented and is known to be linked to exporting countries' proximity to Asia where the majority of the demand comes from. More than 80% of sea cucumber fisheries are overexploited, and within those fisheries, high-value species are harvested first. More than half of all sea cucumber fisheries fall prey to illegal fishing operations, and overexploitation continues despite increasing levels of regulation.

Customary custodians

While most sea cucumber fishing zones around Efate have been severely depleted, some small areas still harbour healthy stocks. They are restricted to a few bays and lagoons where customary custodians were able to effectively manage stocks during the 2015 lifting of the ban. Community-based fisheries management – coupled with new national fisheries regulation for quota, size limits and closures – will become part of the array of measures available for beche-de-mer fisheries management in the future. However, with repeated and more severe depletions each time moratoria are lifted, new questions arise on how to effectively recover fully depleted stocks, and whether hatchery-based production can support a cost-effective option for restocking thereby supporting a viable local beche-de-mer sector.

Low-tech and low-cost

ASV's hatchery operations and the activities that will flow from them will answer some of these questions. Its goal of being cost-effective and low-tech has translated into a simple hatchery design and cheap construction, with the structure built entirely of locally sourced materials. The hatchery site selected by ASV is one of the critical factors that will keep costs down over the long term. Water is pumped from 150 m offshore on a reef habitat that is relatively sheltered from the weather. This provides optimal and stable water quality with minimal filtration required before use. The site contributes considerably to minimising technology and costs, and should be a major factor for future similar projects. The structure is simple but effective, keeping larval culture tanks sheltered from the elements and enabling a good level of control of sun exposure, which is important for maintaining tank temperatures that would otherwise vary greatly between day and night and would place larvae under stress. The simplicity of the system – with water coming into the tanks in a straight line from the reef – enables quick and regular flushing of the line and prevents "dead spots" – places in where the water does not flow properly, and which can cause water quality problems.

A simple and low-cost setup to minimise hatchery capital and running costs (image: Michel Bermudes).

Late night spawning shift during sandfish hatchery training (image: Michel Bermudes, SPC).

A long-term plan

It is still "early days" for the fledgling aquaculture entrepreneurs and there are likely to be some challenges ahead, but this is to be expected at the start of such a venture. Some of these challenges are specific to beche-de-mer aquaculture sea ranching operations and include:

- learning and understanding the seasonality of spawning to optimise the six to seven months of production;
- developing nursery techniques that will enable the highest rate of recovery;
- evaluating the best growout technique (e.g. sea ranching, sea pens) and habitat;
- developing a sustainable sea ranching model in collaboration with the national authority to ensure stock growth while providing financial return to ASV and the communities involved; and
- investigating alternative species to maximise the return on investment for the hatchery structure (e.g. green snails, trochus, giant clams or even local oysters could be produced by the hatchery).

The road ahead

It is rare to see private investment in marine aquaculture in the region, and every one of those occasions should be celebrated, supported and monitored accordingly to give them the best chance of success as they tackle each challenging phase of their development. Aquaculture is now seen as a central theme to generating food security and income at the community level. In this context, VFD is committed to working in collaboration with ASV in order to facilitate development and learn from the experience so that in time, similar hatcheries can be replicated across the country where seed can be produced for the small-scale, community-based farming or ranching of marine commodities.

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Nutritional value of the sea cucumber *Holothuria scabra* from Fiji Islands

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Introduction

At least 58 species of sea cucumbers are harvested commercially from the world's oceans, and this practice has existed for over 1,000 years. Sea cucumbers are consumed raw, dried or boiled in many tropical and subtropical countries. Dried sea cucumber is known as beche-de-mer (BDM) and is particularly popular in the over 40-year age group where it is consumed primarily for its perceived medicinal properties. There is high demand for BDM and other sea cucumber products in Southeast Asian countries with China, Hong Kong, South Korea, Singapore and Japan being among the major markets.

BDM processing involves an uncomplicated sequence of actions resulting in a product that is non–perishable if stored in dry, dark conditions. Briefly, post-harvest steps include first boiling, slitting and gutting, second boiling, smoking and finally sun-drying. Current processing techniques (cooking and drying) used in the Pacific Islands have been used since the 1800s and are well documented. However, poor processing techniques often result in poor quality products and loss of revenue; regional extension programmes have been established to address this issue.

There is an increasing global awareness of the human health benefits of seafood relating to their relatively high levels of essential nutrients such as omega-3 fatty acids. Traditional BDM processing involves multiple boiling, salting and drying, which is likely to result in significant loss of important nutrients. Yet, this aspect of BDM processing is poorly documented. This section provides a brief overview of the nutritional profile of sea cucumbers traded in Southeast Asian countries.

Material and methods

Sandfish (*Holothuria scabra*) (Fig. 1) were harvested from Tavua Bay (17°26'29.4"S 177°51'44.4"E) in northern Viti Levu, Fiji Islands, at low tide. They were left on a flat surface for five minutes, and then their lengths and wet weights were recorded. The samples were then gutted and held in an esky (portable cooler) with ice for immediate transportation to the University of the South Pacific (USP) Laboratory in Suva.

Figure 1. Sandfish (*Holothuria scabra*) harvested from Tavua Bay, Fiji (image: Ravinesh Ram, 2015).

The sandfish were cooked in 45°C water and the temperature was slowly increased to 80°C. They were cooked for around 20 minutes or until they became cylindrical in shape, hard and bouncy. Samples were then sun dried for one to two weeks, then cooked for a second time and fi-

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nally dried. Samples of the dried sandfish were then pulverised and assayed for their nutrient composition. Nutrient analysis (proximate composition – protein, ash, lipid and carbohydrates – and fatty acid profile) was performed at Deakin University in Australia, while moisture content measures – assessed gravimetrically after heating at 105°C for 24 hours until a constant mass was obtained – were done at the University of the South Pacific in Fiji.

Results and discussion

The sandfish specimens used in this study had a mean length of 19.63 ± 1.23 cm and a mean weight of 104.87 ± 9.87 g. Sea cucumbers are regarded as a high-quality seafood with medicinal value and are generally consumed raw, dried or boiled to optimise their medicinal properties. They are rich in protein, which makes up around 50% of the dried product (Table 1), but this richness varies between species. Data for sandfish in the present study showed elevated levels of protein (76.57%) compared with other sea cucumber species exported from Fiji. Because of their high protein content, sea cucumbers are also crushed into tablets as human diet supplements. The moisture content of dried sandfish was found to be 9.48%, which was within the range of other sea cucumber species, which ranged from as low as 1.2% to 15.1% (Table 1). This could be due to the water holding capacity of tissue, which varies among sea cucumber species. The moisture content is obviously much higher in fresh sea cucumbers and generally ranges from 76% to 85% (Omran 2013; Haider et al. 2015). Fresh sea cucumbers, including *H. scabra*, also have high protein and low fat contents, and carbohydrate levels similar to those of protein (Table 1). The carbohydrate level of processed *H. scabra* was 2.63% in this study (Table 1).

The total fat in processed dried sandfish was found to be 1.26% compared with a range of 0.3–9.9% in other sea cucumber species (Table 1). The lipids of processed sandfish contain essential fatty acids, including the polyunsaturated fatty acids (PUFA), which are considered vital for human well-being such as eicosapentaenoic acid (20:5(n-3), EPA), docosahexaenoic acid (C22:6(n-3), DHA) and arachidonic acid (20:4(n-6), AA) (Table 2). These PUFA are associated with reduced risk of coronary heart disease and cancer. The ash content of processed sandfish is 10.06% and within the range of values reported for other sea cucumber species (2.12–39.6%; Table 2). The relatively high values for ash are due to the presence of spicules or ossicles (calcium carbonate) in the epidermis.

Table 1. Proximate composition of processed dried sea cucumbers.

Species	Moisture (%)	Ash (%)	Total protein (%)	Total fat (%)	Carbohydrates (%)	References
Holothuria scabra	9.48	10.06	76.57	1.26	2.63	(Present study)
Holothuria scabra	N/A	2.26	43.43	5.66	48.65	(Omran 2013)
Holothuria fuscogilva	11.6	26.4	57.8	0.3	N/A	(Wen et al. 2010)
Thelenota ananas	15.1	25.1	55.2	1.9	N/A	(Wen et al. 2010)
Stichopus hermanni	10.2	37.9	47.0	0.8	N/A	(Wen et al. 2010)
Thelenota anax	1.2	39.2	40.7	9.9	N/A	(Wen et al. 2010)
Holothurian fuscopunctata	7.0	39.6	50.1	0.3	N/A	(Wen et al. 2010)
Bohadschia argus	13.0	17.7	62.1	1.1	N/A	(Wen et al. 2010)
Bohadschia marmorata	N/A	6.03	43.23	4.83	45.91	(Omran 2013)
Holothuria leucospilota	N/A	4.3	45.71	4.60	44.96	(Omran 2013)
Actinopyga mauritiana	N/A	2.12	48.27	4.99	44.62	(Omran 2013)
Actinopyga mauritiana	N/A	31.81	66.86	0.76	N/A	(Haider et al. 2015)

Table 2: The major fatty acids in processed (dried) *Holothuria scabra*.

Fatty acid	Common name	Content (mg g^{-1} dry)
16:0	palmitic acid	24.66 ± 11.75
18:0	stearic acid	27.78 ± 6.01
16:1(n-7)	palmitoleic acid	11.00 ± 6.51
18:3(n-3)	linolenic acid	Not detected
20:4(n-6)	arachidonic acid (ARA)	19.22 ± 0.97
20:5(n-3)	eicosapentaenoic acid (EPA)	14.45 ± 1.21
22:6(n-3)	docosohexaenoic acid (DHA)	0.49 ± 0.27*

Sea cucumbers also contain essential minerals, including copper, magnesium and potassium, which assist human metabolic processes such as gastrointestinal functioning and nervous and immune functions. Sea cucumber tissues also contain high levels of amino acids and collagen. The most abundant amino acids in sea cucumbers were glycine, glutamic acid, aspartic acid, alanine and arginine that together constituted between 58% and 65% of the total amino acids. Glycine has been reported to help in reducing serum cholesterol levels.

Sea cucumbers serve as a tonic and traditional remedy for many ailments, and are considered to have unique biological and pharmacological properties, including antiangiogenic, anticancer, anticoagulant, antihypertension, anti-inflammatory, antimicrobial, antioxidant, antithrombotic, antitumor and wound healing activities. Such medicinal properties are related to the presence of bioactive compounds such as triterpene glycosides (saponins), chondroitin sulfates, glycosaminoglycan, sulfated polysaccharides, sterols (glycosides and sulfates), phenolics, specific peptides, cerebrosides and lectins. Consumption of sea cucumbers is thought to aid growth, blood clotting and wound healing thereby supporting their use as a traditional remedy for burns and cuts.

Consumption of sea cucumbers is associated with a number of health benefits; however, incorrect processing techniques used in the Pacific Islands are potentially destructive to the nutrient composition of resulting BDM. Repeated boiling and drying reduces levels of proteins, fatty acids, amino acids and minerals during the processing of sea cucumbers. Less destructive processing techniques need to be established that help retain key nutrients, resulting in more nutritious and beneficial products. Further studies are needed in this field, including a study of seasonal changes in nutrient compositions of sea cucumbers that would help define optimal harvesting times.

Acknowledgements

This study was funded as part of the Australian Center for International Agricultural Research project FIS/2010/096, "Evaluating the impacts of improving postharvest processing of sea cucumbers in the western Pacific region". The authors would like to thank the School of Marine Studies, University of the South Pacific, Fiji, for providing the laboratory facilities used for the experimental work. We extend our sincere thanks to Mr Malili Bari and the fishers involved in this study for assisting with the harvesting the sandfish from Tavua Bay in Fiji. The first author was supported by a John Allwright Fellowship from the Australian Agency for International Aid.

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Seahorses: Trade, aquaculture and their long-term outlook in New Caledonia

Antoine Teitelbaum[1] *and Jeff Dubosc*[2]

Introduction

Seahorses inhabit many people's imagination. Although we seldom come across them, these modest fish have fascinated us since time immemorial, but such fascination has led to overfishing in Southeast Asia, where seahorses are turned into powder for their supposed medicinal properties! Not only are they used for medicine, but they often end up dried and sold as souvenirs in markets worldwide. Admiration and extinction certainly make for unlikely bedfellows.

Fifty-four seahorse species have so far been recorded worldwide in tropical and temperate regions. They can be giants or pygmies, spiked, striped or even covered in tubercles and are often found in the seagrass or seaweed beds of calm or shallow waters. They can be camouflaged and bedecked with ornaments that make them look like the *Sargassum* they ride, or change the colour of their robes and blend in with the background, as if they were chameleons of the sea.

This article does not set out to analyse the animal's biology or describe how it is marketed, but, following a brief overview of its current status, will highlight recent seahorse conservation initiatives and business developments in New Caledonia.

Use and regulation

Dried and ground, cooked whole in soup or hung on strings, seahorses are consumed in every conceivable shape or form in Southeast Asia, particularly in traditional Chinese medicine. Official figures put the number of seahorses exported every year to over 80 countries at 30 million.[3] Divers fish for them and they are then usually dried and bagged for sale.

No viable solutions, such as large-scale farming, have as yet been adopted to supply the burgeoning market. In 2016, for example, eight million illegally fished seahorses, valued at USD 4 million and bound for the Chinese market, were seized.[4] As with sea cucumbers in the southwest Pacific, it would appear that no holds are barred when it comes to meeting demand.

Moves have, nevertheless, been made to regulate the trade and preserve the species. Seahorses have been CITES-listed[5] since 2004 in a bid to understand the trade flows related to seahorse fishing, even if consignments often go undeclared and countries do not regulate the trade nationally. Some non-governmental organisations, however, such as Project Seahorse, work on protecting and managing wild stocks of seahorses.

Seahorse farming

Seahorses are live bearers, but are very unusual ones. Once the eggs are mature, the female deposits them in the male's pouch in a vertical mating dance. Once deposited, the eggs are then fertilised and incubated for three weeks by the male that then gives birth to several hundred babies.

A gestating male seahorse with a heavily swollen brood pouch (image: Aquarium des Lagons).

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[3] http://www.dailymail.co.uk/sciencetech/article-3181192/Seahorses-extinct-30-years-Trade-dried-wildlife-souvenirs-marine-creatures-wiped-out.html
[4] http://www.abc.net.au/news/2016-06-22/peru-seizes-8-million-seahorses-illegally-bound-for-asia/7531550
[5] CITES: Convention on International Trade in Endangered Species of Wild Flora and Fauna

Large-scale farming projects for supplying traditional Chinese medicine are often mentioned, but none has yet seen the light of day. Only hatcheries for aquarium seahorses are operating at the moment.

Hatchery production is usually divided into three separate operations: one for producing live prey (*Artemia* sp. and copepods), another for maintaining breeders, and a nursery for growing out juveniles. There is no larval breeding as such, as the initial stages take place in the male's pouch.

The aquarium trade

Aquarium enthusiasts are utterly beguiled by this creature. For the fish-tank buff, it is the perfect guest in a dedicated aquarium or with placid housemates, but he or she needs to know how to feed the insatiable seahorse, which most often prefers fresh food, such as small shrimps, or live prey such as *Artemia* sp. or mysids over flakes and pellets.

The aquarium trade is mainly supplied by seahorse farms, and juveniles are only exported once they are at least 7 cm in length. There are some seahorse farms in the United States (Hawaii and Florida), Australia, various Asian countries and elsewhere, and these usually sell weaned and acclimatised individuals that make for excellent aquarium fish.

The aquarium trade involves many species, such as *Hippocampus erectus* in Hawaii, *H. reidi* in Florida and *H. agustus* in Western Australia, to name but a few.

Seahorses in New Caledonia

Seahorses in New Caledonia are very much alive in local lore. In the past, it was not uncommon for fishers to net a seahorse or to see them drifting in seagrass beds. Today, while they are still familiar to most people, seahorses have become a rare sight in the wild. They are not fished in New Caledonia but because they live in a fragile habitat and are vulnerable to onshore development and urban sprawl, they have gone from being a fairly common species to an underwater myth in the space of a single generation, at least around Noumea, New Caledonia's capital and largest urban centre.

Past and present efforts

Fifteen years ago, *Hippocampus kuda* breeding trials on a prawn farm in New Caledonia were very successful from a technical viewpoint. The aquafarmers' skill and expertise at the time led to seahorse yields in the hundreds. Having breeders in the farm's water supply canals and an abundant provision of post-larval prawns, the breeders' favourite food, was a major asset. Although, the project was discontinued for various reasons, it remains a positive milestone that marks the beginning of New Caledonia's seahorse farming history.

In recent years, after *H. kuda* was broken down into several species by geneticists, Aquarium des Lagons began breeding *H. semispinosus*. By using well-established protocols and closely monitoring the animals, the breeders have been producing over 500 fry a month. Once they are released from the male's pouch, young seahorses receive close attention. They are fed a range of live prey bred within the aquarium, which in turn have grazed on microalgae.

The elegant *Hippocampus semispinosus* (image: Aquarium des Lagons).

Some of the juveniles are displayed in a dedicated tank, where the public can view hundreds of miniature seahorses, while others are released on the coast near Noumea to repopulate areas where they are no longer observed.

Recently, some juveniles grown out to 5–7 cm were given to Aquarium Fish Nouvelle-Calédonie for export on the aquarium market, and the first *H. semispinosus* consignment left New Caledonia bound for the USA with a CITES permit issued by the appropriate authorities. It was a great success, with a 100% survival rate and satisfied customers who have received healthy seahorses that are already eating frozen food. Seahorses are usually difficult to feed because they require live food, but aquaculture helps get the juveniles accustomed to frozen food, making them much hardier and better suited to aquarium life.

This fresh burst of seahorse activity in New Caledonia is another boost to the private sector with the aim of developing commercial production for the aquarium market. The project should get underway in 2017.

Preserving, breeding and developing such iconic but often endangered resources is a commendable quest for today's aquaculture efforts, particularly within a fragile island setting.

All-new Bycatch Management Information System web portal tackles critical bycatch issues

Bycatch in tuna fisheries is the collateral damage caused by fishing gear to non-target species such as seabirds, sea turtles, marine mammals and sharks. In many cases these species are already severely threatened from a variety of activities, creating an urgent need to manage and mitigate impacts from fishing. Streamer lines that deter seabirds, leader materials that allow sharks to bite through, and baits and hooks that are less likely to attract and injure sea turtles are currently deployed in some fisheries. How well do these mitigation measures work in practice? Are the mortality rates now low enough to allow bycatch populations to be sustained? Unfortunately, these questions remain largely unanswered in tuna fisheries and there are no universal quick fixes in sight.

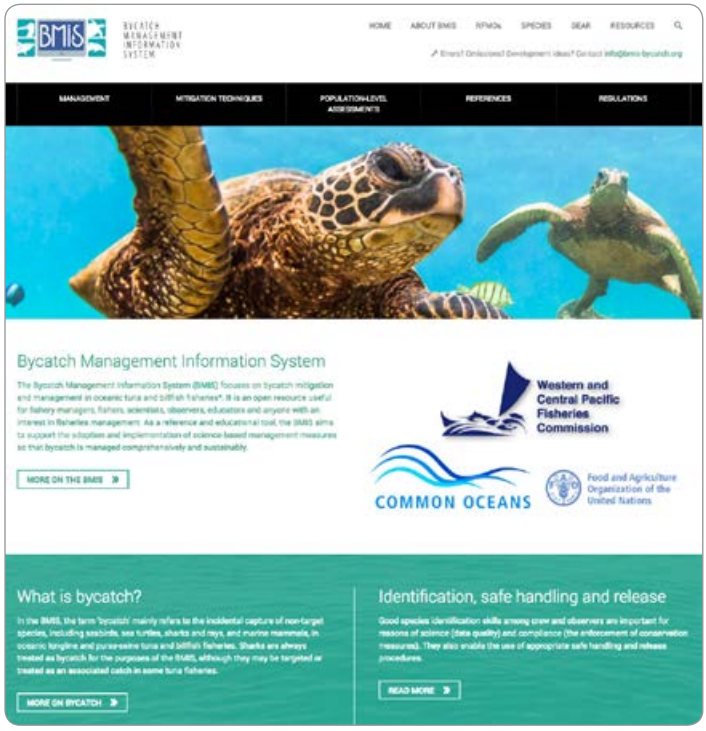
Now re-launched and enhanced with an engaging, user-friendly interface, the Bycatch Management Information System (BMIS) allows searching of over 1000 curated references by species group, fishing gear or mitigation technique, and provides pointers to species identification and safe release guides. BMIS also helps users – ranging from scientists to managers to fishers to the general public – explore management options by linking to information on interaction rates and population status. A built-in blog feature, 'Bycatch Bytes', provides an easy way to keep up-to-date on the latest developments in bycatch reduction.

Learn about past and present efforts to tackle critical bycatch issues and help find solutions by exploring the all-new BMIS at:

www.bmis-bycatch.org

Additional content will be coming online through late 2018 including databases, maps and shark tagging meta-data. User contributions in the form of information, feedback and notes about errors or omissions are always welcome and can be sent to the BMIS Coordinator at info@bmis-bycatch.org.

The BMIS has been developed by the Western and Central Pacific Fisheries Management Commission (WCPFC) and the Pacific Community (SPC) with the support of the Food and Agriculture Organization of the United Nations (FAO) under the Common Oceans (ABNJ) Tuna Project funded by the Global Environment Facility (GEF). This Project harnesses the efforts of a large and diverse array of partners, including the five tuna Regional Fisheries Management Organizations (RFMOs), governments, inter- and non-governmental organizations, and the private sector to achieve responsible, efficient and sustainable tuna production and biodiversity conservation.



The BMIS website home page

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Asian Fisheries Society forms world's first Gender in Aquaculture and Fisheries Section

Meryl Williams, Chair/Coordinator, GAFS Inaugural Officers

As professionalism has grown in fisheries and aquaculture, groups of experts have grown up to better share their knowledge, and, in their special fields, improve the depth of studies and policy advice. Where scientific advice for management is needed, these groups have been formalised by management bodies, such as the Scientific Committee of the Western and Central Pacific Fisheries Commission, while other groups have formed sections and interest groups in larger professional societies. The latter pathway has been taken by the gender in aquaculture and fisheries group in association with the Asian Fisheries Society (AFS).

Since its first women in fisheries activity, held in 1990,[1] the AFS has slowly increased its attention toward women and the gender dimension in aquaculture and fisheries,[1,2] along with growing global attention to gender equality challenges and opportunities. In 2016, the AFS approved the creation of the Gender in Aquaculture and Fisheries Section (GAFS) to more formally promote equitable and effective cooperation among gender in fisheries and aquaculture experts in the Asia-Pacific region and the world. This section is a world first. No other fisheries or aquaculture society has a formal women or gender group.

AFS gender in aquaculture and fisheries activities were led by an informal group of interested experts who have now been charged by the AFS Council with fully developing the GAFS. To date, initial bylaws for GAFS have been written, membership has been opened (see brochure), and Inaugural Officers established[3] to oversee the election of Executive Committee members and ratification of the bylaws.[4]

The Inaugural Officers have begun their work on how to increase membership, services and strategic partnerships of GAFS. Young career scientists and students are particularly welcomed to become members of GAFs, as are women and men from all regions. The Inaugural Officers particularly want to help establish a broadly based membership and Executive Committee to help GAFS work closely with other regional and national efforts, such as those that are starting to grow in the Pacific, such as the Women in Fisheries Network in Fiji.

The objectives of GAFS are to promote equitable and effective cooperation among scientists and academics, technicians, fisheries officers and non-governmental organisation experts involved in issues related to gender in fisheries and aquaculture so as to advance research and practices in the Asia-Pacific region as well as in other regions of the world. GAFS will build on past gender and women's activities of AFS, namely periodic symposia, publishing research and expert opinion, basic training introducing experts to gender concepts, and maintaining an active website and social media presence. GAFS may also play a role in promoting new research opportunities, based in existing institutes.

We greatly welcome GAFS members from the Pacific, a region where fisheries are particularly important to all people. If you join before the end of 2017, you will become a Founding Member of GAFS.

Website: *http://genderaquafish.org/*
Facebook: *http://www.facebook.com/pages/AFS-Gender-in-Aquaculture-and-Fisheries/181176555231544*
Twitter: *@Genderaquafish*

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[3] See the milestones for the AFS gender in aquaculture and fisheries activities - https://genderaquafish.org/gaf-section/about-us/history/
[4] https://genderaquafish.org/gaf-section/about-us/executive-committee/
[5] For more details see our webpages - https://genderaquafish.org/gaf-section/

Federated States of Micronesia 2013/2014 HIES Household fishing (coastal)

Michael K. Sharp[1]

Executive summary

47% of households conduct fishing activities

23% of household food expenditure is spent on fish and shellfish

6% of **total household income** comes from fisheries and accounts for **28%** (e.g. USD 462) of the value **of subsistence consumption**

67% of households practice spearfishing on coastal reefs

Introduction

The Federated States of Micronesia's (FSM) most recent Household Income and Expenditure Survey (HIES) was conducted from July 2013 to July 2014. Around 10% of all households (1,664) were surveyed, covering all four states: Yap, Chuuk, Pohnpei and Kosrae.

This fact sheet presents the results of the HIES in a fisheries[2] context and covers participation in fisheries, fishing catch and effort, household (HH) income from fisheries and HH consumption expenditure on fish and shellfish.

A summary table (Table 3) is provided on page 41.

Fisheries participation

Participation in fisheries was measured using two methods: labour force participation and HH participation. Labour force participation refers to individuals aged 15 years and older who undertook fishing activities as their main or secondary activity. HH participation refers to HHs that undertook fishing activities in the previous three months, irrespective of whether the activity was on a one-off or regular basis.

Labour force participation rate

1 out of 5

of the labour force has a fisheries-related occupation

Around one-fifth (21%) of FSM's labour force[3] has a fisheries-related occupation[4] as their main (9%) or secondary activity (12%) (Fig. 1). Chuuk has the highest fisheries participation rate of all states, with 35% of the labour force participating, followed by Yap (25%), Pohnpei (11%) and Kosrae (9%).

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[2] In the context of this fact sheet, fisheries refer to capture-based marine or freshwater fishing activities, including gleaning, but excluding aquaculture

[3] "Labour force" is defined as the population aged 15 years and over who undertake an economic activity as the main or secondary activity. 66% of FSM's population is aged 15 years and over and has a labour force participation rate of 52% (Yap – 71%; Chuuk – 39%; Pohnpei – 64%; Kosrae – 44%).

[4] International Standard Classification of Occupations (ISCO) codes: 6221, 6222, 6223, 6340, 7511, 9216 (recoded).

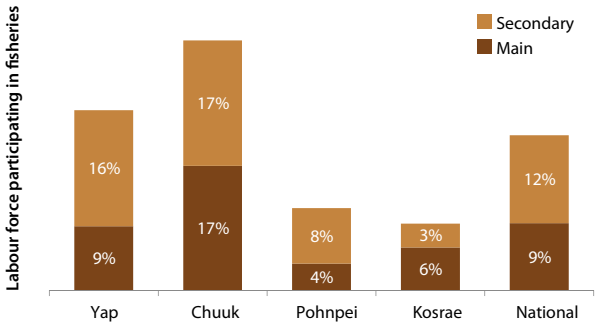

Figure 1. Labour force participation in fisheries as the main or secondary activity, by state.

HH participation in fisheries

47% of HHs in FSM engage in fishing activities. This high fisheries participation rate is common across all states of FSM, with 66% of HHs in Yap conducting fishing activities, followed by Chuuk (49%), Kosrae (48%) and Pohnpei (37%) (Fig. 2). Fisheries participation is mainly for subsistence purposes, with only 13% of fishing HHs selling part of their catch.

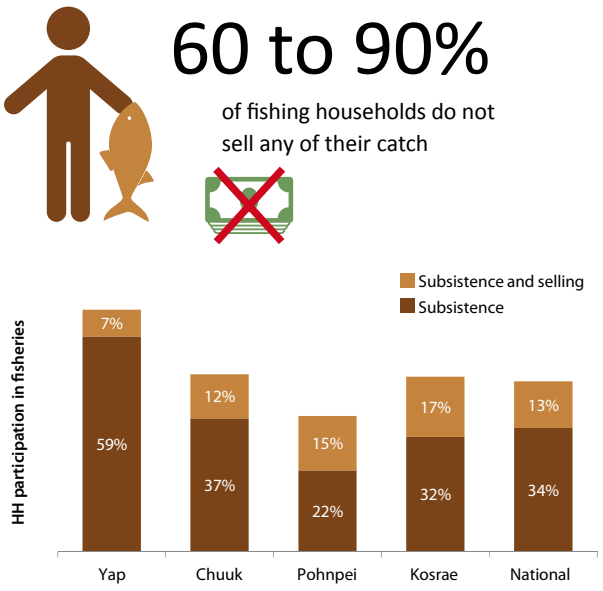

Figure 2. Participation by HH in fisheries, by state.

Fisheries participation by gender

Most of the fisheries labour force (92%) is male (main and secondary activity). Pohnpei has the highest rate of female participation in the fisheries labour force (21%), whereas Yap has the lowest rate (1%).

Similarly, 85% of people engaged in HH fishing activities are male. In Pohnpei, 20% of HH members participating in fishing are female, followed by Kosrae (16%), Chuuk (14%) and Yap (9%).

Fisheries participation by age

Around three-quarters of FSM's fisheries labour force is aged[5] from 15 to 44 years, and over 90% is aged less than 55 years. Likewise, 90% of the population participating in fisheries at the HH level are under 55 years.

2% of FSM's HH member participation in fisheries are aged 13–14.

Fisheries participation by wealth group

There is slightly greater participation in fisheries in lower income quintiles (quintiles 1–3 account for 71% of fisheries labour force participation and 67% for HH participation) [Fig. 3]). Despite the fairly even distribution of fisheries participation among income quintiles, fisheries is nevertheless an important means of income substitution and food security for HHs with relatively low levels of cash income in FSM.

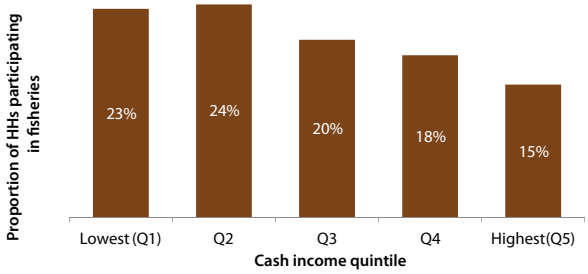

Figure 3. Distribution of HHs that participate in fisheries, by cash income quintile.

In Yap and Kosrae, the participation in fisheries among income quintiles is almost perfectly equal, however, this is not the case for Chuuk and Pohnpei (Fig. 4). In Chuuk, for example, 85% of HHs participating in fisheries are in income quintiles 1–3, which is indicative that participation is for the purpose of income substitution and/or food security. Conversely, Pohnpeian HH participation in fishing increases proportionally with income quintiles, with quintiles 4 and 5 accounting for 50% of total fishing activity, indicating that HH participation in fisheries may be more recreationally oriented (Fig. 4).

[5] Noting that labour force data is limited to persons aged 15+ years old

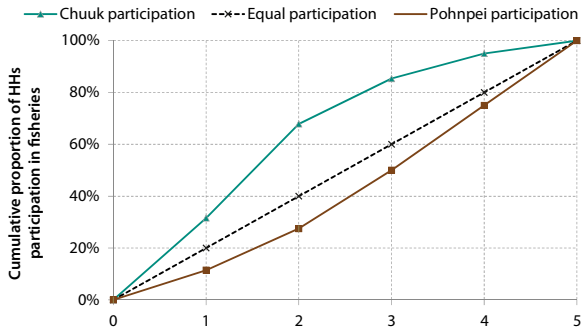

Figure 4. Cumulative distribution of HHs participation in fisheries in Chuuk and Pohnpei, by cash income quintile.

Fishing effort

Methods

The most commonly practiced fishing method in FSM is spear/harpoon (Fig. 5), which is practiced by 67% of fishing HHs (77% in Yap, 69% in Chuuk, 65% in Pohnpei and 28% in Kosrae). Following this is net fishing (51%), bottom fishing (34%), casting (28%), gathering (25%) and trolling (22%). Similar trends exist for each state, with the exception of Kosrae, where net fishing is the most commonly practiced fishing method, with 34% of HHs using it.

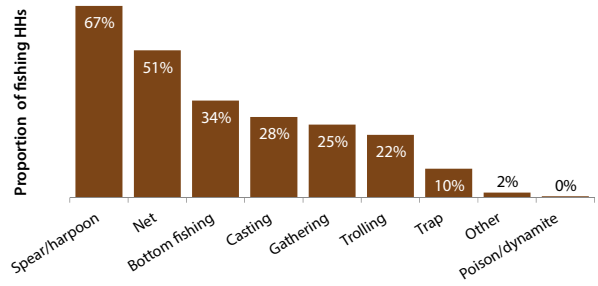

Figure 5. Proportion of fishing HHs practicing fishing methods.

Locations

Across FSM, 70% of fishing HHs conduct fishing activities on coastal reefs (Fig. 6). Other common locations where HHs conduct fishing activities are lagoons (53%), outer reefs (47%), open ocean (35%) and submerged reefs (32%). The locations of fishing are similar in each state, except Kosrae where a higher proportion of HHs fish in the river and a much lower proportion of HHs fish on submerged reefs and in a lagoon.

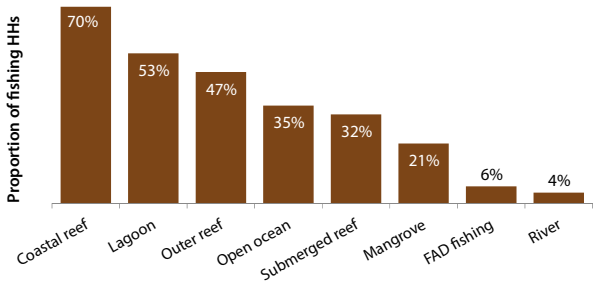

Figure 6. Proportion of fishing HHs, by fishing location

Fishing trips per month

Nearly half of all fishing HHs in FSM undertake 2–5 fishing trips per month. In Yap, Pohnpei and Kosrae, this frequency of fishing occurs in 58%, 57% and 69% of fishing HHs respectively. However in Chuuk, the frequency of fishing is greater, where 24% of fishing HHs conduct 10–12 trips per month and another 10% conduct 20 trips per month. The total number of fishing trips per month in FSM is estimated to be 59,000.

Trip fishing time

87% of HHs in FSM fish for 2–8 hours per fishing trip, with 5-hour fishing trips being the most common.

Total fishing effort

The most frequent amount of time spent fishing per HH per month is 10–19 hours, however, this frequency differs among states. In Yap and Kosrae, HHs most commonly fish for less than 9 hours per month, whereas HHs in Pohnpei fish between 10 and 19 hours per month. About half of HHs in Chuuk spend 10–19 hours, while the other half spend 40–49 hours fishing per month. Total HH fishing effort in FSM is estimated to be 341,000 hours per month.

Transport and inputs for fishing

The main modes of transport to fishing sites in FSM are motorised boat (31%), non-motorised boat (26%), walking (29%) and swimming (14%). This trend is quite similar in each state, however, Yap and Kosrae have a higher number of HHs that walk (40% and 55%, respectively), whereas 37% of HHs in Pohnpei use non-motorised boats.

Fuel and oil account for 71% of the cost of inputs for HHs that sell part of their catch. Expenditure on ice (14%), transportation (5%), labour (3%), maintenance and repairs (3%), and other (4%) make up the remainder of costs.

Fish and shellfish catch

Types of seafood caught

In line with HH fishing locations and methods, 91% of HHs participating in fisheries in FSM catch reef fish, while only 27% catch oceanic fish (Table 1). Two-thirds of HHs participating in fisheries in FSM catch crustaceans and other invertebrates. These figures are fairly consistent across all states. In Chuuk, 76% of HHs catch octopus, while in Yap, 67% catch crab.

Types of seafood sold

Of the fishing HHs that sell fish and shellfish, 80% sell reef fish, 29% oceanic fish, 36% crustaceans and 42% molluscs and other invertebrates (Table 2). In terms of oceanic fish being sold, tuna (skipjack, yellowfin and bigeye) is the most common. For crustaceans, 26% of HHs sell crab, 17% octopus and 17% sea cucumber.

HH income from fisheries

HH income from fisheries comes in three forms (Fig. 7): salaries and wages; subsistence (the value of home-caught and -consumed fish and shellfish); and reserve of small-scale HH fisheries businesses that sell fish and shellfish.

Wages and salaries (cash)

It is estimated that USD 1.9 million in salaries and wages (0.18% of total HH cash income from salaries and wages) is paid to 273 fisheries-related business owners and employees, resulting in an average wage of USD 7,090 per person per annum.[6]

HH sale of fish and shellfish (cash)

The sale of fish and shellfish accounts for an average of 1.4% of total HH cash income in FSM, and 2.7% in Chuuk. In terms of species sold, the sale of reef fish accounts for 56% of total HH income from the sale of fisheries products in

Table 1: Proportion of HHs that catch different categories of fish and shellfish, by state.

	Yap	Chuuk	Pohnpei	Kosrae	National
Oceanic fish	34%	25%	24%	28%	27%
Coastal fish	92%	90%	93%	91%	91%
Crustaceans	72%	66%	50%	25%	60%
Molluscs and invertebrates	48%	83%	48%	22%	61%

Table 2: Proportion of HHs selling different categories of fish and shellfish, by state.

	Yap	Chuuk	Pohnpei	Kosrae	National
Oceanic fish	8%	31%	29%	36%	29%
Coastal fish	82%	75%	87%	70%	80%
Crustaceans	18%	25%	50%	30%	36%
Molluscs and invertebrates	24%	53%	41%	15%	42%

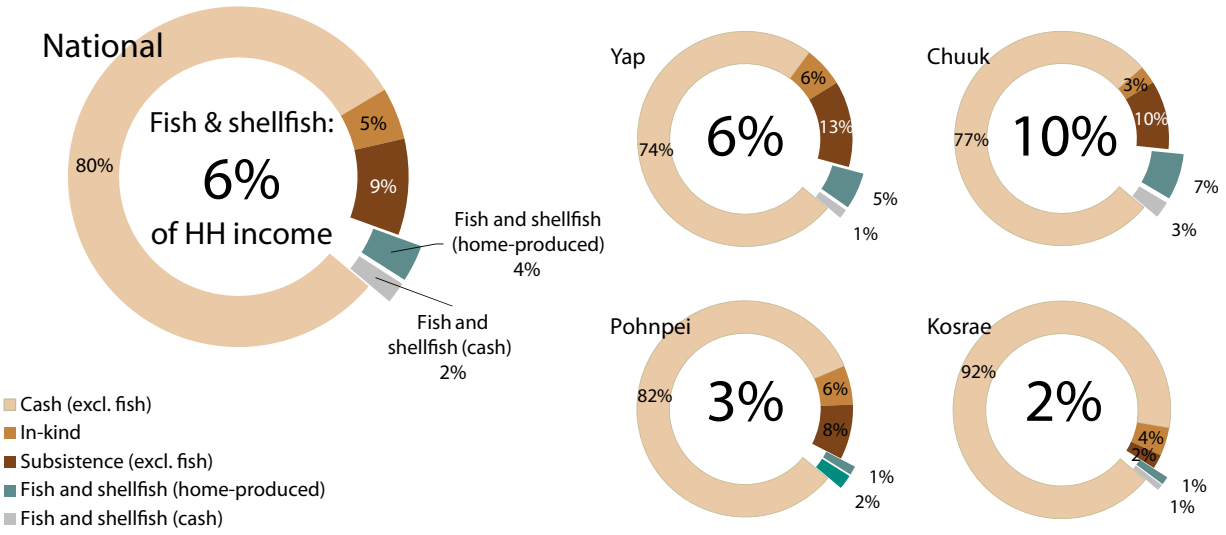

Figure 7. The contribution of fisheries to total HH income (excl. imputed rents), by income type.

[6] In-kind income refers to gifts received from another HH (cash purchased or home-produced) and in-kind income received from an employer. It is likely that a component of in-kind income is in the form of fish received as gifts.

FSM; oceanic fish account for 25%; and shellfish account for the remainder. In Yap, reef fish are of particular importance to HH fisheries income, accounting for 81%.

Subsistence income

Subsistence income is derived from the value of home-produced and -consumed fish and shellfish. Fisheries subsistence accounts for 28% of the total value of subsistence income in FSM. In Chuuk, it makes up 40% of total HH subsistence income, whereas in Pohnpei it makes up 14%. Reef fish account for 71% of the value of subsistence income derived from fisheries.

HH consumption expenditure

HH consumption expenditure occurs in two forms: cash purchases and the value of home-produced and -consumed fish and shellfish.

In FSM, total HH expenditure (cash and the value of subsistence consumption) on fish and shellfish accounts for 10% of total HH expenditure (Fig. 8).

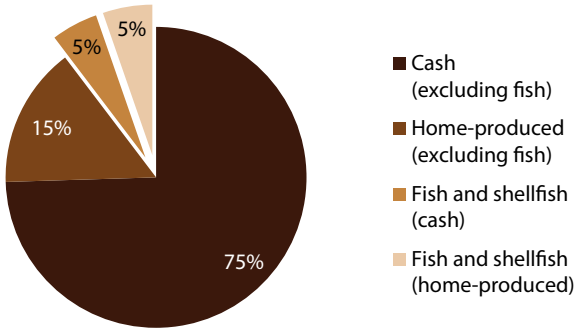

Figure 8. Contribution of fish and shellfish expenditure to total HH expenditure (excl. imputed rents), by expenditure type.

This figure ranges from 6% in Pohnpei to 17% in Chuuk. In terms of total HH expenditure on food, fish and shellfish account for 23% – nearly one-quarter – of total HH food expenditure (Fig. 9). This figure ranges from 16% in Pohnpei and Kosrae to 28% and 29% in Yap and Chuuk, respectively.

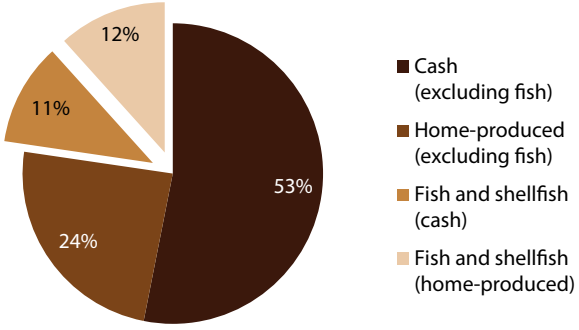

Figure 9. Contribution of fish and shellfish expenditure to total HH food expenditure, by expenditure type.

Pohnpei, FSM (image: Colette Wabnitz).

Reef fish account for 11% of total HH expenditure on food, with canned fish, oceanic fish and shellfish amounting to 5%, 4% and 2%, respectively.

HH expenditure on fish and shellfish consists mainly of reef fish (50%), canned fish (23%), oceanic fish (19%) and crustaceans molluscs and other invertebrates (9%). These figures are similar across all the states, however Kosrae has a higher proportion of expenditure on oceanic fish (39%) than reef fish (38%).

Half of the value of HH fish and shellfish consumption expenditure is cash-purchased and the other half is home-produced. In Yap, 72% of expenditure on fish and shellfish is home-produced, while in Chuuk, Pohnpei and Kosrae home production accounts for 53%, 38% and 32% of HH spending on fish and shellfish, respectively.

Cash expenditure on fish and shellfish

Canned fish account for 42% of total HH cash expenditure on fish and shellfish, while reef and oceanic fish account for 29% and 27%, respectively (Fig. 10). In Kosrae, oceanic fish account for 53% of cash expenditure on all seafood, while in Pohnpei reef fish account for 45%. In Yap and Chuuk, canned fish account for 53% of total cash expenditure on seafood.

Canned fish account for 7% of total cash expenditure on food with both reef and oceanic fish accounting for 5% each. Overall, 17% of HH food cash expenditure is on seafood.

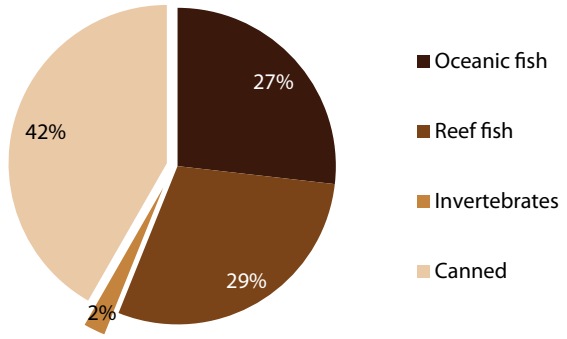

Figure 10. Composition of cash expenditure on fish and shellfish, by type.

Home-produced expenditure on fish and shellfish

70% of total HH home production expenditure on fish and shellfish is through the consumption of home-produced reef fish. Crustaceans, molluscs and other invertebrates amount to 15% of the value of all home-produced seafood, followed by oceanic fish (11%) (Fig. 11).

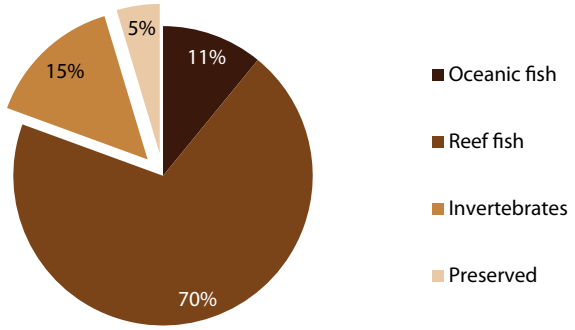

Figure 11. Composition of the produced expenditure on fish and shellfish, by broad type.

Fish and shellfish make up 33% of the value of home-produced food in FSM. 23% is attributable to reef fish, 5% to shellfish and 4% to oceanic fish. In Chuuk, fish and shellfish account for 42% of the total value of home-produced food, however, in Pohnpei this figure falls to 19%.

Table 3. Summary of FSM 2014 HIES fisheries-related data.

	Yap	Chuuk	Pohnpei	Kosrae	National
Fisheries labour force participation (persons)					
Main activity	517	2,130	596	99	3,341
Secondary activity	931	2,144	1,234	55	4,363
Main and/or secondary activity	1,439	4,246	1,780	153	7,618
Fisheries participation (HHs)					
HH participation in fishing activities	1,571	3,338	2,403	525	7,837
HHs selling fish	174	829	965	181	2,149
Persons participating in HH fishing (>12 years old)	2,592	6,512	4,694	723	14,520
HH fishing effort					
Total trips per month	8,538	33,017	14,919	2,513	58,987
Total hours per month	47,161	196,282	82,351	15,152	340,946
Net annual HH income (USD)					
Average total income (excl. imputed rents)	15,843	8,415	16,708	15,141	13,093
Average cash income	11,962	6,727	14,128	14,001	10,788
Average subsistence income	2,919	1,460	1,602	508	1,659
Average in-kind income	962	229	977	632	646
Net annual HH fisheries income (USD)					
Average fisheries wages & salaries (cash)	151	35	198	67	116
Average fisheries business (cash)	74	179	163	71	151
Average fisheries subsistence (non-cash)	870	588	225	186	462
% of total HH income	7%	10%	4%	2%	6%
% of HH cash income	2%	3%	3%	1%	2%
% of HH subsistence income	30%	40%	14%	37%	28%
Annual HH expenditure (USD)					
Average total expenditure (excl. imputed rents)	11,876	7,376	12,574	12,752	10,361
Average cash expenditure	7,972	5,670	9,959	11,660	8,036
Average subsistence expenditure*	2,961	1,502	1,769	542	1,748
Average food expenditure (food only)	5,369	4,329	4,771	5,502	4,722
Average food subsistence expenditure (food only)	2,370	1,501	1,177	534	1,436
Annual HH fish and shellfish expenditure (USD)					
Average expenditure on fish and shellfish	1,492	1,261	749	868	1,071
Average cash expenditure on fish and shellfish	416	595	466	586	519
Average subsistence expenditure on fish and shellfish	910	622	243	197	489
% of total expenditure	13%	17%	6%	7%	10%
% of cash expenditure	5%	10%	5%	5%	6%
% of subsistence expenditure	31%	41%	14%	36%	28%
% of food expenditure	28%	29%	16%	16%	23%
% of subsistence food expenditure	38%	41%	21%	37%	34%

** The value of home-produced and consumed goods*

Discussion

With half of HHs and one-fifth of the labour force in FSM participating in fisheries, the HIES demonstrates that fisheries are of significant social and economic importance in FSM. Fisheries provide HHs with income, food, and help in supplementing income, especially in the case of low-cash earning HHs. In particular, fish and shellfish in FSM are crucial to national food security, accounting for almost one-quarter of HH food expenditure, derived from subsistence fishing, half of which is home-produced.

The importance of reef fish and shellfish in HH expenditure demonstrates a high degree of dependency on reef resources as a mainstay of dietary protein. There may be cause for concern about high levels of coastal resource exploitation, but this cannot be determined until expenditures are converted to production volumes. Oceanic fish, such as tuna and canned fish, also play an important role in providing protein to the population of FSM, however, more so through cash purchases.

Given the importance of coastal marine resources for food and income in FSM, there is a need for sustainable coastal resource management. The results of this analysis provide evidence for the need for FSM to implement the goals, practices and policies articulated in "A new song for coastal fisheries" (SPC 2015), and the new "Regional Roadmap for Sustainable Pacific Fisheries" (FFA and SPC 2015).

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Developing a Pacific Community Marine Specimen Bank

Neville Smith,[1] Connie Donato-Hunt,[2] Valerie Allain,[3] Sam McKechnie,[4] Bradley Moore[5] and Ian Bertram[6]

Introduction

The Pacific Community (SPC) is attempting to establish a regional specimen bank for marine flora and fauna. Specimen bank samples can provide critical information to support natural resource management (e.g. the age and growth rate of fish as a key input to stock assessments, genetic analyses for stock structure). Maintained over the long term, historical samples can be compared with recent samples to understand important changes in key biological processes over time (e.g. increased methylmercury levels in fish due to climate change).

Establishing a regional specimen bank would be a significant and strategic science capacity and capability initiative. In principle, the concept of a specimen bank has received support within SPC and some key potential institutional partners in New Zealand and Australia. Meeting participants at the 10th SPC Heads of Fisheries Meeting also expressed strong support for the proposal. The next step is to use seed funding provided by New Zealand to fully explore the business case, and outline a plan for operationalising a Pacific Community Marine Specimen Bank.

This article briefly outlines the idea behind a regional Pacific Community Marine Specimen Bank, highlights the drivers for a regional bank and the benefits that could be derived from it, and outlines the next steps in developing the proposition into a full-scale proposal.

What is a specimen bank?

A specimen bank is a safe repository for biological samples (e.g. fish muscle tissue, otoliths). At its simplest, a specimen bank could be a chest freezer with some fish stomachs, or some otoliths in an envelope on a desk. A fully functioning and effective tissue bank, however, is much more (see Fig. 1). Specimens are collected in a strategic manner and cover a full range of tissue samples, including whole voucher specimens.[7] Collected specimens are identified as part of the

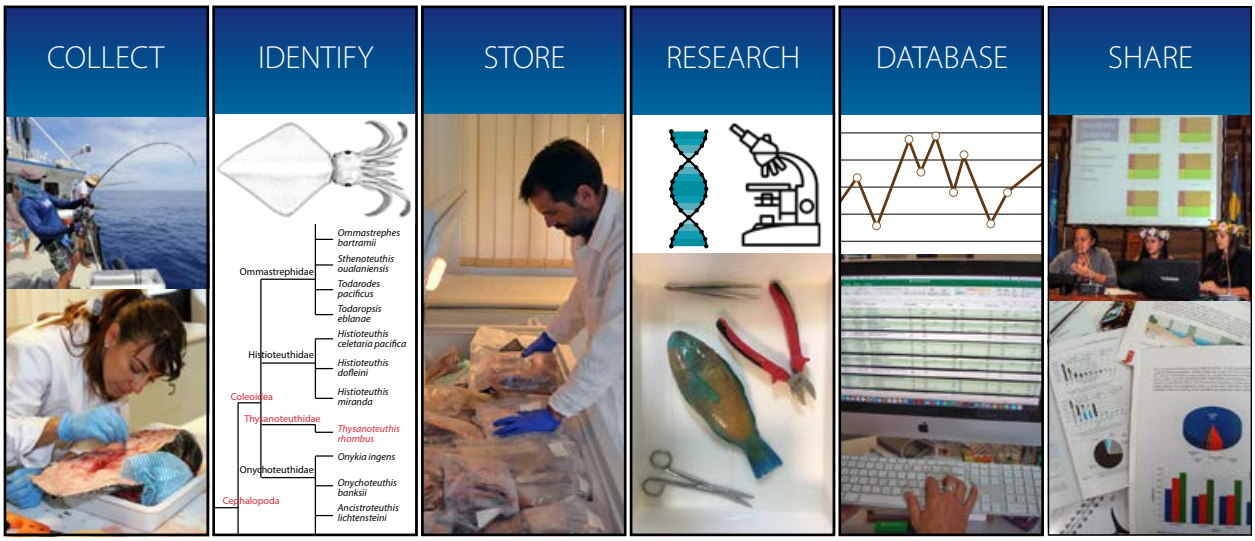

Figure 1: The role of a regional marine specimen bank (adapted from Nelson et al. 2015) (images: Jipé Le-Bars, Beth Vanden Heuvel, Elodie Vourey, Brad Moore, Stephen Brouwer and Laymik from the Noun Project).

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[7] A voucher specimen is a representative specimen of a plant of animal stored for long-term reference. A common example is a whole specimen collected during a research voyage. Voucher specimens are used to confirm species identity in future studies, and as such, provide for quality assurance of species identification over time.

curation process. Once identified, tissue samples are stored in a manner appropriate for the tissue type, and in a way that keeps them useful for as long as possible. Figure 1 shows that research occurs at this point, although the reality is that in many cases, there is research at each step of the process. For instance, data analysis to determine where to sample and when, taxonomic research to identify new species or previously undescribed life stages, and exploring techniques to store specimens and techniques to extend the storage life of specimens. The advantage of properly curated specimens in a tissue bank at this research stage is that they can then be withdrawn from the bank now or at some point in future – in part or in whole – for additional high-value science. Just like research, data are a dynamic part of a specimen bank, with details of a sample collection entered into relational databases, and those samples tracked through identification, storage and research, so that for any sample at any given time, the origin, place of storage, and what has been learned from it are known. Sharing the results of the research is critical, as is making transparent what specimens are held so that other researchers can borrow specimens to conduct relevant science. One way to synthesise all of this is through a specimen bank, which can be thought of as a living learning science system built on the collection and study of biological samples.

The concept

A Pacific Community Marine Specimen Bank would be unique because it would be Pacific Islands owned and operated. While other specimen banks exist, including those containing specimens from the Pacific, what is different about this bank is that it will be located in the Pacific and will form a regional asset where the bank's "biological capital" will be used to invest in the people of the region for a sustainable return on investment. It also has the advantage of providing biological capital insurance for regional partners.

In this context, a tissue bank would include the ability to curate and store a broad range of samples over long periods of time (decades rather than years). Importantly, it would include the associated science resources to analyse and interpret specimens and would act as a teaching facility in building regional capacity. Such a bank would need to take full account of the cultural heritage aspects of collecting, storing, accessing and using specimens.

A Pacific Community Marine Specimen Bank fits with SPC's strategic priorities in that it would provide biological information and knowledge to contribute to increasing economic and food security benefits from sustainable fisheries in the region. There is also potential for such a specimen bank to contribute to and facilitate benefit-sharing among Pacific Island countries and territories arising from the use of marine genetic resources as part of negotiations on biological diversity beyond national jurisdiction / United Nations Convention on the Law of the Sea. It will also improve regional capability and the availability of information to monitor, mitigate and adapt to the environmental impacts of climate change. Further, through careful design and the use of modular "green" freezer technology,[8] the bank will advance the use of renewable energy technologies in the Pacific, a key regional need.

It is, therefore, anticipated that a Pacific Community Marine Specimen Bank will have the capacity to make significant impacts in the region, both in the short term, and in the coming decades by building preparedness for the scientific challenges to come, such as food security and resilience to climate change. Specifically, this will occur through preserving and conserving biodiversity, developing regional solutions to ecosystem-scale challenges, building the capacity of Pacific Island scientists, increasing the scientific basis for climate change adaptation and resilience, supporting enhanced food security and nutrition, providing leadership at the interface between science and cultural heritage, and thinking about the finances of climate and biodiversity.

Drivers for a Pacific Community Marine Specimen Bank

Lessons learned, often the hard way, from other specimen banks at the fringes of the region will need to be carefully considered. Developing expertise in cultural heritage in the region will be drawn on to support the bank's design.

SPC currently operates the Western and Central Pacific Fisheries Commission (WCPFC) Tuna Tissue Bank (TTB), which has been funded by WCPFC since 2015. Since 2001, SPC's Oceanic Fisheries Programme has been coordinating the collection of biological samples of pelagic species from across the Pacific. The current TTB is the result of collaboration between SPC and its member countries, the Commonwealth Scientific and Industrial Research Organisation, WCPFC, University of Hawai'i, National Research Institute of Far Seas Fisheries, and the French Institute for Research and Development.

The notion of a Pacific Community Marine Specimen Bank evolved from the successful WCPFC TTB that now has ongoing operational funding from WCPFC. The funding is used to maintain the WCPFC TTB, which has a particular emphasis on tissue samples of bigeye, yellowfin, albacore and skipjack tunas, and swordfish, and which facilitates the transmission of samples to specified researchers using the access protocols of WCPFC TTB. SPC, as the Scientific Services Provider for WCPFC, is tasked with enhancing and maintaining the WCPFC TTB and, through the biological sampling programme, expanding the inventory of samples held.

[8] Green in this context means using renewable energy sources, to the greatest extent practical, by utilising recycled goods in manufacturing, and using freezing technology that will minimise and/or eliminate future damage to the environment.

The operation of the WCPFC TTB has included the development of standards for training observers in biological sampling (Pacific Islands Regional Fisheries Observer), and the ongoing training of observers across the region in biological sampling data recording, sample handling, and transportation. A web-based tool has been implemented to allow WCPFC members to track the collection of samples. It includes interactive maps where the user can obtain information on the number, type, species and length classes of samples collected from particular exclusive economic zones and high seas areas (Smith et al. 2016).[9]

The current WCPFC tissue bank, however, is tuna-focused, as well as curation- and storage-focused, and the current method of storage for many tissue types does not ensure their longevity. In 2016, WCPFC was informed of the need to design and seek funding for a strategic investment in a super-cold storage facility that would ensure the longevity and relevance of the WCPFC TTB (Smith et al. 2016).

Subsequent relevant developments in 2016 included the rapid and substantive expansion of the collection of a range of non-tuna specimens from across the Pacific for ecosystem monitoring purposes (Allain and Vourey 2017), and the recognition of the need for a similar facility for coastal fisheries science. Participants at the 10th SPC Heads of Fisheries Meeting identified many current and pressing science questions that a Pacific Community Marine Specimen Bank could and should address. The bank seeks to avoid short-term-only considerations by looking well beyond the coming decade in terms of preparedness for the scientific challenges to come. This proposal seeks to bring together several critical threads for preparedness in a centre of scientific excellence: preserving and conserving biodiversity; providing regional solutions to ecosystem-scale challenges; building capacity of Pacific scientists; recognising, respecting, preserving, managing, curating, storing and disseminating information on cultural heritage; developing climate change adaptation and resilience approaches, especially those pertaining to food security; and, public health outcomes.

Case study I: Success with the current Tuna Tissue Bank

As a case study, we briefly consider bigeye tuna age and growth. This research used specimens from the WCPFC TTB and was in collaboration with the Commonwealth Scientific and Industrial Research Organisation in Australia. The team set out to determine at what length and age bigeye tuna reach sexual maturity, the age of bigeye tuna at a particular length, whether there were any sex-specific differences in growth rates, and whether patterns in these data were similar across the Pacific. The study found that approximately 50% of the bigeye population (males and females) reach sexual maturity at a fork length of about 105 cm (Fig. 2), when the fish are approximately three years old. The maximum recorded ages in this study were around 14 years, and there did not appear to be sex-specific differences in growth rates (Fig. 3). Apart from a cluster of larger fish in the east, there did not appear to be clear differences in growth at the regional scale. The value of the WCPFC TTB bank in this case was that a large number of samples were available from a scale comparable to the fishery so as to make the results immediately applicable to stock assessments; in fact, these data are currently being used for the 2017 bigeye tuna stock assessment.

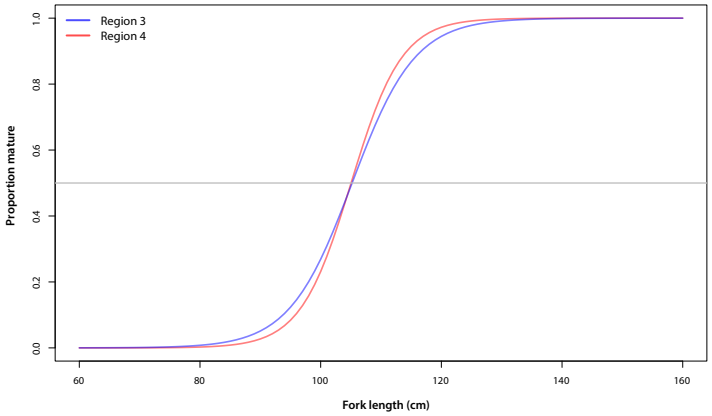

Figure 2. Maturity ogive for bigeye tuna at length in the western and central Pacific Ocean (prepared from data reported by Farley et al. 2017).

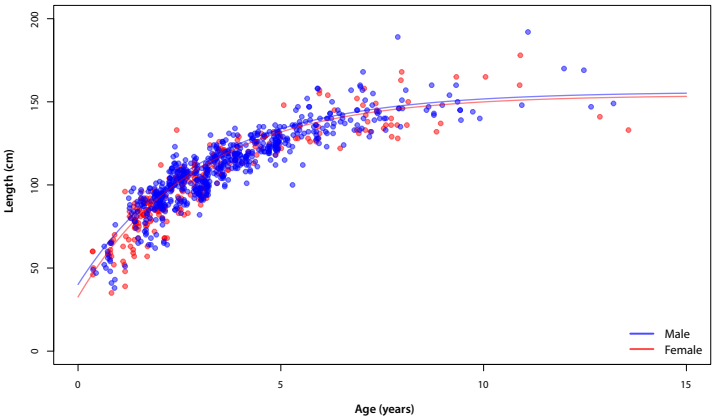

Figure 3. Age of bigeye tuna at length for males (blue diamonds) and females (pink circles) in the western and central Pacific Ocean (prepared from data reported by Farley et al. 2017).

Case study II: Why spatial and temporal coverage are critical

This case study highlights the potential public health benefits of having an active specimen bank. The study is ongoing, and the associated PhD student looking at one component of the methylmercury problem has just finished in April 2017 (Houssard 2017). The first results demonstrate the

[9] See: www.spc.int/tagging/webtagging/BioDaSys

complexity of the problem of methylmercury bioaccumulation in tuna.

Some studies from other oceans suggest that the average methylmercury content in yellowfin tuna has increased over time. This creates a public health perspective that yellowfin tuna is now a riskier food source than it used to be, or maybe even too risky. This in turn poses several questions that science – if we have the samples – may be able to answer. For example, is the increase in methylmercury content in yellowfin really occurring? And if so, why? Is this a new issue? Is it common across all tuna species? Does this also occur in the Pacific? If so, does it impact all of the Pacific islands in the same way?

By using samples from the existing tissue bank and integrating data from other studies these questions have been investigated at the regional scale. Yes, bioaccumulation of mercury in yellowfin tuna does occur in the Pacific, and increasingly so in larger fish. Yes, there are subregional variations in where this occurs, with increasing levels of methylmercury generally detected in fish with increasing southerly latitude (e.g. there is a latitudinal gradient in the rate of bioaccumulation). However, if fish size and sampling location biases are accounted for, and we compare trends over 15 years, there is no change in the rate of bioaccumulation of methylmercury in yellowfin tuna in the western Pacific (Fig. 4).

The spatial and temporal extent of the existing modest tuna specimen bank provided a unique tool to examine methylmercury levels in yellowfin tuna at the regional level and over a decade. The annual sampling allowed inter-annual effects to be separated from decadal shifts in the ecosystem. Moreover, the regional scale of samples analysed allowed the identification of factors (such as a fish length effect, and a location effect) that would not have been detected from more limited-scale, national-level studies, and which could have led to false conclusions. A more comprehensive set of samples collected over time will allow not only further research on methylmercury bioaccumulation in tuna, but also analysis on potential harmful and helpful chemical properties of fish on an ecosystem-wide scale.

Benefits of a Pacific Community Marine Specimen Bank

The assumed benefits of this regional strategic science asset are many, and include: 1) enhanced science capacity and capability; 2) new economic opportunities; 3) heightened biosecurity; 4) enriched human health; 5) improved biodiversity conservation; 6) better sustainable use; 7) increased global relevance and international leverage; 8) deepened awareness of and support for Pacific Island culture and identity; and 9) greater scientific credibility and quality assurance. A critical benefit of any specimen bank is that once it is established, key scientific studies can begin immediately without having to await additional fieldwork – potentially over many years – before adequate specimens are available.

A practical and hypothetical, oceanic example of the value of a Pacific Community Marine Specimen Bank may include the following:

- Tuna tissue samples collected, curated and analysed through the Pacific Community Marine Specimen Bank in 2018 will allow a Pacific Island student to complete their PhD in 2021, and subsequently obtain a job lecturing at the University of the Pacific, with their students using samples from the bank to study for their Master of Science degrees in 2022;
- The student's PhD results show that magnesium levels in tuna drop below those required for good human health with sea surface temperatures 1°C above current, and, as a result, magnesium substitution public health guidelines are implemented in the affected member countries and territories; and

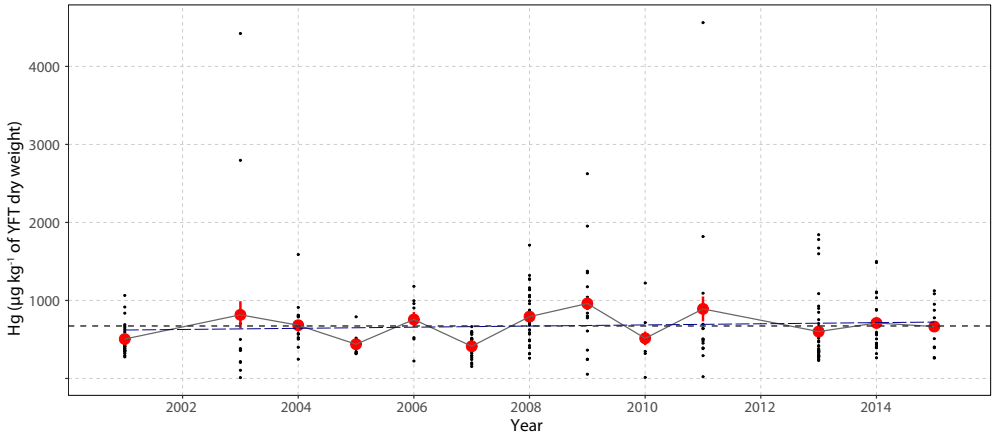

Figure 4. Temporal variation of the methylmercury concentration (µg kg^{-1} of dry weight) of yellowfin tuna (YFT) collected around New Caledonia and Fiji. Red circles represent average annual values, small black dots indicate individual values, and the horizontal dashed line indicates the trend of the time series, which is flat, demonstrating that there has been no change in methylmercury accumulation over time. Source: Receveur et al. in prep.

- The magnesium health supplements that are sensitive to temperatures above 20°C are able to be stored long term in a carbon-neutral modular cold store designed from the technology developed in step one of the project.

Similarly, a practical and hypothetical, coastal example of a Pacific Community Marine Specimen Bank may include the following:

- Sea cucumber tissue samples collected, curated and analysed through the Pacific Community Marine Specimen Bank see a regional agreed on taxonomy and associated identification guides;
- With codified names, market labelling requirements are able to be met and trade barriers reduced; and
- With advanced genetic techniques, traceability to a specific exclusive economic zone (EEZ) (or smaller scale) can be established, and as a result, illegal fishers from outside the region are able to be prosecuted for harvesting inside members' EEZs.

Next steps

Despite these anticipated benefits, the nature and scale of investment required to establish a Pacific Community Marine Specimen Bank requires a comprehensive analysis of the business case and implementation arrangements to operationalise the concept in order for it to maximise benefits for the region, both now and into the future.

Seed funding has been sought and successfully obtained to fund a project to undertake the necessary research and analysis to develop a business case for a Pacific Community Marine Specimen Bank, including a proposed model for how the bank could be operationalised in partnership with regional institutions. The business case will also explore and further define the scope of biological samples to be deposited in the bank, including species selection, sample types and storage procedures.

The business case will be designed for a Pacific Community Marine Specimen Bank that would serve the region to achieve the following:

- Provide a regional strategic science asset, a storage facility to house biological specimens over the long term and the supporting infrastructure to conduct associated scientific research;
- Significantly enhance the collection of a full range of relevant biological specimens of marine flora and fauna from across the region to ensure the bank has an ecosystem baseline, and the potential to monitor the impacts of future ecosystem changes;
- Curate, identify and analyse biological specimens in the bank across the full range of biological, physical, genetic and public health traits, and to store that information securely for future generations, taking into account cultural heritage;
- Integrate data from the bank with data from other information sources – fisheries, remote sensing, and climate science – to investigate relationships and potential impacts of climate change on the ecosystem, including with and without harvesting, to provide scientific knowledge products for biodiversity conservation;
- Use the Pacific Community Marine Specimen Bank platform to educate a new generation of Pacific Island scientists to serve the region into the future; and
- Identify and develop reciprocal capacity sharing and biological insurance for institutional partners across the region.

This business case development project will get underway in June 2017, and a report to the New Zealand government is due in mid-2018. At that time, an assessment about whether to find a suitable donor, or rethink the proposal, will be made. Through the *Fisheries Newsletter*, meetings and media, SPC will keep interested parties updated on the establishment of a Pacific Community Marine Specimen Bank.

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Teacher training on climate change and fisheries educational resources in Vanuatu

Report compiled by Ms Felicity Rogers-Nilwo
National Senior Secondary Curriculum Coordinator, Vanuatu

Introduction

The country of Vanuatu consists of a Y-shape archipelago of 83 islands and their associated reefs. Located in the South Pacific ring of fire and cyclone belt – at latitude 13–21°S and longitude 166–172°E in the western Pacific Ocean – "Vanuatu is among the countries in the Pacific region that are most vulnerable to the impacts of climate change and climate variability" (National Advisory Committee on Climate Change 2005). Vanuatu has been categorised by the United Nations University's 2012 World Risk Report as a country that is highly vulnerable to natural disasters.

The main objective of Vanuatu's Ministry of Education and Training is to provide access to quality education in a safe learning environment. Indeed, the Education in Emergency policy (Government of Vanuatu 2010) states that "schools should be a safe and secure place for learning and students should know what action to take in the event of a disaster". Knowing what action to take implies that climate change and disaster risk management concepts need to be introduced into classrooms in order to build a more resilient ni-Vanuatu population. Climate change education will enhance students' "ability to anticipate, absorb and accommodate or recover from the effects of a hazardous event in a timely and efficient manner" (IPCC 2012).

The islands have a wide range of marine resources that are exploited at the subsistence, artisanal and industrial levels. The current domestic fisheries production trend will not be sufficient to meet a swiftly growing local population. Furthermore, the slow and rapid onset of climate change and natural disasters (e.g. sea level rise, ocean acidification, tropical cyclone and storm surges) may have substantial effects on marine and freshwater ecosystems. Alternative measures for sustainable fisheries, introduced through educational resources, are critical for enabling proper fishery management and guaranteeing food security for future generations.

Empowering teachers is the most effective way to disseminate knowledge, skills and attitudes in schools and communities, and will consequently promote food security and reduce vulnerability to extreme weather events and natural disasters.

Educating people on key concepts of climate change adaptation and fisheries management is by far the best way to mitigate and adapt to these ongoing environmental events. In fact, the Vanuatu National Curriculum Statement, in the section "Environment and Sustainable Production" (Ministry of Education Vanuatu 2010, p. 41) states that:

"every child and student needs to know how human interventions contribute to such occurrences as climate change, soil erosion, or the death of reefs, which adversely affect the environment, and how these changes impact on human lives. We need to ensure that:

- *we harvest our land and sea in sustainable ways,*
- *we promote awareness of the fragility of the physical environment and how human activity affects it, and*
- *young people appreciate that the land and the sea are finite resources."*

"Promoting (improved access to and quality of) formal education as a way to increase people's adaptive capacity is further supported with respect to the negative effects of disasters on people's level of education, which in turn reduces their adaptive capacity, resulting in a vicious circle of increasing risk." (Wamsler, Brink and Rantala 2012: p. 9).

With this in mind, the Curriculum Development Unit (CDU) partnered with the Pacific Community (SPC) and the German Gesellschaft für Internationale Zusammenarbeit (GIZ), and identified four key resources that would empower educators to teach the elements of climate change, climate change adaptation, and fisheries management inside and outside of classrooms. The resources include: 1) "Learning about climate change the Pacific way",[1] 2) "Pou and Miri",[2] 3) "Cloud Nasara Animation"[3]and 4) "Teachers' Resource Kit on Fisheries for Vanuatu,[4] all of which were developed in consultation with the Curriculum Development Unit and were integrated in the current and reviewed Vanuatu national curriculum from Year 1 to Year 13.

[1] http://www.spc.int/wp-content/uploads/2017/01/Climate-change-vanuatu.pdf
[2] http://www.spc.int/wp-content/uploads/2017/01/Pou-and-Miri-learn-to-tackle-climate-change.pdf
[3] https://www.youtube.com/watch?v=AMthanwiOWE
[4] http://www.spc.int/coastfish/en/publications/information-sheets/kit-for-teachers/464-vanuatu-teachers-kit.html

The four resources are designed to encourage students to understand and behave in ways that promote a sustainable future, and are based on the five principles of Education for Sustainable Development:

- learning to know,
- learning to do,
- learning to live together,
- learning to be, and
- learning to transform oneself and society.

A four-day training was organised on Vanualava island, in Torba Province to "teach teachers" on how to use these four resources. The training involved participants from four schools: Arep bilingual in Vanualava, Martin school at Hiu in Torres, Robin school at Toga in Torres and Bagaveguey school at Toga in Torres.

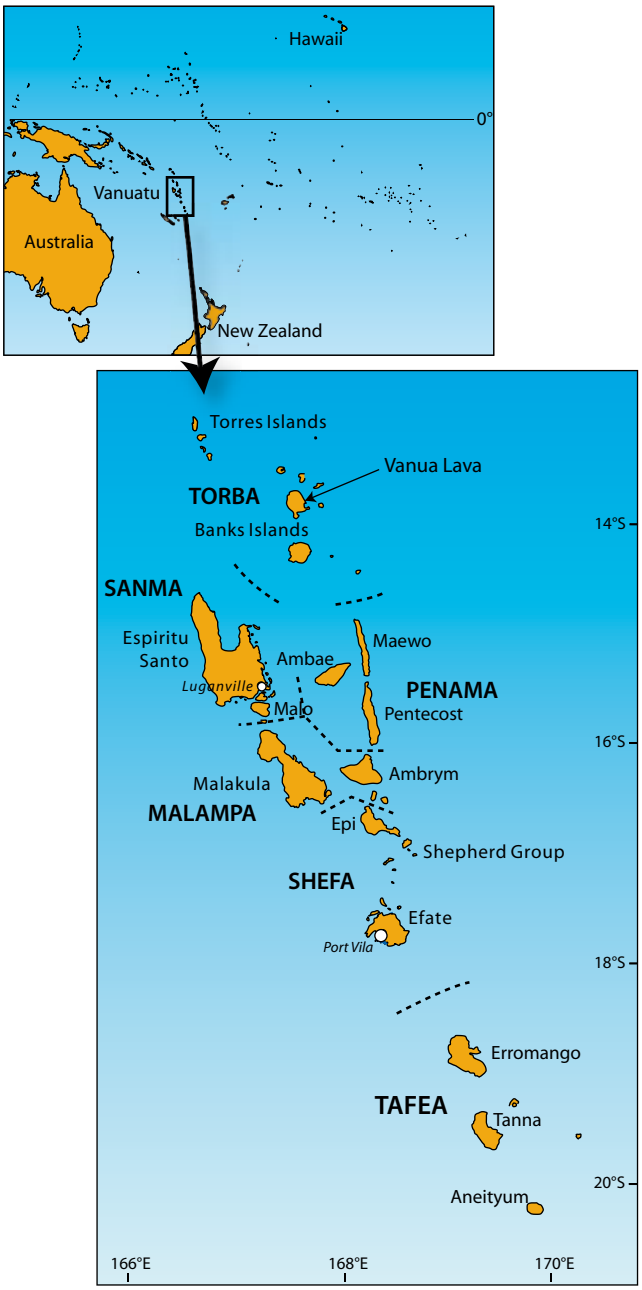
Training objectives

The CDU, under the Vanuatu Ministry of Education and Training, is mandated to carry out two components of the Education in Emergency policy in regards to integrating climate change and disaster risk management concepts into the formal curriculum, and training teachers in the use of emergency education curriculum themes. CDU is currently reviewing the formal curriculum and integrating these concepts and fisheries management themes in several subject syllabi. Moreover, CDU has developed climate change and fisheries information resources in partnership with donor partners; in the midst of the development process, learning outcomes are identified in the current and reformed national curriculum, and are aligned with the main topics in the climate change and fisheries resources.

Nevertheless, based on surveys carried out in schools, many useful resources developed by non-governmental organisations and other institutions are left stacked on shelves and not utilised by teachers. In fact, the primary cause of this is the distribution of resources with no proper training. Hence, an implementation procedure is paramount to allowing the appropriate and sustainable use of the resources developed. Indeed, a teacher training strategy is critical to facilitating the implementation of these teaching and learning resources in classrooms.

The main objective of this training was to increase teachers' knowledge of climate change education and fishery management, and to develop their professional skills on climate change science, climate change adaptation and sustainable fisheries, and become main drivers in building resilience and promoting food security in the education sector.

The training was carried out with two main goals in mind. The first goal was to get teachers to have a competent understanding of climate change, mitigation and adaptation, and fishery management. Although climate change is a current issue worldwide and seems to be a priority on the agenda of many decision-makers, there are actually many misconceptions in schools and at the community level. Confusion surrounding the terminology and concepts is but one of the major barriers in building resilience and promoting sustainable fisheries. Therefore, adequate knowledge is key for a transformative adaptation in the school environment.



The training took place in the nothernmost province of Vanuatu, Torba, which includes the Torres and Banks Islands (illustration SPC).

The second goal was to mainstream climate change, disaster risk and fisheries concepts into teaching programmes. Teachers should be able to identify the subjects with

specific topics and subtopics in which the resources will be integrated. The key messages conveyed in the resources need to be aligned with specific learning outcomes in the teaching programmes. Teachers will have to produce collaborative, inquiry-based student activities using innovative teaching methodologies in order to foster students' knowledge on these sensitive topics.

The subjects include:

- sciences, social sciences and language at the primary level;
- sciences, social sciences, agriculture at the junior secondary level; and
- development studies, earth science, geography and agriculture at the senior secondary level.

Learning outcomes

By the end of the training, participants were expected to be able to:

- incorporate climate science, climate change adaptation and fisheries concepts into teaching programmes;
- actively disseminate knowledge about climate change, disaster risk management (basic climate change science, environmental, social and cultural impacts, mitigation and adaptation measures) and sustainable fisheries, and judge their relevance to their learning context, homes and community; and
- develop an action-oriented learning programme associated with climate change adaptation and fishery management that is relevant to their educational environment, homes and community.

Overview of the training

As an example, we detail below the training that was conducted from 21–25 November 2016 at Arep bilingual school, Sola in Vanualava, which involved two trainers and 10 trainees.

The training targeted both Anglophone and Francophone secondary teachers. The training content included a deductive approach to enable trainees to analyse a specific condition from an overall situation. Analytical and experimental approaches were also used to develop the analytical mind of trainees, as well as "learning by doing" through hands-on activities that not only confronted teachers with the actual evidence of climate change on their environment, but also stimulated their curiosity to make it possible to mitigate and adapt to the ongoing onsets of climate change and fisheries resource reduction.

The first two days of training were allocated to climate change educational resources, and the following two days were devoted to the fisheries resource kit. In order to achieve the training objectives, the training package was carefully developed and adjusted in a way that suited all of the different professional backgrounds and knowledge of the participants, taking into account their language of instruction, subject areas and years of teaching experience.

We briefly describe here the sessions and activities related to climate change and fisheries management that took place over the four-day workshop.

Learning about climate change

The country-specific information kit "Learning about climate change the Pacific way"[5] includes 16 colourful pictures that illustrate the causes of climate change, the mitigation measures to reduce the emission of greenhouse gases at the local level, and adaptation measures to cope with the adverse effects of climate change. It also includes a guide with a description for each picture, suggested learning outcome, suggestions for teaching and learning activities, definitions and background information. The resource already outlines the links between the learning outcomes in the school curriculum and the topic illustrated in the pictures. It was used to animate most of the following activities.

Activity 1: Cooperative grid

This first activity was carried out to introduce the topic of climate change by arousing participants' curiosity on the causes and impacts of climate change, and the appropriate mitigation and adaptive measures. The activity was done primarily to assess participants' level of understanding of climate change and climate change adaptation.

Activity 2: Shrinking island

Participants were asked to draw a map of their island, showing different features and infrastructures. The teachers stood on their maps and imagined different scenarios affecting their island: a tropical cyclone, coastal erosion, sea level rise, land slide. For each of these events, participants had to fold in their maps. At one stage, inhabitants were forced to move out from the island due to death or lack of space on the island.

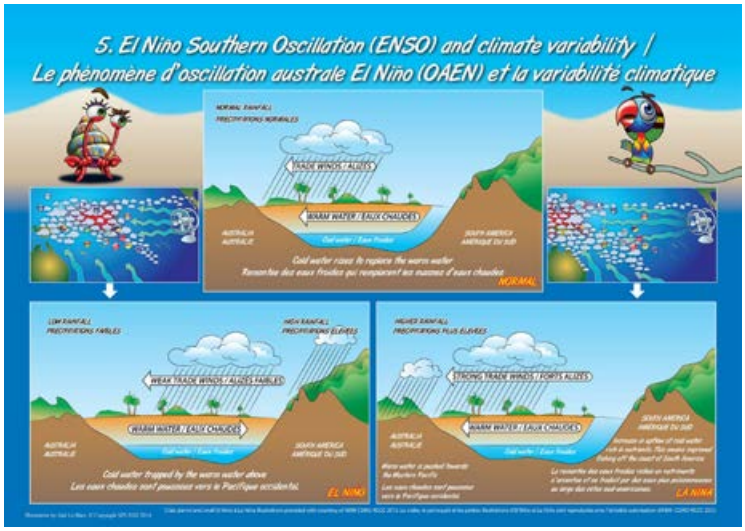
Activity 3: Misconceptions about climate change

Participants were given statements such as "climate change is the same as global warming", or "global warming is caused by a hole in the ozone layer, which allows more solar radiation to reach the earth") and asked to tell

[5] http://www.spc.int/wp-content/uploads/2017/01/Climate-change-vanuatu.pdf

Standing on a hand-drawn map of a "shrinking island" (image: James Melteres).

Pasifika, one of the small posters included in the publication "Learning climate change the Pacific way" (illustration: Jipé Le-Bars, SPC).



The El Niño image from the publication "Learning climate change the Pacific way" (illustration: Jipé Le-Bars, SPC).

if they were correct or false. If false, participants had to say why and rephrase the statement. An open discussion followed and participants were asked to come up with a simple definition of climate change.

Activity 4: General discussion

Using the image of Pasifika, which depicts the general aspects of all Pacific Islands, participants first identified the general aspects of Vanuatu shown in the picture. By carefully analysing the picture, they had to identify human activities that may be destructive to the island. They also had to identify possible risks as a result of climate change and unsustainable practices, and explain why they may be destructive to the island over time.

Activity 5: Water cycle

The water cycle simulation was carried out inside a classroom. Teachers were invited to act as water molecules and act out the process of evaporation, condensation and precipitation in the water cycle. Then the water cycle song was introduced using the tune of "Clementine".

Activity 6: El Niño

Participants looked at the illustrations in picture 5 and drew a diagram showing what happens in El Niño and La Niña years.

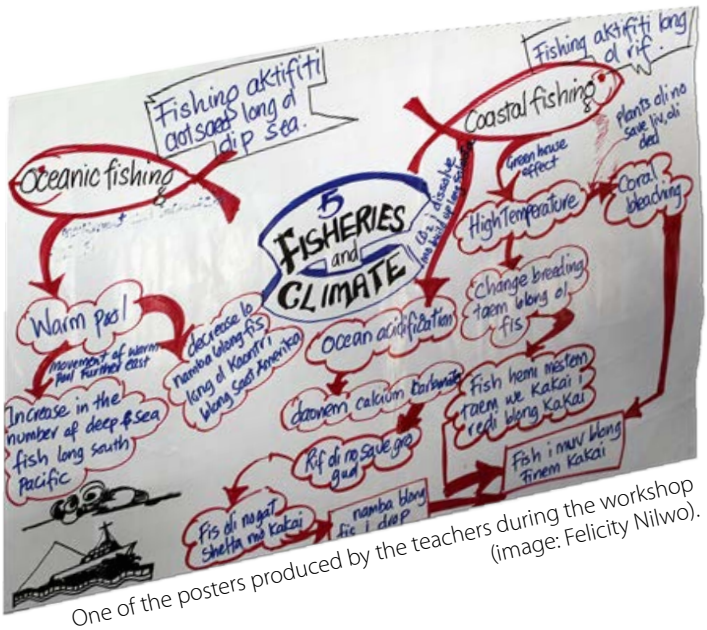
Despite participants being exposed to the information on climate change, and some having seen the "Cloud Nasara" video clip, participants still lacked an understanding of the El Niño Southern Oscillation (ENSO). This was clarified during an activity where participants had to explain to others in the form of an illustration. During the process, they assisted other participants who were still struggling with the notion of ENSO by correcting, clarifying and explaining it to them thoroughly.

Activity 7: Natural and enhanced greenhouse effects

Participants studied picture 6, entitled "Causes of climate change" and followed the step-by step explanation of the greenhouse effect. Then they drew a diagram to show and explain natural and enhanced greenhouse effects. This activity was essential to explain that the greenhouse effect is a natural phenomenon that is being accelerated by human activities.

Activity 8: Interrelationship between the land, the atmosphere and the ocean and impacts of climate change

Teachers were asked to choose a human activity depicted in one of the resource posters and discuss how humans are having a negative effect on their environment and how climate change will make these effects worse.



One of the posters produced by the teachers during the workshop (image: Felicity Nilwo).

Teachers further elaborated on the impacts of coastal changes and sea level rise, ocean acidification, coral bleaching and coral reef damage on the coastal ecosystem. They discussed food security during drought, salt water infiltration into a freshwater lens, and soil and extreme storms damaging crops. They stressed that human actions can increase the vulnerability of our island ecosystems to climate change. It has been identified that if we protect our environment from pollution and waste, we can reduce the stress on ecosystems and increase our resilience to climate change.

Activity 9: Discussion and carousel presentation

Each group of teachers studied a picture and discussed what it shows and how we can get students to carry out some of the activities shown. The groups then prepared a poster to show its findings to others. This activity was designed in a way that will enable participants to explain a particular situation to other teachers. Trainers closely monitored knowledge on the topics.

Activity 10: Discussion

Using pictures 1 and 16, teachers discussed new adaptations to the way of life in Pasifika that had been made. They identified the sustainable practices and described which ones could be put in place to support their schools, and the steps to follow in order to do so.

Activity 11: Pou and Miri

The comic book "Pou and Miri tackle climate change"[6] was used to drive this activity. Teachers identified the key messages in the comic book. They described the problems Pou observes on the island, and identified the causes and consequences of those problems. Using the knowledge gained from the previous resource, teachers described the mitigating and adaptive measures that could be put in place.

Activity 12: Cloud Nasara DVD animation

The third resource, "Cloud Nasara"[7] is a toolkit and a DVD animation on the science of El Niño and La Niña, and their impacts. This resource was developed in three languages: English, French and Bislama. El Niño and La Niña events significantly affect the islands of Vanuatu, triggering very dry or very wet conditions. In fact, these conditions, in conjunction with extreme weather events, can have tremendous impacts on water quality, food security, infrastructure, livelihoods and health.

Activity 13: Early warning, early action

Each group took one of the following scenarios and decided how to prepare for the situation in either a school or a community.

- Average rainfall period
- Less than average rainfall period
- Cyclone season
- High winds and seas warning
- Tropical cyclone warning

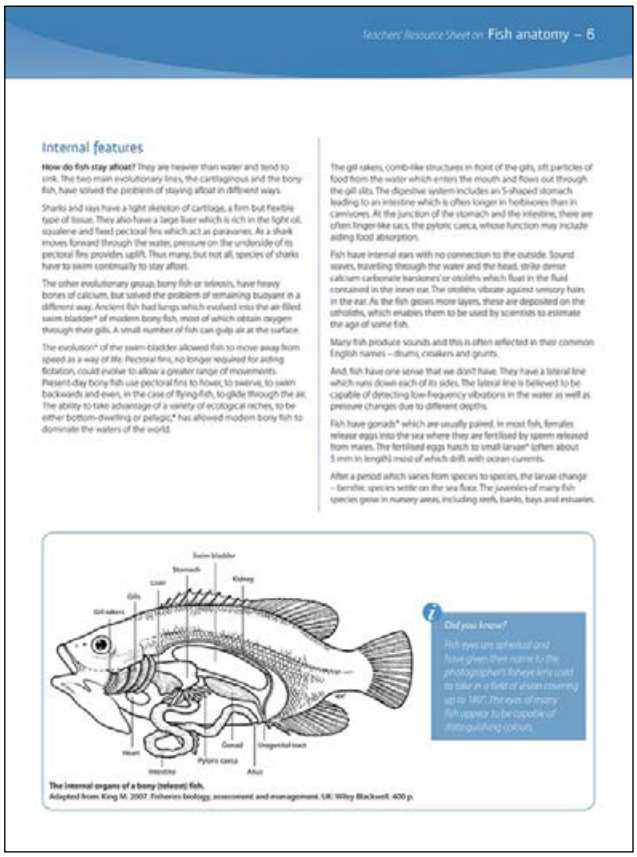
Teachers' Resource Kit on Fisheries for Vanuatu

The "Teachers' Resource Kit on Fisheries for Vanuatu"[8] includes 23 information sheets and a teacher's guide. The link between fisheries and the national curriculum is integrated in the guide. The resource kit also includes suggestions for activities suitable for both younger and older students from the primary level to the secondary level, taking into account their respective learning outcomes. The resource is expected to be used as a supplement to teach fisheries management inside and outside of classrooms, using local knowledge and expertise.

The 23 sheets were categorised by the trainers into five major topics:

1. Species
2. Aquaculture
3. Impacts on fisheries
4. Mitigation and adaptation
5. Job pathways

[6] http://www.spc.int/wp-content/uploads/2017/01/Pou-and-Miri-learn-to-tackle-climate-change.pdf
[7] https://www.youtube.com/watch?v=AMthanwiOWE
[8] http://www.spc.int/coastfish/en/publications/information-sheets/kit-for-teachers/464-vanuatu-teachers-kit.html


Teachers' Resource Sheet on Fish anatomy – 6

Internal features

How do fish stay afloat? They are heavier than water and tend to sink. The two main evolutionary lines, the cartilaginous and the bony fish, have solved the problem of staying afloat in different ways.

Sharks and rays have a light skeleton of cartilage, a firm but flexible type of tissue. They also have a large liver which is rich in the light oil, squalene and fixed pectoral fins which act as paravanes. As a shark moves forward through the water, pressure on the underside of its pectoral fins provides uplift. Thus many, but not all, species of sharks have to swim continually to stay afloat.

The other evolutionary group, bony fish or teleosts, have heavy bones of calcium, but solved the problem of remaining buoyant in a different way. Ancient fish had lungs which evolved into the air filled swim bladder* of modern bony fish, most of which obtain oxygen through their gills. A small number of fish can gulp air at the surface.

The evolution* of the swim-bladder allowed fish to move away from speed as a way of life. Pectoral fins, no longer required for aiding flotation, could evolve to allow a greater range of movements. Present-day bony fish use pectoral fins to hover, to swerve, to swim backwards and even, in the case of flying-fish, to glide through the air. The ability to take advantage of a variety of ecological niches, to be either bottom-dwelling or pelagic,* has allowed modern bony fish to dominate the waters of the world.

The gill rakers, comb-like structures in front of the gills, sift particles of food from the water which enters the mouth and flows out through the gill slits. The digestive system includes an S-shaped stomach leading to an intestine which is often longer in herbivores than in carnivores. At the junction of the stomach and the intestine, there are often finger-like sacs, the pyloric caeca, whose function may include aiding food absorption.

Fish have internal ears with no connection to the outside. Sound waves, travelling through the water and the head, strike dense calcium carbonate 'earstones' or otoliths which float in the fluid contained in the inner ear. The otoliths vibrate against sensory hairs in the ear. As the fish grows more layers, these are deposited on the otoliths, which enables them to be used by scientists to estimate the age of some fish.

Many fish produce sounds and this is often reflected in their common English names – drums, croakers and grunts.

And, fish have one sense that we don't have. They have a lateral line which runs down each of its sides. The lateral line is believed to be capable of detecting low-frequency vibrations in the water as well as pressure changes due to different depths.

Fish have gonads* which are usually paired. In most fish, females release eggs into the sea where they are fertilised by sperm released from males. The fertilised eggs hatch to small larvae* (often about 5 mm in length) most of which drift with ocean currents.

After a period which varies from species to species, the larvae change – benthic species settle on the sea floor. The juveniles of many fish species grow in nursery areas, including reefs, banks, bays and estuaries.

Swim bladder
Stomach
Liver
Kidney
Gills
Gill rakers
Gonad
Urogenital tract
Heart
Pyloric caeca
Intestine
Anus

Did you know?

The internal organs of a bony (teleost) fish.
Adapted from: King M. 2007. Fisheries biology, assessment and management. UK: Wiley Blackwell. 400 p.

Topic 1: Species

Participants usually find this topic very interesting because their lives revolve around the sea. After each information sheet was presented, participants asked questions and sought clarification and additional information.

Sheets 6–13 of the kit were covered during this session, and referred to:

- fish anatomy,
- marine food web,
- ocean species,
- deep water snappers,
- bonefish,
- pearl oysters,
- fresh water species, and
- aquarium species.

Trainers explicitly detailed the content of the sheets, focusing on scientific knowledge, technical and contextualised concepts of fisheries.

Activity: Fish dissection

Prior to the dissection activity, trainers went through sheet 6 on fish anatomy, explaining the external and internal features of a fish. Participants worked in pairs, dissected a fish and identified its internal organs.


Using SPC's information sheet on fish anatomy, two teachers dissect a fish to identify its internal organs (image: Lensley Bani).

Topic 2: Aquaculture

Marine and freshwater aquaculture (sheets 17 and 18) were covered during this session. Trainers detailed the content of the sheets, focusing on scientific and technical knowledge related to marine and freshwater aquaculture. Teachers identified the different organisms that could be farmed in the sea or in ponds filled with sea- or freshwater. They also identified the resources necessary for mariculture or to farm freshwater fish or prawns.

Activity: School project

Teachers were asked to identify a potential project to be implemented in their school and carry out a SWOT (strengths, weaknesses, opportunities and threats) analysis of the project.

It is very interesting to note that during the proposed project activity, all groups chose tilapia farming as their school project activity. They stressed the need to reduce pressure on their marine resources by farming tilapia. SWOT analysis was a very new tool to some participants, and they indicated their gratitude, stressing how important it could be to them.


Freshwater ponds can be used for school project activities related to aquaculture (image: Céline Barré).

Topic 3: Impacts on fisheries

Activity: Collaborative presentation

Using sheets 5, 15, 19 and 20 – which cover fisheries and climate change, modern large-scale fishing techniques, fish spoilage, and fish poisoning and ciguatera – each group of teachers was given a sheet, explaining the different impacts on fisheries. They read through their respective sheet and identified the outcomes of each topic for younger and older students. Then they summarised each sheet in preparation for a presentation to the whole group.

Trainers closely monitored each presentation and gave feedback and additional information when needed.

Topic 4: Mitigation and adaptation

Six information sheets were grouped to cover this topic: 1) fisheries management, 2) no take areas, 3) fisheries assessment, 4) fisheries economics, 5) traditional fishing methods used in Vanuatu, and 6) fish aggregating devices (FADs). Trainers detailed the content of the sheets, focusing on scientific and technical knowledge, relating the concepts of mitigation and adaption to the local context, and detailing the measures that needed to be put in place to allow sustainable fisheries. Teachers identified the benefits of fisheries assessment in providing information for fisheries management. They described the aims of fisheries management and the different rules and regulations to protect seafood species.

FADs were introduced to teachers, detailing their components and the benefits they could provide by facilitating access to offshore marine resources, such as tuna. One of the probable impacts of climate change on the marine ecosystem is the decline and loss of coastal resources; therefore, access to an alternative source of seafood will become vital for coastal communities.

Activity: Collaborative presentation

Each group of teachers was given a sheet explaining different mitigating and adaptive measures to allow sustainable fisheries. Teachers read through the sheets and answered questions for presentation to the whole group.

Again, trainers closely monitored each presentation and gave feedback and additional information when needed.

Topic 5: Job pathways

Using sheets 21, 22 and 23 – which relate to sea safety, job opportunities in fisheries, and financial management of a small fishing business – trainers explained why a fishery is not just about fish, it is also about fishers who catch the fish, people who process and market the catch, and fisheries managers who ensure that fish stocks remain healthy. There are many exciting jobs that involve both inside and outside work. Teachers were asked to assess the different job opportunities the fisheries sector can offer. They also learned that this sector includes some of the most dangerous jobs in the world, globally causing more than 24,000 deaths per year. By using information sheet 21 on sea safety, trainers explained how important it is to pay extreme attention to sea safety, even on small outboard-powered skiffs. The concept of a small fisheries business was also introduced to participants. Since the Torba Islands are quite resourceful, this sheet will assist in educating teachers and students on how to manage a small fisheries business.

Each group of teachers were given a sheet and answered questions for presentation to the whole group.

Again, trainers closely monitored each presentation and gave feedback and additional information when needed.

Field trip

A field trip was organised with officers from the Department of Agriculture to visit the tilapia ponds, where officers provided further information on tilapia farming and how to establish a school project.

A second field trip was made to local tilapia farmers. Both visits stimulated teachers' curiosity about the actions that could be put into place to mitigate and adapt to ongoing aspects of climate change. This will, in turn, support teachers' capacity to integrate action-oriented learning in their teaching practices by adapting some of these measures in their respective schools and context. This field trip took an integrated approach to both fisheries and climate change themes.

Debriefing

The final session was a facilitated debriefing to capture participants' reflections on the fisheries management training. This was an essential part of the training and needed to be attended by all participants. The aim was to capture participants' key recommendations, build on achievements, and address weaknesses and opportunities to improve the training package on fisheries education. Teachers then filled in the evaluation form.

The workshop ended with the handout of copies of the information resources used during the workshop for all primary and secondary schools of Torba Province.

Acknowledgments

Our team for the Climate Change Adaptation and Fisheries Management training comprised Ms Angelinah Eldads-Vira and Ms Felicity Rogers-Nilwo from the Curriculum

Development Unit (CDU), who also developed the year 7–13 Earth Science syllabus, which covers more concepts of climate change and disaster risk management.

The team would like to gratefully acknowledge the financial assistance from SPC-GIZ and UNESCO.

We would also like to thank all participants from the secondary schools in Torba Province who warmly welcomed us at Arep Secondary School and with whom the team shared more than the training content but also their experience and stories about their livelihood.

Our acknowledgements also go to Zone Curriculum Advisors: Mr Louis Klem and Mr Patrick Dingley for representing the Torba Education Office at the official opening and closing ceremonies.

Last but not least, a warm thank you to our partners – SPC-GIZ and SPC's Division of Fisheries, Aquaculture and Marine Ecosystems – for the well-developed resources that were used during the four-day workshop. Such detailed educational resources will empower educators to teach the elements of climate change, climate change adaptation and fisheries management inside and outside of classrooms.

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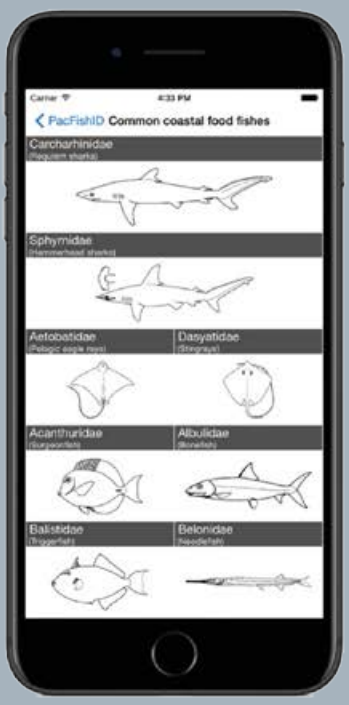
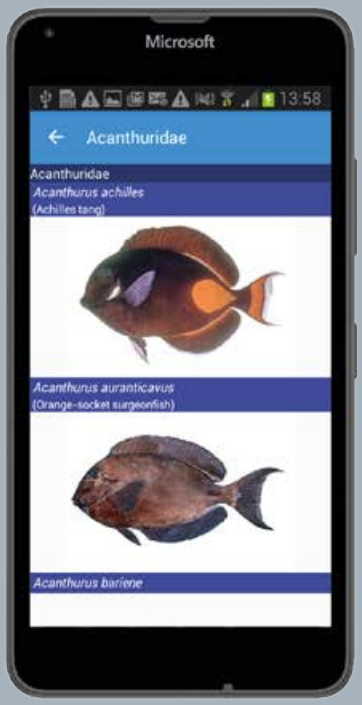
Demonstration of a traditional fishing technique (image: Lensley Bani).

KNOW YOUR FISH?

PacFishID

The mobile application for learning how to recognise Pacific marine fish species is now available on all platforms!





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