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Daykin Harohau of Worldfish Solomon Islands holding a 2 kg tilapia raised in ponds in remote SW Espiritu Santo, Vanuatu (image: Tim Pickering).

Editorial

Tuna fisheries in the western and central Pacific Ocean broke another record in 2014 with an estimated total catch of 2.86 million tonnes, which represents 60% of the global tuna production; but this is not sustainable for many of the target and non-target species (see Hampton's article on p. 7).

At the same time, and at the other end of the fisheries spectrum, farmers dig holes by hand in their backyard to raise tilapia fish that will help them to put dietary protein on the family table. This type of aquaculture, which requires very basic technology and minimal financial investment, is slowly but steadily developing in our region. In Papua New Guinea, it is estimated that more than 50,000 tilapia farms are now in operation, and in one location 'former warriors now work together to farm fish after 38 years of tribal war' (see Sammut's article on p. 19).

However, a trend has developed where farmers rush to build farms without seeking expert advice. As a result, these farms are difficult to operate. A strategy has been applied in Espiritu Santo, Vanuatu, where the Vanuatu Fisheries Department, SPC and WorldFish have joined forces to encourage the forming of farm clusters. This involves using successful 'lead farms' as examples so that farmers can learn from them and meet agreed target specifications (see Pickering's article on p. 2).

Pacific Island tilapia farmers will never produce 2.86 million tonnes in a year, as the tuna fisheries did, but their contribution to food security, especially in places where communities do not have regular access to animal protein, may become increasingly important.

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

South Santo tilapia farmers gear up to increase production

In July 2015, the Vanuatu Fisheries Department (VFD) and the Aquaculture Section of the Secretariat of the Pacific Community (SPC) jointly convened a meeting of leading tilapia farmers in the southern part of Espiritu Santo. This was held to exchange ideas and plan ways to increase production of tilapia to meet the increasing need for fresh fish in Luganville and the inland parts of Santo. The work is being supported by ACIAR's (Australian Centre for International Agricultural Research) Community Aquaculture project, in which SPC, VFD, as well as WorldFish Solomon Islands are project partners.

Sompert Gereva, Principal Fisheries Biologist and Acting Manager, VFD Research and Aquaculture Division, with Lency Kukan, head of the VFD Aquaculture Section (behind fish), holding up a 2 kg tilapia from a pond at the fish farm of Tavui Sosomele (left).

A strategy being applied by the Community Aquaculture project is that of facilitating farm clusters, with each having lead farmers whose farms are maintained at standards that serve as examples for others to see and gain knowledge. One purpose of the meeting in Santo was to identify lead farmers, and then reach an agreement about what constitutes a 'lead farm' for tilapia fish. Collaborative work will then focus on bringing selected farms up to the agreed standards, and find ways to disseminate methods and knowledge from those demonstration farms to other places in Santo.

The expansion of tilapia aquaculture in the Pacific has seen a trend where many farmers rush to build farms and copy things they have seen or heard without waiting to seek out expert advice. The result has been construction of farms that are all of different shapes and sizes and, in some cases, difficult to operate. Similar experiences have been noted in the Solomon Islands; therefore, Daykin Harohau of WorldFish Solomon Islands was invited to attend the meeting to share his experience of facilitating tilapia farm clusters in Malaita. In return, he gained a close look at farming of Nile tilapia *Oreochromis niloticus*, which is present in Vanuatu but not in the Solomon Islands where the tilapia species being farmed is the smaller and slower growing, but more invasive and salt-tolerant, Mozambique tilapia *Oreochromis mossambicus*.

The top priority issues and constraints that farmers identified as needing attention in Santo are:

- ✓ pond construction issues (what is the best pond design?);
- ✓ water supply issues;
- ✓ feed (which gives best results?);
- ✓ pond management issues (stock density and harvest strategies); and
- ✓ market and pricing issues to improve farm income and recoup pond construction costs.

Although farmers began growing tilapia just to supply their own households with fresh fish, which is very scarce anywhere further inland than 3 km from the coast on Santo Island, some identified a commercial opportunity and built as many as 10 ponds each. Farming of tilapia fish is perceived as easier than cattle farming or copra, and a good way to continue generating income in

old age after retirement from other, more physically demanding agricultural livelihoods. Currently, most sales of fish take place in the village or the surrounding district; however, there is also a demand for the fish in the urban market of Luganville. At the end of the workshop, VFD and SPC organised live tilapia sales in Luganville with fish from three South Santo farms as a promotion of tilapia to crowds who were attending the 2015 Independence Week celebrations. Even when priced at VUV 500 per kg[1] (reef fish were selling at VUV 400), the live tilapia soon sold out.

When addressing the issue of what should constitute a 'lead farm', the farmers group deliberated and decided upon the following as target specifications for a 'standard tilapia farm'**:**

1. pond area to be a minimum of 200 m^2 or 20 m x 10 m, capable of producing 200 kg of fish per cycle, worth VUV 80,000;
2. number of ponds: 4 (e.g. convert 10 smaller ponds into 4 larger ponds, to utilise the farm area and water supply more efficiently by reducing the amount of bund);
3. water depth: 60–80 cm (most Santo ponds have been built too shallow);
4. water supply: separate flow to individual ponds, rather than the same water flowing from pond-to-pond;
5. pond water colour to be maintained at a Secchi value of 30 cm (equivalent to a hand disappearing when arm is immersed up to the elbow);
6. stocking density: limited to 5–10 fish per square metre of pond (all farms are currently over stocked);
7. supplementary feeding to be tested, using Pacific tilapia pellets in addition to local ingredients;
8. stock management to adopt five-month batch cycle strategy with total-harvest followed by re-stocking, rather than continuous cycle with partial harvests; and
9. farmers to coordinate their stocking and harvesting, to jointly maintain a near continuous flow of tilapia into Luganville and thus build up the market for tilapia.

We visited farms of four of the lead farmers: Koilo Lutu, Maliu Tapea, Maliu Ato and Tavui Sosomele, who hail from Marua Village in southwest Santo. All four had farms dug by hand to achieve a respectably large total area for the ponds, but were made up of several small ponds of different shapes, sizes and depths. They had been designed without any outside guidance and at each farmer's own initiative. Water flows through the ponds in series (not in parallel) from pond-to-pond to save on piping, which is a mixture of bamboo and PVC pipe. This means that all ponds get the same flow irrespective of volume, so have differing water turnover times. The result is that large ponds are overly green, but the water in smaller ponds is clear from too much flushing. It also means that lower ponds receive the fish waste of higher ponds.

Apart from the above variations from best practice, all of the farms visited were well built, nicely landscaped and well managed. A variety of ideas and innovations could be seen for feeding and greening the ponds. The farmers are doing an excellent job in feeding and managing their ponds within the scope of the on-farm resources available to them. Some of the fish were up to 2 kg in size. Breeding occurs in-pond and is

Tavui Sosomele, tilapia farmer of Marua Village, with farm-fresh tilapia netted from one of his ponds.

continuous, which is well adapted to basic tilapia farming. However, batch culture and complete harvest are innovations that should be adopted next. Growing fish to such a large size and keeping them for so long (up to two years), however, is wasteful of pond space, water and food supply. The turnover of fish biomass through the ponds can be greatly increased by more regular harvesting and selling of fish. In summary, the assessment that was made of the lead farms is that their pond management is very good, but their pond design and fish stock management has room for improvement through further project work.

The VFD and SPC project team will next work with these lead farmers on further improvements in tilapia farm design and practice, based on the lead farm criteria established during the meeting. These lead farms will become a focus for the dissemination of information to other tilapia farmers; for example, via Farm Open Day visits and illustrated knowledge products. In this way, over time, the tilapia fish production capacity in Santo will be built up.

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All pictures in this article by Tim Pickering.

Koilo Lutu beside hand-dug tilapia ponds in operation near Marua Village in SW Santo, Vanuatu.

Tilapia incubator trials to increase seed production in Fiji

Most subsistence tilapia farmers throughout Fiji depend on the Naduruloulou Freshwater Research Station (NRS) hatchery for their fingerling and broodstock supply. The NRS usually produces its fingerlings by utilising open pond or knock-down tank methods. These methods involve housing breeder fish in ponds or tanks and allowing them to breed naturally. Young hatched (swim-up) fry are collected using scoop nets. The Asian Institute of Technology (AIT) has developed an incubator method, which is now used globally to produce billions of tilapia fingerlings. This method involves holding breeder fish in net cages called hapas in ponds and regularly collecting tilapia eggs. The advantage of this method is that a larger number of eggs can be collected and cultured in incubators, in clean water that is under optimum conditions rather than collecting fewer swim-up fry. Larger numbers of breeder fish can also be held in hapas, which enables better usage of space.

Two years ago, the Secretariat of the Pacific Community (SPC) sponsored a representative from NRS to attend hands-on training on this method of seed production at AIT in Thailand. This was the first exposure of this method to the NRS hatchery and it generated interest among fisheries management, who were eager to trial the method and train a group of hatchery staff in order to operate it. In August 2015, in response to a request from the Fiji Ministry of Fisheries and Forests, SPC mobilized to assist with the trialling and transfer of this technology to Fiji. The experiment had two main goals: to evaluate the technique as an option for tilapia seed supply at the national hatchery and to build staff capacity.

The technology transfer initially involved building an incubator hatchery, with follow-on training on operations and best practices. The training component was undertaken over two days at the station and was split between morning lectures and afternoon hands-on sessions. Sixteen NRS staff, including the Officer in Charge (OIC), participated in the training and key staff is now involved in operating the hatchery, and the hapa-based broodstock and nursery systems.

After the training, Dr Timothy Pickering, SPC Inland Aquaculture Specialist, officially handed over the incubator equipment to Mr Sam Mario, OIC of NRS.

NRS staff member collects tilapia eggs from breeder fish in hapas (image: Tim Pickering).

Follow-up actions, for SPC, will involve the provision of ongoing fine-tuning and support to ensure that the system operates well and produces several thousand fry in order to demonstrate the validity of the concept. If NRS chooses to ramp up production in the future then they will just need to add more breeding hapas and incubators to the system. It is hoped that the adoption of the new technology will allow NRS staff to reach their production goals with greater efficiency and for farmers to benefit from a regular fingerling supply.

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Sam Mario (right) and other staff from NRS inspect tilapia fry produced in an incubator (image: Tim Pickering).

Tuna in focus

SPC scientists provide the latest information to WCPFC 11th Scientific Committee meeting

The Oceanic Fisheries Programme of the Secretariat of the Pacific Community (SPC-OFP) is the key scientific services provider to the Western and Central Pacific Fisheries Commission (WCPFC). The main services provided by the OFP to WCPFC are regional stock assessments, evaluations of conservation and management measures, and managing data provided to WCPFC by its members.

A key event on the WCPFC calendar is the annual meeting of the Scientific Committee, which was held during early August this year in Pohnpei, Federated States of Micronesia (also the location of WCPFC's headquarters). Once again, the OFP produced a large volume of material. The team produced 36 working and information papers for the meeting, and made significant contributions to seven others. Some of the highlights of the OFP work submitted to the meeting are as follows:

✓ The total catch of key tuna species in the western and central Pacific Ocean (WCPO) in 2014 has been provisionally estimated at a record 2.86 million tonnes, which is a 6% increase over the previous high that was recorded in 2013. This catch represented 60% of the global tuna production in 2014. The biggest increase occurred in the purse-seine fishery (catching mainly skipjack tuna), which exceeded 2 million tonnes for the first time. See http://www.wcpfc.int/node/21762.

✓ Work undertaken on a recently compiled set of operational (set-by-set) longline data was reported in a series of papers by the OFP's stock assessment and modelling team. This comprehensive data set, which represents almost all of the industrial-scale longline fishing in the Pacific Ocean since the early 1950s, was provided by the fisheries agencies of China, Japan, Korea, Chinese Taipei, United States and other SPC members. The data comprised information on more than 10 million individual longline sets and is, without doubt, by far the largest data set of its type, ever. The data were used to estimate relative abundance trends for Pacific bigeye and South Pacific albacore tuna, and this information was incorporated into stock assessments for these species. See http://www.wcpfc.int/node/21773, http://www.wcpfc.int/node/21781 and http://www.wcpfc.int/node/21782.

✓ A stock assessment analysis of bigeye tuna was conducted on a Pacific-wide basis for the first time since 2006. The objective of this work was to incorporate new information on the movement of bigeye tuna out of the WCPFC area and into the eastern Pacific Ocean, to see if this might have biased the results of assessments. While some changes in results were observed when modelling the stock over the entire Pacific, the essential stock assessment results (that bigeye tuna spawning stock was being depleted by fishing to less than 20% of the unexploited stock level) from the 2015 WCPO assessment were supported. See Figure 1 and http://www.wcpfc.int/node/21774.

✓ A new assessment of the South Pacific albacore stock was undertaken, which updated the previous assessment from 2012. The main conclusion is that the spawning stock has been reduced to less than half of its unexploited level. While this is comfortably within biologically safe limits, the older part of the stock that is exploited by longliners is probably depleted beyond the level than can sustain profitable fisheries. See Figure 1 and http://www.wcpfc.int/node/21776.

✓ An analysis of data from a number of sub-tropical and temperate water skipjack tuna fisheries was undertaken in order to evaluate a hypothesis favoured by some WCPFC members who believe that high catches of skipjack in the equatorial zone are making skipjack less likely to migrate seasonally to temperate waters, and are therefore negatively impacting the fisheries that occur there. The analysis undertaken could not find any concrete evidence to support this hypothesis. At this stage, the question remains open and it would seem equally plausible that declines of skipjack numbers in temperate and sub-tropical fisheries could be due to local exploitation effects, unfavourable economics for sustaining these small-scale fisheries and/or general declines in the overall skipjack stock as a result of fishing. See http://www.wcpfc.int/node/21713.

✓ An analysis of purse-seine catch and effort data was undertaken to try to identify factors that might be responsible for above-average catches of bigeye tuna, which might be the focus of future mitigation efforts to reduce fishing pressure on this species. The analysis examined vessel-specific catches across the equatorial Pacific, and found that over the period 2010–2013, fewer than 5% of the 300-strong purse-seine vessels in the fleet took 25% of the bigeye tuna catch, and fewer than 15% of vessels took about 50% of the catch. This level of concentration suggests that

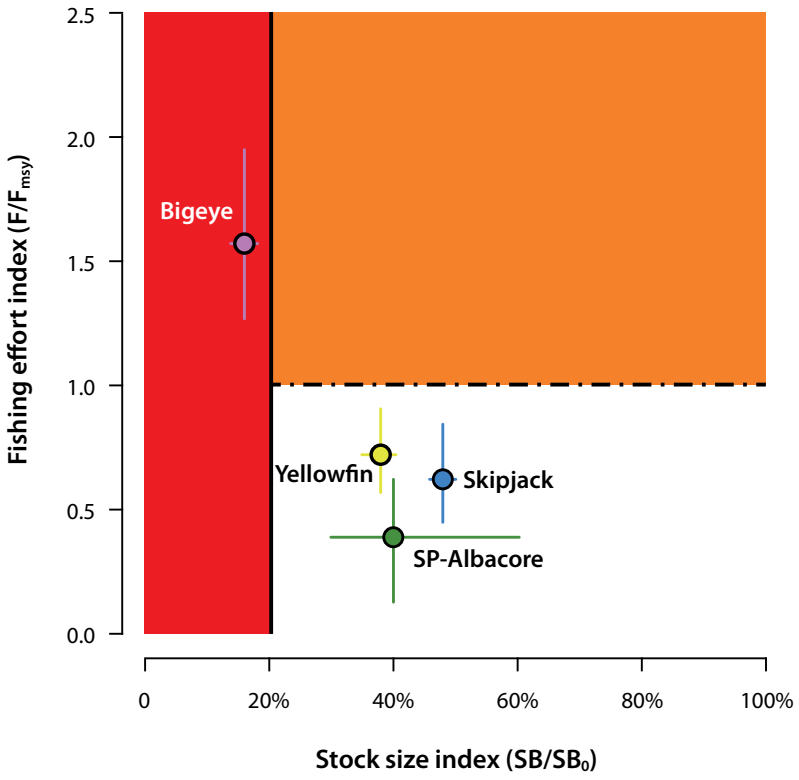

Figure 1. Relative status of the four main tuna stocks against biological reference points

F/F_{msy}: Current fishing effort relative to the fishing effort that would produce maximum sustainable yield.

SB/SB_0: Current number of spawners relative to the estimated number of spawners if the stock had never been fished (SB_0 calculated as an average over the most recent 10 years). 20% is considered to be the limit below which the stock may not be able to successfully reproduce.

there might be ways that these vessels operate, or places where they fish, which if avoided could substantially reduce the catch of bigeye tuna without necessarily, or substantially, impacting the catch of the main target species: skipjack. See http://www.wcpfc.int/node/21795.

✓ A new report investigating the ecosystem effects of fishing in the western Pacific was presented. This work, led by the OFP's Ecosystem Monitoring & Analysis team, shows that the warm pool ecosystem is resilient to considerable perturbation by fisheries, and that this resilience is related to the high diversity of predator species in the food chain that consume a wide variety of prey. The study estimated that the largest impacts of fishing are likely to be on long-lived, bycatch species with lower productivity (e.g. silky and oceanic whitetip sharks, opah, swordfish and blue marlin). These groups are the most sensitive to changes in fishing effort due to their longevity, age at first maturity and low rate of reproduction. See http://www.wcpfc.int/node/21722.

These and other reports have formed the basis of the Scientific Committee recommendations for management action to the 12th Annual Session of the WCPFC, to be held in December 2015 in Bali, Indonesia.

The SC11 executive summary report and all documents presented during the meeting are available from the WCPFC website (http://www.wcpfc.int/meetings/11th-regular-session-scientific-committee), or from SPC-FAME's Digital Library (http://www.spc.int/DigitalLibrary/FAME/Collection/WCPFC_SC11).

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We want more!

10 successful tagging seasons +1: CP11 to be launched

The Oceanic Fisheries Programme of the Secretariat of the Pacific Community (SPC-OFP) has been conducting tuna tagging, which is focused on bigeye tuna in the equatorial central Pacific since 2008. This tagging work has been concentrated on tuna schools that are aggregated beneath the tropical atmosphere and oceans (TAO) oceanographic data moorings (see Fig. 1). In particular, this tagging work provides crucial information for tuna stock assessments and greatly improves the understanding of bigeye tuna movement behaviour. The reports on the 10 cruises undertaken to date are available on SPC's website at: http://www.spc.int/tagging/en/publications/tagging-publications/viewcategory/12.

In 2014, the 10th Central Pacific cruise (CP10) was implemented for the first time with the collaboration of the International Seafood Sustainability Foundation (ISSF) and the US purse-seine company TriMarine International. This joint effort allowed research to be carried out for the first time around drifting fish aggregating devices (dFADs), with the objective of improving our knowledge on dFAD-associated tuna and bycatch species behaviour.

This year, the collaboration with TriMarine will be enhanced with the participation of their fishing analyst Beth Vanden Heuvel during the CP11 cruise. Another fishing company, the Spanish Garavilla group (Isabel brand tuna cans) that operates a fleet of four boats from Manta (Ecuador), will also collaborate by providing access to some of their dFADs.

The main objectives of the cruise are to:

1. provide information for the assessment and management of bigeye tuna in the Pacific Ocean. This will involve tagging and releasing bigeye tuna with conventional tags (CT) and archival tags (AT) around the equatorial TAO moorings that are placed along the 170°W, 155°W and 140°W meridians. The same experiment will be conducted around dFADs; and
2. improve knowledge on tuna and bycatch behaviour around dFADs. This will involve tagging and releasing tuna and associated species with acoustic tags around dFADs, which have been pre-equipped with acoustic receivers.

Tagging platform: For CP11, the project has chartered FV *Gutsy Lady 4*, which is a US-flagged longliner based in Honolulu. Captain Tim Jones has already participated in three previous central Pacific tagging cruises. He is keen to sail again for the project with this bigger vessel (30 metres), which will provide a comfortable platform with enough autonomy to operate over the considerable distances (over 6000 nautical miles) that will have to be covered (Fig.1)

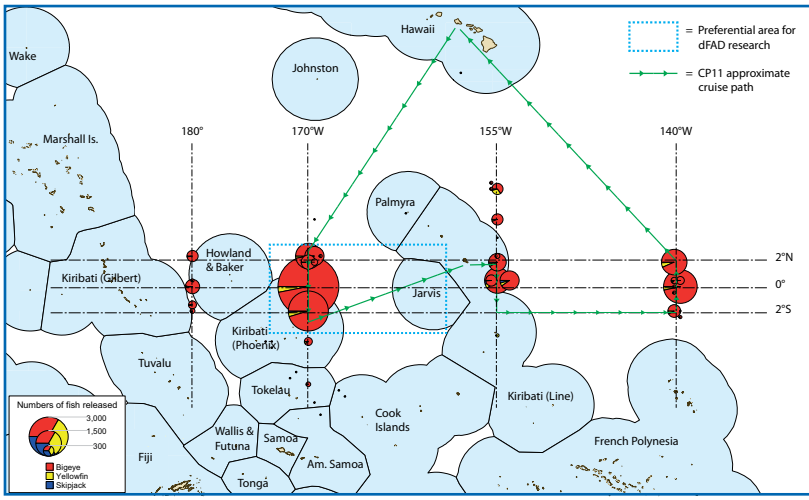

Figure 1. Distribution of tag releases (by species) during the previous CP cruises. The blue dashed line delimits the preferential area of research for CP11.

Figure 2. FV Gutsy Lady 4.

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Was this tuna caught around a FAD or not?

Image: Siosifa Fukofuka.

Scientists of the Stock Assessment Section of the Secretariat of the Pacific Community Oceanic Fisheries Programme (SPC-OFP) have developed a relatively simple statistical technique that is based on observer catch sampling, to determine whether the tuna catch from a purse-seine set is likely to have been associated with a fish aggregation device (FAD).

Tuna purse-seine catches associated with FADs are typically more diverse than catches set on free school tuna, including both smaller target tuna and a variety of bycatch species that are often discarded, which is prompting conservation and sustainability concerns. Furthermore, tuna retailers and consumers have shown an increasing demand for 'FAD-free' tuna and, in many regions, consumers have indicated a willingness to pay a premium for certified FAD-free tuna or even to boycott non-FAD free tuna.

FAD-fishing moratoria, covering the months of July to September, have been instituted across the western and central Pacific since 2009. Nevertheless, there are concerns about adherence to FAD-free fishing requirements and a method for independently verifying FAD-free fishing claims has been sought. OFP's new methodology, which can be easily implemented 'in the field', has a prediction accuracy rate of up to 86%. Details of the methodology have been published, in Open Access format, in the December 2015 issue of the journal *Fisheries Research*[1].

A number of uses of this technique can be envisioned. Most importantly, it provides managers with a means of verifying claims by vessels, particularly during the FAD-closure period, as to whether their catches were likely made on free school tuna. Additionally, observer classification of sets, early in their employment, can be monitored to determine whether they are accurately identifying FAD-association, which is not always a straightforward task as they adapt to the rigors of at-sea sampling. Finally, this methodology allows OFP scientists to retroactively classify historical purse-seine sets by providing valuable information on changes in targeting and capture efficiencies, which will assist in developing appropriate management and conservation targets for tuna in the western and central Pacific.

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[1] http://authors.elsevier.com/sd/article/S0165783615300515

Deployment of subsurface FADs from small vessels for fishing communities in Choiseul

Introduction

Installing affordable, robust and long-lasting fish aggregating devices (FADs) is a common objective of fisheries officers and other people responsible for FAD programmes. A FAD system requires a floatation device, ropes for the mooring, hardware to connect the various parts of the system, pressure resistant buoyancy to lift the lower part of the mooring rope and avoid abrasion on the seabed, and an anchor system to keep the unit in place. In most cases, FAD materials are ordered offshore while the anchor system is sourced locally. On top of the cost of the FAD itself, the costs of deploying a single FAD may be important and generally cover: the personnel involved, the machinery used for shifting or lifting the anchors (Fig. 1), the deployment vessel or, at least, the fuel used for the deployment vessel.

In looking at the partitioned costs for a full FAD operation, it is interesting to note that the cost of deployment can be more than half the expense; especially in the case of nearshore surface and subsurface FADs where the length and cost of the mooring rope is considerably less than for offshore FADs. The reason for the high cost of deployment is the hiring of heavy lifting machinery, to shift heavy anchors around, and the charges for a deployment vessel. With offshore FADs, deployment vessels have to be of a size that allows for a FAD anchor weighing a tonne or more to be carried safely.

In urban centres, large vessels are not hard to find (in most cases), but they still cost a lot to hire. In rural areas, however, the only boats available are those operated by small-scale fishers and water taxis. Deploying FADs in these areas involves costly charters or meticulous planning to utilise passing inter island cargo ships.

In recent years, the evolution of nearshore surface and subsurface FADs in rural areas compelled a re-thinking of the methods used to deploy FADs that use small vessels such as the open Yamaha banana boats. The use of grapnel, Hall or Danforth anchors and chain for nearshore surface FADs made it safe to use 19–23 foot boats for the deployments. The costs of a 25 kg Danforth anchor and a 500 kg cement block anchor are similar. Safely deploying bulk anchors, however, requires considerable attention.

In March 2011, when reflecting on some of the work carried out by SPC, WorldFish and the University of Queensland (UQ) rigged and deployed seven nearshore

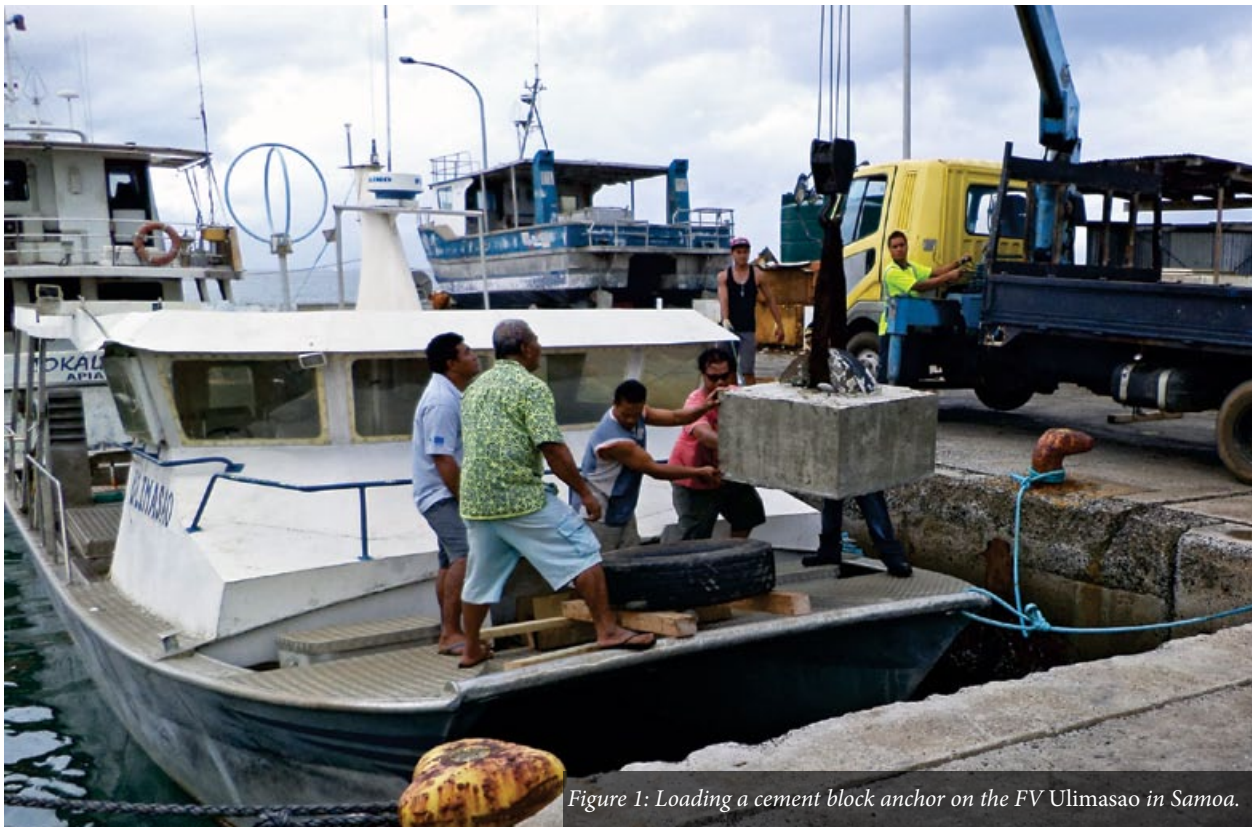

Figure 1: Loading a cement block anchor on the FV Ulimasao *in Samoa.*

surface FADs in the Western Province of the Solomon Islands by using 23 ft open Yamaha banana boats. Three different mooring systems were used: grapnel anchor and chain; drum cement anchor with the rope connected directly to the block, and a heavy single engine part and chain. All the FADs were of the Indian Ocean type – with the exception of the rope in the middle mooring and anchor systems – with a string of floats on the surface.

Deploying the FADs with grapnel anchors was easy as they could be lifted by two men only (Fig. 2).

To deploy the heavy bulk anchors, careful planning and additional safety measures had to be implemented to avoid accidents. The anchor weight was suspended by sacrificial ropes beneath a raft and was towed to the deployment site where it was released by cutting the holding rope (Figs. 3 and 4). In later deployments, WorldFish did not use a raft to tow the bulk anchor but suspended it beneath the deployment vessel itself. However, in both cases, even if the task was carried out by using small vessels, it proved to be very time and fuel consuming because of the drag caused by the un-streamlined weight being towed underwater.

Using a new technique to deploy FADs in Choiseul, Solomon Islands

In April 2015, a FAD workshop was carried out at Taro in Choiseul, Solomon Islands. This was a collaborative effort between SPC, *Deutsche Gesellschaft für Internationale Zusammenarbeit* (GIZ), Solomon Islands Fisheries Division and WorldFish, in order to train staff from the respective organisations on how to rig and deploy subsurface FADs using a 23 ft open Yamaha banana boat for the fishing communities of Subesube, Vurango, Voruvoru, Pangoe, Nuatabu and Posarae.

FADs were standard SPC subsurface units (Fig. 5), with a mooring made of two cement blocks linked to a Danforth anchor to prevent them from sliding along the sea bottom slope.

Figure 2. Deploying a nearshore surface FAD from a 23 ft open Yamaha banana boat using a grapnel for anchor.

Figure 3. Using two boats to tow a bulk anchor to the deployment site.

Figure 4. Preparing to cut the rope to release a ½ drum cement anchor.

A subsurface FAD with 100 kg buoyancy (lifting power) needs an anchor weight of at least 300 kg in seawater. Therefore, 25 kg Danforth or Hall anchors alone would not be sufficient to hold a FAD down. A cement anchor block weighing 300 kg in seawater weighs around 550 kg in air; a weight that can be carried by a 23 ft open Yamaha boat. A metal weight (discarded engine block, etc.) that weighs 300 kg in seawater weighs around 350 kg in air.

For the FAD work in Choiseul, it would have been extremely difficult to lift a single 550 kg anchor block without machinery. Consequently, this weight had to be broken down into two weights that could be physically carried. The six Choiseul communities were requested to each construct two cement anchor blocks of 55 cm x 55 cm x 38 cm. These blocks weighed around 260 kg each in air so the combined weight of each pair was 520 kg. Although these blocks fell short of the recommended 550 kg combined weight, the weight of the 5 m anchor chain and the Danforth anchor made up for the difference. Eight men were needed to lift the blocks by using a long and solid wood log (Fig. 6).

For previous deployments done by SPC or WorldFish in the Solomon Islands, the bulk anchors were suspended under large floats or under the deployment vessel and released by cutting the holding ropes. For these deployments in Choiseul, the cement block

Figure 5. A subsurface FAD unit ready for loading.

Figure 6. Loading a cement block on to the deployment vessel.

anchors were loaded on to a platform that was fitted on a 23 ft open Yamaha banana boat. This platform was constructed with several specific features, as detailed in Figure 7.

Two boats were used to deploy the subsurface FADs; one used as a barge – with the engine removed – carrying the complete FAD (Fig. 8) and the other used to tow the 'barge'. The use of two boats was a safety measure that was undertaken to maintain a minimal number of people close to the deploying platform. In retrospect, only one 23 ft boat is needed for the whole operation, provided it is powered by a 40 horsepower outboard engine or less. The weight of an engine of more than 40 hp would add to the weight of the FAD, and would overload the boat and compromise safety.

All the deployments were carried out in good weather (Fig. 9), efficiently, with ease, and most importantly: safely.

Additional buoyancy could have been used to stabilise the deployment vessel, although this was not tried during the project. This could include having large floats lashed tightly to the sides or by tying a second vessel of alongside the deployment vessel. This would be a good safety measure to consider for future operations.

Conclusion

The FAD deployments carried out in Choiseul established several important factors:

- ✓ Using small boats can drastically reduce the cost of nearshore FAD deployments.
- ✓ By using small boats, it is possible to deploy nearshore FADs with the cement block anchors carried on-board rather than suspended beneath the boat or towed beneath floats. For obvious safety reasons, the carrying capacity of the boat must never be exceeded, while ensuring that the anchor weight is sufficient to hold the FAD in place.

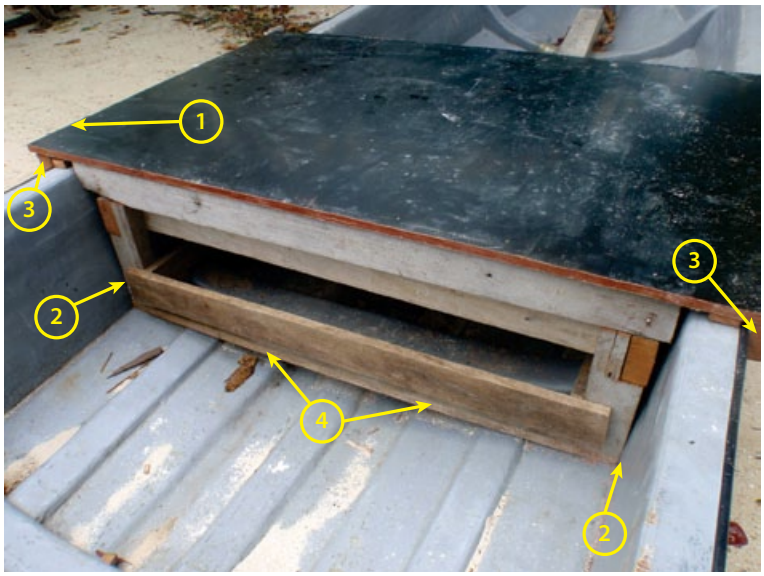

Figure 7. Deployment platform:

1. *The table-top overlaps the gunwale by 8 cm on each side of the vessel. This allows the cement anchors to safely clear the boat sides when deployed.*
2. *The inboard platform structure is constructed as close as possible to the insides of the bulwark.*
3. *Longitudinal wood battens are placed along the outside of the gunwale to lock the table in place.*
4. *The vertical supports rest on transverse and longitudinal base planks to spread the load.*

Note: The whole platform is lashed to the boat's transverse structure (not visible on picture) to prevent it from shifting.

Figure 8. FAD system loaded and ready for deployment.

Figure 9. Cement block anchor about to be deployed.

- ✓ Several countries in the region have already successfully ventured into addressing the use of small boats in FAD deployments:
  - French Polynesia constructed a small barge on which the anchor can easily be carried and towed. Deployment using this method is efficient and safe (Fig. 10).
  - Vanuatu developed the innovative *Vatuika* FAD design (see article on page ...) for which 12 to 16 bags filled with sand are used for anchors with each bag weighing approximately 60 kg; thereby, a 12-bag system weighs 720 kg and a 16-bag system weighs 960 kg. This design requires a single boat for the FAD deployment and eliminates the cost of constructing cement block anchors, which results in a great reduction in the overall FAD expenditure.
- ✓ Subsurface FADs require heavier anchor systems than surface FADs.
- ✓ The anchor system during the Choiseul trial included 2 x 260 kg cement blocks, 5 m of chain and a 25 kg Danforth anchor. In retrospect, this is considered excessive. Combining a cement block that weighs around 200–300 kg, 10 m of chain and a 25 kg Danforth anchor should be sufficient to moor a subsurface FAD with 100 kg buoyancy. This would make the system lighter to carry and easier to deploy.

The Choiseul experiments gave very positive results, but the quest for affordable, robust and long-lasting fish aggregating devices is not over. SPC's Nearshore Fisheries Development Section will keep collaborating with fisheries departments and other partners involved in FAD development, such as WorldFish, to ameliorate FAD systems and to develop affordable and safe ways to deploy them.

Figure 10. Barge used in Tahiti to carry the cement block anchor.

One step in the collaboration will be an SPC/WorldFish regional expert consultation on nearshore FADs, which is to be held in June 2016. It will be an opportunity for nearshore FAD experts in the region to share their experiences and develop best practice principles to guide nearshore FAD deployments in the future. More details about this consultation will be given in the next issues of this newsletter.

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All pictures in this article by William Skimi, except for Figure 10 picture by Mainui Tanetoa.

Vatuika FADs survive category 5 cyclone Pam in Vanuatu

The Vatuika fish aggregating device (FAD), also known as Vanuatu FAD (Amos et al. 2014), has proven its strength against category 5 tropical cyclone, Pam. Since 2012, 26 FADs, which use a new design developed in Vanuatu, have been deployed around the country; 13 of which are in the Shefa and Tafea provinces – the two provinces most affected by cyclone Pam. Of these 13 FADs, four were quickly lost because of vandalism or for unknown reasons, which left nine in the water before cyclone Pam hit Vanuatu on 13 and 14 March 2015. All of these nine FADs survived the cyclone and were still attracting fish and serving fishing communities in their respective areas when this article was written (July 2015).

The *Vatuika* FAD design

The *Vatuika* FAD design (Fig. 1) was elaborated and fine-tuned from 2012 to 2014 by George Amos and Graham Nimoho, fisheries officers from the Vanuatu Fisheries Department (VFD), with the support of the Japanese International Cooperation Agency (JICA) *Grace of the Sea Project*, Phase II.

The Vanuatu Fisheries Department felt that it was important to give a local name to this new design to mark its ownership over it. *Vatu* means money and *ika* means fish; a well-built and long-lasting *Vatuika* FAD will provide communities with fish and wealth.

The *Vatuika* FAD is a combination of the float section of the Indian Ocean FAD promoted by the Secretariat

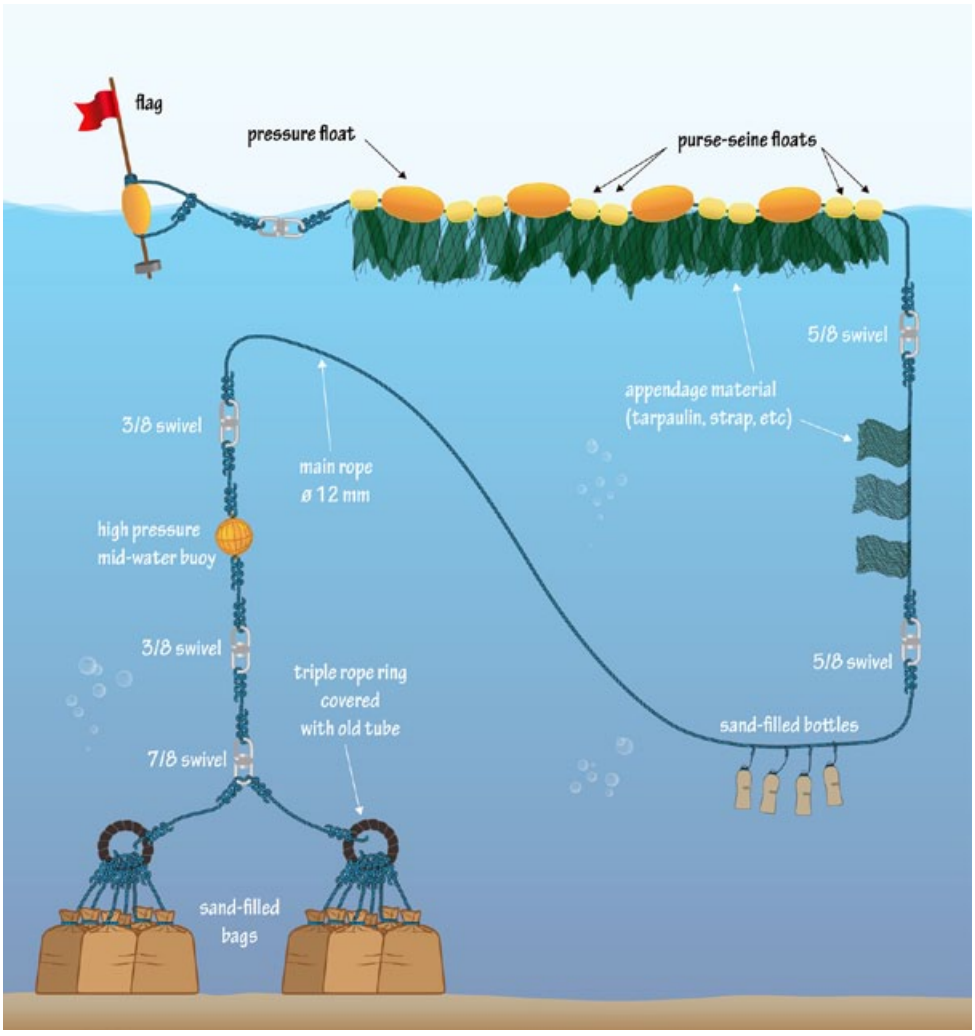

Figure 1. Vatuika, *the low-cost Vanuatu FAD (illustration: Boris Colas).*

of the Pacific Community (SPC) (Chapman et al. 2005) and the mooring section (main line and anchor) of the Caribbean design promoted by JICA (Horner 2011).

The Indian Ocean FAD design (Fig. 2) was first modified in Vanuatu by reducing the surface float section to minimise strain on the main line, but its anchor remained an issue. The heavy (around 1 tonne) concrete or engine block used in the original design presented several drawbacks: 1) it required heavy machinery to be displaced and transported; 2) it required a relatively big boat for the deployment; 3) it didn't settle well on the hard seafloor and steep slopes; and 4) it was expensive to build or acquire.

The Caribbean FAD design introduced in 2012 by JICA did not stand Vanuatu's rough sea condition. The buoys of the floating section easily tangled up and FADs were quickly lost, but this design had a low-cost mooring section that was easy to construct, with an anchor that could be built using a material that is widely, and freely, available locally: sand!

Fisheries Development Officer George Amos came up with the idea to use the best parts of each design to produce the *Vatuika* FAD.

The float section of the Caribbean FAD design was replaced with the float section of the modified Indian Ocean FAD used in Vanuatu. Adjustments were then made to the weight of the anchor (the sand bags), taking into account the reduced buoyancy of the floating section, to make sure that the whole system would be easy to carry on to and deploy from a banana boat – a type of boat widely used by fishers around the country (Fig. 3).

The section of surface floats that are in line with the Indian Ocean design solves the issue of ropes tangling in current, as was the case with the Caribbean design. The small size of the mooring rope (12 mm diameter), provides little resistance to the current and reduces strain on the whole mooring system. Sand is available anywhere around islands and can be easily sourced at the deployment site, which solves the logistical difficulty of heavy anchor block manipulation.

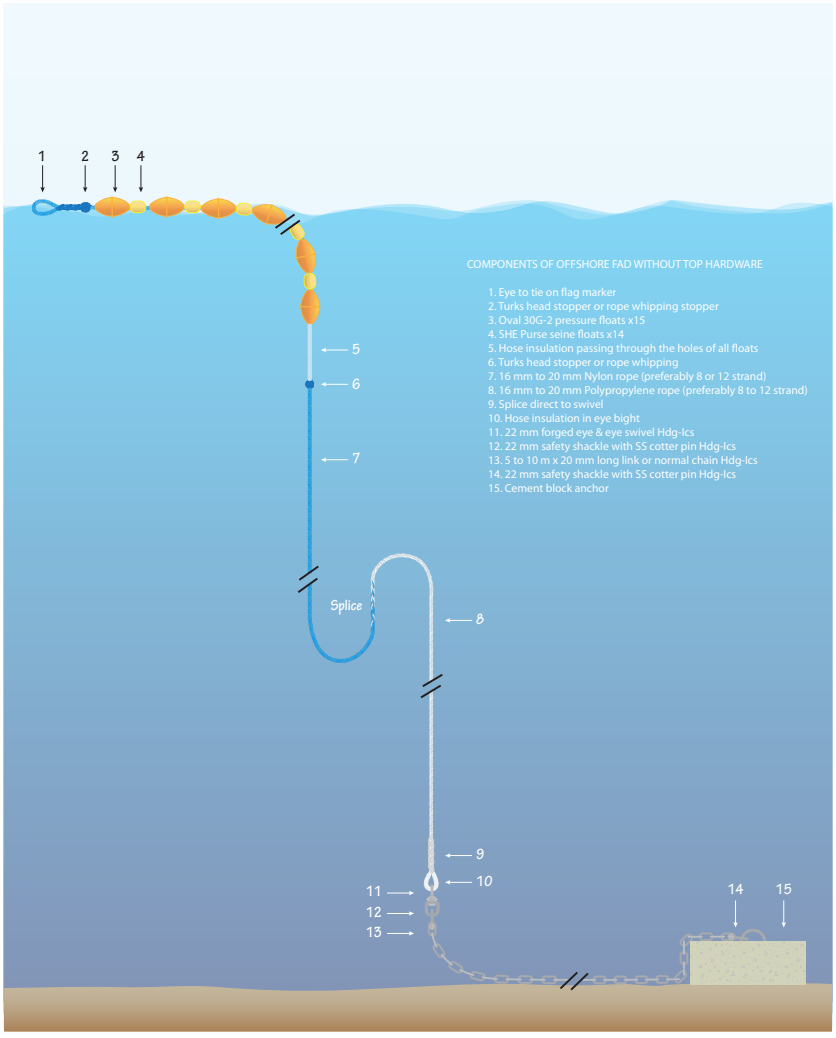

Figure 2. A typical SPC Indian Ocean FAD design (not showing the appendages and the flagpole usually added to the top of the mooring) (illustration: Boris Colas).

Figure 3. Vatuika FADs can be deployed from locally available banana boats (images: George Amos).

FAD cost

The *Vatuika* FAD is relatively less costly to construct and deploy than other FAD designs used before in Vanuatu. Total cost for materials, construction and deployment is USD 1,300 for 1200 m depths, USD 950 for 400 m depths and USD 750 for 300 m depths. All the materials needed for the floating and mooring sections (floats, ropes, shackles and swivels) can be carried by planes and small boats to deployment localities. Communities can then assemble the FADs in their villages by building the anchors with bags of sand and then do the deployment with their own banana boats. It allows the setting of FADs in remote places to which the VFD rarely has access.

FADs management

The Lelema community on Efate Island, as well as the charter boat operators in Port-Vila and fishers' associations in other islands, maintain their own FADs in their respective areas. All visit their FADs regularly to change the floats (when necessary) and to collect catch data that they then submit to VFD. The management of the *Vatuika* FADs by users largely contributed to their success.

Performance

The massive seas (12 m waves) generated by cyclone Pam left no one believing that the FADs would 'ride the storm'. However, to the surprise of everybody, all nine FADs at Efate, Emae, Tanna, Futuna and Aneityum survived the cyclone and were used to catch fish a few days later. For instance, two days after the cyclone, fishers in Port-Vila were back to the FADs to catch fish to feed their families. Donors, including the French Government, JICA, the Asian Development Bank, SPC, the Vanuatu-Climate Adaptation Project (V-CAP), the Save the Children Fund, the WorldFish Project, World Vision and fishing industry operators came forward to financially support the FAD programme given that it's an efficient, and quick-to-put-in-place, tool to sustain Vanuatu people's livelihoods.

Ownership of design and ways forward

VFD believes that the *Vatuika* FAD design, elaborated by fisheries officers George Amos and Graham Nimoho, is the perfect design for Vanuatu conditions. The new FAD development programme implemented by VFD is based on the *Vatuika* design, and communities are encouraged to form their respective fisheries committees or associations as a prerequisite for support with FAD fishing developments.

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Project launch: Improving technologies for inland aquaculture in PNG

Sister Pauline and Tripiso go shopping for barbecue tilapia on the Highlands Highway near Lake Yonki in Eastern Highlands. There are now an estimated 50,000 tilapia farmers in PNG (image: Tim Pickering).

A new inland aquaculture research project was launched in Goroka, Eastern Highlands Province, Papua New Guinea (PNG) on 11 August 2015. The project, led by Associate Professor Jes Sammut of the University of New South Wales, Australia (UNSW) and Jacob Wani (PNG National Fisheries Authority), will continue to research low-cost technologies to improve production of freshwater fish by small-scale farmers in PNG. The AUD 4.1 million project will run over four years.

The project is funded by the Australian Centre for International Agricultural Research (ACIAR) and National Fisheries Authority (NFA), and is the flagship project for inland fish farming in PNG.

Many rural communities in PNG do not have regular access to protein and survive on less than AUD 1.25 per day. A lack of protein causes stunting in children and a range of health issues from malnutrition. A low protein diet also lessens the lifespan of the elderly and sick.

Associate Professor Jes Sammut said:

> Fish farming enables rural people to produce their own protein. There is no need for refrigeration because fish can be caught, cooked and eaten as required. Improving farm production also creates a livelihood opportunity for farmers. Fish can be sold or traded for other commodities. We work with small-scale fish farmers who have struggled to farm fish because of the lack of fish husbandry skills and the high cost of farm inputs in PNG. Fish feed currently accounts for 60 to 80% of the cost of production. The project will build on our past work on alternative, cheaper sources of feed ingredients and investigate the role of natural food sources in the growth of farmed fish. Our previous project made inroads on the understanding of fish nutrition in pond systems. The new project will involve a series of trials comparing fertiliser and formulated feed combinations as well as the use of agricultural by-products as ingredients in pelleted feeds.

The HAQDEC freshwater aquaculture research station at Aiyura has undergone major upgrades to be in readiness for its role in the Australian ACIAR funded PNG Inland Aquaculture project (image: Tim Pickering).

Jacob Wani stated that:

> Broodstock management and fingerling production technologies will also be developed further under the new project. Quality fingerlings are critical to successful fish farming in PNG. We are currently maintaining two family lines of tilapia and will create new family lines to ensure robust broodstock and quality fish fingerlings are available to farmers in PNG.

Associate Professor Jes Sammut added:

> Our previous work has shown that fish farming can generate significant social impacts. The project team has helped warring tribes create peace through cooperative fish farming. Sister Pauline Kagl, who is a key project team member, has used fish farming to help people overcome drug addiction and restore their status in society. Our other team members have helped disadvantaged people build self-esteem and support their needs through fish farming.

Havini Vira, a student at UNSW and Project Manager said:

> Our interventions have stopped tribal fighting at several locations. Former adversaries also come to us for assistance with fish farming. At one of our locations, a former warlord became the lead farmer and was eventually elected as a councilor. Former warriors now work together to farm fish after 38 years of tribal war. The killings have stopped and the community has rebuilt its economy under a peaceful environment.

The inland aquaculture project includes a Fish for Prisons and a Fish for Schools programme. The prison programme has helped inmates to produce fish for the prison kitchen and has provided a livelihood option for prisoners who are released back into society. 'The ACIAR and NFA collaboration with Bihute Prison has been life changing for our inmates and those we have released from prison,' said Corporal Alois Siune from Bihute Prison. Associate Professor Jes Sammut said 'Once inmates are released from prison, the project team continues to provide technical assistance and mentoring. Former inmates have been able to become community leaders through fish farming and have not reoffended. We will continue working with prisoners and ex-inmates over the next four years.'

UNSW students, Havini Vira and Justin Narimbi, will play a key role on the project. Havini has been appointed Project Manager and Justin will lead field trials on fish feeding strategies. 'Havini and I will be applying new skills to the project from our postgraduate research at UNSW,' said Justin. Havini and Justin submitted their theses at UNSW in August and September 2015, respectively.

The project is based on a partnership model and brings together UNSW (the Commissioned Agency), NFA, The University of Technology (PNG), the Australian Nuclear Science and Technology Organisation, the PNG Department of Agriculture and Livestock (DAL), The Sisters of Notre Dame and RDS Partners. The project is also linked to other aquaculture programs in PNG and the Pacific.

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Public expenditure of Pacific Island countries and territories fisheries agencies

The sustainability of inshore fisheries resources is of vital concern to the 22 Pacific Island countries and territories (PICTs) as they are fundamental to people's livelihood and food security (Fig.1). Inshore resources are increasingly under threat due to population growth and increasing commercialisation. Improving the management of small-scale fisheries, based on co-management approaches, is recognised as a regional policy priority (e.g. FFA and SPC 2015; SPC 2015; MSG 2015). The important role of community-based management has been established and it is now essential to explore and clarify the role of government agencies within these approaches. The Secretariat of the Pacific Community (SPC) was funded by the Australian Government through the Department of Foreign Affairs and Trade (DFAT) to commission a study of the elaboration of the Noumea Coastal Fisheries Strategy and, specifically, to review national coastal fisheries policies, staffing and budgets in relation to the potential task of sustainably managing coastal fisheries. The main findings of this study are summarised below.

In the Pacific Islands (as a whole), there are:

- exclusive economic zones (EEZs) covering 29,000,000 km^2 and 22 fisheries agencies with 1,277 staff and USD 72,000,000 budget for operations; and
- inshore fishing areas covering 350,000 km^2 with 614 staff (dedicating at least 25% of their time to inshore fisheries issues) and USD 11,900,000 budget for operations.

The value of fisheries production (2007) was over USD 2,000,000,000

In the Pacific Island countries (excluding dependent territories and PNG), there are:

- EEZs covering 17,500,000 km^2 and 13 fisheries agencies with 836 staff and USD 15,600,000 budget for operations; and
- inshore fishing areas covering 141,000 km^2 with 399 staff (dedicating at least 25% of their time to inshore fisheries issues) and USD 3,500,000 budget for operations.

The value of fisheries production (2007) was over USD 1,100,000,000 (Govan 2015, p. 25).

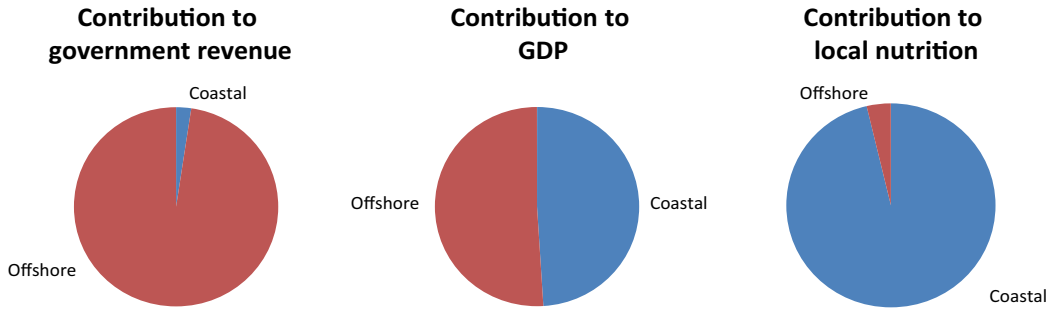

Figure 1. Relative importance of offshore and coastal fisheries in terms of types of benefits in the Pacific Islands Region (data from Gillett 2009).

Findings and recommendations

Coastal and inshore fisheries policies do not adequately support sustainable management

- The majority of PICTs do not have coastal fisheries policies; however, three PICTs do, four are in the process of drafting them, and two may be adequately covered in other policy.
- The lack of coastal fisheries policies is compounded by their low likelihood of resulting in improved fisheries management, according to current experiences.

➤ **Improving coastal fisheries management in the short term should be better addressed through improved drafting of work plans, staff job descriptions and allocation of increased and decentralised budgets.**

Governments are not allocating adequate operational resources for coastal fisheries management

- Most fisheries agencies usually do not clearly distinguish budget lines or staffing between coastal fisheries management and other functions. Aid projects and funding for fisheries development do not make up for the lack of investment in routine resource management and may actually have negative impacts.
- This is of particular concern given the low levels of budgetary and staff support relative to the massive coastal and oceanic resources for which the PICTs are responsible and upon which they are highly dependent.

➤ **National fisheries agencies should be encouraged to specify and report budgetary and labour allocations for sustainable coastal fisheries management.**

➤ **National coastal fisheries management allocations can be used as an indicator against aspirational targets such as investment per value of production or the area managed.**

Low resourcing of sustainable management is particularly alarming in the lesser developed countries with projected near-term deficits in coastal fish production

- More than 84% of the region's population reside in countries that are projected to experience a deficit in the supply of coastal fish for food security, and a further 11% reside in countries projected to experience problems with this supply.
- The lack of sustainable management investment gives rise to grave concerns when the impact of projected deficits in fish supply on predominantly fisheries dependent subsistence populations in lesser developed countries.

➤ **Adequate support for sustainable coastal fisheries management must be ensured in lesser developed countries and requires particularly urgent attention from donors and political leaders**

Despite encouraging progress in community-based fisheries management (CBFM) there is a long way to go

- More than 900 communities are documented as implementing CBFM; however, over half of those are Fiji and Samoa alone.
- It is unclear to what extent CBFM occurs in villages that have not been surveyed by government or non-governmental organisations, but more than 90% of the 11,422 coastal villages do not appear to be receiving support to implement CBFM.
- There is not sufficient information available to determine the effectiveness of most reported sites or the extent to which CBFM occurs autonomously in the remaining villages.

➤ **Governments should ascertain the extent to which CBFM effectively occurs and determine the most cost-effective strategies to support, extend and sustain these practices.**

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Alternative futures for the Pacific food system

The food system of the Pacific region is undergoing profound changes that will be felt for generations. The main pillars of food security – availability, access, and consumption of nutritious food – are being challenged by rapid population growth and urbanisation, shortages of arable land, and cheap, nutritionally poor food imports from burgeoning global trade. As a result, many Pacific Island countries and territories are now dependent on imported food, and the incidence of non-communicable diseases (NCDs) is among the highest in the world.

Climate change brings further threats as well as opportunities. Critical changes, such as sea level rise and more acidic oceans, are already 'locked in', as are population increases to 2030, but societal responses to those changes are uncertain and unpredictable. Although sectoral approaches to improved food security are necessary, they are not sufficient in their own right, because of the many linkages and feedback loops within the food system. Trade policy, for example, will impact on public health and the environment.

The Secretariat of the Pacific Community (SPC) is collaborating with partners to create narratives about how the Pacific food system may evolve and be influenced by a changing climate. In the face of great uncertainty and complexity, narratives can help catalyse policy responses in ways that more technical analyses cannot.

The purpose of this document is to introduce four plausible scenarios for the future of the Pacific food system as it evolves and is affected by climate change. To generate these scenarios, SPC gathered a diverse group of people from the Pacific region at a workshop in Nadi in August 2015. Individuals were chosen for their experience and did not represent member countries. The group was tasked with imagining the food system in 2030, and the policy implications of events and trends in the interim period.

Image: ACIAR.

The scenario process

Scenarios are 'what if' stories about the future – rather than attempting to forecast a single future in the face of many uncertainties, scenarios represent multiple plausible directions that future drivers of change may take. A set of contrasting scenarios can be used to develop and test policies, plans and strategies. In a time when we are faced with an over-abundance of sometimes conflicting information, scenarios offer meaningful and diverse stories about the future.

The group followed a process used by the Consultative Group for International Agricultural Research (CGIAR), in its Research Program on Climate Change, Agriculture and Food Security (CCAFS), to first identify drivers of change that were both important and uncertain and then use them to develop scenarios that paint plausible but very different futures. This process resulted in two 'axes of uncertainty' that, together, summarised what the group felt were the most important and uncertain drivers of change.

The first axis was 'governance of natural resources'. This included the governance of both water and land resources, and was concerned with regulations and policies at all levels, as well as the capacity to implement them. Central to this axis was the extent to which tenure and rights are defined, and the strength of institutions that guide development and limit impacts. The second axis was identified as 'economic connectedness to the rest of the world'. Trade, remittances, migration, tourism and tuna fisheries may all become more or less important, depending on a multitude of choices in the coming years and decades.

The combination of these two axes of uncertainty led to four scenarios, one in each quadrant. To develop the four scenarios, groups of participants explored what the combination of the two extremes of the axes underlying their scenario could mean; in 2030 and in the shorter term. Participants considered what would happen to all of the drivers of change identified in the first exercises, and described in detail the consequences of each scenario for various dimensions of food and nutrition security, food system activities and climate change adaptation. Each scenario was named, and a narrative was created to describe it. These scenarios will be further developed in the coming months. Here we provide an abstracted version of the scenarios to illustrate the approach and outcomes of the workshop.

Tales from the future

SCENARIO 1 – TUG OF WAR: High connectedness coupled with well-governed natural resources.

By 2030 exports, imports and tourism have increased in the Pacific region. Many people have been able to take advantage of the economic development that has resulted, but not everyone; although many people are more prosperous, there is also increased inequity. The diets of the poor are getting steadily worse. There is effective governance of natural resources at local, national and regional levels, and more fish and trees are being sustainably produced. National and regional initiatives to adapt to climate change have worked, and agriculture is now more productive. Tuna helps to fill the food security gap that still exists, despite better management of coastal fisheries. But little attention has been paid to marginalised and vulnerable people, and bottom-up approaches to community development are hampered by lack of capacity and resources. Regulation of natural resources is strong, but there are gaps, such as the lack of food standard regulations. The better-off are doing well, but the poor and vulnerable are not, and as a result, society has more choices but also more gaps.

SCENARIO 2 – LIVING ON THE EDGE: Low connectedness coupled with good governance of natural resources.

By 2030 regionalism has grown and the Pacific is less dependent on the outside world, and, collectively, countries produce enough food for their people. Although environmental degradation related to climate change and extreme events is widespread in the region, governance of natural resource has improved, agriculture and fisheries are strong, and the food system is resilient to shocks. In some places root crops and other traditional foods have replaced rice as part of a renaissance of traditional ways of life. Nevertheless, local economies in the lead-up to 2030 remain fragile, and there are still challenges related to food and nutrition security. Food crises in the next decade precipitate deep changes in societies, and set countries on contrasting development pathways. Many Pacific islands are under-populated, with waves of migration of young people; the population is ageing; and leaders are calling to the diaspora to come back and contribute. Serious questions are being asked as to whether the Pacific development pathway is viable in the long term, particularly on atolls with few resources and high vulnerability to climate change.

SCENARIO 3 – CASH NOW, PAY LATER: High connectedness coupled with poor governance of natural resources.

In 2030 the region is deeply embedded in global markets, and business, at least for some, is booming. Countries are using their new-found wealth to invest in infrastructure, schools and hospitals. The tourism industry is expanding rapidly. Governments have not prioritised better governance of their natural resources, which has allowed extractive industries, such as fishing, and forestry and agriculture, to expand unsustainably. Many local communities have been displaced to marginal land and towns to make space for primary industry, which has affected lifestyles and increased the dependence on cheap, unhealthy imported foods. The epidemic of NCDs has had a crushing impact on lives and national economies. Many negative environmental impacts are emerging, which are now starting to affect local food production and tourism. Inequitable distribution of wealth, elite control of land and resources, and large populations of unemployed youth, are fomenting civil unrest and political instability.

SCENARIO 4 – CRISIS IN PARADISE: Low connectedness coupled with poor governance of natural resources.

In 2030 growing populations are placing huge pressure on food systems, especially for poor and vulnerable people. Coastal fisheries continue to decline, and rural people see little benefit from tuna fisheries. Communities cope as best they can with climate change, but, because their natural resources are degraded, they have fewer options to reimagine their future. There is widespread criticism of governments for failing to address the declining state of the environment. Agricultural production continues to decline, and half of all Pacific Islanders are food insecure or malnourished, with devastating impacts on public health and economies. The decline in dietary diversity is deepening the problem of malnutrition. Trade in fish and timber has shrunk, because there is little left to sell, and tourism has declined because the region has become unattractive to visitors. Government investment in infrastructure, especially health facilities and transportation, is low because of limited economic activity. Urbanisation and migration continue apace, with most young people leaving rural areas in search of economic opportunities in towns and outside their countries. Prolonged political instability has resulted in chaotic policy environments. Community capacity has gradually eroded due to a lack of action, results and trust. The weakened social fabric and simmering discontent is heightening fears of serious social unrest.

Next steps

Over the coming months SPC and its collaborators will further develop these scenarios as a contribution to regional and policy development. The scenarios will be underpinned by quantitative analyses of the different dimensions of the food system, including fisheries and forests, trade, affordability and consumption, and public health. The regional scenarios will be down-scaled and used in national discussions about food system futures.

Once fully developed, these scenarios may catalyse new conversations and promote more integrated policies that connect different parts of the Pacific's regional and national food systems as they respond to the challenges of climate change. Clearly, a 'business as usual' approach to local, national and regional policy development and implementation will not best serve the people of region.

Further reading

- CGIAR CCAFS Program and methods: https://ccafs.cgiar.org/scenarios and https://cgspace.cgiar.org/rest/bitstreams/51647/retrieve
- SPC's website on climate change: http://www.spc.int/en/our-work/climate-change.html

Acknowledgements

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Original illustrations by Roger Harvey.

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Image: Céline Barré.

Assessing the vulnerability of fish spawning aggregations in the Great Barrier Reef: A new approach for fishery managers?

Many reef fish species form large spawning aggregations at certain times of the year. These aggregations maximise spawning success for these species, but also make it easier for fishers to target and catch large numbers of fish. While fishing of spawning aggregations can provide fishers with good catches, catching too many fish and disrupting spawning can lead to the over-exploitation and potential collapse of fish stock. While these problems are well recognised, it can be difficult for fisheries managers to identify targeted fishing of spawning aggregations and to assess the risk this poses to fish stocks.

Research in the Great Barrier Reef has developed a *Tiered Analysis Approach*[1] to analyse fisheries logbook data to assess the vulnerability of fish populations to fishing during the spawning seasons. This approach was used to assess fisheries targeting coral trout (*Plectropomus* spp.), redthroat emperor (*Lethrinus minatus*) and the Spanish mackerel (*Scomberomorus commerson*). The analysis found that while the fishing during the spawning season did not increase the vulnerability of the reef dwelling species (coral trout and emperor), itw did increase the vulnerability of the epipelagic Spanish mackerel. The research recommends using a tiered approach that considers multiple types of fishing vulnerability analyses and metrics. Without a tiered approach, those species most vulnerable to fishing and thus amenable to spawning season specific management of fishing may be overlooked.

Further reading

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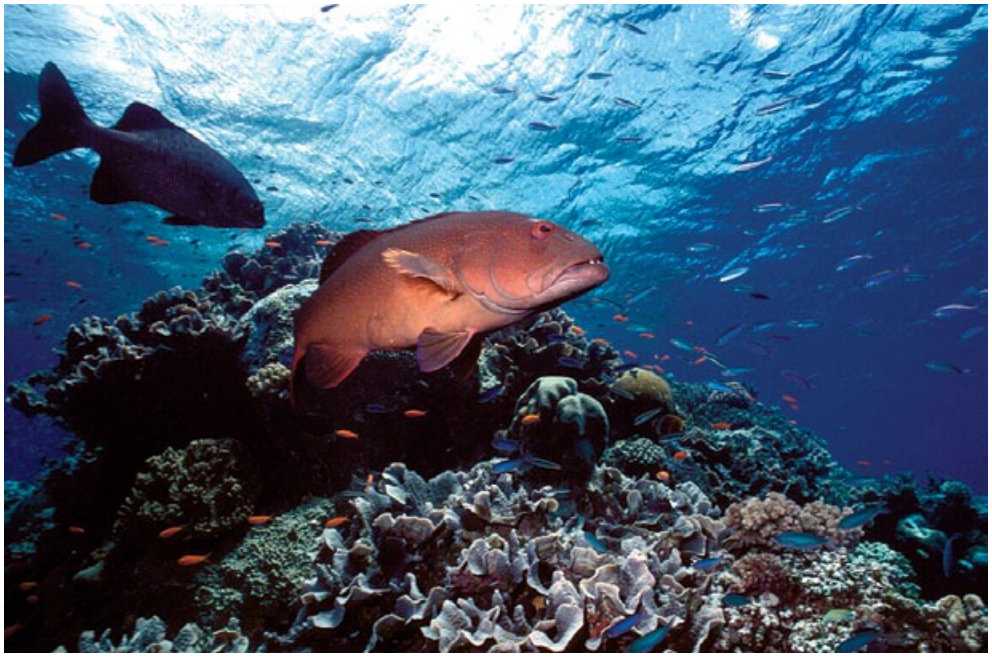

The analysis found that fishing of the leopard coral trout (Plectropomus leopardus) *during the spawning season did not significantly modify its vulnerability (image source: Great Barrier Reef Marine Park Authority).*

[1] A tiered approach refers to a process in which the exposure or risk assessment uncertainties progress systematically from relatively simple to more complex. An important feature of a tiered analysis is that the uncertainty analyses may be refined in successive iterations. (Source: http://cfpub.epa.gov/si/)

New Caledonian Offshore Fishers Federation launches 'Responsible Fisheries' ecolabel

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Introduction

Offshore fisheries in New Caledonia experienced a revival in the 2000s, after a halt in issuing fishing licenses to foreign vessels.

A few years later, the creation of the Offshore Fishers Federation gave a new boost to the sector. The Federation allowed the five longline fishing companies in New Caledonia, by then better organised and working together, to speak with a single voice in order to make their skills known and recognised; i.e., selective, environmentally responsible, longline fishing (one hook = one fish).

In 2013, the Federation began to work with the French Agricultural, Agrofood and Fisheries Quality and Origin Certification (AFNOR) Management Agency to allow its members to benefit from 'Responsible Fisheries' certification. This certification provides a guarantee to customers that goes above and beyond current regulations of proper resource management, environmentally responsible fishing practices, and health and traceability regulations that ensure product quality and good onboard working and safety conditions.

In November 2014, after audits by the AFNOR Pacific inspection and certification agency, three of the five local fishing companies were awarded certification.

After a brief overview of the status of offshore tuna fisheries in New Caledonia, this article will describe the 'Responsible Fisheries' management approach, its principles and objectives, and the requirements that a fishing company must meet in order to be certified.

Part of the New Caledonia tuna longline fishing fleet in Noumea harbour.

Offshore fishers: a major development stakeholder in New Caledonia

New Caledonia's offshore fisheries form a commercial sector that comprises a fleet of similar vessels that belong to five fishing companies. In 2014, New Caledonia issued 17 tuna-species fishing licenses for its exclusive economic zone (EEZ).

In 2014, offshore fishers brought in 2781 tonnes – a total of 150,090 fish – (+3 % as compared with 2013). Albacore (*Thunnus alalunga*) is still the predominant species at nearly 60 % of all catches; yellowfin tuna (*Thunnus albacares*) accounts for 26 % of catches.

The most frequently caught species, after albacore and yellowfin tuna, are marlins (Istiophoidae) and mahi-mahis (*Coryphaena hippurus*), which are sold locally. After that is bigeye tuna (*Thunnus obesus*) with the best specimens sold fresh and whole in Japan at auction markets. Then, there are various fish, which are sold locally: opah/moonfish (*Lampris regius*), wahoo (*Acanthocybium solandri*), swordfish (*Xiphias gladius*), sailfish (*Istiophorus platypterus*) and skipjack (*Katsuwonus pelamis*).

Trade circuits

Every year, about 30 % of production is exported (see Fig. 1).

In 2013, the sector's turnover at initial sale totalled some XPF 1135 million (quivalent to USD 13.5 million – August 2015).

Sampling and observers

Since 2002, the Secretariat of the Pacific Community (SPC) has conducted operations to monitor catches at landing and on-board observation campaigns.

The latter consist of identifying and measuring the entire catch, recording the various features of the fishing gear (number of hooks, type of bait used, etc.) and taking samples in order to assess stocks and study tuna biology. In 2014, a total of 22 campaigns were observed on 11 of the 17 active ships, which amounts to 233 days at sea.

Jobs

The number of jobs that are directly linked to offshore fishing – carried out in fishing companies, processing plants and at wholesalers – was estimated at 230 in 2013.

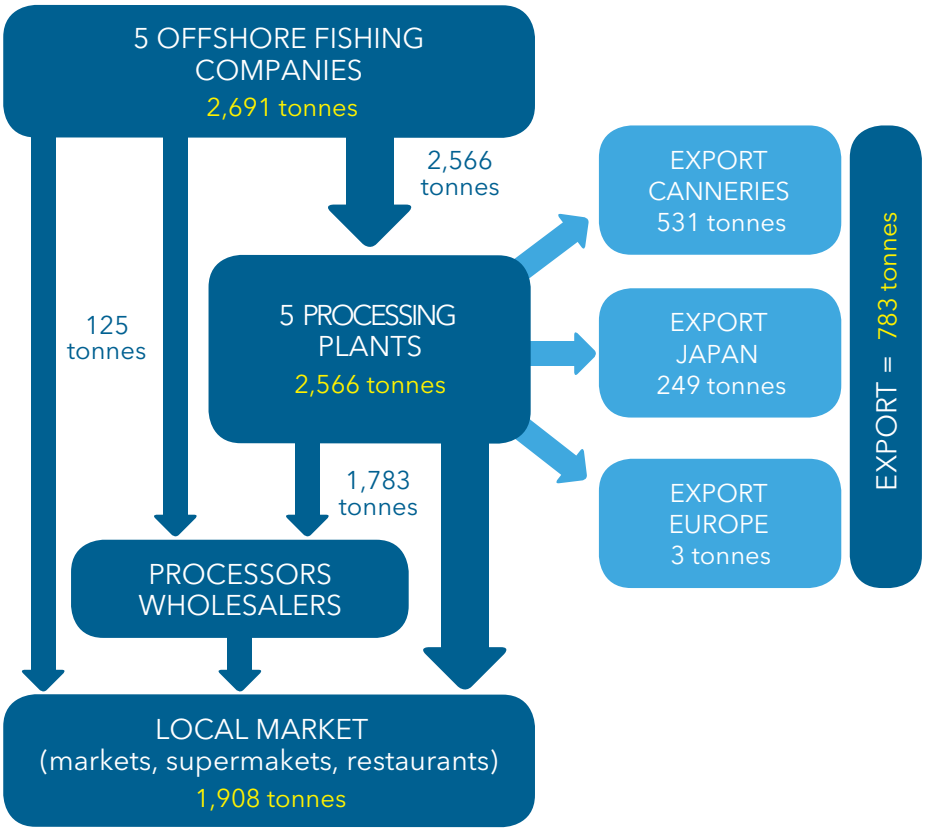

Figure 1. Offshore fisheries trade circuits in 2013 (illustration by Push & Pull).

Fish stocks

In contrast to certain Pacific Island countries and territories, New Caledonia has underutilised both its exploitable resource and existing logistical infrastructure. According to SPC scientists, catches for species that can be taken with longlines could increase to 10,000 tonnes without overfishing the resource. A limited fishing effort in comparison to the surface area of New Caledonia's EEZ, the longline fishing technique that considered to be more selective and the number of fishing licenses, which are limited to local longliners, make New Caledonia's offshore fishery a sustainable activity that has little impact on tuna stocks. What's more, the sector targets species whose stock statuses are satisfactory at the regional level and only the adult specimens that have already reproduced are harvested.

Health surveillance

Offshore fisheries products are subject to several levels of inspection by the Animal Health, Food and Plant Health Inspection Unit of the New Caledonia Department of Animal Health, Food and Rural Affairs, including:

- ✓ the annual surveillance and inspection plan, which meets the European Union's regulatory requirements for exported species (44 samples were taken from albacore tuna in 2014, including 16 that were tested for mercury);
- ✓ specific investigations, carried out in 2011 and 2015 (25 samples were taken from various high-risk pelagic species as well as lagoon fish species, crustaceans and molluscs), notably designed to monitor mercury levels; and
- ✓ official testing as part of the monitoring facilities' compliance with health regulations.

Producers and processors also do regular microbiological self-audits to maintain their health certificates.

In regards to the issue of mercury, a joint approach is underway between four Government of New Caledonia departments (Health and Social Affairs; Animal Health, Food and Rural Affairs; Economic Affairs; and Maritime Affairs) to ensure that the community is better informed about this issue.

Fishing technique and effort

The industry uses a single fishing technique; i.e., longline fishing.

A total of 324 fishing trips took place in 2014. This is a low fishing effort in comparison to the surface area of the fishing zone, since New Caledonia's maritime area covers some 1.3 million km^2.

Processors are subject to the annual surveillance and inspection plan, which meets the European Union's regulatory requirements for exported species.

New Caledonian Offshore Fishers Federation

History

The New Caledonian Offshore Fishers Federation is a non-profit association created on 8 October 2007. Jean-François Huglo, Director of the company Albacore, has chaired it since its creation.

Members

The five fishing companies in New Caledonia have been members of the New Caledonian Offshore Fishers Federation since its creation; i.e., Albacore, Baby Blue, Navimon, Pescana and Sea Horse.

Goals

The goal of the New Caledonian Fishers Federation is to allow local fishing companies to speak with a single voice, particularly with a view to defining their status

and ensuring better recognition of their industry by public authorities. Since November 2013, the Federation has also been the official advocacy and management body (*organisme de défense et de gestion* – ODG) for the offshore 'Responsible Fisheries' ecolabel.

'Responsible Fisheries' approach

The New Caledonian Offshore Fishers Association wanted to begin an approach, in collaboration with the entire profession (five fishing companies), to promote the high quality of its products and its sustainable resource management, and to ensure the continued existence of the industry.

Therefore, with the assistance of the Agricultural Price Control Board (ERPA) and the technical support of Maritime Affairs, the Chamber of Agriculture, and the New Caledonia Animal Health, Food and Rural Affairs Office, the New Caledonian Offshore Fishers Federation gained full recognition as an ODG in November 2013.

This agency advocates the official 'Responsible Fisheries' quality label for offshore fisheries, which is designed to recognise and promote the good practices used by the group over the past few years.

Definition

'Responsible Fisheries' is an overall management approach designed to promote, in addition to compliance with current regulations, practices that are respectful of resources, the environment, fishing products and proper safety and working conditions.

Principles

'Responsible Fisheries' is based on the following principles:

- ✓ Conserving and managing bio-aquatic resources (quality, diversity, availability) against a backdrop of food security and sustainable development;
- ✓ Using environmentally responsible gear and vessels;
- ✓ Implementing selective and environmentally responsible fishing practices;
- ✓ Ensuring that product harvest, handling, processing and distribution are done in such a way to preserve the product's nutritional value, quality and safety; reduce wastage and minimise negative effects on the environment and local communities – preserving 'critical' habitats (wetlands, mangroves, reefs, lagoons);
- ✓ Preserving working conditions; and
- ✓ Responsible, sustainable use of resources.

Products involved

The Offshore Fishers Federation's 'Responsible Fisheries' framework covers the entire catch of New Caledonia's offshore fleet (pelagic fish). Certified products can be whole or cut into portions; raw, fresh or frozen; offered in bulk or packaged. They are destined for the local market via processing plants, wholesalers and large- and medium-sized retailers.

FV Yellow Fin *from the company Albacore, one of the three fishing companies that were granted 'Responsible Fisheries' certification in 2014.*

In 2014, albacore tuna accounted for 60% of all New Caledonia tuna longline vessel catches.

The field covered by this certification – i.e., 'Responsible Fisheries' – is the responsibility of fishing companies and includes all operations from fishing to unloading catches.

Framework

Given that 'Responsible Fisheries' is designed to become, over the long term, the standard for all of New Caledonia's offshore fishing vessels, current regulations were integrated into this framework, thereby ensuring consumers that the fleet complies with health, environmental and work safety practices.

Among the framework's 28 requirements:

✓ 15 are regulatory (i.e. 54 % of the requirements as compared with 50 % in the metropolitan French framework); and

✓ 13 exceed local regulations.

'Responsible Fisheries' products guarantee consumers compliance with requirements that exceed normal regulations, and responsible fishing practices in terms of resources and the environment, quality products and food safety.

Approach timeline

22 November 2013:
The New Caledonian Offshore Fishers Federation is recognised as an *organisme de défense et de gestion* (advocacy and management agency – ODG) for the 'Responsible Fisheries' ecolabel; the technical framework is certified and the inspection plans are approved.

19 November 2014:
Albacore, Navimon and Pescana fishing companies are granted 'Responsible Fisheries' certification.

Responsible offshore fisheries – the four main areas involved in certification:

1. Resource management

Background

Given growing pressures on marine resources throughout the Pacific region, it is important for New Caledonia's offshore fisheries industry to contribute to sustainable management of harvested stocks while engaging in selective fishing that respects both the ecosystem and its diversity. Proper resource management requires the full cooperation of the scientific community, in particular through the provision of reliable and complete data.

Objectives

- Use resources in a sustainable manner.
- Control impacts on the ecosystem.
- Help to improve scientific knowledge.

Framework requirements

– no. 1: Be a member of the New Caledonian Offshore Fishers Federation;

– no. 2: Comply with resource management, conservation and use measures;

– no. 3: Only fish in New Caledonia's EEZ and offload all catches in New Caledonia;

– no. 4: Only engage in longline fishing and limit bycatch; and

– no. 5: Cooperate with scientists in terms of collecting and sharing information.

2. Respecting the environment

Background

Like all human and economic activities, offshore fisheries generate waste. Implementing effective waste management, including storage and disposal, is part of an environmentally responsible approach that meets the needs of society.

In addition, fuel consumption is a very important expenditure item for fishing vessels.

Controlling such consumption is vital on both the economic and environmental levels.

Objectives

- Improve waste management.
- Limit the impact that the waste produced has on the environment.
- Optimise energy consumption.

Framework requirements

- no. 6: Keep household waste on-board and dispose of it at the port;
- no. 7: Keep fisheries-related waste (bait packaging, bits of line, etc.) on-board and dispose of it at the port;
- no. 8: Use specific collection containers;
- no. 9: Prevent fuel-oil pollution;
- no. 10: Recover used oil products and ensure they are treated;
- no. 11: Dry-dock in the designated dry-dock area;
- no. 12: Use biodegradable cleaning projects (deck, refrigerated holds, etc.);
- no. 13: Optimise energy consumption; and
- no. 14: Inform and educate the crew about good environmental practices.

3. Hygiene, quality and traceability

Background

Good hygiene, treatment, storage and preservation practices must be followed from the very start of the supply chain to ensure consumers of the highest quality products.

In addition, priority must be given to product traceability to make it possible to identify, distinguish and enhance the products that are displayed on the shelves.

Objectives

- Ensure product quality.
- Ensure product traceability.
- Enhance products.

Framework requirements

- no. 15: Adhere to proper hygiene and cleaning practices in the areas where catches are processed and stored as well as in ice production and refrigeration facilities;
- no. 16: Properly handle and process catch to optimise its quality;
- no. 17: Ensure catches are properly preserved;
- no. 18: Ensure good hygiene practices during on-board processing;
- no. 19: Ensure the health quality of offloaded fish;
- no. 20: Provide advanced information about catch offloading;
- no. 21: At each landing, provide processing plants with clear and systematic fish-traceability information;
- no. 22: Optimise product development and marketing; and
- no. 23: Provide skippers with regular training in good hygiene practices.

4. Working conditions and boat safety

Background

More attention must be paid to the specific features of the working environment on-board an offshore fishing vessel to improve safety, work and living conditions for crew.

Objectives

- Ensure satisfactory working and living conditions for those who work on fishing vessels.
- Ensure the shipboard staff's safety.

Framework requirements

- no. 24: Ensure proper maintenance of the vessel and its safety systems;
- no. 25: Work to prevent accidents;
- no. 26: Comply with employment contract provisions;
- no. 27: Ensure that living quarters are properly maintained;
- no. 28: Educate the crew about environmental management; and
- no. 29: Provide regular safety training sessions to skippers.

Quality and origin identification labels

In 2008, following a request from professionals and consumers in New Caledonia, all government partners (French Government, Government of New Caledonia, Provinces), in collaboration with the Chambers of Commerce and Industry and consumers, – and under ERPA's coordination – implemented a process to issue and monitor quality and origin identification labels (SIQO-NC) for agricultural, agrofood and seafood products, and to supervise their use at the territorial level (Fig. 2).

There are three categories of labels:

1. environmental quality labels/ecolabels (including 'Responsible Fisheries');
2. premium quality labels; and
3. authenticity labels.

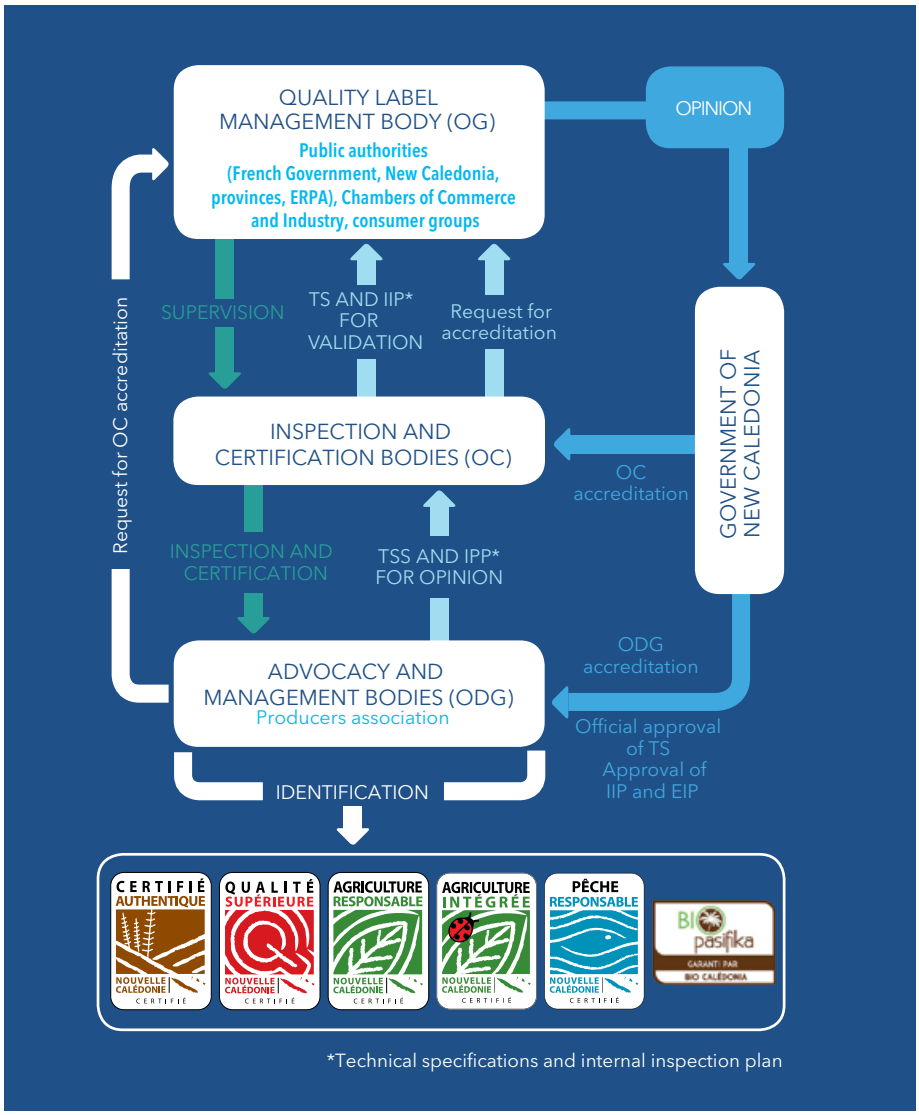

Figure 2. Quality and origin identification label (SIQO-NC) accreditation process (to find out more: www.siqo.nc)(illustration by Push & Pull).

All pictures in this article by Théau Gontard, ERPA.

Bycatch is troublesome – Deal with it!

Shelley Clarke

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Western and Central Pacific Fisheries Commission shelley.clarke@wcpfc.int

I really dislike the term 'bycatch'. Why then does it appear not only in the title of this article but also in my job title? I guess it is because it has become a convenient and well-used term for all those 'other' species that get caught alongside the target tuna. Like the U.S. Supreme Court Justice said about pornography, we know bycatch when we see it – but the problem is that the terms used are inherently subjective. The terms non-target, secondary target, bycatch, byproduct, incidental, discard or trash could all be applied by different people to the same catch.

Regardless of what it's called, and whether it's utilised or not, bycatch usually means trouble for fishers. Fundamentally, bycatch is bycatch because the goal was to catch something else. This means that from the outset fishers are less than pleased when catching bycatch and they may feel less inclined to record this catch with the required level of detail, simply due to lack of interest. As a result, fishers' records of bycatch are often limited or non-existent, and observer programmes cannot always fill the gaps in data quantity or quality. Just as bycatch complicates life for fishers, it also complicates life for the fishery managers. Limited data lead to high uncertainty in the decisions about whether or how to protect bycatch populations from depletion. Bycatch management thus often takes a backseat to more pressing issues associated with managing target tuna species. A third problem with bycatch is that there is usually no quick fix. Mitigation technology may come at a price either in terms of gear cost, crew efficiency or reduced catch of target species, and just banning retention of bycatch will not necessarily prevent catch nor reduce mortality to sustainable levels for the most vulnerable species.

Limited data quantity and quality, which leads to uncertainty in the scientific advice and difficult management trade-offs, are thorny issues with no simple solutions. In tackling these issues for bycatch in tuna fisheries, the Areas Beyond National Jurisdiction (ABNJ or Common Oceans) Tuna Project has its work cut out for it. The Western and Central Pacific Fisheries Commission (WCPFC) has teamed up with the Secretariat of the Pacific Community (SPC) to implement three bycatch components of the Global Environment Facility (GEF)-funded, United Nations Food and Agriculture Organization (FAO)-led, ABNJ Tuna Project over a five-year period from 2014. Given the low probability that bycatch problems will be solved in this timeframe, the project's challenge is to identify ways to make a small, focused investment pay a large dividend over the long-term. This will require finding a way forward despite some imposing roadblocks, such as how to improve the quality and usefulness of collected bycatch data, how to prioritise bycatch management actions in data-poor situations, and how to evaluate the effectiveness of bycatch mitigation measures.

How to improve the quality and usefulness of collected bycatch data?

The first of three components of the ABNJ Tuna Project being implemented by the WCPFC is bycatch data improvement and harmonisation. Back in 2011, when the tuna Regional Fisheries Management Organizations (t-RFMOs) held a joint meeting of the Technical Working Group-Bycatch, all of the t-RFMOs and taxa experts present agreed that data issues were the major problems facing the group (Anon. 2011). Data sharing, subject to the applicable data confidentiality controls, was discussed throughout the meeting as a worthy goal. The group also prioritised adopting minimum data fields and standardised collection protocols to enable interoperability of the t-RFMOs' observer-collected bycatch databases.

Four years on, the ABNJ Tuna Project is working on sparking some progress toward these objectives on two fronts. The first front, interoperability, implies that the bycatch information that is collected should be similar enough in content and format so that, if shared, data from different sources can be combined and analysed. Usually referred to as 'harmonisation,' this is much more difficult than it sounds. For example, each of the five t-RFMOs have different bycatch reporting standards, so which t-RFMO's standards will be selected as the ideal and how will this be decided? If a new, composite set of standards are developed, how can adoption of that set be ensured across five independent organisations with different memberships? If the standards adopted by each t-RFMO represent individual mixtures of science,

practicality, and regional priorities, how reasonable is it to expect that there will ever be global agreement?

Part of the reason for the lack of progress on harmonisation is that simply deciding where to begin is difficult. In January 2015, a meeting of experts was convened with International Seafood Sustainability Foundation (ISSF) support in Keelung, Taiwan to discuss these issues in the context of longline observer data (ISSF 2015). As a result of this meeting, the ABNJ Tuna Project commissioned a review examining what data longline observers should collect in order to best understand bycatch interaction and mortality rates. The resulting study (Gilman and Hall 2015) provides a starting point for data improvement discussions in individual t-RFMOs, but does not depend on the agreement of a single set of minimum standards. Instead, it aims to provide a basis for each t-RFMO to make incremental improvements in a common direction that will allow some components of the various t-RFMO programmes to align sooner than others. The WCPFC's Scientific Committee took the first step in this direction in August 2015 with endorsement of eight modifications to bycatch data collected by longline observers (Table 1). The Commission will consider formally adopting these changes at its meeting in Bali in December.

Harmonisation creates the potential for data sharing, but what progress can be made toward actual exchange? The situation in each t-RFMO varies considerably: in some cases, the bulk of the observer bycatch data is already held centrally, whereas in other cases national programmes hold most of the data and provide only partial summaries to the t-RFMO. For bycatch species such as sea turtles or seabirds that migrate across t-RFMO boundaries, for example in the Pacific or Southern Oceans, analysis of fishery interactions may require not only data sharing within, but also between, t-RFMOs. To encourage thinking about how and whether data can be exchanged, the ABNJ Tuna Project has proposed a summarised template that each t-RFMO can populate with public domain data. These templates can provide a framework for consistent management of bycatch data within each t-RFMO, as well as a convenient inventory of bycatch data holdings and a prospective basis for cross-RFMO data sharing, if agreed (Clarke et al. 2015a). WCPFC's Scientific Committee agreed to trial the template, called the Bycatch Data Exchange Protocol (BDEP), and report back next year (WCPFC 2015).

How to prioritise bycatch management actions in data-poor situations

The 2013 listing of five species of sharks and all manta rays by the Convention on International Trade in Endangered Species (CITES), and the 2014 listing of 21 species of sharks and rays under the Convention on Migratory Species (CMS), leaves no doubt that elasmobranch conservation is a major global concern. The second of the three ABNJ Tuna Project bycatch components being implemented by WCPFC is designed to further the assessment and management of pelagic sharks within the t-RFMOs. Under this component, funding is available for four pan-Pacific assessments, which can provide a basis for regional conservation and management measures. As can be surmised from the discussion above, the major challenges for these assessments will revolve around data quantity and quality. Beginning in 2008, WCPFC designated a number of sharks as 'key shark species' and assessments have been conducted for those with ample observer data – oceanic whitetip, silky and blue sharks (Brouwer and Harley 2015). Some may suggest that assessments for the remaining 'key', but data-poor species should be paused until the data improve; however, ABNJ funding provides an opportunity to do more in the short-term than simply wait. The two examples below describe the potential to explore new

Table 1. Changes in minimum standard data fields for longline observer programmes endorsed by WCPFC SC11 and to be considered for adoption by WCPFC12 in December 2015 (WCPFC 2015).

Data type	Proposed change
Hooks	More detail on hook type (circle, J, etc.) and hook size
Bait	More detail on the proportions of different types of bait used
Leaders	More detail on the proportions of different types of leaders used
Branchline weighting	More detail on the use of different types of line weighting
Shark lines	Record the number of shark lines used (if used)
Lightsticks	More detail on the number and position of lightsticks used (if used)
Seabird mitigation	More detail on the use of tori lines, dyed bait, underwater or side-setting and offal management
Hooking location	For silky or oceanic whitetip sharks, sea turtles, seabirds and marine mammals, record whether hooked in mouth, hooked deeply (throat/stomach), hooked externally and whether hook and line removed

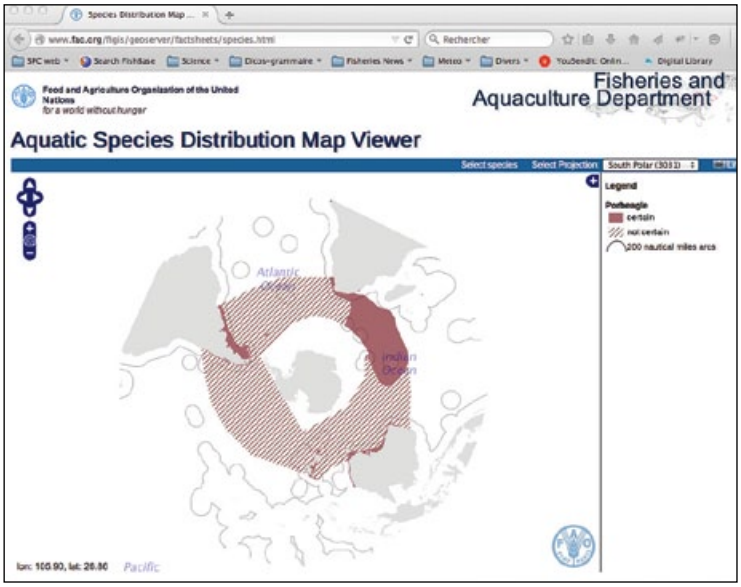
analytical approaches for data-poor sharks, open new avenues of collaboration and contribute to the global conservation dialogue.

The first pan-Pacific assessment will be an analysis of the status of the southern hemisphere population of porbeagle sharks (*Lamna nasus*). This species was listed by CITES on Appendix II primarily based on declines in the northern stock. ICCAT attempted to include South Atlantic populations in its 2009 stock assessment, but concluded that data were too limited to provide a robust indication of stock status. The Commission for the Conservation of Southern Bluefin Tuna (CCSBT), with responsibility for areas in the South Pacific east to New Zealand, across the southern Indian Ocean and west to the Argentinian Atlantic, asked the WCPFC and ABNJ Tuna Project in March 2015 to coordinate an assessment across the joint t-RFMOs. This kind of approach allows access to data sets beyond those held by CCSBT members and enables coverage of the whole of the southern stock.

NIWA (New Zealand) has been selected as the coordinating consultant for the southern hemisphere porbeagle assessment. The study design involves obtaining indicators of stock status, such as trends in catch rate and size, from national scientists and combining these in both quantitative risk assessment and age-structured stock assessment models. The study will use the available information on shark biology and population dynamics to structure the models. In addition to being able to evaluate the stock status to the best extent possible, this collaborative and integrative approach will highlight where the greatest uncertainty lies and thus point to where investments are needed in better datasets. This type of approach also helps with the understanding of the risk associated with each fishery sector and shark population component (sex or life stage) and thus allows more focused management. The study kicked-off in August 2015 and will run for approximately one year.

Plans for a second pan-Pacific assessment are emerging after the WCPFC Scientific Committee noted its interest in a pan-Pacific assessment of thresher sharks based on consideration of trends and vulnerability. Like porbeagle, the bigeye, common and pelagic thresher sharks are listed as WCPFC key sharks (as 'threshers'), but analysis has thus far been constrained by data quantity and quality (Rice et al. 2015). In the case of threshers, many catches are not recorded to species, so preliminary work on species separation will be necessary. Recent studies of thresher catches in the Eastern Pacific indicate that common (*Alopias vulpinus*) and pelagic (*A. pelagicus*) threshers dominate, but in the Western and Central Pacific bigeye threshers (*A. superciliosus*) appear to be the most abundant thresher species, particularly in the waters off Hawaii (Clarke et al. 2011, Rice et al. 2015). The thresher species complex as a whole shows low productivity and high susceptibility to longline fishing

The ABNJ (Common Oceans) Tuna Project is coordinating the first global shark stock status assessment for the southern hemisphere population of porbeagle shark (Lamna nasus) *(image: Malcolm Francis).*



Southern hemisphere porbeagles (Lamna nasus) *may have a circumpolar distribution that intersects with all five tuna RMFOs' convention areas (http://www.fao.org/figis/geoserver/factsheets/species.html?species=POR-me&prj=4326).*

From top to bottom: common thresher (Alopias vulpinus)*, pelagic thresher* (A. pelagicus)*, and bigeye thresher* (A. superciliosus) *(illustrations: Les Hata).*

compared with most pelagic sharks (Cortés 2008, Cortés et al. 2010). Drawing upon ABNJ funds to conduct some form of stock status assessment for one of the thresher species in the next year could inform not only t-RFMO actions but also potentially preparatory discussions for the September 2016 CITES meeting, should thresher listing be proposed.

How to evaluate the effectiveness of bycatch mitigation measures

Bycatch mitigation refers to actions taken to lessen the impacts of fishing activities on non-target organisms. In tuna fisheries, mitigation has taken the form of tori (streamer) lines aimed at reducing seabird hooking rates, regulations on leader material aimed at reducing shark catches, and restrictions on types of hooks and bait aimed at reducing sea turtle interactions. How well do these mitigation measures work in practice, and are the mortality rates now low enough to allow bycatch populations to be sustained? Unfortunately, these questions remain largely unanswered in tuna fisheries. While it may feel good to adopt mitigation measures, it is not

Tori (streamer) lines scare seabirds away from baited hooks as they enter the water, reducing bait loss and seabird hooking (image: Lucy Kemp, Marine Photobank)

Sharks are usually unable to bite through wire leaders but have the potential to 'self-release' from monofilament leaders under some circumstances (image: Terry Goss Photography USA, Marine Photobank).

enough to just hope for the best. In order to confirm that good intentions actually make a difference in the water, mitigation measures need to be followed up by implementation, monitoring and data analysis to determine if they are working.

The third component of ABNJ Tuna Project's bycatch work programme entrusted to WCPFC and SPC is focused on promoting effective bycatch mitigation. This involves publicizing new mitigation technologies as they are discovered and helping to evaluate what is, and is not, working effectively in ongoing fisheries. One aspect of this work is re-developing the WCPFC's existing Bycatch Management Information System (BMIS) as a global resource. The 'new look' BMIS will present a broader range of material, particularly regarding the management of bycatch, including species interaction rates and threats, population-level assessments, and national and international management schemes (Box 1).

One of the longstanding obstacles to examining whether bycatch mitigation works is data; as described above, this includes lack of harmonisation, sharing, quantity and quality. The WCPFC's mitigation work under the ABNJ Tuna Project aims to tackle this through a workshop format, which allows temporary pooling of data from different sources for joint analysis and subsequent publication of the findings (only). The first workshop topic will be sea turtle bycatch (Clarke et al. 2015b). Although the WCPFC has had a sea turtle conservation and management measure (CMM) in place since 2008, there has not yet been any formal assessment of its effectiveness. Other t-RFMOs also have sea turtle topics in their work plans but are struggling with data issues, particularly because sea turtle data are even more sparse than that of the data-poor sharks. Using ABNJ funds, SPC will convene a workshop to focus on characterizing interaction and mortality rates by species based on factors such as hook type, bait type, time of day, depth, location, season and year. Once a baseline is established, a second workshop will be held to explore the effect of various mitigation options, including the existing WCPFC CMM, on sea turtle populations. The first workshop is planned for early 2016 with a focus on Pacific longline fisheries, including the Eastern Pacific, if possible.

Box 1:
New modules under development for the updated Bycatch Management Information System

- ✓ bycatch interaction rates
- ✓ bycatch threats/mitigated threats
- ✓ population-level assessments
- ✓ implementation levels for mitigation techniques
- ✓ national and international agreements (e.g. CITES, CMS)
- ✓ static maps of bycatch distributions, threats, etc.
- ✓ bycatch data harmonisation across t-RFMOs
- ✓ E-monitoring

The analysis is expected to be similar to the shark mitigation analysis presented by SPC at the recent WCPFC Scientific Committee meeting (Harley et al. 2015). This analysis investigated the theoretical effectiveness of the new shark CMM 2014-05 in reducing mortality to overfished oceanic whitetip and silky sharks. Specifically, the analysis showed that if all fleets banned wire leaders, or if all fleets banned shark lines, the estimated mortality reduction from the current baseline would be between 15–25% for both species. If all fleets banned both wire leaders and shark lines, mortality would be reduced by 30–40%. Further work will be undertaken to explore how these estimates would change depending on which fleets choose to ban which gear – a choice provided for under CMM 2014-05. These types of analyses, which we hope to produce at the sea turtle workshops, provide essential input for managers' decision-making on bycatch mitigation.

Sea turtles can bite off small pieces of finfish bait and thus avoid becoming hooked but they tend to swallow squid bait whole and ingest the hook as well (image source: NOAA Fisheries, Southeast Fisheries Science Centre).

Conclusion

Whether due to formats, access, sparsity, unreliability, or a combination of these, bycatch data and thus bycatch management is troublesome. But allowing the status quo to continue could have severe consequences for shark, sea turtle, seabird and marine mammal populations, as well as for ocean ecosystems as a whole. Over the next four years, the ABNJ Tuna Project aims to synergise ongoing initiatives to reduce the ecosystem impacts of tuna fishing. The challenge is to identify practical and achievable steps that will move us closer to that target in that timeframe.

WCPFC's and SPC's ABNJ work involves a mixture of ambitious initiatives and smaller steps that may appear inconsequential, but can lead to significant incremental progress over time. All of the initiatives might not be successful, but they are designed to, at a minimum, clearly establish what we already know and what we still need to find out. Likewise, some of the smaller steps may not lead to major changes in the short-term, but they can remain as building blocks for future efforts.

Bycatch work within the t-RFMOs can be constrained by a limited appetite for these issues amidst the competing priorities of managing some of the world's largest and most valuable commercial fisheries. Working in this space, though, is working at the front line of bycatch impact where management's direct influence can be felt. There's no better place to deal with it!

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