Informing community-based fisheries management with spawning potential surveys

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Introduction

Since 2012, the David and Lucille Packard Foundation has funded the development and application of a new approach to community-based fisheries management (CBFM) of reef fish in the western Pacific called spawning potential surveys (SPS). The approach uses a new length-based and simple technique to assess local stocks (Hordyk et al. 2015a,b; Prince et al. 2015a,b) and provide scientific management advice on minimum size limits, mesh and hook sizes, and fishing pressure to communities. The aim of the Packard Foundation's Western Pacific Program has been to trial the new approach in the Pacific, and develop a communications strategy to support its implementation.

A team of non-governmental organisations (NGO) and donor partners working with local communities were involved in carrying out the programme, and trials began in Palau in 2012, Solomon Islands and Fiji in 2014, and northern Papua New Guinea (PNG) in 2015. In each country, early results have been encouraging. Partnering communities have been motivated to engage in CBFM and to begin implementing new forms of management techniques. The most exciting facet of this work has been how effective the SPS approach has been at informing communities about the overfishing crisis they face, and this is the focus of this article. Working with our communications partner, cChange of Fiji, we have found that the blockages to change are surprisingly simple and easy to overcome, using simple but highly targeted messaging.

Communicating for change

J.P. Kotter established an eight-step model for achieving change (1995). The first four steps all focus on communications and can be summarised as follows:

1. Inspire people to change by increasing their sense of urgency for change and making the objectives of change real and relevant.

2. Build a guiding team by getting the people in place with the right mix of skills and social levels, and who are emotionally committed to change.

3. Establish the right shared vision of change to focus the necessary emotional, creative and organisational energy needed to drive change.

4. To create "buy in", involve as many people as possible, appeal to people's needs by communicating the essentials as simply and effectively as possible.

A methodology for achieving change, called the Nudge Theory (Thaler and Sunstein 2008), proposes that the everyday choices that largely determine a society's cumulative impact on the environment are largely instinctive and emotional, rather than being thought through rationally and logically. These instinctive and emotional patterns of behaviour, called heuristic frameworks, save mental energy by making small, everyday choices easy and automatic. These choices are largely inherited without introspection as communal standards from surrounding societies, through tradition, family, friends and church. The Nudge Theory proposes that to successfully manage change, existing heuristic frameworks need to be understood and explicitly addressed, or they will simply absorb programmes of change, as societies continue to think and act heuristically and instinctively.

Heuristic thinking about fishing

Universally, Pacific Island communities are deeply aware of, and concerned about, the decline of marine resources without consciously connecting their own fishing behaviour to their observed changes in the marine environment. They are aware of the symptoms of overfishing: having to go farther afield to fish, fishing in deeper and deeper water, fewer and fewer large fish. They see the foodweb being fish down (Pauly et al. 1998); that is, the large-bodied, higher order predators such as groupers and sharks are disappearing first, followed by the larger parrotfish, snappers and emperors, and then all of the prized medium-bodied species and even the smaller-bodied species, until eventually, only the fish that once no one wanted to eat are left and people start eating what was once considered bait fish. Communities are aware of all of this, but in our experience they do not (prior to our intervention) interpret these events as symptoms of overfishing.

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For them the fish are like the air and water: renewable resources that almost all of us take for granted as we breathe and drink without consciously thinking about their sustainability. For Pacific Island people, fish and fishing are constants in their lives; fish have always been there for food, and people have always fished for food. This is summed up by the Pacific-wide saying of "God will always provide", which means fish have always been there, and presumably will always be there. We find, however, that apart from community elders, most people are generally unaware of the extent to which new fishing gear – and the ability to keep fish cool and transport them to market – have changed traditional fishing practices, let alone the degree to which this has allowed fishing pressure to escalate. Prior to our education programmes, we found that community members generally associate observed declines in local resources with other environmental changes they see occurring, or hear about. Sedimentation from building the ring road in Palau, unsustainable forestry practices in Solomon Islands, the destruction of juvenile fish and shellfish habitat from mangrove cutting, and previous destructive fishing practices and coral bleaching caused by climate change in many places. It is not that these many factors are not having an impact, but the primary factor that can most effectively be addressed by communities to address food security and maintain biodiversity is the unrecognised effect of overfishing. The fact is, overfishing is driving the loss of biodiversity and food security across the tropical Pacific, and its effect is being exacerbated by the loss of habitat caused by the other factors.

The Pacific way of thinking about fish is primarily concerned with not wasting food as encapsulated by the widespread saying that "the smallest fish have the sweetest meat", which is the metaphoric equivalent of the expression that "the sweetest meat is closest to the bone". Both sayings exhort (young) people not to waste the smallest or last bit of meat and encourage a "waste not, want not" way of thinking. So, no small fish is ever released to continue growing and start breeding, because that would be a nonsensical waste of good food.

Changing the Pacific way of thinking about reef fish

With the communications materials we have developed with cChange, we have created a sense of urgency and have built consensus within communities using simple imagery to make the connection between the changes being observed and the central cause of overfishing, thereby enabling communities to correctly attribute the observed changes to overfishing. Our simple graphics explain how: 1) traditional fishing techniques have become vastly more effective over time, 2) human populations have grown considerably (meaning there are more mouths to feed), 3) the incentive to fish has increased due to the development of cash-based societies, and 4) the penetration of consumer goods and access to markets have grown with the availability of ice, coolers and modern transport.

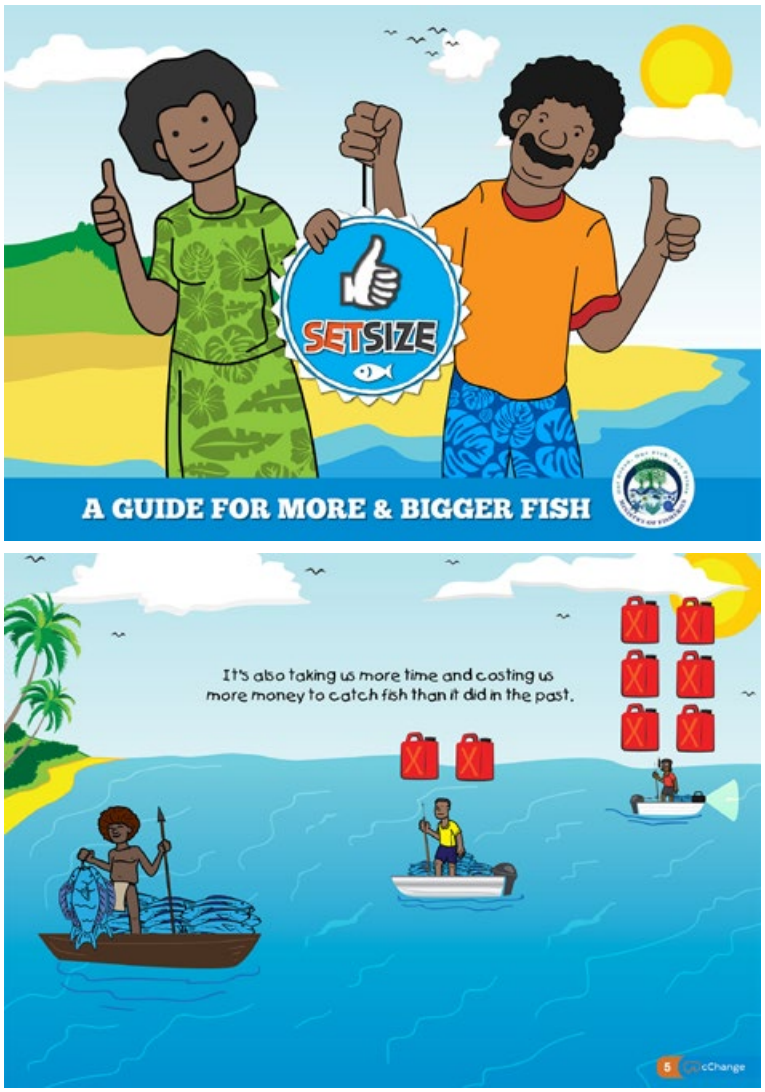

Figure 1. The cover and a page from *A guide for more and bigger fish*, one of the communication tools developed with cChange. Image: cChange

Typically, towards the end of an initial morning talk with a community, we break our workshops into small groups to discuss:

1. Which of their species are changing the most in terms of declining fish size, needing to go farther afield to catch them, declining catches and catch rates; and

2. Which species are most important to them, or would be the worst for them to lose.

In terms of adult education, this exercise serves a useful purpose by giving participants time to internalise and apply the concepts they have just learned to their own experience, thereby affirming with their community what we are teaching. As the break out groups report on their discussions to the workshop, with the help of guidebooks, we match scientific fish names to local names, and stories of fishing down the local foodweb. Through this process, we

begin to prioritise species that can be specifically identified and monitored by communities, and a sober appreciation of the overfishing crisis facing each community settles in. Fascinating, but sad, insights are provided into the extent that local foodwebs have been eroded. North of Madang in PNG, where a good day's catch now looks like a smash and grab raid on a marine aquarium, we were told that mangrove jack (*Lutjanus argentimaculatus*) was an important customary species for traditional feasts on during the annual initiation of girls into womanhood. The timing of that ceremony was based on the season when that species came inshore and could be caught in abundance, but is has not been caught in over 20 years, and the current cohort of young men have never caught, seen nor tasted one. Today, it is only known through oral tradition. We have also received eerily similar accounts from numerous communities of how large aggregations of Chinamanfish (*Symphorus nematophorus*) formerly came into the shallows on certain moons to attack land crabs, releasing their larvae into the sea. Traditionally, a handful of fish would be speared each moon, and were so highly prized that some communities reserved them for high ranking elders. However, in each case, after the first community member acquired a net and discovered that the entire aggregation could be encircled, it took just three moons to wipe out the aggregation. In each place, this often-told story ends the same way; for the last 20–30 years this fish has not been seen, or an occasional individual fish is seen rarely.

We now find that with these report-back sessions we can diagnose the extent to which local foodwebs in each place have been fished down. Is a community still concerned about the large-bodied groupers and parrotfish (e.g. in Macuata, Fiji), or is it mainly worried about small-bodied emperors and snappers (e.g. in Palau and Tavua, Fiji) or the loss of small wrasses and damselfish (e.g. in Madang, PNG)? After the report-back session, we crystallise for workshop participants the insights gained from the working groups with a series of images portraying the fish down of the foodweb – with images of the main species on plates, and the number of fish on plates diminishing in successive images – while we rhetorically ask each community where they are in this progression, and where they will end up. The last image in this series simply portrays a tin of fish sitting on a plate.

Developing a simple vision for change

At this point, the community is invariably asking about solutions, which as with most sustainability issues, is to change old ways of thinking and behaving (Hardin 1968).

We then begin to directly challenge their old heuristic way of thinking about fish (i.e. that the smallest fish have the sweetest meat), by describing how they think differently about the natural productivity of their gardens. Common sense dictates that in gardens, small plants and animals are nurtured until they have grown big, have ripened and have reproduced sufficiently to ensure future generations of plants and livestock. For this we generally use imagery of a pig farm that the World Wide Fund for Nature (WWF) in Fiji helped communities build to fund community schools. Piglets were bought and nurtured so that they grew up. The communities did not kill and eat the piglets, even though their meat would have been sweet, instead they were reared to produce three or four litters to stock the farm with, before being used for food themselves. In the context of gardens this is common sense, but while reefs are "marine gardens" they are treated differently, and it is considered a virtue to catch and eat a fish before it can breed and increase the population on the reef.

This analogy works powerfully in all settings, and can be adapted to the different cultures and traditions of fishing communities; for example, using chickens instead of pigs for Seventh Day Adventists, Muslims and South American communities; goats in Kenya; and coconuts or other fruits with communities north of Madang (PNG) and in Buddhist Sri Lanka. Whichever variant is used, we invariably see workshop participants opening their eyes wide, nodding their heads and murmuring affirmation, as the illogicality of their old heuristic framework becomes apparent, and their need for change is perceived.

In our workshops, this analogy brings us naturally to the question of "how much breeding is enough?", which we address by getting communities to think first about human couples who require, on average, about two surviving children to replace themselves and to keep the population stable (actually 2.1 surviving children per couple to make up for adults that do not have children). Above this replacement level, human populations grow, and below this level without immigration, they decline. We equate this concept to the fisheries concept of spawning potential ratio (SPR), which with communities we refer to simply as spawning (Mace and Sissenwine 1993; Walters and Martell 2004). Unfished fish live out their natural lives and complete 100% of their natural potential for reproduction or spawning. Fishing shortens their natural life span and reduces their potential for spawning below 100% of the natural unfished level. From scientific studies (Mace and Sissenwine 1993) we know that around 20% SPR is the replacement level for fish, just as 2.1 children per couple is for humans. Below 20% SPR, fish populations become increasingly likely to decline through the lack of young fish (recruitment overfishing), but above 20%, spawning populations can rebuild depleted populations and restock reefs.

On this basis, we inform our partnering communities that our breakthrough in data-poor fisheries assessment and management can be used to help them understand how much "spawning" is currently occurring in their fish stocks, and to develop simple management strategies to maintain spawning at sustainable levels. We then ask communities if they are prepared to work with us to initiate community-based SPSs and, if they are, proceed with teaching them how

Figure 2. Learning to measure fish in Solomon Islands. Image: Andrew Smith

to measure the length of fish (Fig. 2) and macroscopically inspect them to determine whether they are immature or mature (Fig. 3). In many communities, we first engage workshop participants in constructing fish measuring boards out of plywood and old measuring tapes previously used for laying out coral reef transects, so that they can begin collecting SPS data (Fig. 4). Again, within the context of adult education methodologies, and regardless of the value of the data community members may collect, these hands-on activities usefully consolidate the concepts being taught, and enable community members to validate the information for themselves. We invariably find that community members are extremely interested in acquiring these skills, particularly the ability to examine gonadal status and determine whether fish are mature or immature. To our surprise, only a very few of the most expert artisanal fishers have prior knowledge about this. For most of our workshop participants, this is entirely new, informational and transformational for their understanding of local overfishing.

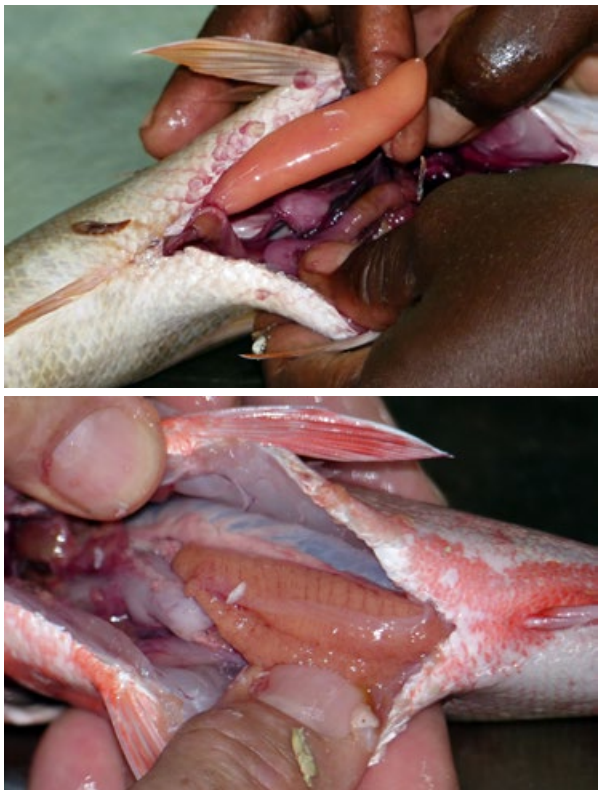

Figure 3. Learning to evaluate female gonad maturation stages is part of the training. Top: developing, bottom: ripening. Images: Andrew Smith

To illustrate the great interest that community members have in these matters, a Fijian WWF staff member working on a different project told us he had visited a remote island in Macuata Province some months after we had trained community fish measurers in a central location, and observed that every evening when the men gathered to drink kava, their main topic of discussion concerned how the observer gauged the maturity of fish, and the gonadal

Figure 4. Making a fish measuring board in Fiji.
Image: Jeremy Prince

status of the fish he was observing in their catches. Similarly, in the Western Province of Solomon Islands where, with WWF, we have been measuring the fish catches brought in by surrounding communities, the communal examination of fish has engendered great discussions between the nighttime spearfishers, who catch predominantly immature fish, and the hook-and-line fishers who catch a much higher proportion of mature fish.

Informing CBFM with spawning potential surveys

The results of the SPS methodology are easily turned into simple management advice for communities and governments that can then be used to conserve sustainable levels of spawning potential and maintain optimal harvest levels.

We have developed rules-of-thumb for setting minimum size limits at a size that ensures all fish complete at least 20% of their spawning potential before being caught. If all fish complete at least 20% of spawning potential, and most fish get to survive some time longer, then on average the stock of fish will achieve 30–40% of spawning potential, an internationally accepted target level for sustainability. In Fiji, the size at which fish reach 20% SPR is being called the "set size" of a species, after the Fijian tendency to use the word "set" the way Anglophones use "OK"; in PNG pidgin, the communities we work with refer to this as "rit mak" (right mark). For snappers, emperors and parrotfish, the rule-of-thumb for estimating the size at which 20% SPR is achieved is simply to multiply by 1.2, the size at which a species matures (the size at which 50% of the fish in a size class are adults).

Of course minimum sizes will not work with some species and fisheries; nets catch and kill a wide range of sizes, the swim bladders of hook-and-line-caught fish hauled up from the depths inflate and die if returned to the water on the surface. For these fisheries it will be necessary to adaptively manage the size of fish being caught by trial and error over time by adjusting the way the fishing is done to protect enough of the adult fish. The size of fish being caught can also be managed by communities by prohibiting some fishing techniques, setting minimum sizes for net mesh and hooks, regulating where and when fishing occurs, and by controlling how much fishing takes place, by adjusting the length of closed and open fishing seasons, by controlling the number of fishing permits issued, or by setting daily trip limits. All of these measures can directly and indirectly be used to manage the size of fish in a stock. With our approach, a target composition of sizes in the catch can be estimated for any stock – this is the size composition expected for the stock when the target 30–40% of SPR is maintained. Communities can then compare their own catches to the target size composition: if the sizes in their catches become smaller than the target indicating insufficient spawning potential is being maintained, they will know they need to implement more management measures (e.g. larger net mesh and hook sizes, shorter fishing seasons, fewer fishing permits, lower daily trip limits). Alternatively, when the size of the fish in their catches become larger than the target size, catches might be increased a little by relaxing management.

With these simple techniques, adaptive, science-based CBFM is now possible for communities. We are already seeing our partnering communities intuitively adopt the methodology and these concepts to evaluate their stocks and inform discussions within their communities about trialling new forms of management.

Early signs of success

Although it is still too early in the process of developing and implementing spawning potential surveys to be able to have achieved clear improvements in the abundance of fish stocks, some first signs of success are apparent, at least in changing community attitudes to the overfishing crisis and in motivating changed behaviour.

Palau

In Palau, with The Nature Conservancy (TNC) and the two northernmost states of Kayangel and Ngarchelong, we began in August 2012 with an initial training course that ended with a week of fishing, during which trainees measured about 900 fish, of which 65% were observed to be immature. By June 2013, some 2,089 fish had been sampled and six initial assessments completed. The results of

the assessments were reported on to the communities in each state, leading up to a joint summit meeting of the two states, attended by community members, traditional male and female leaders, and state and national politicians. Participants at the meetings agreed that the two states should move towards the coordinated implementation of new fisheries management laws. The mood of these meetings was summed up by Harper Skang, advisor to Ngarchelong's State Governor, who said, "We knew the house was burning down but did not understand why. Now that we do, there are many things we can do about it."

Steven Victor, Director of TNC's Micronesia Program, wrote to Dr Carmen Revenga, TNC's Sustainable Fisheries Director that:

- The method was well received in Palau and we have been able to collect enough data for some species that we can begin to discuss management options.
- It fits well with community-based fisheries management.
- I found the technique to be simple so that every fisherman can implement it. The data analysis seems very straight forward.
- The results just reinforced what fishermen knew about fish decline and made them understand how the fishing effort is leading to the decline.
- Basically, they realise that they are not giving the fish a chance to reproduce and if they continue to fish the way they do, then there will be no fish for them.

By September 2013, some 3,711 fish had been measured and 13 assessments developed, and by the time the initial sampling programme was completed in January 2016, 10,618 fish of 153 species had been measured, allowing us to: 1) evaluate the spawning potential of 18 species comprising >70% of the catch, and 2) provide advice on establishing minimum size limits.

New fisheries management laws – including temporary bans on catching groupers, size limits for an initial seven species and licensing of fishers – were legislated by Kayangel State in 2016 and Ngarchelong State in mid-2017, and a broader national discussion initiated about changing management arrangement.

In Palau, the Packard Foundation funded the Palau International Coral Reef Centre to conduct extensive baseline, stereo-video surveys of the country's northern reefs in late 2015, which were repeated for the first time during the second half of 2017. The results suggest that already some slight improvements in fish biomass and size have occurred on the reefs closest to the largest communities. Too soon to have resulted from the new legislation, if real and not just statistical anomalies, these early survey results may support community claims that prior to the legislated changes coming into effect, at least some fishers began to voluntarily catch and release fish below the proposed minimum sizes.

In October 2015, while my colleague Dr Steven Lindfield and I were fishing with a group of Palauans to collect gonad samples, we requested that they release fish that were smaller than the proposed minimum size limit. Much discussion ensued about the fact that it was the first time the Palauans had ever caught and released fish, but they acknowledged that it "felt good". Recently, in early November 2017, I was again fishing with a group of Palauans, this time for a fish barbeque, and was quietly thrilled to see them spontaneously releasing small fish without comment, as if it was now entirely routine.

Fiji

In Fiji, we began with WWF Pacific and 12 communities in the northern Province of Macuata on Vanua Levu as partners, and additional support from New Zealand Aid. With an initial workshop held in the chiefly village of Naduri in October 2014, we trained a fish measurer from each community, built measuring boards, and prioritised 20 species. By mid-2016, some 5,226 fish had been measured and, on that basis, initial five stock assessments were completed. In November 2016, the assessments were reported to the partnering communities who agreed that fishing for camouflage grouper (*Epinephelus polyphekadion*) and brown-marbled

Figure 5. More than 10,000 fish of 153 species have been measured in Palau, allowing the spawning potential of 18 species to be assessed. Image: Andrew Smith

Figure 7. Mathew Mirak with his fish measuring board and fishing canoe, Papua New Guinea. Image: Jeremy Prince

grouper (*E. fuscoguttatus*) would be banned during 2017 prior to the implementation of an initial minimum size limit in 2018.

In November 2016, with WWF, we also began working with the large urban community of Tavua on the north coast of Vitu Levu. By June 2017, with the data collected by community members and the Institute of Applied Science at the University of the South Pacific, it was possible to complete an assessment for the thumbprint emperor (*Lethrinus harak*), which is now the main species caught by that community. Our reporting of that result lead the Tui Tavua to declare an immediate six-month closure for that species and the implementation of a minimum size limit that will come into effect in 2018. In September 2017, WWF opened a third site in the Yasawa Islands northwest of Vitu Levu, and the community there began measuring a list of priority species. Parallel to WWF, the Wildlife Conservation Society has also been working with communities in Ba at the western end of Vanua Levu, measuring four main species of fish and mud crabs.

This grassroots work with the communities has been accompanied by a growing national awareness of the need to reform reef fish management. Within the Ministry of Fisheries, a Coastal Fisheries Management Division has been created to parallel the Offshore Fisheries Management Division, which has been in existence for many years. Community complaints that markets were not complying with the bans implemented in 2017 galvanised Ministry of Fisheries staff to work with the police and NGO legal advisors to resolve legal issues previously interpreted as preventing the enforcement of fisheries regulations in the market place. It is hoped that it will prepare the way for more effective enforcement of the first minimum size limits to be implemented in 2018.

In September 2017, NGO partners reached an agreement with senior Ministry of Fisheries officials and the Minister on a two-year timeline to use the results from the SPS monitoring programmes to reform and re-implement the existing system of size limits that has never been enforced.

Papua New Guinea

In March 2015, north of Madang on the north coast of Papua New Guinea, with staff from WWF PNG and funding from WWF, Australian Aid and John West, we provided an initial training for a few community members and provincial fisheries staff. By June 2017, approximately 4,000 fish had been measured and recorded using local names; at the time of writing, only 2,551 of these records had been matched to scientific names (152 species). The data collected are of extremely high quality, enabling good preliminary estimates of size of maturity to be developed for eight species and initial assessments of three species. Due to the extremely narrow reef area and large (human) coastal population, the marine foodweb in this area is extremely depleted, despite the basic fishing techniques used from single dugout canoes. The small species of emperorfish and snappers that normally dominate the catch in heavily fished areas have become extremely rare (<1% of the catch), and the main species being caught are damselfish and small wrasses. Fishers there tell me that they "no longer fish for meat, but now fish for soup".

Unlike Palau and Fiji, to date there has been very little buy in by government agencies but the community work is being coordinated by an extraordinary community member name Matthew Mirak (Fig. 7) who has trained and now supervises six fish measurers in neighbouring communities. Initially annoyed at being sent along to our training because it did

not teach him to fish more effectively, Matthew went on to deeply assimilate the SPS concepts. He spontaneously converted our pig analogy into a calculation of his community's yield of coconuts based on the number of trees it owns. He compared this to how many were being eaten, on average, at each meal, proving to his elders they would never have excess for making copra and earning income, unless they controlled consumption. Using this analogy, he moved on to convincing his community that it also needed to manage their fish, winning community agreement in the first year for a daily bag limit on rabbitfish during their spawning season, the timing of which he determined from his examination of gonads. Having been sensitised to the overfishing issue, when the run of rabbitfish through the spawning season was noticeably poorer than in previous years, the community moved quickly in the second year to agree to a three-year fishing ban, which they intend replacing eventually with a minimum size limit.

In the absence of government buy in, but with the support of WWF, fish measurers and their communities have begun discussing how they can work through local government frameworks to achieve the systemic reform they are now thinking is needed.

Solomon Islands

In February 2014, we began working with WWF Solomon Islands around Ghizo Island in the Western Province, and were again initially supported by WWF Australia and Australian Aid and John West, but now also being partially funded by the European Union and USAID. Beyond the challenges confronted in every situation, this project faces a particularly diverse mix of communities using a wide range of fishing gear and non-specific names for a particularly diverse reef fish fauna. Rather than develop community-based fish measurers, it has been necessary for the WWF project team to conduct most of the fish measuring with fishers who bring coolers of fish to be measured on their way to the market in return for fresh ice and a token payment. By October 2016, some 5,962 fish (224 species) had been measured on the way to market and nine species were assessed and their sizes estimated.

Beginning in 2017, WWF began working with communities around Nusatuva, on the south coast of neighbouring Kolombangara Island, measuring about 1,000 fish during the course of the year. While only a couple of hours by outboard-powered boat from Ghizo Island, it is beyond

Figure 8. In Solomon Islands, the WWF project team first conducted fish measuring around fish markets. Image: Andrew Smith

easy access to the Gizo fish market (most people still sail or paddle). Consequently, the state of the Nusatuva foodweb, which is still dominated by large-bodied species of groupers, snappers and parrotfish, is completely different from that around Ghizo, where the population has fuelled fishing pressure, which in turn has eroded the foodweb down to predominantly small- and medium-bodied emperors and snappers.

Buy in by both provincial and national government has been slow, but since presentations to a National Environmental Symposium about the project, levels of interest have increased, and negotiations are underway for incorporating the approach into the fisheries course being developed by the Solomon Islands National University. The Solomon Islands communities we work with have not yet made any decisions about implementing management trials. The issue of fishers from outside their communities encroaching on their fishing grounds, and not complying with agreed management measures, looms larger over all discussions to date. An association of fishers has been formed to foster intercommunity dialogue about change, and the provincial government's management committee is supportive of incorporating agreed to measures into regulation, but their capacity for enforcement is weak.

Looking ahead

In developing the spawning potential surveys methodology, we have been asking communities in each country to work with our NGO partners to conduct community-based data collection programmes for assessing the spawning potential of their main stocks and to develop species-specific management advice to inform discussions on trialling new forms of management. In addition to collecting the data needed to develop the approach, we have discovered that the community-based monitoring programmes are an extremely effective communication strategy, allowing people to see for themselves that much of the fish they catch have never bred, and through their own perception of overfishing, become viscerally committed to changing current fishing practices.

But in the big picture, this cannot be the final form of our methodology. There are simply too many communities, too many lagoons, and too many small-scale fish stocks to imagine that conducting community-based monitoring programmes with every community can offer a broad- scale solution to the depletion of the Pacific's reef fish stocks. Nor is it pragmatic to think that every species in every lagoon can end up with its own size limit or size composition target. Our developing SPS approach must lead to more generic solutions that can be spread throughout the Pacific with modern community technologies and passed by word of mouth between neighbouring communities. To this end, we think of our current partnering communities as "beach heads" in the region, giving us a toe-hold into the region and helping us develop our methodology, and providing local champions and some success stories to work with as we look to stepping up the approach for the broader region.

We are using the local estimates of size of maturity gifted to us by our local partners, along with available published estimates, to cluster all the main reef fish species into groups that can be covered by a limited number of size limits or targets (probably about 10). In Fiji, with an eye for branding and cognizant of Fijians' regard for royalty, the partners are already calling this the "Prince set size system" and have committed to finalising an initial version in the first half of 2018. From the literature and our own studies, we can already see that size at maturity varies between countries (mainly it appears in relation to latitude), which probably provides a proxy for ambient water temperatures (Pauly 2010). The initial version of the Prince set size system will be something like a Pacific-wide average system tuned towards Fiji, which will be better than nothing for any country, but probably a bit too large for countries closer to the equator and too small for higher latitude island groups. But the meta-analysis we are developing will enable us to study how fish size varies across the Pacific, and I am confident that within the next 1–2 years we will be able to provide a means of adjusting the Prince set size system up or down in relation to countries latitude and water temperature in a way which adapts for each country, releasing us from the need for conducting community-based sampling program in each location. Nevertheless, teaching community members to look inside a fish to validate the approach for themselves will remain an essential part of our overall communications strategy.

And while introducing a system of minimum size limits is likely to remain an important initial step in our strategy, it cannot be the only message put forth. Increasingly, the broader range of fisheries management measures successfully developed by our "beach head" communities will need to be incorporated into our ongoing communication strategy: establishing minimum mesh and hook sizes, regulating fishing methods, designating fishing places, setting daily catch limits. In terms of empowering the transmission of SPS through the Pacific's scattered and remote communities, we envisage that underwater video of recovered reef fish populations, both before and after, along with the experience and testimony of our local champions will be essential ingredients of our long-term communication strategies. This body of information will need to be made widely available in hard copy forms for communities that have no access to power or the Internet. We are starting to see smart phones being used to share video clips in the remote communities we work with, and so breaking down our messages into short "memes" that can easily be shared could encourage extensive transmission of information.

On the basis of their experience to date, the team of collaborating partners that has been fostered by the Packard Foundation's Western Pacific Program since 2012 are confident that the SPS approach supported by the communication

materials is on the verge of creating a solution to the reef fish crisis that has been spreading across the Pacific. The Western Pacific Program originally intended to support the development phase of SPS and some aspects of a roll-out campaign to extend it through the region. Recently, however, the Packard Foundation's board decided to close the Western Pacific Program and stop funding work in the Pacific Islands region by 2020. Most, but probably not all, of what is envisioned above will be completed and available by that time, but it is our hope that by seeing the potential in this approach, other donors and partners will pick up where the Western Pacific Program leaves off, completing any unfinished aspects of the SPS communication strategy and investing in its implementation across the Pacific.

The communications and assessment materials referred to in this article are freely available from the author at biospherics@ozemail.com.au or the website www.biospherics.com.au.

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