THE BAREFOOT ECOLOGIST'S TOOLBOX

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LAST UPDATED : MARCH 2021

Contents

CHAPTER FOUR

RUNNING SPAWNING POTENTIAL SURVEY WORKSHOPS

Introduction

This chapter focuses on the communication materials, developed to facilitate the SPS workshops, and which in shorter or longer formats we use repeatedly through the SPS process.

As you work through this chapter, it is assumed you will have already downloaded a copy of the powerpoint presentation entitled '1. Community Presentation with pigs & notes' that is available on the 'Facilitation & Communication Tools' page of the biospherics.com.au website from which this chapter will have been originally downloaded.

So as to keep the size of this chapter small enough to be easily downloaded, in most cases the slides in that presentation will be discussed by their order and number, rather than included as figures in this text although that would have been preferable.

Based on my prior experience talking with Australian fishers, this communication material was initially developed working with communities in Palau and Fiji. There is apparently, however, a universality in what fishers observe world-wide, that they will recognize in these materials, and respond to where ever you are working. I and my colleagues have now successfully used these materials throughout the Pacific, in southeast Asia, Africa and South America. While the graphics were specifically tailored for the Fijian communities I was working with 2014 - 2020, our experience suggests that fishers are much the same regardless of cultures, regions and nationalities and get these wordless images. This is not to discourage anyone from adapting and shaping this material to be more local appropriate for your own communities, but even before you get to that stage, do not be scared of running this material past the fishers you know. I will guarantee you will all get a lot out of the discussion this material will facilitate.

You will find a version of the text I use when speaking with communities in the notes of the power point presentation. There is considerable overlap in content between those notes and this text, but the overlap is not complete as the aims of each text is different. The aim of this chapter is to develop in readers a general familiarity with the narrative supported by the material, as well as the broader context for the messages being communicated;

the what, how and why. The text in the powerpoint is meant to be more narrowly useful as presentational notes.

I wish you all the success I have enjoyed talking these materials over with fishers and the communities they live in.

Perceiving Overfishing

Declining Catch Rates and Fish Size

We start our presentation (slides 1-14) talking about the symptoms of overfishing that community members will be experiencing, but most probably without understanding that they are caused by local overfishing.

The need to travel further to fishing grounds, and use more fuel, in an attempt to simply maintain catches and catch rates (slide 2), the size of fish getting smaller over time in the catch (slide 3) and the markets (slide 4). The changing size of the fish is often seen most starkly if you can look back at pictures from fishing competitions to compare the size of the trophy fish from several decades ago, to the current size for which trophies are being awarded (slide 5).

With slide 6 we challenge workshop participants to test what we are saying, by simply asking an old and young fishermen, how much time they typically spent or spend fishing and what their typical catches are?

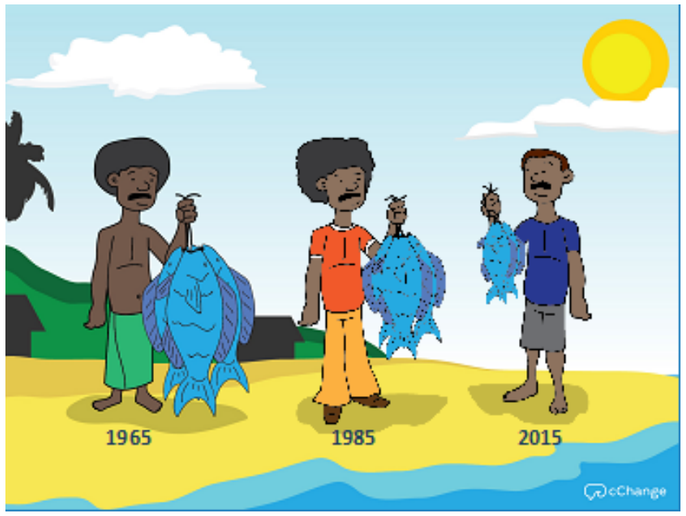


Figure 1. A symptom of overfishing; the declining size of fish in the catch.

Fishing Down Food Webs

Next (slides 8-13) we move on to talk about the concept of fishing down the food web (Pauly et al. 1998) through which the mix of species being caught changes over time, as the species most prone to depletion become scarcer and fishers learn to target less favoured species that are still relatively abundant. Explaining this process provides something of a foundational story for fishers, a basis for understanding 'how we got here'. This will have been their lived experienced but they are unlikely to have perceived it as a symptom of overfishing. Simply as another way 'all things change'. Providing this new deeper understanding of their own lived experience will powerfully enhance the credibility and value they place upon the entire SPS process.

Our slides depict this relatively accurately for Indo-Pacific reef fish. The specifics of fishing down the food web will differ from place to place and with other species assemblages. Knowing how much fishers love to see their own reality I strongly recommend those working outside the Indo-Pacific to research their own local version of fishing down the foodweb and develop their own version of these slides. Fishers are experts in what they do so it is important to get the detail right. Again, however, my experience to date is that even without local adaptation, these Indo-Pacific specific slides still manage to convey the general message well beyond the context of the Indo-Pacific.

Slides 8 & 9 introduce the concept of the intact food web as a pyramid with the largest predatory fish at the top with the smallest prey species supporting the base. Sequentially the slides remove the layers of the pyramid. As each layer of the food web is removed text is revealed summarising the universal sequence of human preferences; big is best (slide 10), high market and cultural value (slide 11), easy to catch (slide 12), ending finally with, "eventually only the fish no-one wanted are left" (slide 13). At this point I like to digress into some anecdotes to stress the reality of this final statement and allow a little time for this reality to sink in.

Fishers love anecdotes and a lot of their learning and communication is through the medium of storytelling, as it is for many societies (Bateson 2001). You are welcome to start by borrowing mine, but my advice is to gather your own as well, through your own observation and experience. Particularly by doing some serious listening to the fishers you meet.

The small red spot emperor depicted in the second last line of these slides is *Lethrinus rubrioperculatus* called rekruk, or white snapper, in Palau. I think mainly because of its small size and the way schools of them attack baits and prevent larger bigger better fish from being caught, the Palauan's used to despise this species. Australian fishers feel similarly about schools of puffer fish descending upon their baits preventing anything else being caught. There was a time in Palau when if you gave rekruk to someone it was regarded as an insult, and if a restaurant served you white snapper you would not return. In 2013 while training a team of Palauans to measure fish in the northern port of Ollei, an older chiefly fisher wandered over and asked what we were doing. We struck up a conversation on these matters, before he went back to sit in the shade of the fishing hut to chew some more beetle nut. After a bit of a chew he meandered back and told me; "You're right you know Jeremy. When my grandfather first taught me to fish 50 years ago, he taught me that if we started catching rekruk we were in the wrong place and should move to catch some good fish. Today if I move away from the rekruk we end up going home with an empty cooler." By 2016 it was almost impossible to get any other type of fish in a Palauan restaurant, and I heard that there was a time when because of the numbers of tourists the restaurants stopped serving any type of fresh fish to Palauans, so there would be enough for the tourists. By 2019 a potential sign that fishing pressure on the Northern Reefs might be backing off and the stocks turning the corner was that the rekruk seem to be getting bigger.

A Fijian equivalent of this story concerns *Terapon jerbua* the crescent banded grunter, that many Pacific islanders prefer to avoid. In the Pacific many villages still lack modern standards of sanitation, so the ocean side is still used as a convenient natural waste disposal system. The crescent banded grunter is a very efficient part of that system, and for that reason for many people there is a 'yuk factor' around catching and eating the species. So, having been sensitised by these slides, when in 2019 the crescent banded grunter started turning up for the first time in the Labasa market, local fishers recognised it in a very visceral way as 'fishing down the food web' and a clear sign that things

were getting worse on their fishing grounds.

This is a good point to allow for a break in the workshop proceedings to let participants ask questions of clarification and discuss what they have heard amongst themselves. Often the local equivalent story will bubble up out of the meeting participants.

Serial depletion

Following on from these anecdotes illustrating the concept of fishing down the food web, the next slides (16-20) introduce the concept of serial depletion, by which fisheries are depleted sequentially rather than at the same time everywhere at once. Fisheries biologists have had a tendency to assume that because many fish have pelagic larvae that swim freely, the larvae move over long distances and connect fish populations over broad areas. Since the 1950s and until recent decades it was most commonly assumed that marine populations are 'open' meaning that the larvae settling into any location have little relationship to the local adults, because having drifted so far there is little chance of them returning to the location of their parents. The implication of this is of course, that you need not manage the fish on your reef because larvae from somewhere else will keep replenishing it. Today we are beginning to understand that in the same way people orientate towards a specific area as 'home', and may live locally to where they were born for their whole life, or remember the area of their birth wistfully no matter where they settle, fish also tend to be much more 'place-based' than we ever imagined likely. In scientific jargon we call this 'philopatry' meaning the love of place.

In the context of Indo-Pacific reef fish the studies of Almanny et al. (2007) are classic for demonstrating philopatry and over turning our previous belief in 'open populations'. Just before the spawning season they injected radio-active isotopes into female clown and butterfly fish living on a small (0.3 km^2) patch reef. The isotopes injected into the mothers effectively tagged or labelled their eggs and larvae, so that at the end of their 11 and 28 day larval life they could be found and identified as the progeny of the injected mothers. What they found was a high degree of self-recruitment, some 60% of the young fish settling back around the injected parents on that patch reef were their own offspring.

From this and other similar studies we are learning that not just with clownfish and butterflyfish in the Indo-Pacific, but for most of the Indo-Pacific reef fish, and it might be said most coastal fish and invertebrate species everywhere, localized recruitment is apparently the norm, not the exception we once thought it to be (Swearer et al. 2002). The implications of this changing understanding for our field are huge, firstly it means that we are facing the challenge of managing many more small-scale fisheries than anyone ever imagined. Every lagoon through the Pacific contains 100+ different fisheries each needing to be assessed and managed as its own independent unit of stock. Fortunately, another implication of this is that community-based management, even over relatively small scales, can be far more effective than we would have thought possible 15-20 years ago.

In the context of our workshop we simply want to portray the concept that similarly to humans, fish live in small communities, and can be depleted community by community. So that while the same process of depletion will occur everywhere if not managed, its timing is unique in each place depending on the level of fishing pressure applied in each place at each time.

To depict this concept, we use slide 16 which portrays the serial depletion of the sailfin snapper (*Symphorichthys spilurus*) in Palau, which is similar to the Chinaman fish (*S. nematophorus)* found in the southern hemisphere of the Indo-Pacific. These species apparently spend a lot of time feeding in the deeper mid-waters beyond the reef where they are relatively safe from heavy fishing pressure. However, their vulnerability is apparently a love of land crabs. In many places I have been given very similar accounts of how on the moons when the land crabs come down in hordes to the water's edge to release the larvae from their hatching eggs the sailfin snapper once gathered in big schools to hunt crabs at the water's edge. Traditionally in many places the snapper were hunted with spears thrown by hand from above the water, and perhaps as many as a 6-12 would be caught each moon. In some communities this highly prize catch was reserved for high ranking men and women in the community, and no doubt the successful fisher curried favor with their catch. The multiple accounts I have gathered from far flung Pacific locations all have an uncanny similarity. At some

stage gillnets become available to the community and someone had the bright idea of placing a ring of net around the snapper schooling in the shallows. With each account I was told that for just three moons catches of hundreds of snapper at a time were possible, and then nothing. My informants invariably hang their heads and quietly add that in the 20-30 years since sailfin snappers have only been seen as the odd one, or perhaps rarely two together.

I don't know if something similar happened in Palau, but from the accounts I have read and from what I have been told, I know that originally sailfin snapper, were once common throughout Palau, which is only about 100 km from north to south. But by the 1950s people in the main population centre of Koror could no longer catch this fish without travelling north or south by boat to the fishing grounds of the outer communities. By 1980 people everywhere in Palau were seeing the numbers decline, and it was no longer caught around the main islands and communities. Today we only know of two aggregation sites still occurring in the extreme south and north, remote from human communities, and in deep water with strong currents making them very hard to fish.

From this slide I segue into talking about how serial depletion is occurring at the regional scale (slide 17).

The process of overfishing and fishing down the Food Web is happening right across the Pacific Ocean, and in every place it happens the same way, although it happens with different timing in each place depending mainly on how many people live in each place, the extent of their reefs, and how easy or hard it is to get their fish to markets.

The biggest fish markets in the world are in Asia, Tokyo, Hong Kong and Shanghai, and almost two thirds of all the fish caught in the world pass through those main Asian markets. They especially prize Pacific reef fish, because that is their traditional fish, now severely depleted in their local waters, so they come to the Pacific countries wanting to buy fish. By knowing how quickly and easily fish can be sent to markets in the main towns of Pacific countries, and especially the main Asia markets, you can pretty accurately predict how depleted the fish stocks are going to be in any place. If it is very difficult and takes a long time to get fish to big markets, then you are more likely to see the bigger bodied species of reef fish.

Countries and locations accessible to the Asian markets have already lost almost all their reef fish, so through much of the central Philippines and western Indonesia, regions which once had the entire Indo-Pacific assemblage, you will now see only a few small species on their reefs. The biggest bodied species of grouper, the bumphead parrot fish (*Bolbometopon muricatum*) and humphead wrasse (*Cheilinus undulatus)* which were once common everywhere, have become very rare in almost all Pacific countries, and are locally extinct in many places. You have to go to very remote areas, big marine reserves that are being enforced, or places where they are doing a good job of management, if you want to see them. Some scientists are saying that by 2040 these biggest species could be totally extinct throughout the region (Sadovy et al. 2003, 2013; Dulvy & Polunin 2004).

Palau

To make the scale and scope of serial depletion at the regional scale real and not just academic I use the comparison of catches from Palau (slides 18 & 19), Macuata on the north coast of Vanua Levu in Fiji (slide 20), and the north coast of PNG (slides 21 & 22).

When Bob Johannes first went to Palau in the 1970s and talked with fishing communities they told him they were deeply concerned about the declines they were observing in sailfin snapper, mullet, gold spot herring, rabbitfish and long-nose emperor which the nets, they got first from the colonizing Japanese, had made easy to catch (Johannes 1978). And the big groupers species and bumphead parrotfish and humphead wrasse which spearfishing and especially spearfishing at night had made easy to catch. These species (slide 18) were all in trouble by the 1970s and going down fast.

In 2015, when with the help of Palauan fishers, we began measuring catches, almost none of the species they were worrying about back in 1970 were still important to them (slide 19). Of the original larger bodied fish only, the long nose

emperor no longer seen in large schools, and square tailed grouper, which they banned from catching during the spawning season, were still important to them. All the most important fish were the smallest types of grouper, parrotfish, snappers and emperors. The small bodied paddletail snapper (*Lutjanus gibbus*) had been the single most important for many years, and it was these species most worrying Palauans because they saw them getting smaller and harder to catch. The white snapper (*L. rubrioperculatus*) was displacing the paddle tail snapper as the most important food fish in terms of quantity, and once the Palauans, didn't consider it worth catching.

Macuata in Fiji

In 2015 when I talked with the communities in Macuata, the northern Province of Fiji, a long way away from the Asian markets, but which is now sending a lot of fish to markets in Suva the main city of Fiji. They told me they were worrying about almost all the types of fish the Palauans worried about back in 1970. The sailfin snapper, mullet, rabbitfish and the big bodied groupers, bumphead parrotfish and humphead wrasse which spearfishing and especially spearfishing at night made so easy to catch (slide 20).

PNG north coast

But the process of fishing down the food web doesn't stop when you get down to the small emperors like white snapper in Palau. Unless overfishing is solved with effective management the food web continues being eroded. The catches of the communities I work with north of Madang illustrate this point very graphically (slides 21 & 22). Those communities once had all the big bodied Indo-Pacific species, and the large bodied snapper, the mangrove jack (*Lutjanus argentimaculatus*) is a totemic species in that area. Traditionally an annual feast of mangrove jack celebrated girls becoming women. The timing of that ceremony and feast coincided with the mangrove jack migrating from their feeding grounds in deep water, to spawn in the shallows of the estuaries where they were relatively easy to catch.

Each of the two slides (slides 21 & 22) we use show what today is now considered a good catch for one fisher fishing for one day. To me these catches look like the result of a smash and grab raid on a marine aquarium. One catch is just a handful of tiny colorful wrasse and trigger fish (slide 21), the other is a clutch of damselfish (slide 22). These communities told me that the current generation of 25 – 40 year olds only know about mangrove jack through their traditions, they themselves have never seen one, let alone caught and eaten one.

Some people have the mistaken idea that overfishing only occurs when big boats and commercial interests become involved, and even argue that subsistence fishing can never be a problem and cause overfishing. Let me respond to that perception by noting that, in this area north of Madang, there is no access to fish markets and fishing is entirely for subsistence. The communities in this area also have a tradition by which each fisher must hand carve their own canoe before they can go fishing. Only one fisher is allowed to fish from each canoe and they fish with very simple hand-made lures, wooden reels and basic spearfishing equipment. They are perhaps the purest example of subsistence fishing I have come across to date. But their coastline is very steep and there is almost no lagoonal area, the population pressure along the narrow coastal plain is relatively high, so that relative to the scale of the fish stocks fishing pressure is very high. It is the level of fishing pressure relative to the scale of the local resources that drives depletion, if populations are large enough relative to the reef area, even without the incentive of selling fish to markets, simple subsistence fishing depletes coastal fisheries.

When I show these pictures to communities in Macuata or other places where communities still have reasonably good catches, spontaneous raucous laughter breaks out at the ridiculous idea that people would actually fish for these colourful ornamental species. But the laughter quickly dies away, leaving an empty poignant silence. As the real message of those images finally sinks in and the gathered community begins to ponder the idea of this being their own future. Once when I revisited the communities north of Madang I showed them this same presentation. I told them how I use the slides of their catch with communities in other regions, and about how the people in other places respond. After think deeply about what I had said,

Mathew Mirak my amazing community partner for that project responded; "You know Jeremy, we no longer fish for meat, we fish for flavor in our soup."

The take home message from all of this, is that the process of fishing down the food web occurs in much the same way in each place, but with different timing, depending on how heavy the fishing pressure is in each place. This means we know with certainty what will happen in each place, if communities do not manage their fisheries effectively. It is not a matter of if, but when.

Here we again allow a break for people to rest, reflect, chew some beetle-nut or smoke a cigarette, and to talk amongst themselves.

Why is this Happening Now?

Continuing towards the goal of addressing existing heuristic frameworks for thinking (or not thinking) about overfishing we obliquely tackle the assumption that because fish have always been there, they always will be; 'God will always provide'.

We do this with slides 24-28 by addressing a question that might be at the back of people's minds; why is overfishing occurring now? Fishers in these communities have been fishing for 100s of generations, why should overfishing be occurring now when it did not occur before? (slide 24).

Growing Populations

Throughout the Indo-Pacific region, as well as many of the regions where subsistence fishing is important, populations are growing rapidly. In Fiji the population has trebled since the 1950s (slide 25). So one reason for the current overfishing crisis is that there are simply more mouths to fill. In many countries fish is also increasingly being seen as the healthier food option, so each mouth is wanting to eat more fish. Add to this the fact that in many regions, particularly in Asia where the world's biggest fish markets are located, fish stocks have declined due to historic overfishing, so those markets are wanting to buy more fish from other regions.

All this adds up to a growing demand for fish.

Better Fishing Gear

And today, people are a lot more effective at catching fish than they once were (slide 26).

In the old days, fishers needed to be experts about each type of fish and when, where and how they could be caught. Fishers needed to know to make the right fishing gear out of local materials. Hooks were difficult to carve out of bone or shell. So fishers mainly used gorges instead, just a straight piece of bone or shell with a line of natural fibre to the middle of the gorge. The gorge would be put length-wise into a bait, the idea being that when a fish ate the bait, the line to the middle of the gorge would be pulled, and the gorge would turn side on wedging in the gills of the fish. But gorges had nothing like the effectiveness of the steel hooks now bought cheaply in any fishing shop. To be successful the size of gorges had to be exactly matched to the size of the fish being caught. Too big and the gorge would not be able to turn side-on, it would simple pull back out of the fish's mouth. Too small and although the gorge would turn side on, the fish could simple open its mouth and release the gorge.

Nets were much rarer and laboriously home made out of native flaxes and other fibres. Instead of putting a net around a school of fish, more commonly through the Pacific Islands leaf sweeps were made by weaving coconut fronds together. Like a grass skirt 10s and 100s of meters long they were used to herd fish aggregations close to shore where they could be speared or scooped up in baskets. Most fish would escape by swimming through the leaves. Rabbitfish, for example, live in the seagrass and are not so scared of swimming through a leaf sweep so they more easily escaped. Most spear fishing occurred from above the water. To fish at night the moon had to be big, or a burning torch had to be used. Most fishing occurred in the shallows, because natural fibres floated and were not strong enough to fish effectively in deep water outside the lagoon. More or less the fishing was for small juvenile fish in the shallows, once they became adult and moved out of the lagoon onto the reef edges,

they were relatively safe from fishing and could spend a long, life breeding and keeping the lagoons full or small juveniles.

This has all changed in modern times.

Westerners introduced face masks and skin-diving to the Pacific in the early 1900s because they wanted locals to collect pearl shell for them to buy. Nets can be used to catch entire schools of breeding rabbit fish, gold-spot herring, mullet and scad, when they come close to shore in their spawning aggregations. Almost nothing escapes to breed. After the second world war, modern spearguns became available making it easier to spear the big groupers and parrotfish. In the 1970s and 1980s, underwater torches started to become available making it easier to spear many types of reef fish while they are asleep in shallow water. Unlike the original fishing lines made from natural fibres modern fishing lines are very fine and strong, with modern fishing reels it is possible to fish down to hundreds of meters. Outboard motors let fishers travel to distant fishing ground when all the fish have been caught on the home reefs. And now technology such as GPS, global positioning system, makes it possible to easily find any good fishing spot. Instead of being an expert fisher yourself, you just need to know who the best fisher in your community is and follow them with your GPS.

Traditionally only a few people were expert enough to be the fishing chiefs and the gear they used always let most of the fish escape. Now everyone can be an expert fisherman and few fish escape. We are now taking a lot more of the fish off the reefs, and leaving a lot less fish in the water to reproduce and provide fish for next year.

Cash Economy Incentivising Fishing

As countries have modernized people have got access to health care, education modern services, consumer goods and mobile phones. All this needs to paid for with cash (slide 27), and for many communities catching and selling fish is the best way of earning money. So fishing is no longer just for feeding communities but increasingly it is for earning money.

Access to Markets

In traditional times there were limited means of keeping fish from spoiling, although some fish were smoked, dried and fermented to preserve seasonal abundances, but there was no ice or coolers let alone freezers. In the past, once families and communities were fed they would stop fishing because excess fish would spoil. Today with access to markets, ice and coolers there is never any reason to stop fishing (slide 28). Once the seasons when fish aggregated and could be caught in abundance were the time for fishermen to take it easy because families and communities could be easily fed, today those are the seasons to work harder and make lots of money.

So today fish stocks the whole world over are under more pressure than they have ever been and after centuries of relative sustainability we are all facing an overfishing crisis.

At this point of the workshop we again allow a break for questions and reflection.

Break-out Groups Discussing Symptoms of Local Overfishing

By this stage of a workshop, we are generally approaching the end of the first morning and the concept of overfishing and its symptoms is starting to come together for people. To help adults coalesce and consolidate new concepts it is useful to provide them with opportunities to discuss and apply the new concepts to their own situation. For this purpose, at this stage, we facilitate discussion about the extent to which communities are seeing their fish and fishing changing; falling catch rates, longer fishing trips, smaller fish, changing species assemblage in the catch.

This discussion is facilitated by asking two specific questions (slide 30):

1. WHICH OF THEIR SPECIES ARE CHANGING THE MOST IN TERMS OF DECLINING FISH SIZE, NEEDING TO GO FURTHER AFIELD TO CATCH THEM, DECLINING CATCHES AND CATCH RATES? AND

2. WHICH SPECIES ARE MOST IMPORTANT TO THEM, OR WOULD BE WORST FOR THEM TO LOSE?

If done as a single large workshop group it is important to engage everyone in the discussions; older members of the fishing community, male and female should always be asked directly for their opinions, as well as the main current (and normally younger) fishers. My preference is to break the workshop into smaller groups no bigger than 4-6 fishers, armed with butcher's paper and pens. In that case think carefully about the composition of the groups which should each have some degree of homogeneity in terms of; status level, gender and age, as well as the area people come from, or live in, and the type of fishing they do. If groups are heterogeneous you run the risk of the groups failing to reinforce individual learning because some people stay quiet, or don't share and identify with the experiences of others in the group. People from differing areas may fish for different species and so the symptoms of overfishing they see might look different to them, or involve different species.

Grouping people with similar status levels is more likely to ensure everyone speaks up within their own groups. Grouping people by shared geography and fishing technique increases the degree to which points of view about overfishing will be shared. Within each group the discussion should be about the details of species and places all the members of a group have in mind. When the groups report back their higher-level conclusions can be shared without the specific place-based details being so important.

For example, in a workshop I ran on Manus Island, PNG, there were coastal people with knowledge of marine fish, and 'highlanders' from 40-50km inland who knew about freshwater fish, but very little about marine species. It was important for us to have the 'sea people' and 'highlanders' in different groups so that the discussions in each group could be around shared experiences, allowing the people in each group to apply and reinforce what had just been learnt. Similarly, when I ran SPS workshops in Kenya for people from communities scattered all the way from the major city of Mombasa to the sparsely populated remote area bordering Somalia in the north, it was important to group people by their communities. On the border with Somalia the communites were concerned about the declining abundance of grouper and other big bodied species, like the fishers in Macuata in Fiji. But closer to Mombasa the foodweb has already been fished down and the current concern was about the decline of the octopus fishery they now depend upon. The differing groups each needed to have their own discussions or everyone would have ended up confused and talking at cross-purposes.

Of course, in this context, when it comes to the session when each break-out group reports back, for the edification of the broader group, the specific context of each breakout group needs to be made explicit. The fishers in each group should identify on their piece of butcher's paper and in their report, where they come from (village, area etc) and the type of fishing they do (hook and line, spearfishing etc). As the facilitator you need to be cognizant of this context and you should endeavor to make that explicit for the workshop, by relating it back to the concepts fishing down the foodweb, serial depletion and differences in types of fishing, and geography.

Naming and Prioritizing Species

In terms of adult education methodology this exercise

serves a very useful purpose by giving participants time to internalise and apply the concepts they have just learnt to their own experience, affirming with their community what we are teaching. As a biologist I learnt this serendipitously from experience. My original motivation for facilitating these discussions were far more pragmatic; to identify which species local fishers could identify and name to a species level, enabling them to collect the species-specific data needed for LBSPR assessment.

Some 90-150+ species can be landed by these shallow water tropical reef fish fisheries in the Indo-Pacific, but >85% of the value of the catch will come from a main group 10-20 species. The LBSPR assessments produced through the SPS community-based science program are specific to particular species. Combining the data from multiple species with differing body sizes within a single size-based assessment invalidates the approach. If the local community is going to be involved in data collection the data has to be collected using their local names, but species need to be selected, at least partially, on the basis of having local common names which are taxonomically species-specific. So importantly while this discussion session provides a basis for understanding each communities' species priorities, and which species are most important to them to be assessed and managed, it can also provide information about the species they can reliably identify and name to a species level, enabling local data collectors to be taxonomically precise with the data they collect.

For this purpose I ask the fishers to list and discuss local species of importance and concern using local names, but provide them with copies of fish ID books. In the tropical Pacific we find Allen et al. (2003) a useful standard text. The SPC fish ID guide (Moore & Colas 2016) is also very good for this purpose, perhaps more useful because it is not as comprehensive but more focused on the main food species of the tropical South Pacific, and freely available in electronic form from SPC. We find our participants are inevitably interested in the ID books, and in puzzling out the English name of the species on their list.

If I am working for the first time in a new area with new local names, the night before I facilitate the workshop, I make it a practice to spend some time with a few local fishers, perhaps sharing some kava or a beer, and with the fish ID books encouraging the fishers to find the main local species and equating local and species names. This allows me to prepare for the morning session and often I will have thrown together some powerpoint images of what I expect to be the main species. The next morning, as each breakout group reports back their discussion with the help of guidebooks and projected images, I facilitate discussions amongst the broader group about the extent to which each local name matches specific scientific names, or is applied to a group of species of similar appearance (i.e. small *Lethrinus* or *Lutjanus*). As the species list provided by each break-out group is worked through and tabulated by local name and species name or group, it should be possible to prioritise species for assessment while simultaneously determining which can be identified by local name to a species level, and so are amenable to species specific assessment with community collected data. If possible, some 15-20 species, which are of interest to the community, with local names corresponding to taxonomically specific names, should be agreed by the workshop to work with.

This process can be a bit laborious but it is necessary to be very certain about which species are being worked with before commencing data collection. In any case the fishing communities enjoy it, and the process of applying their new knowledge to their own experience is good adult education practice.

Developing a Shared Appreciation of the Over-fishing Problem

Through the report back session fascinating insights are gained about the extent to which local food webs have been fished down, and a sober appreciation of the overfishing crisis facing each community settles on the workshop. It was during these report back sessions that I was told about the mangrove jack being an important customary species north of Madang in PNG, which is close to being locally extinct in many areas. It was also during these sessions that I received the multiple eerily similar accounts of how aggregations of sailfin and chinaman snapper in the shallows having been wiped out with encircling gillnets in many different places.

I now find that, at least within the context of the Indo-Pacific reef fish assemblage, these report back sessions enable me to diagnose the extent of local overfishing. Is a community still concerned about the large bodied groupers and parrotfish (Macuata, Fiji), or mainly worrying about small bodied emperors and snappers (Palau and Tavua, Fiji), the loss of small wrasse and damsel fish (Madang, PNG), or octopus (Mombasa)?

Developing a Shared Vision for Change

After the report back session, we crystallise the insights gained from the break outgroups and start the process of developing a new vision of the future using a series of images that portray fishing down of the food web as a diminishing supply of food (slide 32 & 33). With these images the main Indo-Pacific species are pictured on plates, in successive images the number and size of fish on plates diminishes, while we rhetorically ask where each community is headed, and where it is going to end for them? The last image in this series simply portrays a tin of fish sitting on a plate.

Figure 2. In the future what is there going to be left for dinner? Slides 32 & 33.

At this point community members invariably begin asking questions about possible solutions. As with most sustainability issues solutions come through changing old ways of thinking and behaving (Hardin 1968) and we begin to directly challenge the old heuristic way of thinking about fish; that the smallest fish have the sweetest meat, with the fact that they think differently about working with the natural productivity of their gardens.

The Reef is a Garden, You Reap What You Sow.

Common sense dictates that in gardens small plants and animals are nurtured until they have grown big ripened and have reproduced sufficiently to ensure future generations of plants and livestock.

This is illustrated with graphics based on rearing well known domestic animals for which it is accepted common sense that they be allowed to grow to adult size and replace themselves several times before they are eaten.

For this we generally use imagery of a pig farm that WWF in Fiji helped communities build to fund community schools (slides 34 – 48). 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 the reefs are the marine gardens of an island they are treated differently, and it is considered a virtue to catch and eat the fish before they can breed and stock up the reef.

We find this analogy connecting gardening and fishing practices works powerfully in all settings and have developed more culturally appropriate variants for different fishing communities using chickens instead of pigs for Seventh Day Adventist, Muslim and South American communities (available on the website), goats in Kenya, and coconuts or other fruits for communities north of Madang, and in Buddhist Sri Lanka (not available on the website). 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 the need for change is perceived.

At this point we again break the meeting to allow for some reflection and discussion.

What Can We Do?

When we return from that short break, we start answering the communities' questions about what can be done about overfishing, with more concrete suggestions for action.

With slide 50 that depicts a whole range of different management actions the aim is to make explicit that there are many ways of managing fisheries, and to discuss a few of them in more detail. But we are working our way towards the next slide (slide 51) which makes the point that all forms of effective management actions will have the same effect of protecting fish until they have grown to a size that is optimal for harvest and allows enough reproduction for the fish to replace themselves. These are the twin points which need to be emphasized here.

Protected Areas and Closures

Permanent or temporary bans on fishing grounds, or part of them can be an effective way of building up fish populations if the area that is closed is big enough, and the period of closure to fishing goes long enough. When areas are too small and the period of closure is short very little effect is seen even inside the closed areas. But they can be very effective at building up the number and size of fish inside the protected area if big enough and closed for long enough.

The thing is that they are proving to be not so effective at managing the fishing grounds and keeping the fishing grounds productive. The theory behind protected areas was to close them up so that fish numbers would build up and spill out of the protected area to replenish fishing grounds. Unfortunately, this theory has not worked so well in practice, because the fish in the closed areas often prefer to stay there, and there is a lot less spill-over than the theories predicted. If protected areas are respected by fishers, the number and size of fish within them does build up, but by itself this has not proved effective at maintaining the productivity of fishing grounds outside. It turns out that to make closed areas work best, you also need to manage the fish outside the closed areas as well, so that fish can be moving backwards and forwards, and the fishers are not reliant just on the relatively small amounts of fishing spill-over from the protected areas.

In a lot of places closed areas get used more like a fish bank, with areas being kept closed for a while and then when the fish have built up opening them up for a period of good fishing. Often when this happens there is a short period of heavy fishing and the area is depleted back to level before it was closed. If, however, the community had agreed to some new management, before they re-opened the closed area; say put some minimum size limits in place, some of the build-up in fish could be protected and made permanent. In this way closures and openings could be an effective way of rebuilding fish stocks for the long term.

Spawning Aggregation Closures and Spawning Season Closures

A specific form of protected areas, or protected seasons is aimed specifically at protecting spawning aggregations of fish, by closing spawning grounds or seasons to fishing. In slide 50 this is depicted by the fish gathering on the heart. These can be very effective ways of reducing pressure on fish when they are most vulnerable, and for making sure the fish are left undisturbed to breed effectively. However, as with permanently protected areas, if spawning aggregation closures are the only type of management, there is no guarantee they will prevent overfishing. That will depend on how heavy the fishing is outside the spawning season and spawning site. If the fish are all caught as juveniles and sub-adults outside the spawning season, there will be no fish aggregating during the spawning season to benefit from the protection. Once again the quality of the management throughout the year and across the fishing grounds will determine the impact of your spawning aggregation closures.

Gear Restrictions

All the countries that now do a good job managing their fish stocks are very careful about the type of fishing gears that can be used to fish for each type of fish. It is not legal to fish anyway you want, with any type, or size, of fishing gear. These laws always aim to make sure that the fishing gear being used:

1. Does not destroy the habitat of the fish, and does not indiscriminately kill many types of fish, other than the target

species. So poisons and explosives that kill everything are always banned. Trawl nets dragged along the bottom behind boats and beach seines with small mesh sizes, are also banned in many places for the same reason, or at least controlled carefully in terms of where they can legally be used, and how many times they can be used in a period of time.

2. Catches the right size of fish and does not indiscriminately catch all sizes of fish. Gillnets are banned in many areas for this reason, or only allowed in some areas if they have sufficiently large mesh sizes to stop them catching the small fish. In many countries, traps must have holes of a certain size built in them so small fish, lobsters or crabs, can escape easily from them.

3. Is not too effective, so that it does not catching the entire population and leave nothing behind to breed. For this reason, many countries ban fixed nets across channels through the reef, or river mouths, spearfishing with SCUBA, and night-time spearfishing, as well as the gear types mentioned above.

Sometimes an alternative to banning a method completely, is to only permit it under limited circumstances. For example, New Caledonia permits night-time spearfishing, but prohibits speared fish from being sold in markets. This allows subsistence fishers to feed their own families with the technique, but does not allow them to catch large amounts of fish for selling. Another way of controlling specific fishing gears so that they are not too damaging for the fish and environment, is to control when and where the gear can be used. For example, gillnets and beach seines catch an indiscriminate mix of fish species and sizes, when used amongst coral reefs, and in seagrass beds, where many types of juvenile coral fish grow-up. However, a gill net with the right minimum mesh size used only along sandy beaches can be highly selective for catching the right size of mullet.

Again, like the management discussed above, these are all good strategies that are used in fisheries management, but used by themselves they are not guaranteed to be sufficient to ensure sustainability. They can all be part of a solution, but they are not the silver bullet.

Restraining Fishing Effort

Central to making fisheries sustainable in almost all countries is controlling how much fishing occurs, what we call the fishing pressure on the stock. This is done by controlling the number of people who go fishing with a system of permits. No permit no fishing. This is hard to do in countries with lots of subsistence fishers because most governments are not willing to tell people they can't fish for their own food. In countries where fishing is just for the market, or recreation, and people do not depend on fishing to stay fed, governments will reduce the number of permitted fishermen to reduce fishing pressure to a level that is sustainable. This of course also means that the government has to be able to accurately assess stocks and estimate what is the sustainable level of fishing pressure.

In countries and communities with lots of subsistence fishery, permit systems can still be used to control how many commercial fishermen are allowed to compete with subsistence fishers and so ensure there is more fish for the community to eat, but used this way the permit system by itself will not be able to stop the fishing pressure of the subsistence fishers from becoming unsustainable.

Limiting Catches

In countries with large valuable fisheries, very effective governance, and accurate stock assessments, the amount of fish that can be caught each year by each fisherman is controlled very strictly. Like controlling fishing pressure, if linked to accurate stock assessment, directly controlling how much fish is caught can ensure sustainability. However, these conditions rarely exist in our context of small-scale fisheries, which normally have little stock assessment, and no effective way of keeping account of how much each fisher catches.

Some communities do still find it useful to place some control on how much fish each community member can catch over a season, or by day or week. This can be a way of roughly limiting how much is caught overall, and a way of sharing out the available catch across community members, of evening it out over the year, and reducing the amount caught during the spawning season, so there is more for other times of years.

Size limits

The simplest single way of guaranteeing sustainable optimal catches is with minimum size limits which make fishers catch and release fish until they have reached the size at which they have fully grown and completed enough breeding to replace themselves. This is one of the few ways which when used by itself can guarantee sustainability, and by far and away the simplest (Prince & Hordyk 2019). Just like humans, fish have to reach a certain size before they can reproduce and then they have to be allowed to complete enough breeding to replace themselves if stocks are going to be maintained. And it turns out that if fish are allowed to grow large enough to reproduce and replace themselves they will also be growing to the size which produces the optimum amount of catch as well.

Letting Fish Get Big Enough to Replace Themselves

In Fiji where locals use the word 'Set' like other nationalities us the work 'OK' we called this size the 'Set Size', in other words the size that is OK to catch. With this SPS approach the Set Size for any species can be simply estimated and setting minimum legal size limits (MSLs) in this way, can by itself, make sure optimal sustainable catches are acheived.

Whatever management technique, or mix of management techniques, a community thinks might work for them, the challenge and solutions to over fishing are the same. The essence of the overfishing problem is always that fish are caught too small and young, before they finish growing and making meat for the community, and before they have had a chance to replace themselves with young fish. That is why local fish stocks decline.

The next slide (slide 51) illustrates this by first showing a small hook catching a small fish when it has only produced a few young. This path eventually leads to fishery collapse, as not enough fish are left to breed and restock the fishing grounds. However the communities choose to implement it, a successful management strategy, or mix of strategies, must protect fish until they have grown and bred sufficiently to replace themselves before they are caught, as illustrated by the second phase of this slide.

Like stopping people eating all the fruit off a tree or digging up the cassava and sweet potato before they become big and ripe. The way of making more food for everyone, is not catching the fish too small, before they have grown big enough, and completed sufficient breeding to replace themselves.

Scott Radway's focus group work in Fiji, as well as studies done elsewhere in the world, show that of all marine conservation issues, people respond most strongly to this need to protect spawning fish. Everyone can relate to the idea that adults and mothers are needed to have children, so the concept of protecting spawning potential in fish resonates.

The point to end on with this slide, is that once they know the Set Size for a species of fish, communities can evaluate for themselves if they have an overfishing problem, and whether or

not the management they try is working, from the size of the fish. If the fish are mainly caught smaller than the Set Size and keep getting smaller their management is not working and they have a problem with overfishing. If they start managing and the fish sizes get bigger, then what they are doing is working. Eventually they want to get the fish size steady above the Set Size then they will be getting the most meat and preserving enough breeding for the future.

How much breeding is enough?

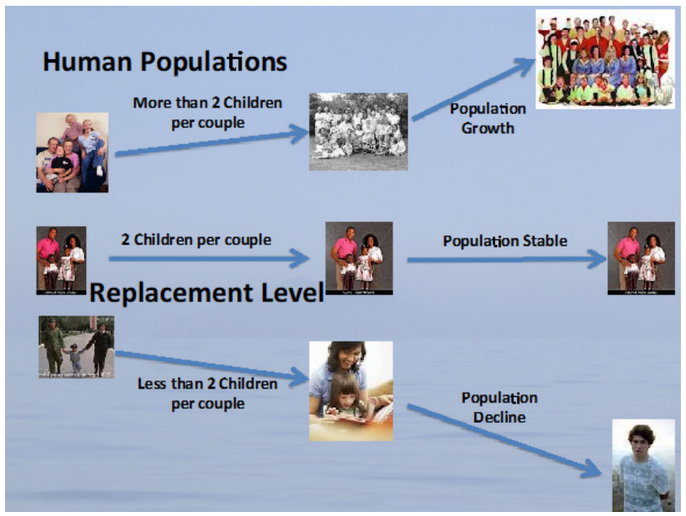
This brings us to the question of how much breeding is enough, what is the fish size which ensures there is enough breeding and how can we work that out?

To answer these questions, it is useful to think first about human populations.

A simple way of working out what is going on with population growth in any country or community is to estimate the average number of children, per adult couple, that survive through to adulthood (slide 53). This is a concept called the 'Total Fertility Rate' or 'Human Reproductive Index' (HRI). Obviously to replace themselves, and keep a population stable, on average each couple needs to have about two children survive them, grow up to be adults and have their own children. This is called the 'replacement level' and it is actually 2.1 surviving children per couple, because not every adult will partner up and have their own children. Those couples who do need to have slightly more than 2 children to compensate for those who have none. Above this replacement level, human populations grow, and below this level without immigration, they decline. In most of the Pacific countries the HRI is well above 2 and closer to 3, so they are growing fast, while for many some sub-Saharan African countries and Afghanistan it is from 5-6 and their populations are growing very fast. But almost everywhere in the world the HRI is falling and already in the developed countries of Europe and Asia well below 2, closer to 1. In the absence of immigration their populations are declining quite rapidly.

Fisheries biologists have a similar concept for fish and other marine animals called the spawning potential ratio (SPR), or spawning per recruit (Mace and Sissenwine 1993; Walters and Martell 2004). Which with fishing communities we refer to simply as 'spawning' (slide 54). The concept is that if there is no fishing, the average fish gets to live out its full natural life span and to complete 100% of its natural amount of reproduction, or spawning potential. If there is some fishing the average life span of the fish is shortened, because some get caught before completing their natural life span, and this means that something less than 100% of their natural spawning potential is completed. In other words, with fishing they only get to complete some proportion, or ratio of their natural or unfished spawning potential. The spawning potential ratio is the amount of spawning when fishing occurs as a ratio of the natural amount of spawning that would occur

without fishing.



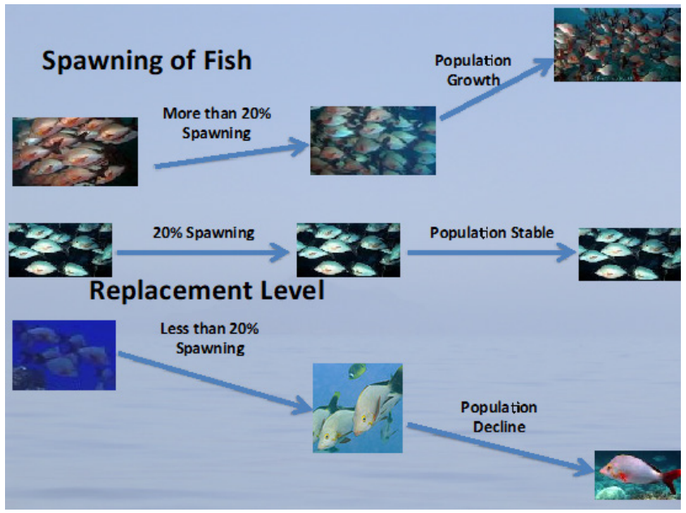


Figure 3. Slides 53 & 54 illustrate the parallel between the concept of the number of surviving children per human couple, and the spawning potential of fish and other marine resources.

From scientific studies (Mace and Sissenwine 1993) we know that about 20% of natural spawning potential (i.e. 20% SPR) is the replacement level for fish. This is equivalent of 2.1 surviving children per couple for humans. Below 20% SPR fish populations become increasingly likely to decline because not enough young fish will be produced to replace the adults. Above 20% spawning, populations can keep reefs full to carrying capacity, and populations depleted previously by fishing can rebuild.

Fishing Down the Size Composition of Fish Stocks

Working with communities to collect information we can work out for any type of fish or marine organism how much spawning (SPR) is occurring from the size to which the adults get to grow, and predict what is going to happen with the fish in the future. We can also work out the size the fish need to achieve in any location to allow sufficient growth and spawning to keep their stocks at healthy levels, the reefs full and the communities well supplied with fish. Our technique (LBSPR) uses the predictable way the size of fish changes with fishing, something fishery scientists have studied for many years and understand very well.

The next graphic depicts the way the size of fish changes as fishing pressure intensifies (figure 4 & slides 55 – 57). This is the only graph we use in the entire SPS process, because unlike scientists, most people in fishing communities do not relate to graphs. But this is a key graph for people to understand the SPS process, and going forward it becomes a key way of relating to the SPS results, and for conceptualizing what is needed to start managing the stocks.

This is the type of graph (slide 56) we produce if we sit down and count and measure all the fish in a catch. On the bottom of the graph we show the length of the fish being measured, the number of the smallest fish (zero mm or cm) measured are shown on the left, and the biggest fish, up to 30 mm, cm or inches, on the right. For this illustration it does not matter whether the measurement is mm, cm or inches, the idea to catch here is that small fish are to the left of the graph and big fish are to the right. Up the side of the graph we show the number of fish counted in each of the size classes along the bottom, from few fish (zero) at the bottom up to many fish (450) fish of a size at the top. The arrow in this example shows the size at which the fish mature – the size they become adults and start spawning. This figure starts off by showing in blue the sizes we would expect to see

if there was no one fishing and the fish were getting to live out their natural life and complete a natural amount of spawning; which we call 100% spawning.

Reading the graph in the first image, we see in this example, that in this sample we measured about 425 fish of size 20, but no fish got as big as 30 & 32. That is because like humans, each type of fish has an average, and a maximum, adult size. Even without fishing they get to a size around which they stop growing, and then over time slowly die-off. In this picture that maximum size is about 29. On the left-hand side of the figure we do not see any really small fish in our samples. This is not because they don't exist, but because they are not caught by the fishing gear. Either because the hooks or nets are too big, or because the small fish are hiding away in the coral, or seagrass or shallows, keeping safe from being eaten by the big adult fish on the reef, and at the same time avoiding being caught in our sample. They exist but we do not get to measure them in our sample. And as long as there are enough adults, there will be plenty of little fish, but unless we use a different type of fishing or fish in different areas, they won't turn up in our sample until they are big enough to get caught.

As we step through the phases of this slide (56) we see how the size of fish in the catch changes as fishing starts and gets heavier. With fishing some of the fish are going to get caught and eaten, before they can grow to full size and old age. As the fishing gets heavier and heavier, less and less of the fish get to maximum size, to complete 100% of their natural amount of spawning. We see the effect of this mostly on the right-hand size, and in the middle, of this graph, where, with successive phases of the figure there start to be a lot less fish in the biggest size classes of fish. And the average size of the fish, starts to get smaller. None of this is because the fish are growing any differently, just that they no longer get to live as long, grow as big, nor breed as much. Eventually in these images most are being caught before they get big and old.

This process continues as fishing gets heavier and heavier, and the longer it goes on. Eventually no fish ever gets as big as they once did, and commonly fishers begin forgetting how big the fish used to get when the fishing was light. This often creates arguments in fishing communities between old fishers who remember catching much bigger fish, and young fishers who have never seen fish that big and are inclined to think the old fishers are simply exaggerating old memories.

While all these changes are going on in the middle and the right-hand side of this graph, over on the left, the small and young fish remain much the same, as long as there is still at least 20% of natural spawning going on, so recruitment, or the supply, of young fish remains pretty steady. While SPR stays above 20% a new crop of little fish will recruit in on the left each year, and keep that part of this graph pretty steady. So long as there is enough spawning almost all the change will be in the number and size of the big and middle-sized fish in the sample

.

But eventually when fishing pressure gets high enough and the level of spawning goes below 20%, the supply of little fish starts failing, and that is when you see change on the left as well. When the recruitment of little fish stops, what you see is the year classes of fish growing bigger and getting fewer, and fewer. For a short-time it looks as if the fish are getting bigger again, and quickly, over just a few years. But this is a really bad sign, it means recruitment has collapsed, and if you keep fishing soon you have caught the last of this fish. That population is about to go locally extinct.

This is how fishing pressure changes the size of fish. This is what we call fishing down the size of fish. And we can use these principals to work-out from our measuring of fish sizes in the catch how much spawning is happening now, as well as the size the fish will need to be to do a sustainable amount of growing and spawning.

So the Spawning Potential Surveys we want to do with the communities need these two types of information (figure 4 & slide 57):

1. The size of the fish being caught, shown by the blue in slide 57 & 60, and

2. The size at which the fish become adults which we call the size of maturity, which is shown by the black arrow in slide 57 & 60.

From the information we can get from previous research about each type of fish we can the work out what the size of the fish would have been like before fishing began, and estimate what proportion of the original spawning is now occurring.

And from these data we can also estimate the size which will ensure all fish complete at least 20% of their natural spawning potential (SPR).

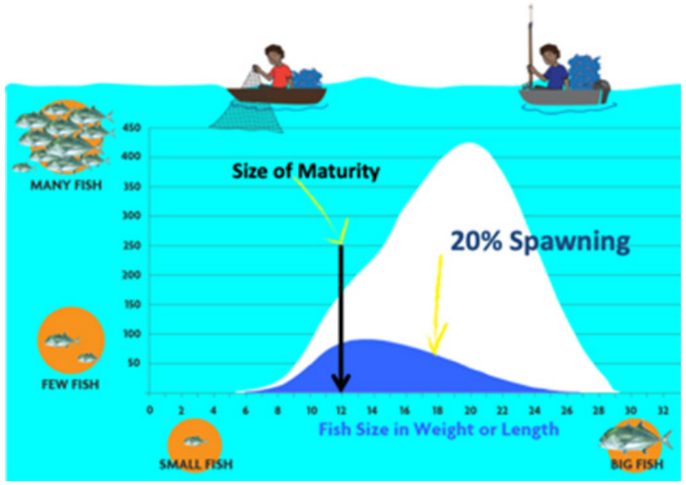


Figure 4. Illustration of how the size composition of fish stocks are fished down and can be used to estimate their spawning potential by comparing their shape without fishing (white) to their current shape (blue).

Permission to Continue

Here the initial meeting should stop and remind the community members that they have a choice as to whether or not they want to become partners in the proposed project. They do not have to proceed with the current collaboration if they see it having little potential relevance or importance to them. The project should not proceed without the strong support of the community. This is the point in proceedings, the participating community members should be talked through the proposed structure of the project and the various roles expected of the community, NGO and government partners. With this information the communities can decide if they want to proceed? Of course, with the workshop already started, the answer will almost invariably be yes. But in asking, and receiving the token answer, it should be made clear to communities that the question of willing collaboration is actual, and in fact remains open for them to discuss later amongst themselves. These projects can, and should, only proceed as long as the community finds itself willing to support the aims and work of the project. The natural resources being assessed and managed by this project ultimately belong to the participating local communities, in the long term the rest of the project team will always be outside advisors.

Establishing Community Science Collaborations

Assuming the community is willing to initiate community-based spawning potential surveys (SPS) we proceed with teaching them how to measure the length of fish and macroscopically inspect fish to determine whether they immature or mature.

Making Fish Measuring Boards

In many communities, we first engaged workshop participants in constructing fish measuring boards out of plywood and old measuring tapes previously used for laying out coral reef transects. Depending on the type of measuring tape used each board costs about USD 8-10 or USD10-20. Full instructions and the required list of materials will be found in chapter 6. The afternoon spent hands-on making fish-board, away from being lectured, provides participants with the mental space they need personally to process the content of earlier sessions, as well as the time to informally discuss and confirm it with their closest colleagues; important parts of effective adult education. Participants also learn how simple it is to make and use a fish measuring board, and the process of making their own measuring boards increases personal investment in the program of fish measuring being organized. Although sometimes, in addition to measuring fish, the boards go onto be used in unexpected ways, such as removable additional boat seating in Fiji.

Inevitably, in the Pacific Islands, whenever groups of men and women come together informally to make something like fish-boards, there will end up being a lot of gentle joking around, teasing and laughing; a festive atmosphere is conjured up out of nowhere. I have happy memories of afternoons spent making fish-boards in Fiji, Palau and the Solomon Islands. All of which builds a collegial spirit of comradery amongst workshop participants who it is hoped will go on working together collaboratively over the long term through their community of practice to achieve change for their society.

Learning to Collect Data.

Commonly the morning after the fish boards have been made, once the polyurethane coating on the new boards is dry, we obtain (normally buy) an entire catch from a local fisher and proceed in a hands-on way to teach members how to:

1. identify a fish,
2. measure fish to the nearest mm
3. macroscopically gauge their gender and maturity, and
4. record the data.

Ideally a local fisher brings a plentiful catch to the beach next to the village you are holding the workshop in, and after a morning spent examining and measuring, it can provide the basis of a tasty meal for workshop participants. Even better is when the workshop is done in the run-up to the spawning season of the fish, so that the gonads of adults are developing, and easily recognized for what they are. Ideally you also want a good range of sizes for several species, from small juveniles to larger adults. That way you will be able to demonstrate the complete range of gonad condition from immature through to well-developed adults.

In reality the pile of fish is often surprisingly difficult to organize and you must make do with what you can get under the circumstances. Commonly it is out-of-season for good catches, or rough seas will have prevented fishing and made it difficult to get a good bunch of fish together. For demonstration purposes some-one will have gone to local fish markets, and purchased the required fish over several weeks so as to have enough for each workshop participant to measure, cut-open and inspect a few fish each. As the sample has been accumulated it will have been kept frozen, until shortly beforehand. In this case make sure plenty of time is allowed for defrosting, at last 48 hours. If the fish are still partially frozen, they are almost impossible to use for the demonstration.

Where fishing pressure is heavy it can be difficult to find fully adult size classes with well-developed gonads in the catch of the main target species. It may well be that well developed gonads will only be found amongst some of the less highly prized smaller bodied species in the catch. Do some research beforehand and get some idea of the approximate size of maturity of the different species in the market. Try and find a species which should maximise your chances of being able to demonstrate both immature and well-developed gonads.

Fish Identification

The LBSPR assessments produced through the SPS program must be specific to particular species. Combining the data from multiple species with differing body sizes within a single size-based assessment invalidates the approach.

In the context of coral reef fish this will almost certainly create complications. In most cases if the local community are going to be involved in data collection the data will be collected using local names which often may lump many scientifically named species into local 'catch-all' names. Data for several species collected under a single catch-all name will not be useful, and will end up being a waste of the data-collector's time. To avoid the confounding of multiple species, species that can be widely recognized need to be prioritized for LBSPR assessment and data collection, on the basis of having local common names which are taxonomically species-specific. As discussed above, you should begin explicitly facilitating discussion around this issue during the break-out sessions held earlier in the workshop. Those facilitated discussion will need to continue through this hands-on fish measuring session. Although the names are not all that important, just for this process of teaching how to measure and macroscopically gauge maturity. Species with confounded names can still be used for this demonstration and teaching how to measure length and gauge. However, before the end of this session you are going to need to have clearly established which local names can be assumed to be species specific.

In a coral-reef setting your participants are likely to spend a lot of time identifying fish to scientific names and discussing how that relates to the local common names they use. I've always found it essential to provide Fish ID books to help with this process. In and of themselves locally relevant Fish ID books are always interesting to people in fishing communities, and the books will have also found use in the workshop break-out session. At this stage of the workshop, you will find yourselves standing in front of a pile of fish, armed with fish ID guide books, and surrounded by a group of enthusiastic workshop participants throwing around a plethora of local names. Your challenge is to make sense of it all. I find it useful to start this session by getting the workshop participants to sort the demonstration catch into separate types, by local name. This will give you a chance to observe which species they lump together and which they group specifically. Although you may need at first to constrain your NGO co-workers who may well have a more scientific view of the world and want the job done right in the first place. Restrain them if you can and you will get a clearer view of how your community data gatherers identify and group the types of fish they will be measuring.

Fish measuring

Two types of information are critical for LBSPR assessment (slide 60):

- length, and
- maturity.

My practice is to the start demonstrating the measuring and gonad gauging with the whole workshop group, initially talking everyone together through the process with several fish. For reasons more fully explored below, I like to find and demonstrate this initially with what I expect and hope will be immature and mature individuals of both a larger, and a smaller, bodied species.

The simplest protocol to learn and teach for measuring fish is to:

1. Place the closed mouth of the fish against the headboard of the measuring board.
2. Use the tip of a knife to pinpoint the middle of the end tail (slide 61) against the measuring tape and then roll the fish away
3. Read the length from the tape to the nearest 1 mm.

With regard to sampling fish to measure, the important thing to teach about length composition samples is that the fish being measured have to be truly representative of the catch. We need to accurately see the normal size composition of the catch, free of any unconscious bias towards selecting certain size classes. Normally unless careful protocols are put in place observers will unconsciously select bigger individuals to measure before smaller individuals. So the best simplest practice is for observers, once they have started measuring a particular species of fish in a catch, to always make sure they measure every one of that species in that catch (slide 62). It is OK not to measure every

species in the catch.

Gauging the maturity of fish

The sex organs or gonads of a fish are normally found as a pair at the very top of their gut cavity, running along parallel to each other just beneath the back bone. Slide 63 illustrates the basic protocol for roughly classifying fish gonads by eye (macroscopically) as either immature, or adult, which includes maturing, resting and ripe stages. The primary distinguishing features we use to distinguish immature from adult gonads are:

- **IMMATURE:** Gonads cannot be found, or only visible as thin twin threads or straps of developing tissue. No three-dimensional structure or gender is obvious.
- **ADULT:** Gonads have a distinct, three-dimensional shape; lobed, and triangular in cross section, for testis, or sausage, tube, or sack-like for ovaries, even when very small. Adult gonads are generally (but not always) longer than one third the length of the body cavity and >1-2% body weight.

Fat around the intestine and / or gonad can appear to be mature male testis in female and immature fish at times. Closer examination will reveal the different 'greasy' feel and different color of the fat.

More detail about measuring and gauging the maturity of fish, crabs and lobster, is provided in chapter 6. A short document entitled '3. Macroscopic gauging of fish gonads document' is available from the biospherics.com.au website and provides further detail and pictures about macroscopically classifying fish gonads.

Data Recording

The excel workbook available from the biospherics.com.au website entitled, '1. Excel template for fish data base with analysis sheets' contains both the template for a data sheet (slide 65) which can be modified as required printed out and given to data collectors. I recommend also preparing a data-gather's satchel containing clip-board loaded with blank data sheets and spare pencils and handing them out to groups of participants.

As I measure, dissect and diagnose the initial fish for my workshop participants, I have some of the participants record the data from the fish I measure. As I enlist each helper to collect the data, I explain the data-sheets to all workshop participants. For the fish I initially demonstrate with, I like to use several people to collect the data for me, after I have helped someone write-down the data for a couple of fish, I pass the duty on to another and briefly explain to them how to do the data. This means, that the same messages about the data collection get repeated very practically in front of the whole group, before they start for themselves. Once I have demonstrated on an initial few fish the workshop is broken into self-selecting small groups (3-4) and each is given a data-gathers's satchel and a small pile of at least one fish per person. I expect each participant in turn to measure, cut-open, inspect and diagnose, and record data for at least one fish. Several fish each is obviously preferable.

Returning to Species Identification

Before proceeding through to setting up the data-gathering program you need to have clearly established which local names can be assumed to be species specific. For this purpose, towards the end of the session draw a group of the most knowledgeable fisher leadership together informally and have another discussion about which local names do and do not match scientific names, revisit the priority species for each community and work out how well they are covered with species-specific local names?

Even where there are few species-specific local names, all may not be lost. Often a non-specific local name can provide the basis for developing a new species-specific version that can be easily picked up and applied by community members. For example, around Ghizo Island in the Western Province of the Solomon Islands misu gets applied indiscriminately to several species of Lethrinid (emperor) with elongated snouts. Only one of which has distinctive yellow lips (*Lethrinus xanthochilus*). So it was a relatively simple matter to teach community observers to distinguish the yellowlip from the other types of misu, and create the new local name yellowlip misu. But be aware; people accustomed to lumping species into catch-all names, are normally unaware of consistent differences between the species they are lumping. They just do not notice the distinguishing

features which to your trained eye seem obvious. They will just see normal variability that their eye and mind take no notice off. If you want to change that you will need to clearly point the distinguishing features out and teach people to look for, and recognize.

Practical Take-away Realizations

Through this final hands-on portion of an SPS workshop I have in mind a few central messages that I want participants to lock onto.

Seeing the Maturity of Fish

My experience with SPS workshops is that it can be literally life changing for fishers to learn how to see the gender and maturity in the fish they are handling. I find fishers love gaining this new skill which they can use to develop a new level of understanding about their catch composition, and how it is changing. On the one hand it makes them a better fisherman by being able to work out more accurately the behavior in the fish they are targeting. On the other hand, fishers are also sensitized by their new knowledge to more deeply appreciate the impact of their own fishing. Everyone understands that to have a future all populations need sufficient adults. Enabling fishers to see the depletion of adults allows them to see overfishing for themselves, and once having been taught to see it, they will never be able to look away.

Learning that Fish come in Different Sizes.

Another important message to cement at this stage is that the different species come in different sizes and become adult at different sizes. There are big-bodied and small-bodied species of fish. Big bodied species begin breeding at a large size and are often depleted by being fished heavily before being able to breed. Smaller species are commonly not fished until they become adults and join adult aggregations. This point gets missed easily and will keep arising naturally through the course material. It can be anticipated that it will give rise to questions through the training workshop. There is normally some assumption that size limits would stop all small fish from being caught regardless of species, rather than that some small species can be caught and sold sustainably at small sizes. In the Solomon Islands I had the local pastor worrying that size limits would mean there were no small cheap fish in the market for the poor people to buy. While in Fiji the women were fretting that size limits would mean they would no longer be able to fish from the shore and would have to go in boats beyond the reef to fish out deep, like the men-folk.

This concern is finally dealt with in real-life by opening up a range of fish together and seeing that some types fish are fully mature when small, while other much larger types of fish are still immature at comparatively large sizes. It is for this purpose that I like to start demonstrating with some small bodied species I expect to be full mature as well as some large bodied species I expect to be immature. Having cut them open I like to find the attendee who raised the issue by asking that specific question earlier in proceedings, and asking that they gauge for themselves the sexual maturity of the specimens in question.

But later in proceedings when they have all had a chance to measure some fish make sure all the participant are noting the species' differing sizes of maturity, by pointing at the main species and asking if they mature big or small?

Life Changing: Matthew Mirak

We invariably find that community members love this hands-on session and are extremely interested in acquiring the skills on offer, particularly the ability to examine gonadal status and determine whether fish are mature or immature. I offer the story of Matthew Mirak as just a single example of how life changing and empowering these skills can be (figure 5). Mathew, who went on to become our principal fish measurer and organizer of a team of fish measurers for the communities around Tupira, north of Madang, in Papua New Guinea, told me how he had been a last-minute inclusion in his first SPS workshop, because another prospective participant had experienced a family tragedy. Matthew knew little of what to expect but had come with the expectation of learning things that would help him catch more fish. The first day left him angry because he seemed to have wasted his time going all the way to Madang for the workshop. It was the second morning when he started to learn how to look inside the fish and collect the data, that his eyes started opening wide and it all started making sense. Thinking it all through he became excited about what he had learnt, but

then, worried about what he could now see was going on in his community. Matthew took what he had learnt home and soon had people in his and surrounding villages making their own fish measuring boards (figure 6). Completely on his own initiative he used his new found ability to gauge fish gonads, to identify the 3-month spawning season of his communities' most important fish, a rabbitfish (Siganid). Armed with that knowledge he began negotiating with his community and the village elders, to place a daily catch limit for community members during the next spawning run, when previously it had been the time for large uncontrolled catches. Sensitised to the issue, when that second season occurred, his community perceived that even with trip limits, their season of rabbitfish was short and thin. As a result the last time I talked with him he told me the village elders with community support had agreed to trial a 3 years complete closure to catching rabbitfish.

Figure 5. Matthew Mirak at Tupira, PNG, with self-made fishing canoe and fish measuring board.

Figure 6. Making fish measuring boards Tupira, PNG, style.

Organizing on-going Data Collection

Formalizing Data-Collection

It is important to formalize arrangements for having the data collected, allocating the measuring boards, setting targets for measurers and the distribution of blank and collection of completed data sheets. What organizations and which people are going to be responsible for which activities.

There should be some formalization of the process by which data gatherers are appointed and given their measuring boards together with the data-gather's satchel containing clip-board loaded with blank water proof paper data sheets and spare pencils.

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