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Putting Fishers' Knowledge to Work

Conference Proceedings

August 27-30, 2001

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Fisheries Centre, University of British Columbia, Canada

Edited by

Nigel Haggan, Claire Brignall and Louisa Wood

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DEDICATION TO DR ROBERT (BOB) JOHANNES

This Volume is dedicated to the late Bob Johannes who inspired the conference reported in these pages. His 1981 book 'Words of the Lagoon' opened the eyes of fisheries scientists to the knowledge, insight and values of those who spend their working lives on the water. The attendance of more than 200 people from 60 countries, Indigenous peoples and Aboriginal organizations is a direct tribute to his ability to bring people together. A fearless and prolific researcher, Bob put tremendous effort into getting natural and social scientists and fishers to harness their collective wisdom to solve management challenges. In spite of serious and ultimately terminal illness, Bob attended the conference long enough to make a keynote speech and challenge us to establish an institute for the research and application of Indigenous fishers' knowledge at UBC. We're working on it!

Dr Bob Johannes being presented with Kwakwaka'wakw artwork by Kla-kisht-ke-is Chief Simon Lucas at the 'Putting Fishers' Knolwedge to Work' workshop in Vancouver, 2001. Dr Johannes was keynote speaker.

Photo by Laurie Ryan

PUTTING FISHERS' KNOWLEDGE TO WORK: PROCEEDINGS FROM THE CONFERENCE, AUGUST 27-30, 2001

Edited by Nigel Haggan, Claire Brignall and Louisa Wood

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Fishing the Tower of Babel

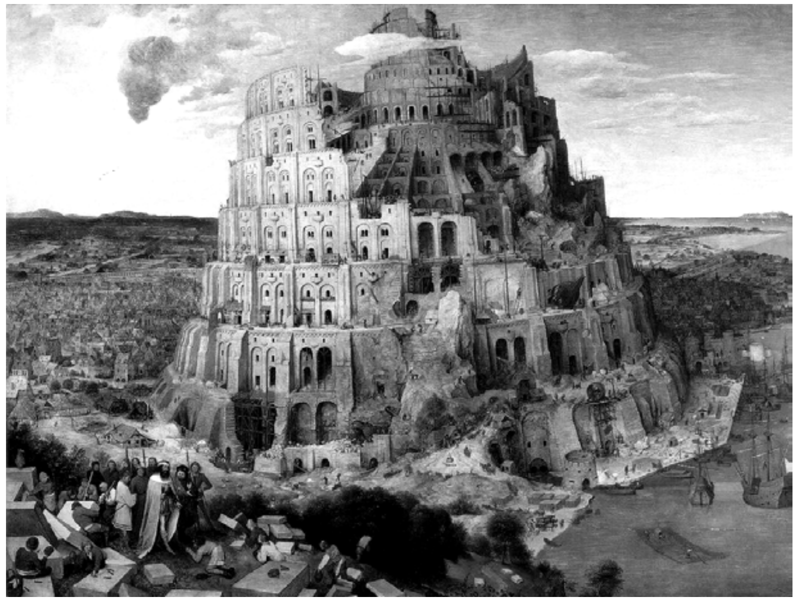

Figure 1. The Tower of Babel, as imagined by Breughal in the 16th Century. The tower stands for the mutual incomprehension of human languages and hence hostility, cacophony and chaos. Pieter Breughal the the Elder, 1563. 114 x 155 cm. Kunsthistorisches Museum, Vienna.

In the Tower of Babel[1] myth (Figure 1), early humans set out to build a tower tall enough to reach heaven, but were punished by a wrathful God for this blasphemous endeavour by causing the builders of each separate compartment to speak a different language. Hence the Tower of Babel causes a previously single and easily communicable human language to become split into many, leading to failure of communication, hostility and even war (Haggan 1998). The story of the Tower of Babel epitomizes the mutual incomprehension, incompatible cultural values and innate hostility of those who speak different languages. The depth of feeling engendered by all this can extend to the belief that only oneself has the true language, and therefore only oneself has a correct understanding of the world.

The ancient Greek natural philosophers made a good job of dealing with it, but nowadays it is very hard being interdisciplinary. Those who attempt to work across disciplinary boundaries often feel they have encountered the Tower of Babel syndrome in their travels, as they are rebuffed, rebuked and chastised for failing to pay homage to some cherished theory, or do not use esoteric jargon understood only by a devout group of practitioners. Accounts in plain language that are understandable to all are often derided as naïve and anecdotal. Yet, as those ancient Greek, Arab and early European Renaissance thinkers understood, true insight may come from simply comparing the same phenomenon from several perspectives. Interdisciplinary workers are brave explorers and should not be chided if they sometimes appear naïve. In fact, a more helpful myth for the interdisciplinary journeyman to muse upon is that of the Babel fish (Figure 2), a symbiotic organism that facilitates complete mutual comprehension[2].

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[1] In the bible, the Tower is reported as being built in the land of Shinar (or Sennar = Babylonia) some time after the Deluge. The story of its construction in Genesis 11: 1-9, attempts to explain the existence of diverse human languages. The Babylonians wanted to express their success and dominance by building a tower: *"Go to, let us build a city and a tower, whose top may reach unto heaven; and let us make our name famous lest we be scattered abroad upon the face of the whole earth"*. An angry and anxious God (*"now nothing will be restrained from them which they have imagined to do")* responded by so confounding the language of the workers that they could no longer understand one another. As a result of the confusion, the tower was never completed, and humans were dispersed over the world. The myth may have been inspired partly by an actual Babylonian tower temple north of the Marduk temple, and mentioned in one of the first histories of the middle east written by a Babylonian priest called Berosus writing in Greek in about 290 BC (his writings have been corroborated in part from ancient cuneiform tablets). In Babylonian the tower was called Bab-ilu ('Gate of God'), of which the Hebrew form is Babel, or Bavel. The other contributing factor in the origin of the Tower of Babel myth is perhaps a play on words between 'bavel' and 'balal' meaning to 'to confuse'. This play on words can be seen in Genesis 11: 9: "*Therefore the name of it was called Babel, because there the Lord confused the language of all the earth.*"

[2] Readers may be interested to learn that the Babel fish has been used as a proof that God does not exist. Adams writes: "It is such a bizarrely improbably coincidence that anything so mind-bogglingly useful could have evolved by pure chance that some thinkers have chosen to see it as a final and clinching proof of the non-existence of God. The argument goes something like this: "I refuse to prove that I exist," says God, "for proof denies faith, and without faith I am nothing." "But," says Man, "the Babel fish is a dead giveaway isn't it? It could not have evolved by chance. It proves you exist, and so therefore, by your own arguments, you don't. QED." "Oh dear!" says God, "I hadn't thought of that" and promptly vanishes in a puff of logic." Readers may speculate as to what the God of the Tower of Babel incident might have done about Adams or his books in the face of this clever argument.

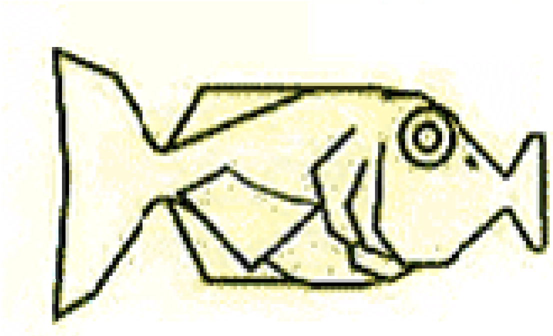

Figure 2. The Babel fish (Adams 1979) is small, yellow and leech-like, and probably the oddest thing in the Universe. It feeds on brainwave energy then excretes into the mind of its carrier a telepathic matrix formed by combining the conscious thought frequencies with nerve signals picked up from the speech centres of the brain which has supplied them. Hence with a Babel fish in your ear you can instantly understand anything said to you in any form of language, and it would be of incalculable help to those seeking to carry out interdisciplinary work. Note that, following Adams, the multilingual Web-based translation engine has been named 'Babelfish'. *[http://babelfish.altavista.com]*

Those who seek to report and find uses for local and traditional environmental knowledge (LEK and TEK) soon encounter the Tower of Babel syndrome. Scientists concerned with ecology and stock assessment are not used to talking to the sociologists, anthropologists and historians who traditionally study TEK and LEK. Equally, social scientists face challenges when reconciling their own research philosophies and perspectives with the results of traditional science's methods and analyses. In the face of such conflicts, and the frequent use of language that obfuscates, it is small wonder that the members of the public-at-large find it hard to understand why things that seem patently obvious to them cannot be used in managing marine resources (Haggan 1998). Generally, those who can overcome the disciplinary Tower of Babel syndrome, and are able to incorporate, and relate to, the public view are those who have engaged in some form of meta-analysis[3].

Throughout his career, Bob Johannes thought broadly, used tools from several disciplines and has shown clearly (Johannes 1978; Johannes *et al*. 2001) that fishers' knowledge can be very precise and helpful to fishery management, in many cases providing more information about fish species, catches, ecology and habits than is officially reported in the scientific record. A good example is that of bonefish (*Albula glossodonta),* which in Kiribati were reported as not being in danger, whereas Johannes found that fishers knew of boatloads of fish being landed after dusk. Likewise, in Lake Malawi, Government 'beach recorders' go home at dusk, missing most of the catch of usipa *(Engraulicypris sardella),* a small planktivorous pelagic fish (Lewis and Tweddle 1990).

In short, LEK and TEK can provide very helpful and accurate information that is easily missed, or could not even be gathered, by official surveys. Moreover, it provides a way for fishers to perceive that they are an essential and important part of the management process and not just the recipients of directives and controls. This was the theme of an international interdisciplinary conference held in Vancouver in September 2001 on *Putting Fisher's Knowledge to Work*. This report publishes over 45 papers as the proceedings of that meeting: as many papers again were delivered orally, listed here by their titles.

The oral papers, discussion sessions, posters and informal gatherings at the conference showed that the use of LEK and TEK is a practical proposition, and is being actively explored in many parts of the world. The authors are a truly interdisciplinary lot; they include government and university fishery scientists, economists, anthropologists, sociologists, historians, fishers and members of Aboriginal nations. Many of them had such a good experience at the meeting that they must have inadvertently gotten a supply of Babel fish to put in their ears. (Did I see a stall in the lobby selling them..?)

And, far from the Tower of Babel syndrome, Aboriginal people were a powerful presence at the conference, and provided us with presentations resonant with knowledge, culture and information. It is a major challenge to resource management to provide equity, support and advice that can be used in fisheries by Aboriginal peoples, while they can provide today's managers with wisdom such as 'seventh generation thinking' and language that expresses stewardship and respect for natural resources as integral parts of whole functioning ecosystems.

Given our theme of overcoming the Tower of Babel, it is fitting that this volume is dedicated to Bob Johannes, a pioneer interdisciplinary researcher who was always ready to listen to and acknowledge different languages or disciplines. Sadly, Bob passed away soon after the meeting.

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3 My personal experience of interdisciplinary projects is that theologians can have more practical insight into how people behave and react than either natural or social scientists (Coward *et al*. 2000).

The Fisheries Centre Research Reports series publishes results of research work carried out, or workshops held, at the UBC Fisheries Centre. The series focusses on multidisciplinary problems in fisheries management, and aims to provide a synoptic overview of the foundations, themes and prospects of current research. Fisheries Centre Research Reports are distributed to appropriate workshop participants or project partners, and are recorded in the Aquatic Sciences and Fisheries Abstracts. A full list appears on the Fisheries Centre's Web site, www.fisheries.ubc.ca. Copies of the reports are sent to all meeting participants, and all papers are available for free download from our web site as PDF files. Paper copies of the reports are available on request for a modest cost-recovery charge.

Tony J. Pitcher
Professor of Fisheries
Director, UBC Fisheries Centre

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EXECUTIVE SUMMARY

This Report documents the presentations given at the World's first international conference on the management value of the resource knowledge of small scale, indigenous and commercial fishers. The conference was inspired by Dr Robert (Bob) Johannes, whose 1981 Book 'Words of the Lagoon', was the first serious study in this area, and was co-hosted by the UBC Fisheries Centre, UBC First Nations House of Learning and the BC Aboriginal Fisheries Commission. Over 200 people representing 23 countries and 36 North American First Nation representatives attended. The conference sought to provide a way to 'step beyond' fishers' frustration that their knowledge is ignored and scientists' standard position that the knowledge is anecdotal, and can not easily be captured in the reports, tables and graphs they are used to.

In total, 48 papers and 26 abstracts of papers were presented during the three days of the conference. These case studies and presentations included Indigenous, Artisanal, small scale and industrial marine and freshwater fisheries in tropical and temperate environments. Species range from turtles and dugongs, through temperate trawl and tropical multi-species fisheries to the aquarium trade. The conference followed themes relating to the use of fishers' ecological knowledge about fishing practices in environmental management; the relationships between fishers' expertise (knowledge) and management; methodological issues/methods for obtaining and accurately representing fishers' knowledge; the ethical issues relating to collaboration between TEK practitioners, managers, academics and industry; and the valuation of fishers' knowledge from an ecological, economic and social approach.

ACKNOWLEDGEMENTS

The conference hosts gratefully acknowledge the following organizations whose financial contributions made the Conference possible: BC Hydro; BC Ministry of Environment, Lands and Parks; The David Suzuki Foundation; the Department of Indian and Northern Affairs, Canada; Fisheries and Oceans, Canada; Fisheries Renewal BC and the 'Coastal Regions and Small Islands Platform' of UNESCO.

We also acknowledge the above organizations and the 'Coasts Under Stress' project funded by SSHRC and NSERC for intellectual input to the conference design. Thanks are also due to the organizing committee for abstract review and to the Fisheries Centre and BCAFC staff who coordinated travel and the 1,001 other arrangements these events involve. We also thank Pam Brown, UBC Museum of Anthropology for input to the evolving '*Fishers' Knowledge at Work*' concept.

My Grandfather's Knowledge: First Nations Fishing Methodologies in the Fraser River.

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My grandfather's knowledge deals with First Nations fishing methodology in the Fraser River and Lillooet, heart of Stl'atl'imx territory. My grandfather's world was ten miles of the Fraser River, the three ranches that he ran, and the livestock that he owned. For the purposes of this presentation I will try to stick to my grandfather the fisherman.

My earliest recollections of going to the river include riding on the old two-wheeled horse-drawn cart. On the way to the river, my grandfather would point out various plants and animals in the ecosystem around us. The earliest fishery was the Zumak or Chinook salmon which were the first to swim up river. I can recall my grandfather getting ready for this first fishery, making his nets. We lived in a house with one-room. This one-room would be full of gill nets in various stages of completion, dip nets, hoops and poles. Everywhere you look there were needles and wooden spacers of different sizes for different nets. He had a sense of excitement about him at that time of year and he would speak in hushed tones "The Zumak are coming, they are coming!" You could sense his excitement. He was my whole world. When he had the spring Zumak gear ready – nets with 6 to 8 inch mesh - we'd head down to the river. That is where he pointed out the various bushes along the way.

We would catch enough for supper and for a couple of days. We had no refrigeration back then and we were not big on canning and drying spring salmon because it is hard to dry. Springs were a break from salt and dry salmon that sustained us through the winter months.

The second fishery my grandfather was involved in was the sockeye. During the interval from catching spring to the sockeye season, he would be working on his ranch. I recall the water system he built, a ditch which was probably about 5 miles long to catch the water from the mountain to irrigate his fields. The man was a magician. The water ran uphill, following him. It was a constant activity of fishing and farming in the summer months. And so in the early summer when the rose petals begin to bloom, he would go fishing for sockeye. I remember him pointing out the rose petals to me.

It was a really busy time because we had to put away enough salmon for the winter months. I don't know how many racks of dry salmon we had. Each rack would hold about 200 a time and we would replenish them 3 times over. So there would be about 600 dried salmon. Salting and drying were the main preserving methods. Getting the fish and cutting it up was a lot of work, from the crack of dawn right to dusk. In this way you went through an apprenticeship as a young person. These recollections come from when I was 4 to 5 years old and my main job revolved on packing fish guts and hanging up the smaller strips of dried salmon. I was a productive little guy back then, it is amazing what a four year old can do!

As you get a little older you begin to pack the salmon to the drying rack. When you are older still, you can handle the ropes and gillnet which are not as dangerous as the dip-net style. The crowning moment of glory would be when you are twelve or thirteen when you handle the dip-net. This was dangerous work because of the fast flowing river. You were then considered a man.

I regret learning how to cut and dry salmon because I got stuck up there with the old ladies. My young buck buddies where down there fishing and I was with the old ladies cutting – but it came to be a useful skill and hopefully I will teach my grandchildren to do that.

In the later part of the year the Hane', pink salmon, would come in. By the time they got to our territory they were basically useless for human consumption. It took me awhile to learn they had a role in the ecosystem and they were there to feed the animals. I hated them because they died right outside my doorstep. I lived right up halfway between the confluence and the spawning ground and they were dying everywhere.

In the grander scheme of things my grandfather's knowledge might be worthless. But it has given much to my family. It allowed us to survive and thrive and to continue to exist. For that it is very useful. It has given me the knowledge of the benefits of hard work and perseverance, the simple pleasure that you get from feeding yourself and your family. I am sure my grandfather was very proud of that fact.

I'd like to speak about my grandfather's father for a bit and his role in Stl'atl'imx history. His name was Ulhwa and he was one of the chiefs that signed the 1911 Stellat declaration of sovereignty. The declaration basically pointed out the perspective that my grandfather's people had regarding their territories and the fact that those territories were being invaded by white people and their impacts upon the fishery. You need to understand that the industrial fishery on the Fraser River started in 1888 with the first legislation that disallowed First Nations people to sell salmon. 1911 is 23 years after. In 23 years, the Fraser River fishery had been decimated to such a degree that interventionist measures such as fish hatcheries were being utilized. In the 1911 declaration my grandfather questions why we arrived at such a state in such a short time. I think that if I fast forward to the future that is very much what I presently see with regard to the salmon aquaculture industry. I view both of our efforts as efforts to preserve wild stocks of salmon that our family has always depended upon for sustenance. So again reflecting upon the comment of utility of this knowledge, I have come to learn that well over 50 percent of the world's fisheries are the so called artisanal fisheries. These fisheries, much like my grandfather's fisheries, only entail small pockets of the ecosystem. The trick for us is to figure out how knowledge from these small pockets of artisanal fisheries relates to the rest of the world to make sure that the importance of these fisheries for the continued survival of our peoples is recognized.

The tools of the trade that my grandfather made were specific to those ten miles of the Fraser River. He knew every back eddy, riffle and run in that ten-mile stretch. He knew which net should be used in which specific spot. He moved upriver as the level of the river receded, and when the fish were very plentiful, he would just use his dip-net and then he could catch as many in one day as with his gillnet. I guess this could be viewed as adaptation to your specific requirements. And again that is very much the nature of most artisanal fisheries. The amazing thing about these simple technologies of small gillnets and dip-nets is that they are still as useful today as they were in my grandfather's time. I still make my dip-nets in the same manner as my grandfather and I pick those same fishing spots in the Fraser River that he utilized. This is termed in modern day vernacular as intergenerational equity – simply, the passing down of knowledge from one generation to the next. So in retrospect, I have been very fortunate. I have had a very good teacher and all I hope to do is to pass on my grandfather's knowledge to my grandchildren. All I want is the same as yesterday, just like my grandfather.

In closing I would like to acknowledge the people who came from all over the world to participate in this conference. We are talking about a world indigenous center that we have hope of bringing together. It can do great things. I always think that if we were to look after our respective backyards and work together in concert we can indeed make this world a better place.

A NATIVE CHANT

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INTRODUCTION

My name is Kla-Kisht-ke-is, I am the seventh ranking chief of the Hesquiat Nation on the west coast of Vancouver Island. The chant I just sang for you goes a long way back in time, but is just as important today. Some of the chants were made while sitting on the shoreline, some in the forest listening to the movement of the trees, some were made listening to ripples and waves on shore, and some of them while looking up at the stars. Our history goes back a long time. In my tribe, they have done an archaeological dating, where we laid our people to rest in a cave. After two years of doing digs, they were startled: "This isn't changing and we have gone back five thousand years". Among the remains were 75 different marine resources. Some people argue that we have no Aboriginal right to certain species. They say we never used them, so I think that they were hoping that those remains were not going to be there. Along with those remains were cedar bark, old masks and different rattles that our people used. I say that to you to make you think about how far back our knowledge and experience reaches. I am not telling you that ours are the best methods. What I am telling you is that we have alternatives to offer: that we saw with our own eyes and learned from our grandfathers.

My dad told me that he started taking me out on a fishing boat that he owned - a thirty-one foot troller[1], and that I was so active on the boat that he had to tie me to the mast for fear of me falling overboard. There is an assumption that our people did not have nets or gear. But different forms of shells were used to troll and seining is nothing new to our people. At 5, I knew all the fishing banks in our territory, including Estevan Point. Banks were different. You knew where to get the cod, the bass, and the salmon. We know the landmarks. There is a great place that has all the food chain - everything literally stopped at this place to feed and it was almost a perfect circle, 3 miles long all around. It is an incredible place for needlefish. There were reefs. You had to know landmarks to get there. My grandfather used to say that this place is important. When I got modern sounding gear, I found out he was right, because when I go there in the morning there is no sign of life, but in certain times of day the needlefish rise up. We knew that there were all sorts of salmon species hanging around there and many other landmarks. We knew that herring, shrimp and needlefish were there. A lot of fishermen would say that they knew there were salmon there and shrimp. The saddest thing in BC was when they commercialized the shrimp, DFO (the Department of Fisheries and Oceans) didn't look at the impacts on the coho salmon. The reason why this area was so popular with fish was because of the tidal currents. My grandfather said that you got to understand the movement of the sea. The moon is an incredible indicator of when the fish start migrating. My dad used to say, 'don't ever go fishing when the flood tides are happening because everything goes behind the reefs.' So the reef is important to us because it offers protection for migrating and local stocks.

If we went up the coast to fish at Kwa-Kwa-wha-as, there is one of our landmarks, a mountain between Gold River and Campbell River. It has a very sharp peak. Once you see the mountain there, you are getting close to the bank. That is important because this bank drops down from 70 to 80 fathoms. Our people knew before the radars and sonars told that this depth of water was important. The food chain is great at that depth.

A little west along this bay is an incredible landmark. When the mountains appear backwards, you know you are at the bank. The bank is just under 100 fathoms, in my young days littered with food chain. It is where we used to see so much shrimp.

We go further, and there is another landmark, with four peaks. When you come to the first peak, that is when you start to put your lines down, and at the fourth peak, you are 22 miles off shore and at an incredible resource bank. 45 fathoms deep, littered with food chain. It is there where many of the migrating stocks from the Fraser River will be. You know that you are going to be catching lots of salmon especially if the moon is right. Sometimes, two days before the full moon, the fish will be nuts, and two days after it will be a lot crazier.

So we went from the traditional fishery to a more technological fishery. The coastal tribes now own some huge fishing boats, for gill netting and

[1] Fishing vessel used in the hook and line fishery for Pacific salmon

trawling. Some fish offshore for tuna. There is an assumption that the Indian people did not go that far. Our archaeology digs show that our people were there. Some people say black cod were not part of Indian food fishery. But Barbara Lane, an archaeologist, showed how black cod was important to our women. Women with nursing children used black cod broth to enrich their milk.

There was a spiritual component of why we did what we did. There was a physical and mental reason why we harvested those resources. Our grandfathers say, 'always look at the day, this is where you learn to look at what you are doing, during the daytime'. You don't just do things without thinking about the consequences of the consequences. What we found out, as we are trying to implement how our grandfather saw it, we have a tremendous struggle. We have some tribes that are affected by development of dams who will never be able to can fish again for their winter food.

Our grandfathers say 'listen to the day - sometimes it talks to us'. Do we really take our time to listen and to look, and see understand what is happening in our area? When the herring industry started, our tribe had twelve people fishing in the harbor before spawning. We went to see this old Chief in Nuu-chah-nulth and he said "What are you people doing? What are you involved in? You are fishing these fish when they are near spawning!" He told us it was the ultimate crime. He was right. Our people put out hemlock branches to collect herring roe for food, it used to be rally thick. Today when we lift the branches we are lucky to have half an inch of herring roe.

In our tribe we talk to the commercial fishermen. We are involved in something our ancestors have never done. Sometimes the DFO listens. Our tribe negotiated for 2 years. We wanted our harbor closed to fishing. They asked us if we had a plan. No, we said, we just wanted it closed. They closed it for us. And I saw what my grandfather saw. When the herring come in so do hundreds of seagulls and ducks of every kind. Everything was there without a plan. There are times when things have to be totally natural, and how we fit into that scheme is important. I don't know who developed "endangered species". Our ancestors said to us that our tribe number over 3000 people. The Europeans came in with a plan to exterminate our people. We went from 3000 to 198. Now we are back to 700 and working harder.

So I think it is important for you to listen. We have talented, educated First Nations people, in BC. We have people who understand about our grandfathers. We have biologists who work for our tribes who understand and listen to the teachings of our forefathers. Our people are not talking about total isolation, because we recognize the fact that the people that are here now are here to stay. We do not want to create an imbalance. Nuu-chah-nulth territory is an example of what happens when we create imbalance. DFO said that the sea otters were extinct from the west coast of Vancouver Island, so they brought some from California. There are more sea otters now in Kyuquot and they are eating all the sea urchin. The people of Kyoquot are almost extinct; compared to the sea otters, we are now the endangered species. We as humans are not as important as sea otters and the sea otters aren't even indigenous. They came from somewhere else.

Some of our people have done very well. They have become very competitive; competition has become part of us over the previous ninety years. Over the past three years our people have been badly affected by regulations, but some of us are still out there. We have one person left who has a halibut license, we have one person who is still involved in the black cod fishery, and one person left in the crab fishery. The list goes on. So our people lived off the sea and we sustained ourselves.

So I leave you with this: think for a moment. You are in a forest. Listen to what it might be saying to you. As you are in the forest, you are beside a little brook, making these little sounds. We're of the same people as those who have been here as long as the rocks have been here.

Thank you.

FISHERS' KNOWLEDGE AND MANAGEMENT: DIFFERING FUNDAMENTALS IN ARTISANAL AND INDUSTRIAL FISHERIES

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ABSTRACT

Differences in characteristics of industrial and artisanal fisheries should be better understood for improved communication between those who do research on local ecological knowledge in these different fisheries. Artisanal fisheries often differ from industrial fisheries in that:

1. Per unit of catch or of areas fished, the numbers of fishers, species caught, gear types used, landing sites and distribution channels are typically far greater, especially in the tropics. Local ecological knowledge is of particularly great value to biologists in such complex settings where conventional biological knowledge is poor.
2. In some areas limited entry (marine tenure) has been well established for centuries. In these areas ethical questions concerning the publication of local ecological knowledge, while by no means non-issues, are often less problematic because the exploitation of this knowledge by outsiders is much less likely.
3. These fisheries are often managed (or mismanaged) by the fishers; in cooperative management arrangements government fisheries personnel are usually the junior partners.
4. Among artisanal fisheries researchers there is an even greater need for closer collaboration between biologists and social scientists. Biologists are much better trained to ask useful questions about local ecological knowledge, put the answers into broader biological context and help restrain social scientists from framing management recommendations that ignore critical biological realities. Social scientists are better skilled in achieving good collaboration and rapport with local people, in interviewing, and in restraining biologists from drawing management conclusions that ignore equally critical cultural realities. The two types of researchers should be working more often in teams.

INTRODUCTION

Members of a group often share assumptions that are valid within that group, but inappropriate when extended beyond it. Such over-generalizing is the bugbear of all trans-disciplinary communication. It is hard to avoid, but we need to try to minimise it.

In this connection some key assumptions of those whose research focuses on industrial fisheries may be inappropriate when extended to indigenous fisheries. Fisheries textbooks, which are often disproportionately concerned with temperate zone industrial fisheries, tend to foster this overgeneralizing.

Here I discuss some examples of this, in an attempt to help improve communication between researchers who study fishers' knowledge and its uses in management in industrial and indigenous fisheries. I, too, run the risk of overgeneralizing, since my perspective is influenced by my greater familiarity with the indigenous fisheries of the tropical Asia-Pacific region than elsewhere. This, at least, is where most of the world's indigenous marine fisheries are found.

Access

One of the most common generalizations is that the fundamental problem with fisheries lies in their open access nature. But in much of Oceania and parts of Northern Australia, Africa, Asia, and Latin America, limited access has long been a feature of indigenous fisheries management (reviewed in Cordell 1989; Ruddle 1994; McGoodwin 1990). Some such systems, like those of the native fishers of the Pacific coast of North America, have largely disappeared. But many others persist[1]. This has several implications for how fishers' knowledge is obtained and employed in management. Who controls the management process is one of them.

Industrial fisheries researchers often make generalizations concerning the need to "empower" fishers, or to "let fishers in on the management process". But in indigenous fisheries, especially on tenured fishing grounds, management is already often largely in the hands of the fishers. Fishers have been thus empowered in the Pacific Islands, for example, for many centuries (Johannes 1979; Johannes *in press*).

[1] Also, some countries' governments are recognizing the need for indigenous fishers who operate under open access conditions to control their fishing grounds and are making appropriate laws. The Philippines, for example, enacted a government code in 1991 that makes coastal management a major responsibility of coastal municipalities.

All the basic marine conservation measures developed in the west only a century ago were used in the Pacific Islands hundred of years ago. Because of their geographic settings, some Pacific Island cultures discovered their marine resources were limited long before Europeans did; unlike Europeans, they had neither a continental shelf fishery nor a large source of terrestrial animals on which to depend for animal protein.

In addition, tropical nearshore fisheries are characterized by many more species, methods, fishers and landing sites per unit of catch than industrial fisheries. Centralized government management is generally quite impractical under such conditions (Johannes 1998).

In some Pacific Island countries, villagers make far more fisheries regulations than governments (e.g. Johannes and Hickey 2002). Governments may still pass some laws pertaining to indigenous fisheries. But government enforcement is typically low to non-existent. In the Solomon Islands for example, single fisheries officers with a small canoe and insufficient fuel, are responsible for government enforcement, among other jobs, in districts encompassing many dozens of small villages and hundreds of kilometres of coastline.

This is not an unusual situation. The cost of centralized government management in these numerous tiny fisheries is generally prohibitive, except in a few high-value export fisheries where the product may be adequately monitored at central collection sites prior to export. If most government fishing laws are to be enforced effectively, it must be done by villagers, and they will do so only if they perceive the benefits (e.g. Johannes and Hickey 2002).

Here, accordingly, it is not fishers who need to be "let in to the management process", but rather fisheries researchers and government fisheries managers. This can be accomplished, as in industrial fisheries, via co-management arrangements. But whereas fisheries researchers are inviting industrial fishers into the management process as they recognize their own limitations, the opposite trend is developing in indigenous fisheries.

In the Pacific Islands, for example, fishers are increasingly inviting government personnel to collaborate with them in devising management measures. This happens when they recognize that their traditional knowledge and management measures, while often still valuable, are no longer adequate to enable them to cope with new problems brought by increasing populations, improved technologies, new export markets, cash economies and other consequences of westernization (e.g. Toloa *et al.* 1991; Johannes and Hickey 2001; see also Purnomo, this volume, for an Indonesian example).

Johannes (1979) foresaw the "demise" of traditional fisheries management in Oceania due to the various impacts of westernization on its cultures. Fortunately he was wrong. Fishers' knowledge of resource depletion and the increasing need for better management, plus a growing recognition that co-management offers a promising way to achieve it, has resulted in a renaissance in village-based fisheries management in the region in the past decade

For example, in 21 Vanuatu villages surveyed by Johannes (1998) and resurveyed by Johannes and Hickey (2002), village-based marine resource measures had more than doubled in eight years. A total of 40 of these measures were operating in 1993. Most had been initiated within the previous three years due to the encouragement of the Vanuatu Fisheries Department. By 2001 five of these measures had lapsed but 51 new ones had been implemented.

In Samoa in the mid 1990s, the Samoa Fisheries Division triggered an upsurge in village-based conservation by giving village regulations formal by-law status. Designed and enforced by the villagers, these bylaws are monitored more effectively than regular government fisheries laws. Within three and a half years of the program's introduction, 52 villages had established their own sets of bylaws (Fa'asili and Kelokolo 1999).

There is still a long way to go before the nearshore resources of Oceania are all well managed, but the current trend is promising.

Collaboration of Researchers

To usefully evaluate fishers' knowledge concerning the species they catch, one must first have a good grasp of what is already known scientifically about those species. For this, social scientists who study industrial fishers' ecological knowledge need only 'bone up' on the published information on one - or at most, a handful, of species and one, or few, methods used to catch them. Learning enough about the many species, methods and habitats that characterize tropical indigenous fishers is not so easy.

As Freire and Garcia-Allut (2000, p. 376) point out:

> *"Fishing strategies in artisanal fisheries are based on flexibility, with a diverse pattern of activity (with respect to the species exploited, location of fishing grounds, and gears used) throughout the yearly fishing cycle. Industrial fisheries present a strategy of intense and continuous exploitation of the same resources in similar habitats using one or a few gears"*

Needless to say, collaboration with fisheries biologists can be especially valuable in studying indigenous fisheries.

Biologists who work with industrial fishers are often of the same general culture and speak the same language. This is seldom the case with those who study tropical indigenous fishers. Accordingly, understanding local culture and custom is more demanding and the input of social scientists if often vital in this connection. Social scientists also tend to be more adept in local languages than biologists.

In short, the need for collaboration between biologists and social scientists in studies of the ecological knowledge of indigenous fishers is even greater than it is in typical industrial fisheries.

Ethics

Security of indigenous tenure over fishing grounds means that dealing with local knowledge ethically is less often a burning issue than it is in industrial fisheries (Nor is it as important as in terrestrial settings where ethnobotanists seek traditional plant-based medicines[2]).

In areas where indigenous fishers hold secure tenure over their fishing grounds, there is less risk in their revealing their specialized knowledge. Indeed, they are sometimes proud to do so (e.g. Johannes 1981; Hviding 1996). This openness stems in part from the fact that these fishers can often exclude outside competitors who might exploit this knowledge[3] from their fishing grounds.

Also, for reasons discussed above, fisheries personnel have little opportunity to use this knowledge to support the imposition of unwanted regulations on indigenous fishers. Important exceptions to this, however, are fourth world fishers, that is, indigenous fishers in countries ruled by industrialized, usually western, powers. North American Native Peoples, American Samoans and Australian Aborigines, for example, may well have justifiable fears in this connection (e.g. Wavey 1993, p. 16).

Knowledge Characteristics

Indigenous fishers are physically closer to their prey than industrial fishers. They see them while gleaning or pursuing them with a spear or castnet on foot, from over the side of their canoes, and from underwater as they spearfish. Their knowledge of the behaviour of fish and invertebrates is thus more intimate than that gained in wheelhouses via echo sounders. But it is limited to shallower waters and smaller areas.

Economics

Indigenous fishers' knowledge is less often "commercial in confidence" than it is in industrial fisheries. For example, although fishing for profit is gradually increasing in Oceania, Dalzell *et al.* (1996) found that subsistence catches were more than twice as valuable as commercial catches in the nearshore fisheries of 22 Pacific island countries. Here in many fishing villages, only a few of the many species harvested are sent out for sale. These tend to be highly valued species that do not need refrigeration, such as various shells and shell products and beche-de-mer (dried sea cucumber). Otherwise, economic activities are often organized along kin-based lines with catches being distributed within extended families[4].

McGoodwin (1990 p. 63) states, *"In traditional subsistence systems, where the main goal is to*

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[2] Although tropical marine biota bristle with pharmacologically active compounds, there are surprisingly few examples of indigenous medicines being made from them. Here, therefore, the need to ensure appropiate recompense for information on locally-used, marine-based medicines seldom arises.

[3] In certain circumstances, however, such knowledge could be used to the advantage of outsiders and the detriment of its possessors. I do not document such knowledge even in reports to the agencies that fund my research (e.g. Johannes and Kile 2001) because even in-house reports have a way of migrating eventually into the wrong hands.

[4] Similar findings have been reported in connection with aboriginal fishers in Canada (e.g. Pinkerton 1987; Usher and Weinstein,1991).

produce food, there is a finite and thus satisfiable demand for the product. But for people living in a market economy ......there is no upper limit on the demand for cash." In indigenous villages, then, profit does not always motivate, capital is not always the engine of production and subsistence economics do not compute in economic models based on assumptions more appropriate to industrial fisheries (Johannes 1989; McGoodwin 1990).

Like open access, overcapitalization is an enormous problem in industrial fisheries. But capital is usually scarce in indigenous societies. Indigenous fisheries involve orders of magnitude less capital per job than industrial fisheries (D. Thompson in Maclean 1988) and under-capitalization has often been said to be a problem.

Management

Industrial fisheries management has typically focused heavily on the population dynamics and physical dynamics of fish stocks and on the quantitative regulation of stock removal. Traditional indigenous fisheries management has focused almost entirely on qualitative controls such as closed seasons and closed areas. This is at least in part because obtaining the necessary information for quantitative management has been beyond reach in these fisheries. Indigenous knowledge tends to be qualitative. Biological management here is not about achieving optimum sustainable yields; it is about preventing serious declines.

Ironically, as we come to recognize that adequate quantitative knowledge for stock-based management is also quite beyond our reach in most industrial fisheries (Walters 1998), the older, more qualitative management approaches used in indigenous fisheries are gaining increasing support from social scientists, economists and fisheries biologists for use in industrial fisheries (e.g. McGoodwin 1990; Pinkerton 1994; Wilson *et al.* 1994; Sainsbury 1998). In addition, Pauly (1997) and others recommend the "rediscovery" in industrial fisheries of the virtues of the decentralized, "place-based management" of indigenous fishing communities.

Mobility

Industrialized fisheries are dominated by large, mobile, largely corporately owned fleets. Owners can move their fleets or their capital elsewhere when a fishery is no longer profitable. The incentive to manage sustainably is thus relatively weak.

As discussed above, indigenous fishers can often exclude outsiders from their fishing grounds. (The 'sea nomads' of eastern Indonesia are a striking exception). The flip side of this practice is that they cannot easily move if their fishery becomes unprofitable. Their incentive to manage sustainably is thus stronger[5].

Such localization of fishing also means that many generations of indigenous fishers have operated in the same limited area over centuries, refining and passing on their knowledge. In the process this knowledge has become encyclopedic in some of these cultures (Johannes 1981; Hviding 1996; Johannes and Hviding 2001).

This UBC meeting was an exceptional opportunity for a large number of researchers on industrial and artisanal fisheries to compare experiences and perspectives. During the meeting it became obvious that some fundamental differences in the nature of the fisheries that the two groups study result in important differences in their approaches to research on and use of fishers' ecological knowledge as well as to other subjects. It also became obvious that each group can learn much of value from the other. Communication between our two groups will proceed much faster, however, if we become more aware of some of the differing perspectives and assumptions that underlie our thinking and methods. This short paper, written after the meeting, is a preliminary attempt to improve that awareness by demonstrating how differences in such things as access rules, biodiversity, fishing methods, mobility, intellectual property issues, and co-management power relations influence the thinking of our two groups.

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[5] This incentive can be overwhelmed, however, by the condition of Malthusian overfishing (too few fish to feed a desperately hungry population). The problem is concentrated in parts of Asia and Africa.

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Questions

Saudiel Ramirez-Sanchez: You assume that the conservational ethics of indigenous people existed in the past and then decayed with contact, but that they can go back to those ethics. How do you go back? These cultures and ethics are no longer isolated from outside influences.

Bob Johannes: I didn't mean to suggest that at all. Times have changed. Traditional conservational efforts would not work in these altered circumstances that use a cash economy. However, the conservational ethic can be used as a foundation. That's what is happening in Somalia in a big way. There's still ownership of fishing grounds and that is an incentive to conserve, because no one else can come in and fish. I didn't mean to suggest that these cultures are frozen in time.

THE ROLE OF FISHERS KNOWLEDGE IN IMPLEMENTING OCEAN ACT INITIATIVES IN NEWFOUNDLAND AND LABRADOR

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ABSTRACT

Emerging community-based approaches to management reflect the changing role of government. As a basis for Integrated Management in Newfoundland and Labrador, a program was initiated in 1997 to prepare an inventory of coastal resources. In order to make the initiative inclusive and ensure input of local knowledge, a community-based approach was developed. Community groups have used the information for planning economic development activities that may help diversify local economies and sustain rural settlements. Eco-tourism, including whale and seabird watching, kayaking, and hiking, has been highlighted and opportunities for diversification and development in the fisheries have been recommended. The results of the work have also been used extensively by DFO in planning and conflict resolution in the aquaculture industry, environmental assessments related to coastal developments, and sensitivity mapping for environmental emergencies.

Communities have also played a key role in the identification of Marine Protected Areas in Newfoundland and Labrador. The Eastport Peninsula Lobster Fishermen's Committee proposed closing two critical areas of lobster habitat to all fisheries. The goal of the project is to sustain and enhance the local lobster fishery for commercial harvesters in the area. In October 2000, Eastport was officially announced as an Area of Interest in the MPA Programme. In 1999, representatives of the communities of Port Hope Simpson and Williams Harbour, proposed the establishment of a MPA in Gilbert Bay, a long narrow inlet adjacent to the two communities. Concern was expressed that the genetically distinct cod stock in the Bay could be eliminated during a pulse fishery. The goal of the project is to increase understanding of the cod stock and its habitat requirements and determine what sustainable harvest options may be available. In October 2000, Gilbert Bay was officially announced as an Area of Interest in the MPA Programme.

BACKGROUND

Newfoundland and Labrador, located on the Atlantic coast, is the most easterly province in Canada. It has a landmass of 400,000 sq km and 28,800 km of coastline. The majority of the province's 539,000 people reside in coastal communities.

In the early 1990s, groundfish stocks were at such low numbers that severe restrictions on catch limits were introduced, and a moratorium on the commercial harvest of Northern cod (*Gadus morhua*) was implemented.

The implications for rural Newfoundland and Labrador, which rely so heavily on the fishery, were devastating. Unemployment rates rose to 18.3% provincially as compared to 7% nationally, and a subsequent outmigration of residents in search of employment resulted.

In recent years, fishing efforts have been redirected towards other species including northern shrimp (*Pandalus borealis*) and snow crab (*Chinoectes opilio*). In fact the value of fisheries landings in 2000 was $538M, the highest landed value ever recorded in the history of the province. However, the shellfish fishery is not as labour intensive as traditional fisheries, and therefore has not brought significant relief to rural communities where unemployment remains a concern. Also, these fisheries are often prosecuted offshore by larger ships in areas that are not within reach of the traditional inshore fleet.

New activities are arising along the coasts of the province. Aquaculture, eco-tourism, recreation, and the oil and gas industry now compete for ocean space that was historically restricted to the traditional fishery and marine transport sectors.

The potential for conflict among these ocean users requires that an open process involving all interested and affected stakeholders be established to promote conflict resolution and prevention.

In 1997, Canada introduced the *Oceans Act*. The *Oceans Act* identifies the geographical boundaries of Canada's oceans areas, identifies the Department of Fisheries and Oceans Canada (DFO) as the lead federal authority in oceans related issues, and lays the groundwork principles for Canada's future management of its oceans.

The *Oceans Act* is based on the premise that oceans must be managed as ecosystems, and that all activities that occur within estuaries, coastal, or offshore waters are managed through a collaborative effort by all stakeholders. Supporting principles include sustainable development, integrated management, and use of a precautionary approach. The *Act* also includes provisions for the establishment of Marine Protected Areas and the establishment of Marine Environmental Quality guidelines, objectives, and criteria.

The economic, social and cultural significance of the fishery to the lives of the residents of Newfoundland and Labrador requires that fishers, as key stakeholders, contribute to and collaborate in the management of ocean resources.

INTEGRATED MANAGEMENT (IM)

Integrated Management is an ongoing process which brings stakeholders together to collaboratively manage activities within and affecting the oceans and resolve/ prevent conflict. It incorporates the social, cultural, environmental, and economic values of the stakeholders involved.

COMMUNITY BASED COASTAL RESOURCE INVENTORIES (CCRIS)

In 1997 a program was initiated to develop an inventory of coastal resources which would form the basis for integrated management in the province. It was decided that a community-based approach would be adopted. This would ensure that communities were included and encouraged in the collation of local knowledge. A procedures manual for community based coastal resource inventories in Newfoundland and Labrador was developed in 1998 to guide the process.

Community groups, in partnership with Fisheries and Oceans Canada, have been involved in project planning, soliciting funding, training, project monitoring, and quality control. The primary focus of these projects has been the collection of information required in the management of the oceans. Individuals and groups targeted for interviews have included those having special knowledge, interests, or expertise in the oceans, including local environmental or recreational groups, diving clubs, and so on. However, local fishers have been the primary target group. The interviews have focussed on the collection of such information as the types of fish, marine mammals, marine plants, spawning areas, types of commercial fisheries, the locations of wharves, fish processing plants, and boat repair facilities, etc. The scope of the inventory may also include the collection of information of cultural and/or recreational significance, or any other category that time and money permit and local people consider relevant to the inventory. The deliverables of the Community based Coastal Resource Inventories include both a final hardcopy and digital report, along with a database of coastal resource information.

Information from the database can be extracted to create a series of atlases, or maps, illustrating key resource information. CCRIs have been completed for nearly the entire insular portion of the province and work has begun in Labrador.

Interested and affected stakeholders can use the coastal resource inventory information for planning economic development and diversification activities, and highlighting emerging eco-tourism, recreational, or fisheries prospects.

MARINE PROTECTED AREAS (MPAS)

Marine Protected Areas are areas that require special protection. In order for an area to be designated as an MPA under the *Oceans Act*, it must meet one or more of the criteria outlined in the *Act*. These include the conservation and protection of commercial and non-commercial fishery resources and their habitats, endangered or threatened marine species and their supporting habitats, unique habitats, areas of high biodiversity or biological productivity, or any other resource or habitat deemed to require special protection by the Minister.

MPAs have no minimal level of restrictions. Any activity restrictions are determined on a site by site basis by stakeholders in conjunction with Fisheries and Oceans Canada. MPAs can be flexible in time and size, and are important because they are proactive and precautionary, contribute to an ecosystem-based management approach, and form the basis for marine conservation, education, and research.

There are currently 3 pilot projects also referred to as Areas of Interest or AOIs under the Marine Protected Areas Program in Newfoundland and Labrador. Two of these are located on the island of Newfoundland in Eastport and Leading Tickles, while the third is located on the southern coast of Labrador in Gilbert Bay (see also Gosse *et al.* this vol). All of these initiatives were grass roots driven with proposals being received from local community sponsor groups requesting that these areas be considered under the MPA Program.

Eastport

On the Eastport Peninsula of Bonavista Bay, lobster fishers were concerned about declining lobster (*Homarus americanus*) catches. In 1995, they formed the Eastport Peninsula Lobster Protection Committee (EPLPC). They approached DFO with an interest in implementing conservation and protection measures that would promote a sustainable lobster fishery. The fishers implemented a program of v-notching[1] egg carrying females. The retention of v-notched lobsters is illegal, thus these spawners were excluded from the commercial fishery in subsequent years. Also, the fishers decided to explore the idea of closing areas to lobster fishing to promote egg production in local populations and increase recruitment. Local lobster fishers had great knowledge of the locations of potential juvenile lobster rearing habitat appropriate for such closures. They undertook consultations with other fishermen from surrounding communities to inform them of the committee's plans and to determine historical fishing boundaries. Subsequently geographical boundaries were established that recognized traditional fishing areas. Fishermen from the Eastport Peninsula created a management area in which they agreed to restrict their lobster harvest. Fishers from surrounding communities who did not have an historical claim to this area agreed not to fish within the boundary. In 1997, the EPLPC approached the DFO to close the area around 2 small islands (approx. 2 sq. km) to lobster fishing. By choosing Round Island and Duck Islands for closure the EPLPC hoped to strike a balance by maximizing the benefits of increased egg production and recruitment, while minimizing the number of fishers that would be impacted by displacement from these areas.

DFO staff have worked closely with the EPLPC and other partners including Memorial University of Newfoundland to monitor and evaluate these conservation and protection initiatives. These groups have collaborated on projects that include lobster tagging and the collection of detailed catch per unit effort information from lobster fishers. Based on commercial fishery monitoring (log books and at-sea sampling) and research around Round Island and Duck Islands, it is estimated that approximately 20% of the total population egg production in 1999 was attributed to v-notching and area closures (Ennis, G.P. personal comm.). This success illustrates how traditional knowledge and scientific knowledge can complement and enhance each other.

1 A 'V-notch' is punched out of the tail of female lobsters. This notch persists through successive moulting so that females can always be identified and returned to the sea.

In 1999, the EPLPC submitted a proposal requesting that DFO consider Round Island and Duck Islands under the Marine Protected Areas Program. Following an internal review of the proposal, the Round Island and Duck Islands were officially identified as Areas of Interest or pilot projects on October 13, 2000. Building on their success, the EPLPC is now considering expanding their conservation and protection initiatives to include other species such as lumpfish (*Cyclopterus lumpus*) and sea urchins (*Strongylocentrotus droebachiensis*). The Department is working with the fishers in setting up a Steering Committee co-chaired by a representative from the fishers committee and DFO. This steering committee would be comprised of representatives from interested and affected stakeholder groups such as the local town councils, provincial government departments, tourism associations, schools, etc. with the local fishers as the sponsor group being most represented. DFO would assist the Steering Committee in undertaking public consultations, developing a management plan for the area, soliciting funding, etc. The Steering Committee members, including the local fishers, would provide local knowledge and expertise in identifying potential conflicts, identifying information gaps, providing project coordination, etc. Local fishers support the inclusion of other stakeholders on such a steering committee recognizing that it will add breadth and depth to the management of local oceans resources and the potential for economic spin offs that would benefit the community.

DFO has used this success in Eastport as an example for other groups interested in similar initiatives, not only from a scientific or technical perspective, but to illustrate the importance of community support and resource stewardship, transparent consultations, and information exchange.

Gilbert Bay

In Labrador, the residents of the communities of Port Hope Simpson and William's Harbour have expressed concern about the status of a genetically distinguishable population of Atlantic cod that resides year round in adjacent Gilbert Bay.

Historically, migratory northern cod would intermix with cod from Gilbert Bay in the outer portions of the bay where a trap fishery was prosecuted. Despite the moratorium, the numbers of migratory Northern cod in this area have not returned to historic levels. With the opening of the commercial index fishery in 1998, significant fishing effort has been directed solely at the Gilbert Bay population, whereas historically fishing pressure was shared between both stocks.

Residents of the local communities of Port Hope Simpson and Williams Harbour approached DFO to consider Gilbert Bay under the Marine Protected Areas Program and on October 12, 2000, this site was officially identified as an Area of Interest or pilot project. As with Eastport, the sponsor groups are currently working with DFO to set up a steering committee, undertake consultations, and develop a management plan.

Staff from Memorial University of Newfoundland have been conducting research in Gilbert Bay for several years and have worked closely with the sponsor groups and DFO. The Department recently interviewed fishermen from the area using a semi-structured approach guided by a questionnaire (Morris et al., 2001). Until recently, little fisheries information had been recorded in Gilbert Bay so the traditional knowledge gained as a result of these interviews was helpful. Fishers were asked about specific topics including background information, fishing methodologies, and commercial and non-commercial fish stock status. In addition, general discussion and dialogue was encouraged and in many cases, those being interviewed asked as many questions as the person conducting the interview. Those interviewed had questions about the Gilbert Bay cod, and the role of the Marine Protected Area with respect to commercial fishing activities. It was noted that some fishers were more inclined to share information in an informal setting as opposed to a public forum. Additional discussions after the interview often revolved around the importance of information transfer between scientists and local resource users. As limited fisheries information had been recorded in the area, the traditional knowledge gained as a result of these interviews helped determine the species of fish present in the area, types of commercial fisheries, and the types of gear used. Traditional knowledge was also compared to scientific information to see if similar observations or trends were supported.

Leading Tickles/Glovers Harbour

A coastal area adjacent to the town of Leading Tickles, located in Notre Dame Bay, is the third Area of Interest under the Marine Protected Areas Program in the province. In 1997 the local fishers committee and the Town of Leading Tickles submitted a proposal to DFO requesting that the Leading Tickles/ Glovers Harbour area be considered under the Marine Protected Areas Program. On June 8, 2001 the Minister officially identified the site as an Area of Interest. Fishers expressed a desire to promote a sustainable fishery resource, particularly for lobster, flounder (*Pseudopleuronectes americanus*) and cod, and to protect critical habitats. Using the Eastport example as a model, the fishers decided to initially concentrate on lobster conservation. Discussions were held regarding the possible future closure of some areas surrounding Leading Tickles to lobster fishing. Potential sites for closure were chosen by fishermen given their knowledge of local juvenile lobster rearing habitat, prevailing winds, and currents. Sites chosen included small islands and sheltered coastal areas. DFO staff, representatives of the sponsor groups, and staff from the local economic development corporation worked together to implement a lobster tagging and retrieval project. A lobster logbook program was also developed whereby local lobster fishers would record catch and fishing effort data to establish baseline information from which to monitor future conservation and protection initiatives. In order to create more detailed maps the collection of georeferenced bathymetric information was initiated around specific islands and coastal areas. These maps will be used in the future to create grids and assist in the collection of detailed habitat information such as substrate type and composition, presence/ absence of aquatic vegetation, etc. using underwater cameras and divers.

Bilateral consultations have begun with potential stakeholders, and a steering committee has been formed and has had its first meeting. The mission statement for the area has been developed by the fishers and town council and reads "To work in partnership with stakeholders to develop, enhance, and manage the future of local fishery resources and supporting habitats". As with the other projects, the steering committee is co-chaired by a representative from the sponsor groups and DFO.

CONCLUSION

These are just a few examples of how the knowledge and expertise of local fishers can be used in ocean management. Both scientific and traditional knowledge are important and the benefits of availing both in collaborative efforts is apparent.

While the fishery still plays an integral role in the economy and culture of Newfoundland and Labrador, other users of ocean space are emerging. *Oceans Act* initiatives such as the compilation of coastal resource inventories and the siting of marine protected areas require the involvement and support of both local fishery interests and other emerging interests in coastal communities.

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QUESTIONS:

Chad Paul: My question has to do with your comments on traditional knowledge and the socio-economic overview. When you speak of Traditional Ecological Knowledge, are you referring to aboriginal people as well, or just fishermen?

Annette Power: In Labrador, most fishermen are aboriginal and they will certainly be included.

Chad Paul: Will they be included in the socio-economic component as well?

Annette Power: The department's role is to lead facilitation of the Oceans Act's initiatives. We contribute funding to them. We told the groups that are interested in establishing MPAs that that we will look at the bio- and socio-economic overviews. These overviews are compilations of existing information. Once the information is compiled, the steering committee, in which aboriginal groups are encouraged to be involved, will identify information gaps and guide the resources that we'll spend in the future.

James Bryant: Why is it that fisheries take information from local fishermen only when there is complete collapse of fisheries on both coasts? Fishermen have tried to work hand in hand with fisheries managers, but they don't take their knowledge into consideration.

Annette Power: I'm not in a position to answer that.

CLOSING THE LOOP: COMMERCIAL FISH HARVESTERS' LOCAL ECOLOGICAL KNOWLEDGE AND SCIENCE IN A STUDY OF COASTAL COD IN NEWFOUNDLAND AND LABRADOR, CANADA

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ABSTRACT

The intercouncil SSHRC/NSERC research project Coasts Under Stress (CUS) is investigating historical use and management of natural resources (e.g. fish stocks, forests and gas-oil reserves) on the east and west coasts of Canada, focusing on interactions between changes to the natural environment and social changes, as well as the ways these have affected human and environmental health. One goal of CUS is to document the local ecological knowledge (LEK) of resource users in order to investigate how LEK and science combined can help us understand changes in environmental health and develop effective strategies for future ecological recovery. LEK is a rich source of information on natural resources that is often not readily available in written form. Scientists often overlook the value of LEK for documenting long-term trends in local resource availability and the factors responsible for those trends.

The ecological knowledge of fish harvesters consists of facts obtained through firsthand experience during years of observation while fishing. Harvesters' inductive-deductive reasoning, however, may lead to an incomplete understanding of how nature works. The value of the scientific approach to understanding nature lies in the rigors of hypothesis testing, which exposes those areas of a paradigm where knowledge is incomplete. Thus LEK, when integrated with results derived from formal scientific research, can often provide a fuller understanding of the natural environment and more complete information for management decisions. This paper diagrams the benefits of this two-way flow of information between scientists and local experts. Our research methodology combines scientific and harvesters' knowledge of cod coloration to obtain a fuller understanding of the stock structure of coastal cod in Newfoundland and Labrador, Canada.

INTRODUCTION

In the process of living and working in marine environments, fish harvesters acquire a detailed knowledge of that environment and their local fish resources. In general little of this information has been used within scientific study relative to what is available, or to what might be used (Berkes 1993, Pinkerton 1994). The participation of fish harvesters in research is usually not explicitly acknowledged as a methodological approach in scientific publications (Fischer 2000). Fisheries scientists have generally not systematically collected, recorded and evaluated the knowledge from harvesters. In addition, where more systematic LEK research *has* been carried out, this research has rarely been followed up or combined with systematic scientific research intended to verify, where possible, the observations and interpretations of harvesters and to extend this knowledge (for an exception to this general pattern, see Sutton 1998).

With the failure of management plans to prevent the collapse of the cod fishery on the east coast and the salmon fishery on the west coast of Canada, many fish harvesters have lost faith in the ability of scientists as well as government to protect their livelihoods (Coward *et al.* 2000). This lack of confidence, manifested by industry wanting more say in issues that concern it, makes it imperative to devise new approaches to stock assessment and management (Gendron *et al.* 2000). One approach is the active involvement of local experts with scientists and managers in research activities and management planning.

Finding ways to compare fish harvesters' observations and data drawn from more traditional scientific sources could improve the potential for more informed and more accepted decisions of stock status and management (Neis *et al.* 1999a). This paper outlines a framework for how LEK and science can be combined to produce effective knowledge about fisheries and fish ecology. It then uses the CUS coastal cod project to illustrate the basis for this general argument. The primary goal of the coastal cod project is to use a combination of LEK and science to identify locations along the northern peninsula and west coast of Newfoundland and along the southeast coast of Labrador where coastal populations of Atlantic cod (*Gadus morhua*) may exist or may have existed in the past. Towards this end we investigate the reliability of cod coloration as an index of bay stocks.

ELEMENTS OF LEK

The ecological knowledge of resource users consists of facts obtained from firsthand experience during years of observation and interaction with their local environment. Fishery resource users develop a detailed knowledge of their resources, their environments and their fishing practices (Neis *et al.* 1999a; 1999b). Throughout their careers, fish harvesters observe fish morphology (e.g. coloration and body size), fish behavior (e.g. spawning and migration), trends in fish landings and changes in fishing effort. From patterns and trends observed over time, many fish harvesters use a process of inductive-deductive reasoning (Figure 1) to distinguish between different runs of fish, to explain observed behavioral differences and changes in behavior, and to account for trends in abundance and effort. They then make predictions about the state of resources and arrive at assessments of different management initiatives. This inductive-deductive reasoning of harvesters, however, is limited where it lacks means to validate deductions and interpretations about how nature works and how nature interacts with human behavior.

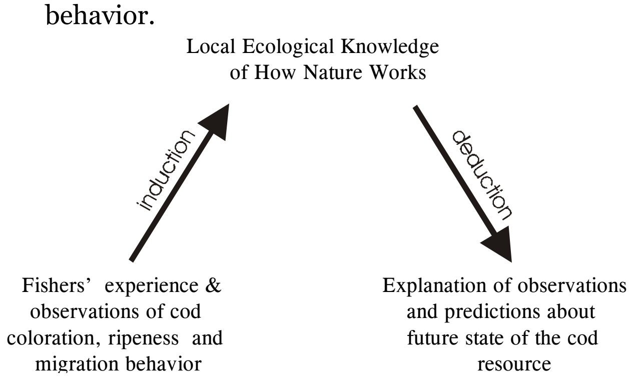

Figure 1. The inductive-deductive method of reasoning used by many fish harvesters to distinguish between different types of cod, to explain and account for their observations and to make predictions and assessments about the future state of the cod resource.

Scientific Hypothesis Testing

The value of the scientific method of investigation lies in the rigors of hypothesis testing, which can test the validity of theories through experimentation and field studies. This involves the checking and rechecking of procedures, elimination of sources of error, and further testing by colleagues of experimental or field study results published in journal articles. Theories are then refined or refuted on the basis of how well they stand up to this testing. Occasionally new theories arise to replace existing theories. Through the scientific method (Figure 2) science closes the induction-deduction loop of knowledge development used by fish harvesters, providing a more complete understanding of nature.

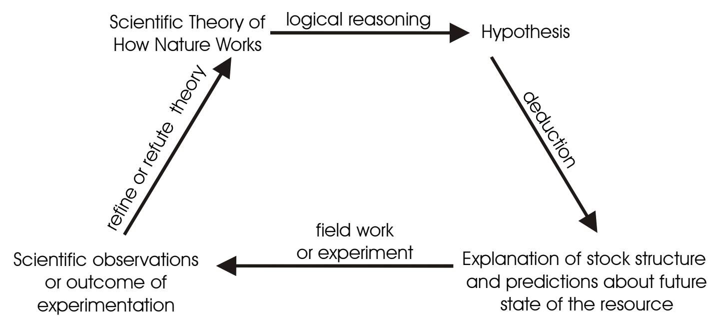

Figure 2. Method of hypothesis testing used by fisheries scientists to validate theories regarding stock structure (adapted from Wroblewski 1983). Science closes the loop of inductive-deductive reasoning used by many fish harvesters.

However, despite its strengths, there are many limitations to science. A major limitation can be an insufficient observational base to verify theories and scientific hypotheses. Such a situation may result from the monetary and time constraints that often limit the amount of scientific research that can be conducted (Fischer 2000), and from limits in the spatial and temporal scale of scientific observations. In this context, the knowledge and observations of local resource users can supply a wealth of information for scientific hypothesis testing.

Temporal and Spatial Dimensions of LEK and Scientific Knowledge

Scientific knowledge is often based on sporadic observations covering large spatial scales whereas local expertise is based on continuous observations within small local fishing areas (Fisher 2000). The strength of fish harvesters' knowledge lies in their years and sometimes generations of continuous interaction with local environments, whereby they acquire a wealth of information that is often not readily available to science. The strength of science lies in the rigorous procedures that allow scientists to test some of the assumptions found in harvesters' knowledge and the validity of their interpretations. Science can do this by trying to "extract" LEK from harvesters and then testing it, but a potentially more fruitful approach involves scientists and fishers working together in participatory research projects (Fisher 2000). Joint research teams combine LEK and scientific knowledge, leading to a more complete understanding of nature and the effects of our interactions with nature.

Fish Harvesters LEK, Science and Management

The observations and detailed information fish harvesters provide, combined with the method of validation used by science, allow for improved predictions and assessments of the state of our marine resources. Through this two-way flow of information, scientists and harvesters can work together to provide a more detailed assessment of stock structure to be used in management decisions for utilization and conservation of the resource (Figure 3). Harvesters, scientists and managers potentially benefit from management regimes that are based on more informed estimates of the state of our resources and shared responsibility for management or stewardship (Felt, Neis and McCay 1998). It is this flow of information we are attempting to achieve with the Newfoundland and Labrador coastal cod project we are carrying out with the Coasts Under Stress research program.

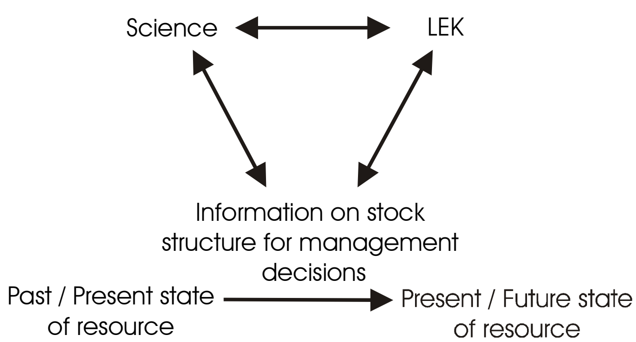

Figure 3. Idealized flow of information between local resources users, scientists, and managers.

Case Study – Newfoundland and Labrador Coastal Cod

Since the collapse of the northern Atlantic cod stock in the early 1990s, most of the adult cod remaining in Newfoundland waters are found in coastal areas. Historically, offshore components of northern cod stock would migrate to the coast in a summer feeding migration (Rose 1993),and contribute to the inshore catch during summer and fall (Lilly 1996). These fish would then migrate back offshore to overwinter and spawn near the edge of the continental shelf (Myers *et al.* 1993; Wroblewski *et al.* 1995) (Figure 4). During the summer feeding period, cod from offshore components would mix with inshore cod, which are year-round residents of coastal waters (Ruzzante et al 1996; 1997). Before being decimated by overfishing between the 1960s and the 1990s,(Hutchings and Myers 1995; Myers *et al.* 1997), the offshore components constituted the major portion of the population (Lear and Parsons 1993). Coastal components associated with the bays and headlands of the coastline, Templeman and Fleming 1956; 1963) had been documented but were considered of minor importance in managing this resource (Lilly 1996). In Newfoundland and Labrador, as elsewhere and with different marine species, cod were managed in very large spatial units and, within these, were treated as though they were panmictic (Wilson and Kornfield 1997). As a result, until recently, limited effort was directed towards the systematic scientific study of coastal components and there were no separate management units for such components.

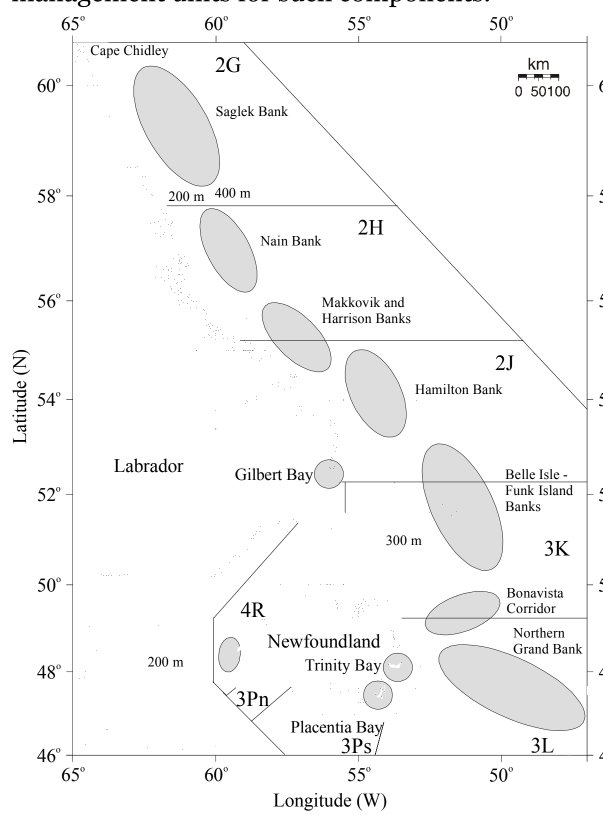

Figure 4. Bathymetric chart of the Newfoundland and Labrador shelf, showing the major banks and the Northwest Atlantic Fishery Organization (NAFO) management units (2GHJ, 3KL, $3P_sP_n$, 4R). Shaded regions represent the approximate locations of subpopulations of Atlantic cod, associated with scientifically documented inshore and offshore spawning grounds (modification of Fig. 1 in Smedbol and Wroblewski, in press).

The collapse of the offshore components of the northern cod stock off Newfoundland's northeast coast and the coast of Labrador in particular, (Atkinson *et al.* 1997; DFO Science Stock Status Report 2001), and scientific and harvester documentation of aggregations of cod in the major bays of eastern and southern

Newfoundland (Rose 1996; Smedbol *et al.* 1998) have heightened scientific interest in the population structure and ecology of coastal cod. Recent research has indicated that inshore overwintering/spawning components exist in Trinity (Smedbol and Wroblewski 1997) and Placentia Bays (Bradbury *et al.* 2000), Newfoundland and in Gilbert Bay, Labrador (Ruzzante *et al.* 2000; Green and Wroblewski 2000) (Figure 4). Research has also revealed that populations of Atlantic cod inhabiting the marine waters off Newfoundland and Labrador consist of genetically distinct offshore and inshore or coastal spawning components (Taggart *et al.* 1998 and references therein). This research suggests that these localized spawning groups may be relatively independent subpopulations. Such populations may have been endangered after the collapse of the commercial fishery offshore when fishing effort was redirected towards these inshore areas. This has critical management implications. In order to manage such stocks effectively, it is necessary to assess them independently, understand their relationship to other populations and establish a management regime that will prevent localized overfishing and promote the recovery of depleted local stocks (Wilson and Kornfield 1997).

Table 1. Categories of Newfoundland and Labrador cod, based on overwintering and spawning habitat, post-spawning migratory behavior, and body coloration.

Overwintering habitat	Location of spawning grounds	Post-spawning migratory behaviour	Colouration
1. Offshore- continental shelf [1]	continental shelf [1]	migrates to coast to feed [1, 2]	countershaded [3]
2. Offshore- continental shelf [1]	continental shelf [1, 2]	non-migratory - remains on shelf [1]	countershaded [3]
3. Inshore- bays (e.g. Trinity, Placentia, Gilbert Bay) [4,5]	bays [5,6,7]	remains at coast [3, 4]	countershaded (deep) brown (shallow) [8,9,10]
4. Coastal- headlands [3]	coastal deeps [11]	remains at coast [11]	countershaded [3]
5. Salt-pond (e.g. Holyrood Pond; Occasional Hr.) [12]	salt ponds [12]	non-migratory, landlocked [12]	brown [12]
6. Inshore juveniles -bays and coast [11]	no spawning (juveniles of types1-4) [11]	immature- non-migratory [11]	brown[13]

In recent years, some scientists researching local stocks have drawn on information from fish harvesters obtained either directly from these harvesters or from published sources quoting these harvesters (Ames 1997, Wroblewski 2000; Maurstad 2000). Over the past decade, LEK research in Trinity, Bonavista, Placentia and Fortune Bays and historical, archival research involving documents quoting fish harvesters, have provided information related to inshore populations of cod as well as to factors fish harvesters have associated with trends in those populations (Hutchings, Neis and Ripley, forthcoming; Neis *et al.* 1999b). Previous work with harvesters (e.g. Neis *et al.* 1999b) and recent scientific work (e.g. Green and Wroblewski 2000; Ruzzante *et al.* 2000), suggest the presence of six categories of cod in Newfoundland and Labrador, distinguished by overwintering and spawning habitats, post-spawning migratory behavior and coloration on their wintering grounds (Table 1). For our research we are interested in the different coloration of cod in each of these six categories.

[1] Templeman 1974,
[2] Lear 1984
[3] Templeman 1966
[4] Green and Wroblewski 2000
[5] Smedbol *et al.* 1998
[6] Morris 2000
[7] Lawson and Rose 2000
[8] Neis *et al.* 1999b
[9] Wroblewski 2000
[10] Bradbury, I. pers. comm., Memorial University of Newfoundland. September 2001.
[11] Templeman 1979
[12] O'Connel *et al.* 1984
[13] DFO 1995

Although significant variation exists between individual fish, there are two general color patterns, countershaded and brown, that dominate. Countershading, a color phenomenon of gradual shading from light underneath to darker on the back, is seen in cod inhabiting deep (100-500m) waters (Table 1 categories 1-4; Figure 5). Countershading provides camouflage to a pelagically swimming cod in deeper offshore waters, as well as in deep water trenches of some bays and off headlands.

Figure 5. Countershading provides camouflage to a pelagically swimming fish in deep waters.

Distinct from this, shallow water cod have a characteristic red to yellow-brown coloration (Table 1 categories 3,5-6; Figure 6). These cod are generally referred to as brown cod. The brown coloration allows the fish to blend in with its shallow water habitat, a phenomenon known as adaptive coloration. Brown colored cod are found in shallow water bays and salt-ponds. The recently identified cod in Gilbert Bay are often reddish or golden-brown. These represent a genetically distinct population of cod (Ruzzante *et al.* 2000) that were first recognized by local resource users based on their presence year-round and their distinct coloration (Wroblewski 2000). Scientific research suggests the red-brown coloration results from an abundance of red pigments (carotenoids) obtained through ingestion of invertebrates containing carotenoids synthesized by plants and passed through the food chain (Wroblewski 2000).

Figure 6. Brown coloration in inshore Atlantic cod.

This research illustrates that LEK is valuable in discerning stock structure in Newfoundland and Labrador cod (see Wroblewski 2000). The discovery of a genetically distinguishable population of cod in Gilbert Bay implies that other such populations may exist or may have existed in the past in similar oceanographic areas in Labrador and coastal Newfoundland. Our knowledge of fish coloration and the fact that color is readily observable leads us to ask whether or not cod coloration can be used as a reliable indicator of stock components.

Fish coloration is very complex, changeable, and many gradations of color exist between the two general patterns shown in Figures 5 and 6. This fluidity is widely recognized by fish harvesters. Indeed, one fisherman noted during an interview:

> *"There's a lot, they're not all the same thing. You know what I mean, not all the same color… There's no one of the cod all the same color"* (unpublished research transcript #7, 2000).

For a discussion of some harvester observations of cod coloration see Neis *et al.* (1999b), Hutchings *et al.* (1995) and Potter (1996). Nonetheless, color has been successfully used to indicate bay-scale population structure in Gilbert Bay, which in turn prompted the necessary scientific research that distinguished these cod from other populations (Wroblewski 2000). The identification of bay stocks, such as the one in Gilbert Bay, has implications for management. Recently, Gilbert Bay has been declared an "Area of Interest" under DFO's Marine Protected Areas (MPA) program (DFO press release, 13 October 2000) and efforts of scientists and local residents are now directed toward establishing Gilbert Bay as eastern Canada's first MPA. A goal of the CUS coastal cod project is to combine fish harvesters' knowledge with scientific knowledge to identify other locations in coastal Newfoundland and Labrador where local inshore stocks of cod may exist or may have existed in the past. For the purpose of this paper, an inshore stock of cod is defined as cod that are resident in the inshore environment year-round (i.e. overwinter, spawn, and feed inshore; category 3 in Table 1).

Our attempt to identify other inshore populations of cod began with interviews of retired fishermen in areas along the coast of southern Labrador and northern Newfoundland. Interviews with fish harvesters living between Lark Harbour, Newfoundland and Cartwright, Labrador, were conducted to learn about the location and history of inshore Atlantic cod. Retired fishermen, 26 in total, were interviewed during 2000. These interviews were conducted to create a baseline of information from which to generate further questions and research objectives. Information recorded was from memory and not from logbooks or other sources. Interviews were tape-recorded. Interviewees were shown a series of pictures of different fish species and asked questions and encouraged to talk about whether they had observed the species. If so, harvesters were asked where they had seen them, what time of year, and if they had noticed any changes in abundance over time. Many questions were asked regarding spawning and migration patterns for cod.

To obtain information on inshore cod, color was used as an entry point into a discussion of cod stock structure. Interviewees were shown a picture of the reddish-brown Gilbert Bay cod and asked whether they had seen cod like this in the area where they fished. Positive responses led to further discussion about the abundance of these brown cod, what time of year they had seen them, if they fished them, where and how they were caught (i.e. if they ever fished for them through the ice) and also whether they had seen them in a ripe condition (i.e. running with eggs or milt). This discussion provided information on the historical presence/absence of inshore cod. As anticipated, interviewed fishermen from southern Labrador and coastal Newfoundland were very knowledgeable about cod within the region. Most had heard of, or had seen, what they referred to as "bay cod" and were able to differentiate between resident inshore cod and migratory offshore cod by color and season of capture. Various names were used by fishers to refer to these inshore cod including foxy, red and shoal-water cod, kelp fish, or simply brown cod. Here are comments from two fishermen interviewed:

> *"You get the black cod. You go up where they calls up there off of L'Anse aux Meadows... There's shoal water there, four or five fathom of water... seem like that fish stays on that ground there.... Kelp fish, some people calls them. The old people call them shoal water fish right."* (unpublished research transcript # 7, 2000).

> *"I've seen red cod... In the fall, odd one we caught it..... Just call them red cod"* (unpublished research transcript #5, 2000).

From our interviews we generated maps plotting reported locations where inshore cod had been observed by fishermen throughout their fishing careers. Areas where there was an indication of overwintering brown cod were Lark Harbour and Bonne Bay, Newfoundland (Fig 7a) and St. Lewis Sound, Occasional Harbour and Sandwich Bay, Labrador (Fig 7b).

Harvesters' explanations for the occurrence of these brown colored cod vary. Some speculate

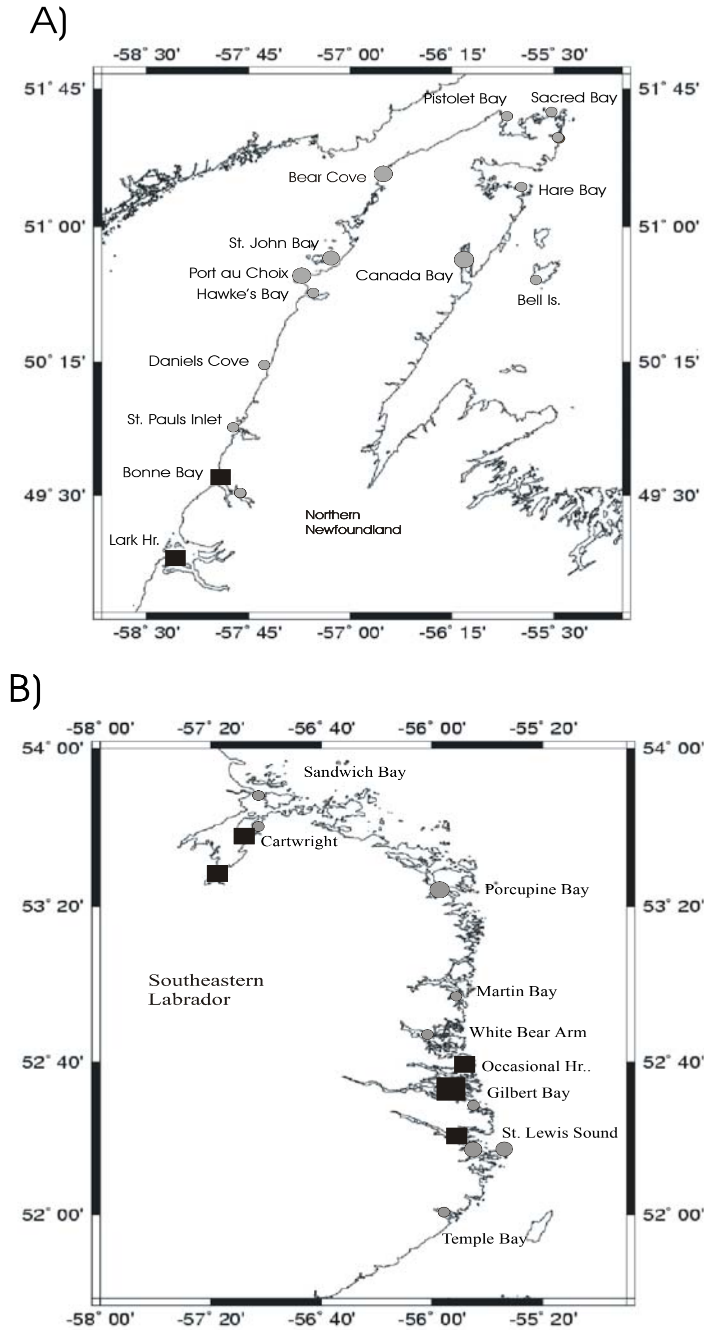

Figure 7. Enlargement of (a) the northern peninsula of Newfoundland and (b) southeastern Labrador, showing locations of brown cod sightings, a possible indication of a local population, revealed from interviews with retired fishermen. Circles represent areas where cod were observed at various times of the year and squares represent areas where there was an indication of overwintering brown cod. The size of the circles/squares suggests the amount of detail surrounding the observation (the certainty of each sighting) where larger shapes represent a greater amount of information.

that their distinctive color has to do with migration into freshwater. Others mention the

influence of diet, bottom substrate, water coloration (clear vs. murky), duration in freshwater, or the presence of kelp. One fisherman in particular was quite eager to offer his opinion:

> *"Do you want me to tell you the reason that cod got a different color from that one? That [brown] fish was caught in shoaler water than this one. This fish came up out of the deep water, [the one] with the white belly"* (unpublished transcript # 10, 2000).

Interviews also suggested that some fish harvesters believe offshore, countershaded cod move into the bays to feed during the spring/summer and change color (become either darker or more brown in color). One noted:

> "*If it's in shallow water so long, it will turn right dark…I always thought that the fish changed its color when it came in shoaler water and I can't believe anything else.*"(unpublished research transcript # 10, 2000).

Another fisherman, when asked when brown cod would be observed, commented:

> *"Brown ones? In the summer time. They get into the bay, up at the end with freshwater. They used to turn it then, they turn burnish a bit eh? That's in the fresh water see?"* (unpublished research transcript # 16, 2000).

Our research raises the question "how can fishers' knowledge of cod coloration be used to indicate the existence of local bay stocks of Atlantic cod?" Using a combination of information from local experts in the area and scientific literature about fish coloration, a color change experiment has been conducted in an attempt to answer this question. In particular, this study considers the questions "How quickly does cod coloration change?" and "To what extent?"

In August 2001, scientists and students from Memorial University, and local fish harvesters from Williams Harbour and Port Hope Simpson, Labrador, worked together to set up a color change experiment. Our goal was to capture what harvesters refer to as offshore colored and inshore colored cod to document if, and to what extent, color changes over time. Harvesters from the area set up holding pens at a location near the mouth of Gilbert Bay (Figure 8, location A). One resident of Williams Harbour was hired to take university researchers fishing in areas known by local residents to be "good fishing grounds." Most residents in the area were interested in our research and participated by providing helpful advice and comments that aided the success of the experiment.

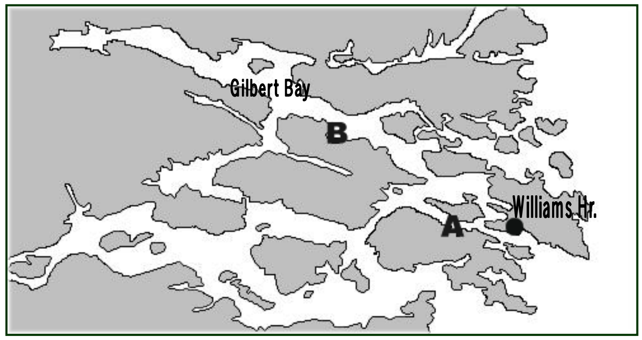

Figure 8. Map of Gilbert Bay showing locations of fish pens from August-October 2001 (A) and October 2001-Spring 2002 (B).

In total, 238 Atlantic cod were captured live and placed in holding pens in Gilbert Bay. Of these fish, 95 were considered by residents to be undoubtedly offshore cod and 73 unmistakably Gilbert Bay cod. Each individual fish was tagged for later identification, measured and weighed, and given a score based on color (ranking from 1-5, where 1 is a countershaded offshore cod, 3 is a brown cod and 5 is a cod with significant red pigmentation), photographed at the time of capture, and placed in a holding pen. Fish were fed a diet of capelin and herring. A second examination of each individual fish took place in October 2001. Lengths, weights and photographs were taken and each fish was again given a number based on color. Additionally, blood samples were taken from each individual. Some fish were sacrificed to obtain otoliths for length at age analysis. The fish were relocated to overwinter at a second location further up within Gilbert Bay (Figure 8, location B).

Visual analysis in October revealed a change in color had occurred, in particular among the brown colored cod. Average initial and final color (based on the color scale of 1-5) for both groups (brown and countershaded) were calculated to quantify the observed change. The average color of the initially countershaded cod decreased from 2.1 to 1.7, indicating these fish became slightly more countershaded in appearance. The change in color of the brown cod was more significant. The average color score of the initially brown cod decreased from a

3.6 to a 2.3. Thus, the "inshore" cod had lost their brown coloration and become countershaded in appearance. Our results demonstrate that if inshore cod are fed a piscivorous diet (a typical offshore diet primarily of capelin), in less than 2 ½ months the brown coloration would be lost. Or restated, the brown coloration results from cod in the bay environment feeding on a diet of crustaceans and other invertebrate species rich in carotenoids.

Discussion

Our interviews revealed that fish harvesters possess a wealth of knowledge concerning cod coloration, spawning behavior and migratory patterns, and that color can be used as an entry point into a discussion that provides information critical to the understanding of stock structure. Fish harvesters' knowledge of cod coloration and migration patterns (i.e. non-migratory bay cod and migratory offshore cod) set the rationale for our color change experiment.

Coloration in fishes is primarily due to skin pigments. A fish acquires its red, yellow and orange pigments (carotenoids) through food – the only way they can obtain them (Bagnara and Hadley 1973). The reddish-brown coloration of Gilbert Bay cod results from a diet rich in carotenoid-containing invertebrate species (Wroblewski 2000). Morris (2000) has shown that cod in Gilbert Bay feed predominantly on benthic invertebrates such as shrimp and mysids, amphipods and various crab species. In the color change experiment, fish were held in net pens and fed a diet of capelin and herring. The loss of red coloration from experimental fish confirms the role of diet in the coloration of Gilbert Bay cod. Despite the information available on fish coloration, there is no known scientific literature investigating coloration as an indicator of stock structure in Newfoundland cod. Our research suggests two hypotheses: 1) brown cod represent offshore cod that came into the bays in spring/summer, feed on carotenoid-rich invertebrates, and turn brown; 2) brown cod represent cod that remain in the bays year round, feeding predominantly on carotenoid rich benthic invertebrates.

The paradigm surrounding the behavior and migration of northern cod (i.e. offshore cod migrate inshore guided by migrating capelin on which the cod feed (Lear and Green 1984) does not support the first hypothesis. Research in Bonavista Bay has shown that offshore cod migrating inshore in the spring feed intensively and almost exclusively on capelin (Lilly and Botta 1984). This suggests that an offshore cod migrating inshore and acquiring a reddish-brown coloration is possible but unlikely due to the preference for a capelin diet. The results from the color change experiment demonstrate that a reddish-brown cod will lose its red color in a period of less than 2 ½ months when feeding on a piscivorous diet. Harvesters' observations of brown cod, therefore, are indicative of cod that were at the time of the observation, or had recently been, feeding on invertebrates in the inshore environment. Whether or not cod stay year round in the bays cannot be determined on the basis of brown color alone. Note that cod resident in the deep waters of Trinity Bay are countershaded (see category 3, Table 1). Overall, a brown coloration suggests that cod are of the inshore group rather than the offshore group. As such, that cod is of concern to management plans for inshore stocks.

Conclusions

Commercial cod fishers use their experience and observations to explain patterns and trends in the fishery. The detailed observations related to fish coloration, spawning and migration they acquire are highly valuable to science. This knowledge, however, has to be blended with scientifically rigorous forms of research that close the induction-deduction loop, providing a more complete understanding of nature. Local ecological knowledge of brown cod, when integrated with a formal scientific study of cod coloration, can play an important role in the identification of local stocks of cod. The variability of coloration, however, allows us only to make general conclusions regarding the duration of cod in the inshore environment through its diet of benthic invertebrates. Thus color is a useful, but not-conclusive indicator of cod stock structure. The existence of a genetically distinct population of cod in Gilbert Bay suggests that populations may be present in other bays in Newfoundland and Labrador. Further research is needed to identify the location and status of these populations, and new management strategies that preserve these fish populations, such as the establishment of marine protected areas, should be encouraged.

Acknowledgements

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QUESTIONS

Saudiel Ramirez-Sanchez: In your diagram you talk about what fishermen know about the environment in a materialistic way. Traditional Ecological Knowledge also has an ethical component attached to it. Why is it not in your diagram? The values that are attached to it are severed.

Nigel Haggan: To rephrase the question, there is an ethical dimension to Traditional Ecological Knowledge but it doesn't seem to be reflected in your diagram and your approach. How would you incorporate it?

Karen Gosse: We're continually interacting with fishers, not just taking their knowledge. We use their advice and their ideas. They are the main people up there. I was mainly a bystander on my own project. The project is not to just take knowledge and run away with it. Coasts Under Stress is organized in such a way that we work continuously with the people, have meetings and tell them what we found. My goal is to find other areas where co-management works. The people in Gilbert Bay are the ones who wanted the MPAs.

Robert Chriseiger: Species on the east coast are different from those on the west coast. We can't apply the science from one to the other. No one is using the experience that we acquired here. Knowledge is a wonderful thing. I attended a meeting about taking salmon fry out of the river with Carl Walters and Mike Harcourt among the attendees. This was in October 1999, two years ago, and nothing has been done. We have lost the entire year class. We should have a national symposium to let everyone know what's happening. The salmon fishery used to be a $2 billion dollar industry but this year I only fished two days. I hope that Mr. Haggan will find time to discuss this during this conference because British Columbia is very reliant on salmon. I'm sorry to distract from the east coast, but we have our own problems here.

Karen Gosse: Our project is on both the east and west coast. My case study is on the east coast, but there are similar studies on the west coast.

APPLYING LOCAL AND SCIENTIFIC KNOWLEDGE TO THE ESTABLISHMENT OF A SUSTAINABLE FISHERY: THE WEST COAST VANCOUVER ISLAND GOOSE BARNACLE FISHERY EXPERIENCE

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ABSTRACT

Goose barnacles were commercially harvested in British Columbia from 1978 until 1999 in a high value, passively regulated fishery with no limits on the number of licenses issued or the total allowable catch. The fishery was closed by the federal Department of Fisheries and Oceans in May 1999 due to concerns about the lack of (1) biological and stock assessment information on goose barnacles, (2) information on the ecological impacts of harvesting to the rocky intertidal community, and (3) consistent catch reporting by harvesters. Several goose barnacle harvesters had also expressed concern that localized stocks were being overfished. Under federal Acts, ecosystem-based management and a precautionary, phased approach to data collection and fishery development are now required before the fishery can be re-opened. Harvesters are playing an active role in the development of assessment and management frameworks for a sustainable fishery by participating in a multi-stakeholder working group that was formed to address issues among First Nations, management agencies, and harvesters, and to co-ordinate the implementation of relevant biological studies. Harvesters provided previously unreported information about the locations and characteristics of marketable and non-marketable populations, food fishing areas, and harvesting practices. This information has been used in developing currently on-going stock assessment and ecological impact assessment studies and determining experimental harvesting sites. Harvesters' knowledge has also provided insight into why previous management strategies and license conditions, such as catch reporting, were not successful. How both harvesters' knowledge and scientific knowledge are being incorporated into the development for a sustainable goose barnacle fishery is discussed.

INTRODUCTION

In British Columbia, licensed invertebrate commercial fishers have long been involved in the stock assessment and management of their respective fisheries. Most invertebrate fishers' organizations participate in stock assessment surveys. Fishers help select the general locations of surveys and often provide logistic and personnel support for these surveys. For some fisheries, geoduck for example, fishers also advise in setting quotas for the management areas from a range of options.

In 1998, the goose barnacle (*Pollicipes polymerus*) fishery was identified as lacking the biological understanding and the stock assessment and management frameworks necessary for precautionary management. Within the Stock Assessment Division of the Department of Fisheries and Oceans Canada (DFO), a framework has been developed for the provision of scientific advice for the management of new and developing fisheries, including established fisheries whose expansion is limited due to a lack of information of the species distribution and abundance (Perry *et al.* 1999). This framework includes three phases for the precautionary development of a fishery:

Phase 0: collection of all available information on the target species, and from similar species elsewhere, to provide a baseline with which to advise on alternative management options and to identify areas where information is lacking;

Phase 1: surveys and experimental fishing with the objective of the collection of data required to fill in the information gaps identified in *Phase 0* and to explore the fishery potential;

Phase 2: a limited commercial fishery is developed, while stocks are monitored and management strategies are evaluated.

Lauzier (1999) recommended the mandatory participation of trained harvesters to collect data for stock assessments, including on-going surveys and gathering of biological information. Such involvement would give harvesters some understanding of the requirements to collect scientifically rigorous information, and allow DFO the opportunity to incorporate and confirm historical, traditional, and anecdotal information. Harvesters would be given an active role in stock assessment activities and would assist in developing management strategies for a stable, sustainable goose barnacle fishery. This paper describes how knowledge from former commercial goose barnacle harvesters was gathered and used in *Phases 0* and *1* of the new and developing fisheries framework.

Goose barnacle biology

The goose barnacle (*Pollicipes polymerus* Sowerby, 1833) (Subclass Cirripedia, Order Thoracica, Suborder Lepadomorpha, Subfamily Pollicipinae) is a stalked, or pedunculate, barnacle, characterized by a pliable, muscular armoured stalk (peduncle), with a strong attachment system, and a series of thick plates covering the rest of the body (capitulum) (Figure 1).

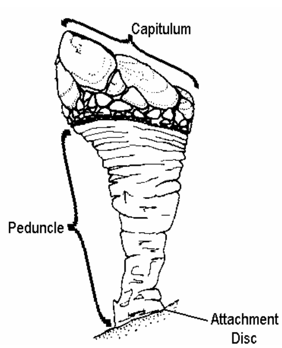


Figure 1. Schematic lateral view of the goose barnacle (Bernard 1988).

Goose barnacles are found from Sakhalin Island in the Northwest Pacific Ocean, throughout the Aleutians, and down the west coast of North America to Cedros Island, Baja California Sur, Mexico (Bernard 1988). The rocky open exposed coast is the preferred habitat of goose barnacles, where they are typically closely crowded (Barnes and Reese 1960, Ricketts and Calvin 1968, Newman and Abbott 1980). Goose barnacles often occur in distinct rosette-shaped clusters 20-40 cm in diameter (Figure 2), with large older individuals at the centre, surrounded by a gradation of smaller younger individuals at the edge (Bernard 1988).

Figure 2. Distinctive clumps of goose barnacles on the West Coast of Vancouver Island, June 2001. (J. Lessard photo)

Goose barnacle populations are usually concentrated in the mid-intertidal zone, but a few occur from over one metre above the highest high water level down to the shallow subtidal (Austin 1987). Goose barnacles are often found closely associated with, and attached to, California mussels (*Mytilus californianus*) and acorn barnacles (*Semibalanus cariosus*) (Austin 1987).

In the lower mid-intertidal, goose barnacles often occur interspersed in dense aggregations with California mussels to form the distinctive *Pollicipes-Mytilus* community, or matrix (Barnes and Reese 1960, Hoffman 1989). There have been a number of extensive studies of this community and the effects of competition, predation and disturbance on succession in this ecosystem (Dayton 1971; Paine 1974, 1980; Paine and Levin 1981; Wooton 1992, 1993, 1997).

The exposed rocky intertidal community is subject to continuous physical and biological disturbance, creating periodic free space, and allowing a large number of species to utilize the same potentially limited resource. Mussels beds do recover from disturbance, and the rate of recovery depends on size of the gap, season in which the gap was formed, intertidal elevation, angle of the substratum and intensity of larval recruitment (Seed and Suchanek 1992). Major disturbances in the mid-intertidal range may require 8-35 years to fully recover (Paine and Levin 1981).

Commercial fishery history

First Nations people have historically harvested goose barnacles on the west coast of Canada (Ellis and Swan 1981). There is traditional knowledge from First Nations harvesters that only specific sites were harvested, and that repeated harvesting was thought to improve subsequent harvests. Goose barnacles are still harvested for nutritional, social and ceremonial purposes.

In British Columbia, goose barnacles have been fished commercially since 1978 and landings have been reported since 1985. Initial rapid growth peaked in 1988, with 467 licences issued and reported landings of 49 t. From 1995-1998, landings were 8-10 t/yr. The commercial goose barnacle fishery was concentrated on the West Coast of Vancouver Island, with sporadic landings from the Central and North Coasts. A strong market demand exists for goose barnacles in Spain, estimated at 2,000 t/y (Proverbs, 1979) and substantial demand in Portugal for live barnacles of ~ 4 cm overall length. Stocks in Spain have been severely depleted and are now managed under strict conservation measures.

Before its closure in 1999 (see below), this fishery was passively managed. It had unlimited entry, no size limits, no quotas or total allowable catches (TAC), and was open year-round. DFO assumed that the fishery was limited by market demand and accessibility to suitable product. It was also estimated that less than 10% of the stock was available to the fishery due to inaccessible harvest areas, and/or unsuitable size and quality of product for the market (Clark, 2001). Management measures included small permanent area closures (e.g. for Parks), a gear restriction limited to hand tools or hand picking, and catch reporting requirements. There was relatively low compliance of catch reporting. The high initial participation rate and high reported catches, followed by a decline to low levels, are classic signs of a "gold-rush" fishery. Much of the decline in landings, however, can be attributed to the loss of markets in Spain.

1999 Fishery Closure

DFO closed the commercial goose barnacle fishery on May 30, 1999, due to concern over the ecological impact on mussel beds and on goose barnacle stocks and lack of data on the fishery. Insufficient stock assessment data (e.g. biomass, distribution and abundance), biological data (e.g. recruitment, growth and mortality), and inconsistencies in fishery data resulted in a lack of confidence that the resource was being managed in a precautionary manner. Examination of export records from the Canadian Food Inspection Agency (CFIA) showed considerably larger amounts of product being reported as exported, compared to the amount of product being reported as harvested on sales slips or harvest logs (Figure 3). However, exported weights were not verified, and some export certificates may have been cancelled, therefore the actual amount exported is not known. Reported sales slip landings were also considerably higher than the reported harvest log landings, which was another major inconsistency that could not be resolved.

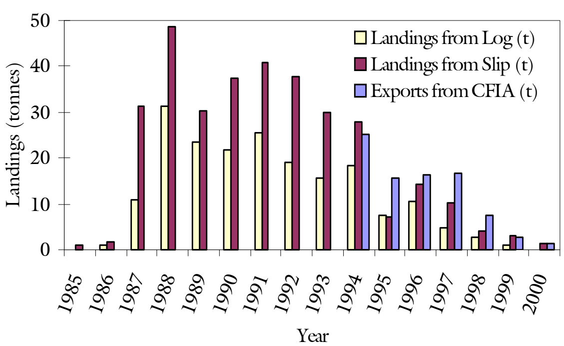


Figure 3. Goose barnacle fishery landings 1985-2000 and exports 1994-2000

Experienced harvesters also expressed concerns about local stock damage caused by inexperienced harvesters attracted by the high value of the fishery, and who were only interested in short-term high yield gain. There were reports of relatively large areas of rocks (>2 m^2) cleared of mussels and barnacles. Results from a test fishery during the mid-1980s showed that on average, 50% of the harvest was not acceptable product (the level of experience of participating harvesters is unknown) (Austin 1987). Austin (1987) also observed that harvesting goose barnacle adults attached to mussels and acorn barnacles resulted in a higher quality product, and probably caused the mortality of the substrate species. From the limited information available on the commercial goose barnacle fishery, and the concentrated effort of the fishery in particular areas due to accessibility, it had become apparent that the past passive management approach to the BC goose barnacle fishery was not precautionary. An appropriate management framework had to be designed and implemented, to actively monitor total catch and stock conditions, set appropriate exploitation levels, and respond to changes in a timely manner.

METHODS

Systematic sampling to gather harvesters' knowledge for Phases 0 and 1 of the New and Developing Fishery Framework, was not possible because there was no list of all the people that had harvested goose barnacles. For example, many unlicensed harvesters were known to have sold their product to a licensed fisher. Harvesters tend to be localized i.e. they harvest close to where they live. Geographical coverage could only be obtained in areas where there had been a commercial fishery.

Working group

In response to the fishery's closure in May 1999 and following recommendations from Lauzier (1999), DFO and the Nuu-chah-nulth Tribal Council (NTC) initiated a multi-stakeholder "Goose Barnacle Working Group" (GBWG). GBWG has representation from goose barnacle harvesters and buyers, DFO, First Nations, and other government management agencies such as Parks Canada and BC Parks. Two harvesters' organizations have been formed to date, but independent harvesters remain. The "Canadian

Goose Barnacle Cooperative" was established shortly before the closure of the fishery and the "West Coast Goosenecks Association" was formed in the spring of 2000. Several meetings have been held since the spring of 2000 with approximately 25 harvesters from coastal communities who identified themselves as experienced commercial harvesters.

The GBWG operates under the guidelines of a joint policy framework to establish area-based management in the NTC/West Coast Vancouver Island area. The goals of the GBWG are to 1) determine opportunities for developing a sustainable, ecosystem based, commercial goose barnacle fishery on the West Coast of Vancouver Island; 2) establish cooperative relationships for the ongoing management of a fishery; and 3) work towards the goals, principles, and objectives of the GBWG and the West Coast of Vancouver Island area based management board. To date, the GBWG has focused on defining the scope and location of stock assessment, ecological impact assessment activities, and experimental harvests.

Informal conversations

During the data gathering of the *Phase 0* of the New and Developing Fisheries Framework, known experienced harvesters were contacted by phone and through the GBWG, and were asked to provide information on their understanding of the biology of goose barnacle, methods of harvest, and data lacking in the logbooks.

Interviews

In total, 21 harvesters were informally interviewed. Josie Osborne (NTC) conducted the interviews at three different locations on Vancouver Island (Kyuquot, Parksville and Ucluelet). Harvesters were asked to provide information on the distribution of goose barnacles, using nautical charts, and to indicate whether they fished there often, occasionally or never. Data were then digitized into a geographical information system (GIS) by DFO staff. For this study, harvesting areas falling within boundaries of overlaid federal and provincial parks and Ecological Reserves were removed for the survey site selection (see Figure 4).

Survey and experimental fishery

DFO staff designed a two-part survey: stock assessment and habitat impact assessment, to collect the necessary scientific data on goose barnacle biology and distribution, and on the ecological harvesting impacts. To assess the biomass available for a harvest, survey sites had to have goose barnacles of good harvesting quality and quantity. Conversations with harvesters had revealed that they tend to be very localized and harvested close to home. Harvest log records substantiated this with landings concentrated in specific areas. For these reasons, the West Coast of Vancouver Island was separated into three study areas: Ucluelet, Tofino and Kyuquot (Figure 5). Specific survey sites were selected with the help of local experienced commercial harvesters. Each survey crew consisted of two DFO staff and two or more experienced harvesters. Data needed for collection were identified in the *Phase 0* study. Field data sheets from other species' surveys were modified based on discussions with harvesters.

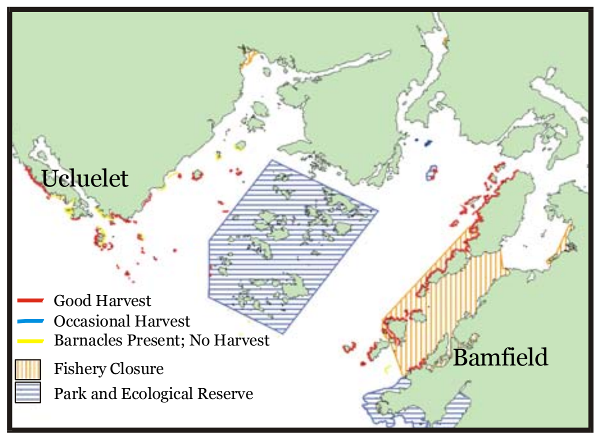


Figure 4. Goose barnacle fishery distribution in the Ucluelet area

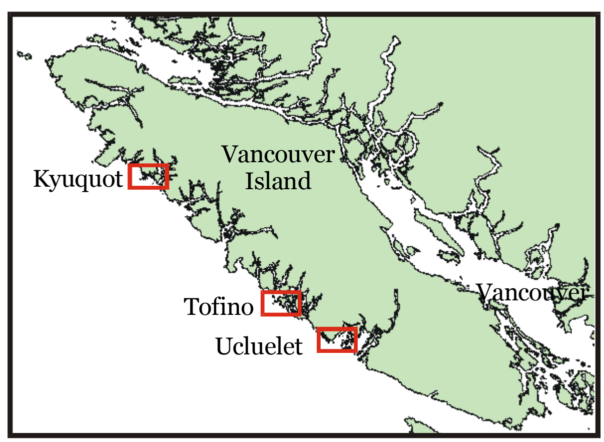


Figure 5. Study areas off the west coast of Vancouver Island.

A bed, defined as a continuous patch of goose barnacles, was delineated at each site to allow for manageable assessment units that could be surveyed in the limited time between low and high tide. Specific beds were selected for their representativeness as an area index site and/or suitability for experimental harvest. At each bed selected, an initial transect was laid out along the middle of the bed's longest axis. Bed width was measured at selected points perpendicular to this transect. Time and bed size permitting, additional transects were laid parallel to the centre line transect. Twelve 0.25 m^{-2} quadrats were placed at random along each transect. In each quadrat, all goose barnacles were counted, tidal elevation and matrix depth were measured, and harvest potential was assessed by an experienced harvester. Six of the 12 quadrats were randomly chosen for biological sampling. A 0.04 m^{-2} quadrat was placed within each selected 0.25 m^{-2} quadrat, and all goose barnacles within the smaller quadrats were taken for later processing at the field laboratory.

In conjunction with stock assessment procedures, "habitat" samples were randomly taken from two of the six 0.04 m^{-2} quadrates along each transects. In addition to goose barnacles, all biota was placed in plastic bags, frozen and transported to the Pacific Biological Station. Species identification and enumeration was then analyzed in detail for ecosystem assessments.

Experimental harvests were opened on September 12, 2000, in all three areas. Scientific licences were issued to the two harvesters associations. Individual participation was determined by the harvesters' organizations.

Harvests were conducted during low tide cycles in September, October, and December 2000, at previously surveyed sites or at new sites that were surveyed just prior to harvest. A harvest monitor familiar with the sites had to be present during the harvest. During the experimental harvests, prescribed stock assessment protocols and habitat assessment procedures were followed. Harvests continued at each site until harvesters considered that there were few marketable goose barnacles remaining. Dockside weights were recorded on DFO harvest log forms for the catches of each harvester from each site.

During each harvest cycle, the catches of each harvester were sampled at four random times. Harvesters were asked to separate each of these catch samples into marketable-sized barnacles and discards. The samples were processed at the field laboratory to determine average harvest and discard weight, and abundance. Marketable barnacles were returned to the corresponding harvester.

Results and Discussion

The detailed survey results will be reported later in a document that will outline management options for a commercial fishery. Since harvesters had little to contribute on the design of the habitat impact assessment, these data are also not included here. This discussion will focus on integrating what was learned during the surveys with traditional knowledge.

Discussions with experienced harvesters and observations of their fishing techniques revealed that harvesting impacts are probably less than previously thought by DFO science staff for three reasons. First, harvests which resulted in large bare patches of rocks, or "clearcuts" in forestry terminology have mostly been the work of inexperienced harvesters. Second, on acorn barnacle substrate, what appears as a "clearcut" may actually be a natural process that occurs when acorn barnacles age and die. The acorn shell weakens and fractures, and the whole community attached to the acorn barnacle substrate is lost when the shells detach from a rock substrate. Third, the actual harvested clumps of goose barnacles in mussel-dominated matrix usually consist of only 4-8 adults, and the size of holes left by experienced harvesters on the matrix were quite small, analogous to divots on a golf course. During the June 2001 survey in the Tofino and Ucluelet areas, it was observed that specific sites experimentally harvested in the fall of 2000 could no longer be identified. During the experimental harvest, sites with repeated visits, also showed little harvest impact only a month or two later. Evidence of First Nation's harvests for Mothers Day celebration was barely visible six weeks later.

Experienced harvesters provided information to DFO science staff on rapid recruitment and recovery times (about one month) of goose barnacle beds at particular locations. First Nations harvesters have long thought that harvesting improved the productivity of goose barnacles at particular locations. Initially, this information seemed to conflict with information gathered from the scientific literature and the results of past scientific experiments (see Austin 1987). Science staff assumed that recruitment and recovery mechanisms were driven by mainly by processes outside the goose barnacle bed. While this may be the case with goose barnacles on acorn barnacle substrate, it was quickly realized that rapid recovery of the harvested sites and recruitment to the fishery in the sea mussel matrix is probably from internal processes within the bed. As the mussel matrix shifts to fill in gaps on the surface, smaller goose barnacles below the surface of the bed quickly start growing, and their capitulums quickly reach the surface of the bed. A hole provides previously hidden goose barnacles with improved access to their food source, thereby accelerating their growth. However, not all newly exposed goose barnacles necessarily recruit to the fishery, especially those anchored deep in the matrix.

Product quality is another important factor. Goose barnacles vary considerably in body shape and size due to local conditions such as wave exposure. Stalk configuration, not overall weight, determines consumer product quality, thicker stalks are considered to be higher quality product.

Goose barnacle distribution and fishery maps

Harvesters willingly shared their particular harvesting areas. Figure 4 shows the distribution of goose barnacle fisheries in the Ucluelet area identified through the interview process. Most experienced harvesters have developed an understanding among themselves, as to who can harvest a particular site. Therefore, harvest location does not appear to be a major issue *among* experienced harvesters, however, confidentiality is an issue *between* experienced harvesters, who have developed the knowledge over time, and newcomers to the fishery.

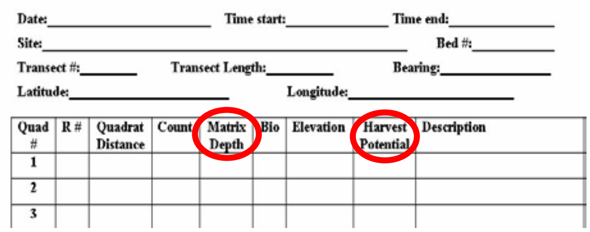
Information on the locations of goose barnacle beds was from harvesters' memories, and sometimes individuals did not agree on what constituted a good fishing location. It was also revealed that several harvesting areas did not appear on charts (i.e., rocks not documented on charts), and several harvesters had difficulty identifying area on charts because they did not navigate with charts on the water. They noticed that goose barnacles on some rocks recovered from harvesting extremely quickly and could be visited as often as once a month. However, other rocks had to be left for several months before they could be harvested again.

Not all former harvesters could be interviewed, therefore the maps developed represent a preliminary assessment of goose barnacle distribution. There may also be areas where harvesting has never occurred, and therefore the presence and distribution of goose barnacles in these areas remain unknown.

Overall, interviews provided useful information that was previously lacking. Harvest location reported on harvest logs was mostly by DFO Statistical Areas and Subareas, which do not provide bed-specific information. Georeferenced harvest locations were seldom obtained, as the majority of goose barnacle harvesters did not have Global Positioning System (GPS).

Modifications to the survey design

Based on discussions with harvesters on their understanding of the biology of goose barnacle, two data fields were added to survey sheets (circled in Figure 6). It was recognized that preferred, harvestable, goose barnacles are mostly attached to mussels or acorn barnacles. Therefore, the depth of the mussel and/or barnacle community was added as a data field to give a measure of the matrix constituents. Within a specific quadrat, not all goose barnacles are of good quality. To reflect this, and to eventually adjust the harvestable biomass estimate, an experienced harvester participating in the survey assessed the amount of harvestable barnacles in each quadrat.


Date:________________ Time start:__________ Time end:___________
Site:____________________________________ Bed #:_________
Transect #:______ Transect Length:________ Bearing:____________
Latitude:_______________ Longitude:_______________

Quad #	R #	Quadrat Distance	Count	Matrix Depth	Bio	Elevation	Harvest Potential	Description
1								
2								
3								

Figure 6. Example of data sheet used in the field survey. Data fields added based on discussions with harvesters are circled in red.

Concerns were expressed by harvesters as to why low density or empty quadrats would be enumerated in a random survey design of a delineated bed. Experimental survey design and statistical analysis are concepts that are difficult to explain and justify to people with no formal scientific training. The immediate goals of science staff and harvesters appeared to diverge. On one hand, harvesters wanted to see results showing relatively high densities. However, using only high-density quadrat data in extrapolations would have resulted in a high biomass for a relatively small area and exclusion of potential biomass in lower density areas. In contrast, researchers strive for the most realistic estimate, with valid confidence intervals. This is achieved by enumerating an appropriate number of quadrats (including low and zero density quadrats), extrapolating densities over the total bed area, and obtaining a total harvestable biomass estimate. The long-term goal of both harvesters and researchers is to establish a sustainable harvest and to achieve long-term stability of harvested beds.

Experimental harvest - Fall 2000

In total, eleven harvesters participated in an experimental harvest of 1,800 kg of goose barnacles. Valuable information was collected on the amount and type of discard, methods of harvest (acorn barnacle substrate vs California mussel substrate), recruitment processes, recovery time, and the ecosystem impacts of harvests.

When comparing pre- and post-harvest biomass estimates, only the Food Island site in the Ucluelet area showed a significant difference (Figure 7). Level of harvest varied from 0.15 kg/m^2 (Nicolaye Channel site, Kyuquot area), to 1.44 kg/m^2 (Starlight Reef site, Ucluelet area). 3 to 36% of the estimated site biomasses were harvested in 2000. Fishers' concerns about concentrated effort in limited areas during the experimental harvest, lead to design changes in the 2001 experimental harvest, resulting in an expansion of the areas permitted for harvest.

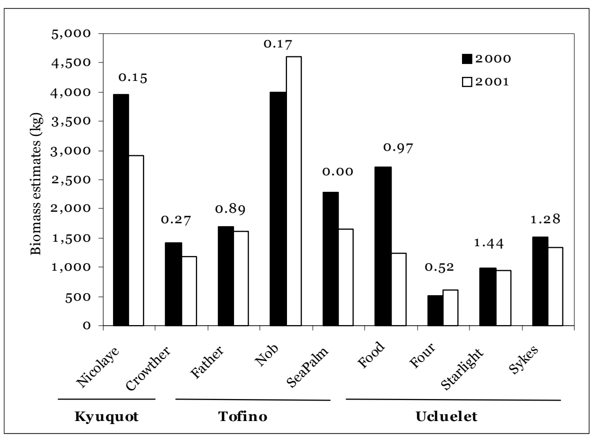


Figure 7. Biomass estimates for the 2000 and 2001 surveys by sites. The amounts of goose barnacle harvested during the fall 2000 experimental harvest are in black.

CONCLUSIONS

It is difficult to assess the completeness and accuracy of anecdotal data, but this does not detract from its importance for consideration when assessing a traditional fishery. Anecdotal data used in this study is the result of long-term (years and generations) personal observations. There were disagreements amongst experienced harvesters as to what constituted a good fishing area or a harvestable clump of barnacles as personal perspectives vary. Some anecdotal information may be flawed. However, absolute terms or values are not always necessary if trends are all that is required to direct a scientific study in the right direction or to formulate the relevant questions for an investigation. One of the lessons learned in this study is that a large amount of anecdotal information provided tendencies and directions that would have taken years to assimilate in a scientific study.

Collecting anecdotal information has also provided an opportunity to establish improved communication among stakeholders. Harvesters provided information to researchers and resource managers that was not otherwise available, and information was provided to the harvesters as to the information requirements for a sustainable fishery. Consulting with harvesters before and during surveys, integrating their knowledge in the study design, as well as soliciting and seriously considering their advice greatly increased their cooperation with DFO. With improved working relationships, common short-term and long-term goals have been established. The GBWG is expected to continue to have a significant role in defining who will participate in any future commercial fishery. It will also actively influence the development of the final management strategy.

In conclusion, integrating traditional knowledge and anecdotal information with the scientific information derived from literature surveys and biological surveys has been a positive experience that has lead to better understanding of the dynamics of the goose barnacle community and the impacts of harvesting activities.

ACKNOWLEDGEMENTS

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Questions

Ron Hamilton: I'm from the area where most of your slides were taken. My mother's people have been fishing in that area, according to archaeologists, for 4000 years. The title of your talk says putting fishers' knowledge to work, but you didn't say anything about using the knowledge of my people, or the traditional methods for fishing. Have you done any work in our community?

Joanne Lessard: Yes. Some are involved in the working group.

Ron Hamilton: Your slide says "Fisheries", but you only referred to the commercial fishery. It seems that our history in the area is always ignored. You didn't find it important enough to put it in and the only thing you thought was important enough was the commercial fishery. Do you know about the war between the Maaķtlayt-h and the Hachaa-at-h over the gooseneck barnacle? Have you read about it? It shows how important the species is to us.

Eduardo Espinoza: How do you appraise the quality of your information?

Joanne Lessard: This is a big problem. There is no easy way to verify the information. For the other anecdotal knowledge, hopefully an ecosystem assessment will verify it. I don't know the results of that assessment. When the fishery was closed, we couldn't get much information.

PARTICIPATORY RESEARCH IN THE BRITISH COLUMBIA GROUNDFISH FISHERY.

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ABSTRACT
The benefits of full participation by fishers in stock assessment research are demonstrated through two examples from the groundfish fishery in British Columbia, Canada. The first example summarizes a joint acoustic study to estimate the biomass of a shoal of widow rockfish (*Sebastes entomelas*) in BC waters. In this example, the fishers posed the initial experimental hypothesis, provided the essential background information needed to plan the study, and were full participants in the conduct, analysis, and documentation.

The second example describes the impact of a fisher critique of a stock assessment of silvergray rockfish (*S. brevispinis*). They argued that the observed trends in size and age could have been caused by the introduction of Individual Quota Management, because IVQ's had led to subtle shifts in the spatial distribution of catches. In response to their criticism, a preliminary study was jointly conducted; the results of which partially supported their concern. These results are now being used to improve the sampling and assessment techniques.

We suggest that it is a mistake to focus on fishers simply as data collectors or knowledge sources, thereby ignoring their skills in hypothesis formulation, research design, and interpretation. Phrases such as "incorporating fisher (local, or traditional) knowledge" are not only incorrect but are pejorative in implying that fishers are limited in what they can contribute to the scientific process. We suggest that Participatory Research represents a more effective intuitive framework for incorporating their full expertise into fisheries research. In this paper, we have summarized the characteristics of two studies that facilitated the participation.

INTRODUCTION

Fisher Knowledge is a pejorative phrase!

There are demands from many quarters that fishery research and management be more effective in collecting and using "local" or "fisher" knowledge. As commented by Roepstorff (2000), any catchy first word and "knowledge" will suffice in this context (see also Agrawal 1995 and Sillitoe 1998). The premise is that individuals who are intimately associated with the resource have a wealth of knowledge that can enhance research and improve management. Mackinson and Nøttestad (1998) state that this knowledge is either overlooked or dismissed immediately without consideration, apparently by all researchers and managers. It is widely asserted that continued failure to use these assets will lead to poorer research and management failure (Dyer and McGoodwin 1994, Gavaris 1996, McGoodwin *et al.* 2000).

The previous papers have emphasised the role that fishers can play both in data collection and demonstrate the wealth of *-knowledge that fishers possess (McGoodwin *et al.* 2000, Ruddle 1994, and particularly, the exceptional work of Johannes 1978). Some emphasise specific topics for which fisher knowledge is most useful. For example, Neis *et al.* (1996) report on the knowledge of stock structure changes in catchability, information on abundance in a closed fishery, and the potential impacts of re-opening. Fischer (2000) identifies the information available on "local fishing performance" and the "physico-chemical environment and living aquatic resources".

Governmental policy commitments also acknowledge the potential value of *-knowledge. The Department of Fisheries and Oceans (DFO), Canada instituted the fisher-based sentinel survey program in 1994 for East Coast groundfish, in part to: "… blend the traditional knowledge of fishermen with the objective rigour of scientific data gathering." (Hon. B. Tobin, Minister of Fisheries and Oceans, Sept 1994). In the same year, DFO also made a commitment to bring *-knowledge into the peer review and advisory process (Boulva 1994).

This trend is not uniquely Canadian. The International Council for Exploration of the Seas (ICES), the principal marine and fisheries science advisory body for the North Atlantic, is in the process of bringing resource users into its review and advisory processes. To the south, the U.S. National Marine Fisheries Service has funded a large number of collaborative programs. These include US$5 million allocated for the "Cooperative Research in the Northeast" program, and the US$90 million allocated for cooperative research projects on salmon with fishers, tribal councils, and communities in the Pacific Northwest (OMB 2001). The International Pacific Halibut Commission

(IPHC) has also established an industry-composed Research Advisory Board that not only reviews IPHC research programs but actively participates in the design and implementation of many research programs (B. Leaman, pers. comm.[1])

The call to make better use of *-knowledge is justifiable; however, the greatest gains may come from changing the nature of the interaction. We suggest that compartmentalising and confining the potential contributions from resource users as cheap data collectors or as sources of background knowledge is missing the point, if not condescending. It ignores the greater potential benefit and enrichment that comes from working with equals, rather than with unpaid technical help. The literature from agricultural extension work has, for some time, emphasized that these same possessors of knowledge are also effective at hypothesis formulation, experimental design, and interpretation (Sajise 1993, Sillitoe 1998). This premise also has a history in terrestrial ecology, where "amateur naturalists" have long had a respected role as observers of nature, and as framers and testers of hypotheses about the areas that they knew well. As posed by Sajise (1993), how could knowledge accrue (as opposed to just being passed on) without someone applying elements of the scientific method:

> *"There is ample evidence now [in the field of agriculture] that local people do their own research; maybe not in the same formal and rigorous way that researchers do it in terms of having statistical designs, replications and anlaysis but they do* research" (Sajise 1993, p.3)

Even the simple process of data gathering should be viewed as a cooperative task. To gather new information, people must be involved emotionally in the process (Zajonic 1980). In field ornithology, the astuteness of the observations of dedicated naturalists has long been acknowledged as a touchstone for observations and theories of "professionals". This potentially rewarding interplay between those closest to the resource and those conducting scientific studies also underscores the need to create a willingness among all parties to share data, and collectively reach a better understanding of the resource (Brown 1988).

Although the scientific skills of resource users are now well recognised in agricultural research, they are rarely acknowledged in fisheries literature even by those who emphasize that fisher knowledge is under-utilised. Exceptions include comments that fishers are effective at formulating testable hypotheses (Neis *et al.* 1996, Hutchings 1996, Ames *et al.* 2000).

The tendency to compartmentalise the potential contribution by fishers results from a reliance on the "data collection" model for linking fisher knowledge (Fischer 2000) to other sources of information on stock status. It assumes that for local knowledge to contribute it must be systematised, stored, manipulated, and made intelligible to others in a manner similar to treatment of data from conventional monitoring sources (Ferradás 1998). Although there is a place for this model, it represents an appending of fishers to conventional scientific research as junior partners. It maintains for researchers, the "we vs they", and the "*-knowledge vs science" dichotomies (see discussion notes appended to Sillitoe 1998). We argue that fishers' experiential knowledge is not only sophisticated, but also derived from their skills as experimenters. Fisheries research should move towards the Participatory Research (PR) model long recognized in agriculture (Chambers *et al.* 1989, Sajise 1993) but only recently acknowledged in fishery research (McGoodwin *et al.* 2000, Neis and Felt 2000).

As outlined by Fischer (2000), PR is a joint exercise by a team, in which the so-called researcher is an influential member but does not occupy the top position in the traditional hegemonic framework. The participation can be "full" wherein all players participate in development of questions, hypotheses, design, and execution. Participation can also be marginal; consisting of simple data collection such as completion of logbooks, or assisting with tag recovery activities. This model already has well-established precedents in multi-disciplinary scientific research wherein fisheries scientists, physical and biological oceanographers, statisticians and modellers have collaborative projects. A single team member may be accountable for administrative aspects of the project, but acknowledges other team members as peers in planning, conducting, and interpreting the science. It should not be considered revolutionary to view partners from the fishing industry in a similar light.

In this paper, we describe two examples of PR from research on the groundfish fishery off the

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West Coast of Canada. We suggest that they indicate the effectiveness of PR and show that the distinctions made between data collection, knowledge gathering and application of scientific method, cease to be meaningful within the context of genuine participation. The paper is written in the narrative style of chronicling the studies as they transpired as opposed to the usual methods-results-discussion sequence of scientific articles. It seems more effective in this case, because the message lies in the process as much as in the results. The narrative style captures the interpersonal nuances that increased the effectiveness of the studies. Following the two examples we summarize the characteristics of the work that facilitated the participation and conclude with general commentary on the role that PR can play in fisheries research. Although our discussion relates to commercial fishers, we suggest that the principles apply equally to other harvesters or knowledgeable partners.

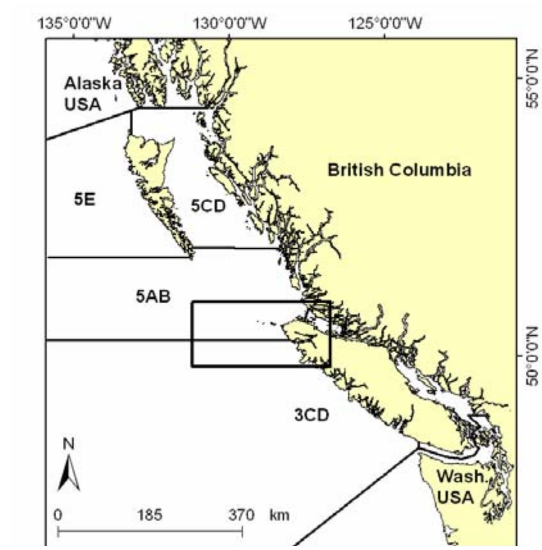

Figure 2. Location of widow rockfish study area and silvergray rockfish assessment regions. Inset indicates area shown in Figure 2.

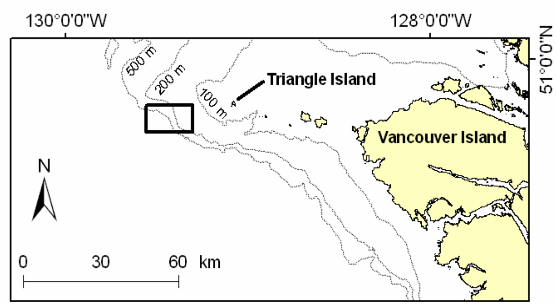

Figure 1. Location of widow rockfish study site off the northwest coast of Vancouver Island. Inset indicates area shown in Figure 3.

Example 1: Acoustic estimation of widow rockfish (*Sebastes entomelas*)

Background

We first present a two-year study of a mid-winter shoal of widow rockfish off the central coast of British Columbia (BC) Canada (see Stanley *et al.* 2000 for details on the acoustics and estimation methodology). Figures 1 and 2 illustrate the study site. Rockfish (*Sebastes* spp.) are a particularly appropriate genus for PR because there have long been differences of opinion between stock assessment staff and industry experts regarding biomass estimates and quotas. (Leaman and Stanley 1993).

Rockfish are thought by government assessment staff to have been severely overfished by foreign fleets before 1977 (Archibald *et al.* 1983). Furthermore, age composition of catches also implied a low natural mortality rate (M); probably less than 0.05 (Archibald *et al.* 1981). The implied low productivity and history of overfishing has led DFO implement conservative harvesting regimes for trawl-caught rockfish for more than two decades. From the industry perspective, there is no corporate memory among fishers of "proven" overfishing for these stocks. This combined with the strong acoustic sign and high catch rates of these aggregating species imply to fishers large biomasses relative to other species, inconsistent with the "low" rockfish quotas.

Unfortunately, many of these shoaling rockfish species show a fondness for untrawlable bottom, which presenting severe problems for swept-area survey methods for estimation of abundance. The shoals also show an affinity for near-bottom distribution, limiting the effectiveness of acoustic estimation methods, although the shoals can reflect a strong acoustic signal. With general distrust of commercial CPUE as an abundance index, there was no means for resolving the issue to either party's satisfaction.

In this context, the senior author, a government biologist, made a trip aboard a commercial trawler in 1996 to discuss recent stock assessments with the skipper, Captain Brian Mose, an industry advisor on groundfish management. During the many long discussions in the wheelhouse, Capt. Mose commented that most fishers felt that widow rockfish quotas (Stanley and Haist 1997) were overly conservative. The fishers were aware of one shoal of widow rockfish, which, if estimated, would probably indicate by itself that coastwide biomass estimates for this species were too conservative. Furthermore, this shoal, which regularly formed each winter off the central coast of BC, was predominantly widow rockfish, off bottom at dusk, and predictable in its occurrence, thus making it a reasonable candidate for acoustic estimation. Captain Mose noted that even if the study failed to indicate a large biomass, the study could only help since it would be the first directed field research on this species in Canadian waters. It was also noted that the estimation of one rockfish shoal would provide a much-needed quantitative reference point for enhancing dialogue between fishers and biologists about what fishers observed on their sounders and in their nets. Finally, while not explicitly thought of as PR, the principals hoped that the program would serve as a model for developing closer research collaboration between industry and government staff.

Methods and Results

Surveys of the shoal, located at the edge of the continental shelf, were conducted in early February of 1998 and 1999 (Stanley *et al.* 2000, Wyeth *et al.* 2000). Timing and location were based on fishers' knowledge. Two commercial trawlers, the "Frosti" (1998) and the "Viking Storm" (1999) were the catcher vessels and provided the acoustic scouting. During the study, these vessels conducted mid-water trawl hauls to identify species and size composition of the shoal. They also sounded the perimeter of the study site for evidence of movement to and from the area. Costs of these vessels were provided by a trawl fishery association, the Canadian Groundfish Research and Conservation Society (CGRCS). In addition to the activities of the charter vessels and concurrent with the study, the team requested that all active fishers communicate the location and dimensions of any other widow rockfish shoals that were observed.

A fisheries research vessel, the "W.E. Ricker", provided the acoustic platform. In addition to the captain running the charter vessel, an additional trawl-fishing captain was on board the W.E. Ricker in both years. The captains participated equally with regard to survey design and assisted with scrutinizing the acoustic data. For example, they recommended that a deeper acoustic sign at 225 m was that of yellowmouth rockfish (S. reedi) and should be excluded from the biomass estimate.

Prior to the arrival of the W. E. Ricker, the study team on the commercial trawler scouted the site to select the acoustic transects. An important element of the interaction was to circumscribe the shoal to the satisfaction of all participants while still accommodating sea conditions and orienting the transects perpendicular to the longitudinal axis of the shoal.

The team selected 11 transects in 1998. These extended across the shelf break (Fig. 3) and covered a total area of about 25 km². The set of transects were travelled in the same direction and order. At the completion of each of 20 replicates, the vessel returned to the start point. During each return trip, the fishing captain piloted the W.E. Ricker over the longitudinal axis of the shoal, to re-affirm the general location of the shoal. Each replicate and return trip required two hours. The design was similar in 1999, except that the transects were spread over a broader area to encompass additional acoustic sign to the northwest (Wyeth *et al.* 2000).

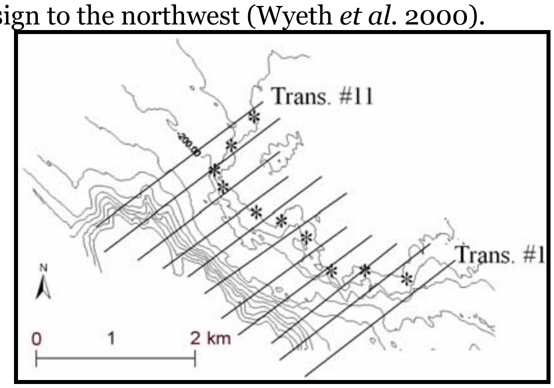

Figure 3. Location of transects relative to longitudinal axis of the widow rockfish shoal (*= approximate shoal location).

One of the most exciting and effective aspects of the study was that acoustic specialists on the W. E. Ricker were able to provide biomass estimates of the shoal during the cruise. Thus, by the completion of the 10th replicate in 1998, the team was aware that the estimates were consistently indicating about 2,000 t of widow rockfish. While disappointing to the team, since these values did not disprove an implied coastwide biomass of 15,000-30,000 t, the immediate feedback provided the opportunity to vary the design to see if some of the biomass was being missed.

The fishing captains questioned in particular whether the 11 repeated transects were, by chance, consistently missing the denser portions of the shoal. They hypothesised that the biomass estimates could be highly sensitive to transect choice owing to the variable density within the shoal. The team had planned to repeat the same transects to study diel vertical movement, however, since the credibility of the estimates was at stake, the team chose to vary the design. Starting with replicate #11, the entire pattern was progressively offset to the northwest by approximately 180 m. While the new sets of transect still indicated about 2,000 t, making the modification not only tested the robustness of the estimates, but assured the fishing captains that they were equal participants in the study. The fishers' concern about the representativeness of the transects was viewed as a valid scientific question that should be addressed.

Although changing the transects helped reduce scepticism about the estimation process, the fishing captains remained concerned that the survey spent too little time over the shoal and too much time where there were no fish. Therefore, they surmised, it could lead to a biased estimate. The team accommodated this concern by extrapolating a biomass estimate from each return trip that ran over the longitudinal axis of the shoal. Fish density estimates for these transects were extrapolated under the assumption that the shoal was 0.5 km wide, the approximate average width of the shoal. The team found in both years that although these single transects concentrated on the shoal and provided a consistent display on the monitor, the extrapolations did not indicate any more biomass estimates than the standard design.

Finally, the fisher captains questioned whether a 2000 t estimate was consistent with the fact that they could catch from this shoal up to 50-100 t in a few minutes. The team therefore convened a small meeting aboard the W.E. Ricker during the 1998 cruise. The observed density estimates were converted to potential catch rates based on the net specifications and simplified assumptions of catchability. These estimates were found congruent with the catch rates the fishers had observed. The importance of this interaction was that the referential ground-truths of all participants were given their due. Scientists might have responded that commercial catch rates were simply not a concern. They had used an acoustic methodology that is documented, peer-reviewed, and scientifically sound. However, what comes up in a net is the real point of contact between those who fish and what is in the sea. The fishers were correct in suggesting that acoustic estimates of densities and maximum catch rates had to be congruent, or somewhere there was an incorrect assumption or calculation.

Encouraged by the success with one shoal in 1998, the senior author was ready to expand the approach and attempt a coastwide biomass estimate in 1999. However, during the follow-up meeting, the industry commented that while widow rockfish were caught elsewhere on the coast, they were so unpredictable in time and space that a large-scale survey would likely be unproductive. Thus, within the course of this project, the fishers not only identified a fruitful direction of research, but also prevented a wasteful one.

Instead of an expanded survey, the team re-examined the same study site in 1999. The two main objectives were to ensure that the 1998 estimates were not anomalous and to obtain estimates during days with stronger tides. In reviewing the 1998 study, fishers commented that the shoal had been estimated only during days of the weaker neap tides. They typically saw more acoustic sign and had higher catch rates on days when the tides were strengthening, just prior to the new or old moon. The 1999 results indicated a similar biomass as 1998, and provided no evidence of a significantly larger biomass during days with stronger tides. At conclusion of the study, there was a consensus that the project had exhaustively addressed the initial question of estimating the biomass of the shoal.

The team's success in 1998 also led them to examine the potential for conducting acoustic biomass estimates directly from commercial vessels. The practicability of adapting commercial fishing vessels to acoustic research platforms had already been demonstrated for herring on the Canadian East Coast (Melvin *et al.* 1998). The 1999 field trip successfully connected digitising equipment to the sounder on the Viking Storm. The calibration was successful and inter-calibration with the W.E. Ricker system indicated that the acoustic output was comparable (Wyeth *et al.* 2000). This confirmed that future shoal estimation could be conducted directly from commercial vessels.

EXAMPLE 2: SILVERGRAY ROCKFISH (*SEBASTES BREVISPINIS*)

Background

The second example chronicles the events related to an assessment review of silvergray rockfish (Stanley and Kronlund 2000). This species is a minor element in the BC bottom trawl fishery with annual coastwide harvests of approximately 1000 t from four areas (Fig. 4). Although the harvest is small, the choice of quota is contentious. Each vessel requires sufficient individual vessel quota (IVQ) of silvergray rockfish to accommodate the bycatch of silvergray rockfish that accrues as they target other species. If an increase in abundance of silvergray rockfish is not matched by a higher quota, the species becomes an increasing nuisance in that other species cannot be fished without the vessels exceeding their IVQ's for silvergray rockfish. With 100% observer coverage, vessels may have to stop fishing completely when they reach their area-specific silvergray rockfish IVQ although they may not have captured the remaining IVQ's for other species.

Assessment information on silvergray rockfish is limited. Commercial CPUE is not assumed to index abundance and fishery independent indices are not available for a variety of reasons (Stanley and Kronlund 2000). The lack of a credible abundance index forces assessment staff to rely primarily on untuned catch-at-age stock assessment. These analyses indicated that the fisheries on three of the four stocks are currently relying on a strong recruitment mode centred on the 1981 yearclass. Although difficult to distinguish from increasing recruitment, the analysis indicated a modest fishing down of older age classes. This apparent reduction in the older ages was interpreted as indicating that exploitation has been at, or above, a sustainable rate, at least prior to the current recruitment pulse. Hence, although the stock is currently benefiting from the presence of a large yearclass the estimates of instantaneous fishing mortality (F) indicated that harvests should not be increased.

The trawl fishery representatives commented that silvergray rockfish were becoming harder to avoid, which implied to them that biomass was increasing and therefore the quotas should be raised. Furthermore, they suggested it was incorrect to assume comparability in the age composition over time, because the fishing locations had changed. They noted that samples had been collected from commercial landings on an opportunistic basis, such that sample location was determined by the fishery. With the introduction of IVQ's in 1997, the small individual quotas for silvergray rockfish had forced the fleet to move away from areas of higher catch rates. Most of the catch, and therefore the samples, were now being collected from other locations where silvergray rockfish catch rates were lower. They reasoned that the age composition might differ in the new locations. Therefore, it was incorrect to infer population dynamics from trends in the age composition.

The senior author responded that a simple review of the distribution of the samples had not revealed gross changes in area or depth of capture. Because there was no demonstrable bias in age composition, the stock assessment advice was accepted as the basis for the management plan.

Methods and Results

Following the review process, the senior author conducted an observer trip on another commercial trawler, the "E.J. Safarik" in February 2001 with another industry associate, Captain Reg Richards, one of the principal trawl fishers operating in Area 5E. Captain Richards had been an advisor during background work on the assessment, and was critical of the resulting quota. The objective of the trip was to provide the senior author with an opportunity to discuss the assessment as well to provide Captain Richards the opportunity to demonstrate how IVQ's might have changed the sampling of silvergray rockfish in Area 5E.

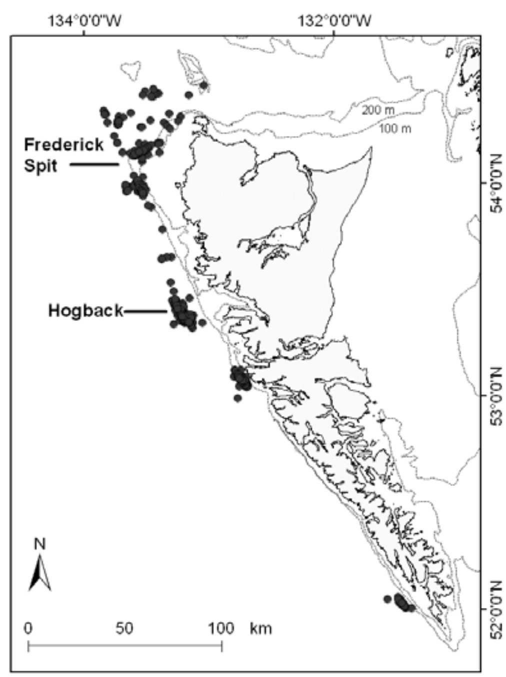

Figure 4. Locations of bottom trawl tows which captured at least 200 kg of silvergray rockfish. Data are from 1996 to September, 2001.

Captain Richards explained that the fishery for silvergray rockfish had traditionally concentrated on the "Frederick Spit" grounds near the Canada/Alaska border (Fig. 4). With introduction of IVQ's in 1997, the fishers had switched to the "Hogback" grounds to avoid high catch rates. There they targeted on redstripe rockfish (S. proriger) while slowly accumulating their IVQ of silvergray rockfish. He questioned whether the relative absence of older fish from recent samples might have resulted from the shift in source of the samples from the Frederick Spit to the Hogback fishing grounds. He offered to conduct 1-2 tows on both spots so that the senior author could obtain a comparison of the age composition.

When the three samples were collected and analysed, they indicated a significant difference in age composition (Fig. 5). The Hogback sample indicated the typical 1981-recruitment mode, whereas the two samples from Frederick Spit were much older. This led the senior author to look more closely at the spatial distribution of the samples used in the stock assessment. These indicated that through 1998, the samples were representative of the entire area and consistent in age composition over time and space (Fig. 6). Thus, the assessment, based on data through 1998, was not biased in that respect. However, as of 1999, the samples were restricted to the Hogback. Thus, the fishing captain's concerns had revealed that the fortuitous representativeness of the commercial sampling was deteriorating and future assessments would be compromised.

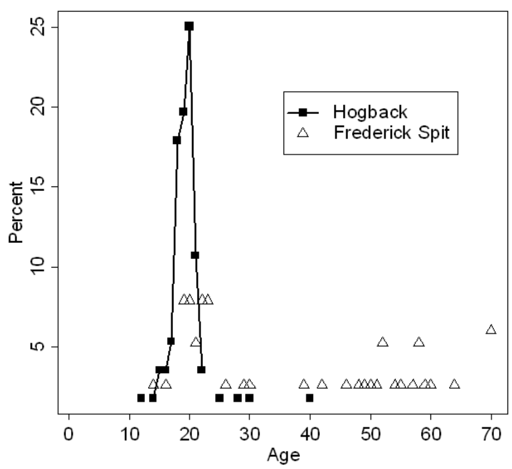

Figure 5. Percent composition by age of silvergray rockfish samples taken during February 2001 observer trip.

The concern that age composition might vary with changing fishing patterns led to discussions with Captain Richards over how to consistently obtain representative samples from the whole area. The senior author could not envision a survey that could provide the samples without capturing most of the 5E quota of about 200 t. Captain Richards proposed a solution wherein he would trawl a set of specified tow locations but avoid excessive catches by cutting a hole in the forward part of the codend. This mini-survey is planned for January 2002. In addition to this attempt to modify sample collection, the senior author noted that future assessments would pay more attention to the fine-scale spatial distribution of the samples.

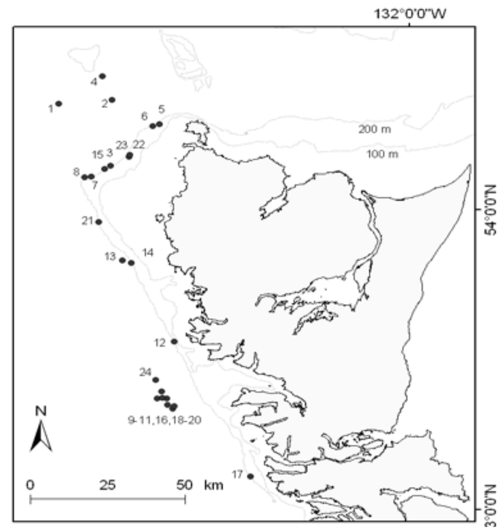

Figure 6 Location of silvergray rockfish samples used in 2000 silvergray rockfish assessment for area 5E (Stanley and Kronlund 2000).

Further analysis indicated that the two 2001 Frederick Spit samples differed not only from the 2001 Hogback samples but from all previous Frederick Spit samples. They differed although they were collected within a few kilometres, in the same months, and only a few meters shallower than previous samples. When informed of the results, Capt. Richards commented that these slightly shallower locations were rarely fished. While attempting to provide the silvergray rockfish samples from the Frederick Spit sound, he had moved slightly shallower in hopes of also obtaining canary rockfish (S. pinniger) to sample. He hypothesised that the older fish represented an unfished group of "homesteaders". There has long been a suspicion among biologists that some rockfish species may exhibit a range of behavioural modes, ranging from highly mobile to refugial (MacCall *et al.* 1999).

Discussion

Data collection, fisher knowledge and science

The two cases provide numerous examples of the data collection opportunities provided by commercial fishers and the role that fishers' knowledge can play in assessment research. Background information and integrative thinking was required to conceive and conduct the widow rockfish survey. Fisher awareness of how the fishery was evolving in response to IVQ's led to the perspicacious critique of the silvergray rockfish assessment.

More importantly, the two examples show that fishers bring far more to research than cheap data collection and background knowledge. The initial hypothesis for testing the biomass of the widow rockfish shoal was generated by the fishers. Similarly, the request by fishers to examine the sensitivity of the estimates to transect choice enhanced the credibility of the estimates to all participants. The critique by fishers following the 1998 survey also led to the test of tide effects in 1999. Furthermore, their knowledge about the coastwide distribution of widow rockfish prevented a pointless and wasteful expansion of the scale of the project

In the second example, it was the fishers' comments about the comparability of samples over time, which led to an examination of the spatial distribution of the samples and illustrated the need for a more rigorous sampling design. In this case, the quality of future assessments will be improved because the fishers used their knowledge to pose alternative hypotheses and suggest ways to test them. Participatory Research thus integrates questions raised by the observations of traditional users with typical activities of government and academic researchers (Pinkerton 1994).

The participatory nature of these two studies also provided benefits beyond the stated objectives. Fishers aboard the research vessel, and those that visited during harbour days were introduced to high quality digital acoustic equipment and to the methodologies and assumptions that are required to convert digital backscatter measurements to biomass. They not only became educated about the strengths and weaknesses of acoustics for assessment, but also learned that output from split-beam sounders can provide information on fish size frequencies. This equipment is now being purchased by the trawl fleet to help reduce bycatch during midwater trawling (B. Mose, pers. comm[2].). Conversely, fishers educated acoustic staff about the nature and variability of the echo sign they have observed and the extent to which side-lobe interference over high relief bottom can generate false fish sign. Although this phenomenon is well known, the actual examples surprised acousticians leading to changes in how echograms are scrutinized following surveys of near-bottom species (R. Kieser, pers. comm.[3]).

Tactics which facilitated participation

The participation was facilitated by a variety of attributes of the studies; however, we emphasize that the following discussion is largely from hindsight. None of the participants was aware of the extensive literature pertaining to *-knowledge or PR, nor was the present document a planned outcome.

Both initiatives were facilitated through joint meetings during observer trips and stock assessment meetings and therefore, represent time away from traditional roles and being on the other's "turf". Both initiatives required that participants question each other in their areas of expertise. Just as the questions had to be posed with appropriate respect, the answers had to be complete and non-defensive. The scientists had to abandon the attitude of "leave the science to us", as the fishing captains had to accept that that objective, quantitative verification of viewpoints is essential to resolving differences in points of view or hypothesis testing.

The participation was also facilitated by computer technology. This included our ability to provide biomass estimates during the survey and the use of 3-dimensional graphics to present the finished results (Stanley *et al.* 2001). While not available to all studies, they illustrate the benefits in participatory research of rapid feedback (Zwanenburg *et al.* 2000) and the value of mutually understandable graphical images (Walters *et al.* 1998).

Much of the previous discussion relates to enhancing communication. While an obvious goal, an interesting example of the cost of not communicating is provided by a retrospective look at the early days of stock assessment in BC from approximately 1980 to the mid 1990s. During those years, fishers were excluded from assessment meetings because, among other reasons, it was felt that their presence would promote biased interpretations of results and inhibit debate among the scientists.

It was believed that bias would be promoted because it was assumed that the financial interests of fishers would render them unwilling to contribute objectively. This risk cannot be ignored, but we have found that trust and respect among fishers and assessment staff can be a sound foundation for candid and objective

[2] B. Mose. 641 Hollywood Rd, Qualicum Beach, BC. V9K 1M3.

[3] R. Kieser. Fisheries and Oceans, Canada. Pacific Biological Station, Nanaimo, BC. V9R 5K6

exchanges in many settings, including assessment meetings. Moreover, it is well documented that scientists do not have a flawless record of objectivity. For example, instances of confirmatory bias are very common in science (Nicholls 1999). Even when scientists specify the error rates that are the basis for traditional hypothesis testing, or the probabilities associated with Bayesian decision support (McAllister and Kirkwood 1998), fisheries data are highly uncertain. This makes the tails of the likelihood profiles poorly determined, and the reliance on formal use of probability-based methods more form than reality (Patterson *et al.* 2001). Often the nature of the dialogue in an assessment meeting must focus more on the justification for assuming that alternative information sources and interpretations are reliable and credible, rather than on statistical nuances that have weak empirical foundations. Hence, without actually lowering their standards of rigour, the science participants may find other grounds for accepting and rejecting ideas that are both sounder and more meaningful to their research partners.

An example of an overly ambitious attempt to invoke rigour relates to estimation and mis-use of relative error from biomass surveys. In the 1980's, government and industry assessment consultants estimated relatively tight precision around the biomass estimates following 3-week surveys. Fishers questioned how scientists could be so sure of the precision, when fishers observed for some species, an order of magnitude variation from one set of lunar tides to the next. The assessment staff were using the relative error calculated from individual surveys as a surrogate for the expected "within-year" variance of the abundance index. Although discontinued for these stocks, this remains a common practice in stock assessment although numerous studies have shown much greater variance among replicate surveys than what is inferred from individual surveys (Stanley *et al.* 2000). This statistical short-cut obviously results from the prohibitive expense of conducting replicates or extending the duration of surveys. Nevertheless, fishers' intuition was correct in that precision inferred by assessment staff could not truly reflect the background "noise" that should be expected in the index.

The fear that debate would be suppressed by the presence of industry representatives arose because it was assumed that fishers would equate "uncertainty" with a lack of knowledge (Preikshot 1998) and that this would further erode credibility in the assessment advice. However, excluding fishers from the healthy debate reinforced their belief that researchers overestimated the accuracy of their stock assessments.

Once fishers observed and participated in the debate, they became reassured that researchers and managers understood the limitation of the data, the techniques, and the advice. Fishers were already experientially aware of how hard it must be to estimate abundance. What worried them was the possibility that research staff did not know it. Fishers may become more sceptical of the science the more they know; but scepticism is a good thing when it prompts constructive follow-up (McGoodwin *et al.* 2000). While still evolving, the process for BC groundfish has now progressed from where fishers and other interested groups were present only at the final review meeting, to being present at a series of meetings. These include workplan prioritisation and a pre-assessment meeting in which authors outline the data sources and methods that will be used.

This trend is not limited to the research on Canada's Pacific coast. As stakeholders have taken an increasing role in assessment meetings in Canada, documents from the Canadian Stock Assessment Secretariat Proceedings provide growing evidence of their interpretative skills. Summary documents frequently include a section on "Industry Perspective" (see Stock Status Reports on http://dfo-mpo.gc.ca/csas).

Strategies which facilitated participation

A strategic issue that contributed to these studies was the growing role of industry-funded research. It not only increases the available resources, but also by decentralizing the control of resources leads to new research directions (Chambers 1989). We do not argue that industry should control all or most resources, but do argue that there are benefits when they have significant influence.

These industry-based research organisations also provide venues for fishers to discuss scientific ideas, directions, and hypotheses apart from the tense atmosphere of stock assessment or management meetings (B. Turris, pers. comm.[4]). It has been conjectured that an essential step to maximising the value of resource users as research partners is to support mechanisms that encourage the users to seek excellence and test

[4] B. Turris. Canadian Groundfish Research and Conservation Society. 333 Third St., New Westminster, BC. V3L 2R8.

ideas together, on their own terms, and in their own language (Rice 1998). The research collaboration is then the blending of ideas that meet standards of excellence applied by both the scientific and user communities. These meetings are thus industry analogues to scientific conferences and workshops. Assisting the blending of ideas is the growing tendency for these industry organisations to fund science-industry liaison positions (V. Boudreau, this volume) and hire fisheries data analysts. The liaison positions work to keep communication lines open. The consultants provide an increased opportunity for fishers to question and understand technical issues. The "tutoring" process is especially important because of the technical syntax employed during official meetings. Fishers often complain that technical staff should make a bigger effort to make their presentations more understandable. Finally, the allocation of research funds by these groups has educated them in the cost of science (and educated scientists in the cost of fishing), just as joint authorship of a primary paper (Stanley *et al.* 2000) conveyed to fishers the commitment required to communicate research results.

Using examples from our work and that of others, we have identified some means for enhancing communication and building relationships that lead to PR. Tactics notwithstanding, PR ultimately relates to the process of building mutual respect. The most important attribute of the two examples, was the willingness of both parties to view and identify the problems with respect to each party's terms of reference. Both studies benefited from the collaborative atmosphere in which neither "scientific" nor "fisher" interests felt threatened, and all parties were assured that they brought vital skills and knowledge (Sillitoe 1998).

Participatory Research can thus be both a means and an end (Sajise 1993). It appears to be a means for coping with the "Conflicting dogma of the omniscience"...that researchers know better because of their formal education, and fishers know better because of their experiential background. It tends to break down the hierarchical vision of knowledge wherein the higher order science is considered the work of the privileged and the business of people formally trained in public institutions (Pálsson 2000).

Developing this working relationship is a two-way process (see many other papers in this volume). As government staff work to change their style (McGoodwin *et al.* 2000), and mature the relationships with their clients, so must their clients. Candid commentary from either harvesters or environmentalists can only be expected in an atmosphere of respect (B. Dickens, pers. comm.[5]), and when all participants share a goal of finding solutions, not merely getting attention. A commitment to PR fortunately makes this an attainable goal.

The costs and risks of participatory research (PR)

While we extol the potential benefits from PR, we acknowledge its costs. While we argue that "one cannot communicate too much" and endorse the idea of paid liaison positions, we must acknowledge that these resources could also be directed at an endless number of other beneficial initiatives. Biologists have much to learn by making observer trips on commercial vessels, but time at sea is time away from detailed likelihood profiling, complex ecosystem modelling, and career-advancing research projects.

We have noted the benefits of having fishers participate in the assessment review, but these same fishers are now complaining of meeting fatigue and are attempting to rotate others into these roles (as, indeed, are many assessment staff). Strategic planning has to cope with these conflicting needs. Our underlying belief is that any initiative that brings more research assets into the process has to be cost-effective.

As PR may incur different costs, it also incurs risks. Building relationships is not a simple matter of parachuting biologists on fishing boats or dragging fishers to stock assessment meetings. All participants need to learn how to critique each others' hypotheses and information, jeopardising neither rigour nor respect. In peer review meetings, there are frequent instances of ill feelings arising among scientific peers due to particularly critical reviews and debate. Even after individual fishermen and scientists have learned to respect and value each others' creative hypotheses, criticism and sources of new information, the relationship can be strained by the challenge function of peer review.

> *"The problems that attend interdisciplinary research are, however, legion; it regularly founders on the rocks of misunderstanding and the unwillingness of specialists to generalize*

[5] B. Dickens. 1678 Admiral Tryon Blvd. Qualicum Beach, BC. V0R 2T0.

> *and compromise. An integrated perspective implies a willingness to learn from one another...."* (Sillitoe 1998, p. 231)

Leaman and Stanley (1993) describe an attempt to improve stock assessment science through PR that partially failed because of a lack of preparation and abundance of naïveté. We could provide similar examples of failures to create working relationships between governments and academic institutions, or academic institutions and harvesters. These initiatives were well intentioned but paid too little attention to project preparation and conditioning expectations, and spent too little time nurturing the relationship. They also may have suffered from attempting too much, too fast. The two examples presented in this document clearly benefited from being small and narrowly defined in scope. As learning to fish can be thought of as a journey by Icelandic fishers, so can we perceive PR (Pálsson 2000). It is part of a long process of small steps wherein harvesting and research could become the same thing (J. Prince, pers. comm[6].).

We have provided two examples of PR and summarized the elements and approaches we think that facilitated the process. It seems like a dazzling glimpse of the obvious, but if it were so obvious, examples of PR in fisheries and marine science would be common, not rare. The overall issue is building effective working relationships, a goal than indeed should be "dazzlingly obvious".

ACKNOWLEDGEMENTS

We note that the two examples provided above are only two examples of many similar activities currently underway within the Department of Fisheries and Oceans, Canada on the Pacific coast. In fact we are obliged to comment that participatory research or studies using *-knowledge have a long history on Canada's Pacific, as we are sure they have had elsewhere. Although these keywords never identified in the publication titles, many fishery researchers over the courses of their careers have accrued extensive commercial fishery time in the process of joint conduct of fishery research with fishers. These would include in BC waters, Neil Bourne, Dan Quayle, Terry Butler, Keith Ketchen, and Bruce Leaman. In fact, the sharing of knowledge and joint participation in fishery research has a long history. It is to be remembered that the first coelacanth specimen was obtained because of shared interest in fishes between a young museum curator and a trawl skipper (Weinberg 1999).

As did the studies summarized above, the present paper benefited greatly from discussions and fishing trips with trawl fishing captains including Captains Kelly Anderson, Brian Dickens, Brian Mose, Reg Richards, and John Roche. Review comments from Bruce Turris, Norm Olsen and Bruce Leaman greatly improved the manuscript.

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Questions

Robert Chriseiger: What is the base of the food chain? What is the source of food for rockfish and hake?

Richard Stanley: They are mostly shrimp from the deep scattering layer.

Robert Chriseiger: Why is it that Americans have banned fishing of krill, but we're taking 10,000 tonnes? That is part of the food chain. It is killing part of the food chain.

Richard Stanley: They assessed the amounts just as they did other species and set a maximum amount to catch.

Robert Chriseiger: We're fishing an unknown quantity. That could be the last of the food chain. How do we deal with it?

Richard Stanley: There are stock assessments done.

THE DISCOURSE OF PARTICIPATORY DEMOCRACY IN MARINE FISHERIES MANAGEMENT

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ABSTRACT
Participatory marine fisheries management systems bring together diverse stakeholders to share knowledge, authority, and responsibility for regional planning. As such, the intent of participatory or cooperative management endeavors is to move away from top-down, non-participatory governance systems that exclude local people and fail to meet conservation objectives. Case studies from the United States and Kenya are used to argue that despite official claims to the contrary, revamped fisheries management systems fall short of being genuine participatory democracies, fail to include stakeholders in substantive ways, and do not meet conservation goals. Means to share information in new, more effective ways and build truer, more equitable coalitions are offered.

INTRODUCTION
Since the mid-1970s, a growing number of specialists have considered the inclusion of local communities in environmental management necessary for successful conservation. These experts contend that conventional resource management policies fail because local communities pay the greatest cost for conservation in the form of lost access to resources, but receive few benefits from species protection (Fairhead 1991, Chambers 1997).

Governments have aspired to eliminate the historic antagonism of local people toward resource management plans and instill a sense of responsibility for resources through changes in management that allow for greater local participation. Yet, even seemingly enlightened participatory management initiatives have often failed to appease local people or halt species declines (Little 1994).

In this paper, we argue that there is an inherent flaw in calling for more participatory forms of management when the specific goals are predetermined. Under such conditions, local people's role in the management process necessarily remains prescribed and largely symbolic. The authors contend that, whereas there is a discourse of participatory marine management, the practice remains hierarchical and inclined toward use of the knowledge of those with the most formal education and the least experience at sea. As with flying an airplane or farming a field, the approach to solving fisheries problems must incorporate the practical experience of interested and affected parties. Based on case studies from the United States and Kenya we offer a means to share knowledge in new, more effective ways to build genuine and more equitable coalitions that can perform more effectively.

RESEARCH APPROACH AND METHODS
Political ecologists view environmental crises as inextricably linked to a much wider development crisis, including a growing gap between rich and poor and the increasing number of people globally living in abject poverty (Dorraj 1995, Bryant and Bailey 1997). In this context, environmental change is viewed as meaningful to individuals and user groups largely in terms of whether it provides an opportunity or presents a problem (Blaikie and Brookfield 1987). Stakeholder groups in participatory marine management systems, including local people, state agencies, businesses, and environmental organizations, often share the long-term goal of fish stock recovery, but differ on the best means of achieving it. Central among the conflicts over how to best sustain fish stocks are the relative weight that should be given to: fishers' knowledge gained via observation and informal experimentation at sea, the institutionalization of the fishers' knowledge within the decision-making process, and the more formal training of fisheries agents, researchers at universities, and conservationists.

For this paper, Heidi Glaesel, a Ph.D.-holding University professor, draws on library research and dozens of semi-formal interviews with stakeholders from various levels of authority in fisheries management in Kenya (1994-1996) and the United States (2000-2001); Mark Simonitsch draws on experiences as a New England commercial fisherman of more than 35 years, grassroots activist with fisher organizations and worker cooperatives in the United States, Canada, Belize, Guatemala, Honduras, and Spain and as a well informed citizen.

THE STRUCTURE OF MARINE MANAGEMENT IN THE UNITED STATES

The Magnuson-Stevens Fishery Conservation and Management Act (1996), or Magnuson-Stevens Act, is the federal legislation under which the US Congress delegates responsibility for marine resource management to the Department of Commerce. The National Marine Fisheries Service (NMFS) is the federal agency within the Department of Commerce's National Oceanographic and Atmospheric Administration (NOAA) with responsibility for managing fish from three to two hundred miles from the offshore (www.nmfs.noaa.gov). Individual states manage nearshore waters.

In 1976, the predecessor of the Magnuson-Stevens Act, the Magnuson Fisheries Conservation and Management Act, created eight regional fisheries management councils to advise NMFS on issues identified in the federal legislation and to access regional knowledge in developing this advice. Each council has approximately twenty appointed members who vote. The voting members include mandatory appointees from each state, representatives from each state's fishery agency, and at-large appointees from any of the states from within the region. Appointees are nominated through a political selection process that concludes with the various regional state governors independently submitting nominations to the Secretary of Commerce for final selection.

The fundamental task of the fisheries councils is to produce recommendations for fish management plans (FMPs). Local knowledge, in the form of public input, is solicited during the council's preparation of the FMPs. All council actions are in the form of recommendations to the Secretary of Commerce, a member of the President's cabinet and one of the nation's twelve most powerful political appointees. A process exists whereby NMFS reviews the council recommendations prior to their arrival on the desk of the Secretary for final approval. Enforcement of the approved regulations is the primary responsibility of the Department of Commerce. The US Coast Guard and the state fisheries enforcement organizations assist Commerce with enforcement responsibilities, but the primary regulatory effort to recommend, review, approve, implement and enforce fishery laws is accomplished within the Department of Commerce (Wallace and Fletcher, second edition).

How the existing system fails to meet the criteria for a participatory democracy

NMFS, regional councils, SeaGrant Institutes, and mainstream conservation organizations have produced literature on the federal marine management process that promotes a belief that the Magnuson Act and Magnuson-Stevens Act encourages local-level participation and representative democracy (Fowle 1993, McKay and Creed 1999) We contend that opportunities for authentic local-level participation are not as available as the literature suggests, and that the current institutional structure of the marine fisheries management system is far from being a true representative democracy in that the opportunities it provides are largely symbolic.

Democracy has well-accepted criteria, and if all of the criteria are not present then democracy does not exist. First is the right to be included as a full citizen of the organization making the collective decisions to which one is subject. Second, is the right to voting equality. Third, is an equal opportunity for participating effectively in decision making. Fourth is a full opportunity for acquiring an understanding of one's personal interest in the decision and last is the right to exercise with fellow citizens final control over the decisions. (Dahl 1989, p. 170).

No part of the council process fits the criteria for democracy. Council members are appointees and are not elected. By virtue of their formal oath, the appointed members are held to maximizing benefits to the nation, generally interpreted as stricter conservation of marine resources. No council member is permitted to represent any one affected party over any other interested group or place (Fowle, 1993).

Without elections for council membership, the council has no consent from a body politic. Lacking consent, the council has no claim for a constituency. Apart from the council appointees, all other interested parties in the council are without any formal relationship to the fisheries management political process. In this unusual situation, the individuals most affected have no formal political connection with respect to the council process, as citizens, subjects, or members. How can it be claimed that council members are representing the political interests of these people?

The status of membership in the council closely follows the formula recommended by Plato for seeking justice in a totalitarian society. Only "philosopher kings" (seekers of wisdom) were considered fit to practice the "royal science" of politics. Plato deemed the average citizen's "virtue" insufficient, and would have appointed only the few wise people judged to have the highest amount of "civic virtue," to government decision-making positions. Plato, unlike regional councils, left little doubt regarding his belief of the usefulness of local-level knowledge and participation with the statement "Equal treatment of un-equals must beget inequity." (Popper 1962, p. 96).

Many council committees have industry advisory groups. Can the utilization of advisors be the justification for claiming the existence of local level participation? The following conditions exist: First, advisors are volunteers; second, the Council Executive Committee appoints the volunteer advisors in closed sessions. Third, no mechanism or requirement exists for advisors to gather local knowledge using formal or informal methods prior to attending advisor meetings. Advisors are not required to disseminate meeting results locally, nor could they do so given the relatively small number of advisors, large areas and limited council budgets.

Hearings to collect public input are held on occasion, but since council members are not elected and staff members are heavily involved in holding these "hearings," the rich content and useful meaning of a public hearing with an elected representative is not achieved. Meeting attendees have no institutional political connection with the councils at these gatherings that are conducted to obtain "public input" and moderated by a few appointees and staff. The best that can be said for attending public input meetings is that if the attendee is selected to be a speaker (s)he has an opportunity to use his or her knowledge to persuade those few appointees who may be present.

Further loss of meaningful political input occurs when the hearings to gather public input are subjectively summarized by council staffs and lightly reviewed by council members. On more than one occasion, minutes from public input sessions have been verbally summarized and presented to the council when time constraints between the hearings and the council meeting did not permit preparation of a written summary of the public input (MAFMC 1998).

Why Congress chose not to have a Participatory Democracy

How did the situation come about whereby the fisheries governance system chosen by Congress only permits symbolic use of fishers' knowledge? Congress's action to have decision-making by fisheries experts may have come from a concern about ability to achieve national environmental goals if local communities or their representatives shared decision-making authority. Legislators may have understood that inherent with any form of deliberative democracy (representative or otherwise) is the inability to predict outcomes. In short – Congress may have believed a struggle between the desired outcome (sustainable resource goals) and procedure (local-level participation in self-government) to be an unsolvable paradox for a democratic process (Dryzek 2000, p. 141).

The US Congress selected a form of guardianship governance that leaned heavily on a guiding concept of experts managing marine resources for their maximum sustainable yield (MSY). This governing process depended principally on fisheries scientists and managers controlling the technique, distribution and amount of all fishing efforts from a large-scale vantage point. Within ten years of the enactment of Magnuson, it became very apparent that MSY could not be consistently attained by depending solely on scientists and fisheries statistics. Despite the demonstrated poor management performance the entrenched decision making method continued without authentic participation of many of the affected parties (Ludwig, *et al.* 1993, p. 17). If fishers' knowledge is to be put to work in the system, it is essential to understand why the US did not institutionalize authentic local participation and deliberative democracy.

Four elements combined to influence the choice of a governance system where decision making was given to appointed experts, while the public role was reduced to providing "input" to the experts (Scott 1998, p. 4). The first element was the administrative need to document harvesters and marine resources. Official records of names and licenses of boats and captains were developed. A system of maps and charts was combined with the electronic capability to repeatedly and accurately locate geographical positions thereby enhancing enforcement.

The second element was the development of a very strong societal belief in the abilities of scientists and professional managers. This belief was reinforced not only by the economic progress in the United States, but also the actual life experiences of the members of Congress. Many of the legislators voting for Magnuson in 1976 were veterans of World War II where victory depended heavily on the centralized use of expert managers, engineers and scientists. The results of the Marshall Plan's success in rebuilding the economies of war torn Europe was one of a number of examples of remarkable outcomes that could be achieved with a centralized command and control process utilizing professional managers and experts.

A third element militated against developing a process that shared power with communities and incorporated their knowledge. The federal government was strong, authoritative and confident that it could solve any problem. Institutionally guaranteed local participation was not considered vital to good decision-making. By 1976, despite the lack of experience of grappling with common property resources (CPR) solutions, few people in Congress doubted the ability of the federal government's experts to solve any complex problem from a position of centralized control.

Fourth, and very important, is that the seafood industry did not have a functioning network of informally organized representative groups. As a result, Congress received only minor resistance to establishing a top-down governance-structure as it proceeded to enact legislation where the public focus was largely on the benefits from the establishment of a 200-mile exclusive economic zone for U S fisheries.

Large scale management areas thwart democratic input

In New England there are few, if any experienced fisherman who have not belonged, at one time or another, to at least three different fishing organizations. Despite this predisposition "to join", few fishing organizations enjoy a long and vigorous existence and there is little disagreement that fishers' attendance within the council process is poor.

Shouldn't this odd situation raise questions among the managers let alone our Congressional representatives? Fishermen are obsessed with catching fish and are compulsive in discussing fish, fishing and fishing regulations, on the radio, with the cell phone, at the shore, the pier and the coffee shops. In New England there are some 15,000 seafood industry workers (authors' estimate) vitally affected by council decisions, yet, the New England Fisheries Council meetings rarely attract more than 75 people and frequently no more than 25 unless a crisis is in the making. Why is fishing organization and participation so feeble when there are hundreds of fishing communities and businesses intensely interested in the council's performance and who could benefit from engagement? We suggest that the level of participation has very little to do with the traditional and trivial 'rugged individual' stereotyping of fishing people repeated in council literature. This very repetition suggests it is the cultural fate of the majority of fishing people to be non-participating because they are rugged individualists. Fishermen respond to the same social impulses as other Americans. They have retirement savings plans, get divorced, eat at Burger King, visit Disneyland and complain about taxes.

What distinguishes fishing from other occupations is the tremendous self-confidence (not individualism) required to earn a living in a hostile and dangerous oceanic environment (McGoodwin 1990). Fishers understand that, throughout every part of their careers, they will continually confront the necessity to be resourceful when faced with an endless stream of difficulties before returning safely to port with sufficient fish to earn a living.

The amount of engagement of non-appointees with the fisheries decision making institution is like "everything else in organized society, it remains, to a significant extent, the product of particular (institutional) arrangements on which, once established, it continues to depend…" In New England the majority of fishing people are oriented toward a small local community life style, yet the council system is single level, regional and national. "…The failure to press, or even to imagine alternative arrangements makes the resulting approach to politics seem natural" and the fishermen's response seem unnatural (Unger 1998, p. 219)

Dividing the United States into eight large regions for marine fisheries management was a small but incomplete step towards devolving federal power. The regional ocean area governed by the approximately twenty appointed Council members meeting two days every six weeks is generally larger than the combined land area of the member states of the council region. The council areas of responsibility are simply at too large a scale for effective management across culturally and biophysically diverse subregions.

Council meetings are often held at fine hotels in rooms that are largely empty of those who are most affected by the decisions (Bohman 1996, Introduction) The elitism of the present system discourages attendance and participation at meetings. The physical layout of the room at council meetings also serves to intimidate potential speakers who must come forward to an isolated table with a microphone that is surrounded by a large horseshoe shaped council table. A person subjectively chosen by the council chair to comment often finds that his or her time at the microphone is very limited, not occurring at a time relevant to the debate, or interrupted if (s)he is repeating a point previously made by any other attendee.

In short, fishers recognize that their own voice or their voice through smaller-scale organizations is often ineffectual at council meetings; and they recognize that there is little reason to continue to pay dues, attend local meetings, and collectively bring ideas to the regional level, when local organizations do not have a formal place within the region council system. Frequently the principal reason for attending is fear that appointees at the council level do not understand the variety of the consequences of their decisions from Maine to Connecticut.

We have attended many meetings with fishermen in their communities over the years. The most common complaint is that it does no good to attend council meetings. Why? Because attendees intuitively understand that their participation is symbolic – that their attendance or the numbers of people in attendance is not synonymous with participation and that the ability for participation exists only in the role of appointed expert or with the few articulate people who are comfortable with the system and who are known to the principal actors in the council process.

The consequences of being excluded from authentic participation are not neutral. The dearth of opportunities to be involved in the routine tasks of resource decision making has diminished the capacity of fishermen and others to participate in deliberations. Often the result of being excluded is to be distrustful, apathetic and cynical, as the hopelessness of an outcome based on genuine collective deliberations becomes apparent (Brower 1993). The vast majority of harvesters view themselves as politically included only by virtue of having to comply with council's rule making. When fishermen reveal these traits and feelings "the powers that be" view their behavior as that of people lacking the skills and impulses necessary to be participants in co-managing. Fishing people have become burdened with a self-fulfilling prophecy. The less they are involved, the less they understand. The more incompetent they appear the more justification exists for continued exclusion from the process (Simonitsch 1998).

Large scale management areas restrict opportunities to put fishers' knowledge to use

By 1985 it was fairly clear to any serious fisheries observer that the concept of attaining maximum sustainable yields (MSY) for the fisheries was unattainable. Without the collaboration and participation of people with practical knowledge the expert rule makers had been devising plans that lacked an understanding of what made the fish harvesting business actually work. The various rules and regulations were, to a large degree, an abstraction and failed to include recognition of the resourcefulness and competitive nature of fishing, the marketplace, and fishing people. Fishers immediately found many loopholes. Simply having to follow the rules, rather than having been genuinely involved with identifying and incorporating actions for achieving sustainable fishing practices, led to a disaster.

Having excluded the working fisheries public and other affected parties from authentic rule making, Congress unintentionally created the classic "us and them" dilemma. Despite the rather obvious institutional failure, the lobbying of national environmental interests influenced Congress to view the deteriorating situation as a result of an inadequate number and selection of rules rather than a situation requiring institutional changes that promote a distributed social process for making decisions. Congress dutifully enacted a "Sustainable Fisheries Act" (SFA) in 1996 that implemented valuable habitat concerns, but also established rigid goals and timelines that further reduced the potential usefulness for incorporating fishermen's knowledge and authentic local level participation in deliberations (Wallace and Fletcher, second edition). SFA also precipitated a large increase in legal actions by green groups and fisher organizations against NMFS and the Department of Commerce regarding conservation objectives.

Why is there a reluctance to institutionally incorporate practical knowledge? The first reason is that the more the fisher knows the less important is the specialist. Secondly, if the specialist is less important his or her funding is less secure. The third reason is that science is involved with the future and less concerned with the past. Fishing knowledge is history. Fourth is that the knowledge of fishers is not collected into scientific format. Experts often view practical knowledge as a collection of "cracker barrel" information. Scientists are most comfortable with knowledge that is the product of controlled experiments that can be repeated.

Although science is theoretically egalitarian, most scientists have little experience and confidence in the skills, intelligence and experience of ordinary working people. Pascal correctly observed that the failure of rationalism is "not its recognition of technical knowledge, but its failure to recognize any other." (Scott 1998, p. 340).

THE STRUCTURE OF MARINE MANAGEMENT IN KENYA

Despite significant differences in per capita income and length of democratic tradition in the United States and Kenya, the two countries share a very similar history with regard to participatory marine fisheries management. As in the United States, the Kenyan government has relied on large-scale management plans, mapped the seas, licensed fishers and boats, and felt little threat from scattered informal fishing and seafood industry organizations. The discourse of participatory management has been in place in Kenya since the 1970s, but authentic bottom-up management has yet to be implemented (Peluso 1993)

The first notable move toward potentially giving local people greater voice in marine management came in 1979 when two of Kenya's conflict-laden marine parks, Malindi and Watamu, were re-zoned and designated biosphere reserves. The change from parks with no legally sanctioned extractive activities to multi-zone park and reserve complexes with traditional forms of fishing allowed in reserves included plans to incorporate local people into a more participatory management structure. Although the Kenyan government secured United Nations Man and the Biosphere funds for the rezoning, management remained in the hands of the Kenya Wildlife Service (KWS).

By the mid-1990s, additional areas had been set aside as parks without consulting the local communities they displaced. Tensions had mounted to the point of armed assaults on marine park rangers, arson of beachfront park structures, and blatant poaching, all of which threatened Kenya's valuable tourism industry. To gain control of the situation, the director of KWS who publicly opposed participatory management, was replaced by a man known for his people-friendlier approach (Baskin 1994), and a seven million dollar World Bank loan was used to implement a Community Wildlife Officer (CWO) program at each protected area. The sole CWO duty was to understand and assist resident communities to meet their needs (Snelson 1993). Due to widespread corruption and a lack of will for true participatory management, funds for the CWO program "disappeared" within a few years. (www.transparency.org). Additional external funds were secured for local communities living near marine protected areas (MPAs) to provide input into marine resource management in "bottom-up" Integrated Coastal Management (ICM) initiatives. After initial consultations with stakeholders in informal settings and using local languages, additional meetings were held in English at fine hotels. Invitations were not extended to local fishers based on the notion that their will was already known from the initial input sessions (Glaesel 1999).

"Participation" for fishers in the management process is thus a limited type of pseudo-participation which includes consultation and informing, but precludes true partnership through delegated power and cooperation. Local input into marine management is even more restricted along the approximately 95 percent of the Kenyan coast where there are no marine parks or reserves. In this substantial area, the understaffed Fisheries Department governs fisheries management. Whereas many officials in KWS express interest in participatory management, those in the Fisheries Department generally do not. Indeed, several Fisheries Department officials openly express disrespect for fishers and disbelief that they might have anything to learn from unlettered people (Glaesel 2000).

Modifications to the Existing Systems that May Not Put Fishers' Knowledge to Work

Whereas MPAs are certainly an area in which governance structures could be modified to include fishers' knowledge in meaningful ways, this has not been the case in Kenya or the United States. Initial indications are that the newly created US MPA Advisory Commission will likely remain top-down and heavily weighted toward experts with limited inclusion of fisher representatives. Fisher representatives will not be put forward by their own communities but be selected by degree-bearing experts. (John Poppalardo, Fish Expo 2001 NOAA MPA Booth)

Individual Transferable Quotas (ITQs) are currently under discussion in the United States by the Pew Oceans Commission and marine fisheries management councils. ITQs represent a relatively radical economic and social change in the management of marine resources that proponents claim might reduce perplexing allocation issues but would maintain the dysfunctional decision-making process. An additional disturbing aspect of ITQs is that where they have been implemented, such as in New Zealand, Iceland, and Canada, they have favoured the development of large-scale commercial interests. (White 2001).

Very little enthusiasm exists within the US (fisheries management council system, NMFS) or in Kenya (KWS, or the Fisheries Department) for promoting fundamental changes that would insure use of fishers' knowledge. Apparently, change can be considered, but not if it is change to the arrangements for the established order. Neither MPA nor ITQ approaches currently outline clear ways in which fishers' organizations and the knowledge generated from them would have an institutionalized place in the decision-making bodies that generate legislation that, in turn, affects activities in ITQ and MPA areas.

Alternatives that Put Fishers' Knowledge to Work

How can a transformation from the present systems to ones that include actual institutionalization of both fishers' knowledge and participation take place? The present council process will not disappear overnight, nor should we wish for it to vanish. Agreeing now on what the future should look like enables a phased implementation of change in logical manner. By agreeing now, we can create a road map for ourselves and our leaders in government, that would reveal our thought-out desires for coastal life, retention of small family corporations, incentives for good stewardship, recovery and preservation of the habitat, and development of vigorous economic activity that is at the heart of maintaining communities. If we agree now to eventually institutionalize fishers' participation in the decision making process then it becomes easier to strategize and plan the steps necessary to accomplish future goals.

Institutionally guaranteeing the involvement of fishers and the use of their knowledge is imperative and fundamental to creating sustainable fisheries. Failing to formally incorporate this structural change will result in a return to the "old ways" whenever funds are not available for collaborative work or when strong personalities in the system are inclined to have it their way.

Previously in this paper we have benefited from John Dryzek's observation of the paradox "that to advocate democracy is to advocate procedures, to advocate environmentalism is to advocate substantive outcomes." (Dryzek 2000, p. 140) One US NGO has directly confronted the paradox between procedure and outcome. Its concepts could serve as a model to others in the United States, Kenya, and elsewhere, especially if it, and groups using similar bylaws, were formally incorporated into the marine management decision-making process. The organization to which we refer is the Northwest Atlantic Marine Alliance (NAMA), a New England group with diverse multi-state membership that has constructed a self-governing constitution that is specifically designed to provide for sustainable outcomes for the commons and protection of individual rights (NAMA Constitution 1999)

NAMA members work to develop connected, self-governing community based organizations that are interested in achieving sustainable and abundant marine resources in New England. The organization's members include commercial and recreational fishers, conservationists, educators, seafood industry members and ordinary citizens who work together to promote a secure future for individuals and the coastal communities in which they live. Their unique constitutional effort is built on a set of ethical principles, comparable to the US Constitution's Bill of Rights, that provide the moral authority to protect and promote individual rights and responsibilities and the sustainability of common property resources.

One of the important characteristics of the NAMA constitution is its requirement for all decisions to be made at the "most local level possible" by a diverse group of interested and affected parties. The bylaws create authentic bottom-up self-governance structures, while insuring that local, regional and national fisheries governance provides justice for the resource. Considerable energy was spent to avoid dangers from the false supposition that populations are homogenous and therefore majority rule is fair because the minority and majority would have similar basic interests. (Goldwin 1997, p. 66). Although the NAMA governance system requires effective participation of recreational and commercial fishers it is not a plan for fishing interests to control the decision-making process and internally works to prevent the formation of unjust majorities. (Visit www.namanet.org).

A few public examples of marine resource management that nurture participation by groups with a diverse composition are beginning to emerge as success stories in ways that confirm the NAMA belief that affected parties can act accountably if given responsibility. The Mid-

Atlantic Fisheries Management Council's real-time management of Illex squid is a development with exciting promise for increased effective participation. Massachusetts' Striped Bass Advisory Committee is working extremely well to generate responsible recommendations by interested parties that are largely self-organized. Maine recently succeeded in passing legislation that divides the states waters into small-scale lobster and sea urchin management zones. The small-scale zones have enhanced management through putting local knowledge to use (LaPoint 2001) Although zoning won't be the answer for all species, the devolution of power to more local levels will. (Pendleton and Simonistsch 1999).

DISCUSSION

Genuine political participation has much more to recommend for itself than the mere justification that it is the preference of well-meaning people. Using the knowledge of fishers and other interested parties in authentic and fair deliberation forces the involved parties to justify their decisions and opinions by appealing to and defending chosen goals with reason. It is with effective participation in deliberations that a democratic society develops its civic capacities for cooperation, confronting contradictions, tolerance for pluralism and the ability to disagree without anger.

There are three characteristics that must exist before a person can be considered an effective participant in a collective decision making process. First, the individual must have an equal opportunity for placing matters on the agenda. Second, the participants must have an opportunity, equal to every other person's, to engage in full discussion. Third, an equal opportunity must exist to participate in making the final decision, either by voting or by consensus. (Dahl 1989, Chapter 8).

It is through the development and exercise of this kind of public reasoning that mature and effective political responsibility is developed and maintained and not with the accumulation of power and resources and action based on what the majority is presently thinking. The kind of deliberative democracy that evolves from political arrangements with checks and balances, such as the NAMA constitution provides, requires governance decisions and the fair distribution of benefits and burdens not solely on the basis of majority rule, but based on a fair reasoning process that is "public-regarding." (Sunstein 2001).

We believe that the lack of participation is due in large part to the inability of fishers to authentically participate in the decision process. In the United States, the institutional arrangements dictated by Magnuson do create a useful role for the Secretary of Commerce, NMFS, and the council appointees, but fail to give the affected and interested parties any genuine political roles in the governance system. Deliberative shortcomings are easily predicted when similarly thinking people only spend time in dialogue with one another. When diversity of participants is not present, then governance power is not available to those with competing views (Sunstein 2001).

In Kenya, the KWS, the Fisheries Department, and multi-national organizations dictate how marine resources will be managed. In both the United States and Kenya, local knowledge, when formally gathered, is generally undertaken by social scientists, but it is knowledge gained by narrowly defined experts in the "hard" sciences that informs policy making (Huntington 2000). Fishers and other interested parties understand their place in this information hierarchy and see little practical benefit from individual efforts or supporting association efforts when those actions continue to be viewed as producing knowledge that is illegitimate in the current system.

A worst-case scenario has resulted from not institutionally incorporating fishermen's knowledge in the management process. The composition and dominance of the existing governing structures have become taken for granted and the established interests have not only taken on a semblance of naturalness, but have also defined each other as their rival. A part of the mentality of the established interests is to view their wellbeing as connected to the preservation of their positions with respect to membership in officially recognized decision-making bodies, including council and its committees or Kenyan state agencies. Desiring their own survival, the relatively few established players often view initiatives in terms of maintaining their status quo. Political creativity is stifled except where the initiatives do not de-stabilize the existing institutional structure (Unger 1998, p.214).

Authentic democratic deliberations have long been recognized for achieving three important goals with respect to good government. First, self-governance legitimizes the laws we make. Secondly, the very best reason for compliance with the rules is when you make them yourself.

Third, acceptance of accountability in complex situations has been identified as a principal benefit from receiving and assuming responsibility (Boven 1998, chapter 9).

US Fisheries Council literature claims of representative democracy and local participation are simply incorrect. The literature put forth in support of Kenya's ICM plans is similarly incorrect in claiming that a participatory process was used to reach broad consensus on how to address critical coastal management issues (www.crc.uri.edu/field/esa/kenya_current.html)

Literature that merely discourses about participatory marine management is a serious impediment to the real thing. It serves to reinforce distrust between fishers and those with degrees and positions of relative power in fisheries governance who produce the materials. The inaccuracies can also raise false expectations for authentic participation among newcomers to the industry thus alienating new generations of fishing people before truly participatory management systems are implemented.

CONCLUSION

Our experiences in the United States and Kenya reveal an alarming and discouraging state of public participation that respects no border or economic status. Top-down management and coercive conservation will not benefit the environment in the long run. Fishers, fisheries managers, conservationists, and researchers are all experts in that each group has specialized, relevant knowledge that the others do not. All must be harnessed to improve fisheries management locally, regionally, and nationally (Mauro and Hardinson 2000, Johannes 2001). How this knowledge is gained might include everything from fisher-run workshops for state employees, to swapping a day at work periodically with someone in another area of fisheries management, to establishing centers for indigenous fisheries knowledge, and formally reconstituting the management process with internal mechanisms that decentralize authority and create authentic participatory roles for fishers and all other interested parties.

Considering the cultural and political history in the United States the widespread disaffection with the council form of government was inevitable. Rule making by an appointed elite group having no institutionalized connection with those who must follow the rules is generally recognized as politically illegitimate (Bell 1976).

It is time to destroy the durable myth repeated in US. fisheries management literature, that fisheries councils encourage representative democracy and local level participation. Until members of Congress recognize and publicly confront the political reality of the shortcomings of how fisheries people are governed and then understand the undesirable consequences of the present meager process, no useful improvements in the governance process will occur and the performance of the councils will not achieve their potential. Congressional and state representatives have a major responsibility for implementing useful change in the participation and methods for deliberations used in the institutions for managing marine resources. Legislators who do not make every effort to improve our institutions and promote fairness for our resources and citizens weaken their moral claims as protectors of justice and as representatives for citizens and common resources.

It is not sufficient for government to increase the numbers of the fish in the oceans. Fishing people's lives from Kenya to the United States have been unnecessarily and irretrievably altered by the feeble abilities of inadequate centralized command systems. By transforming the fisheries governance system fishers, and all of the parties with vital interests in marine resources, will begin to build an improved relationship with the ocean (Norse 1993). The authors of this paper do not contend that use of fishers' knowledge in democratic deliberations will guarantee desired outcomes. We do believe that with fishers fair inclusion among a diversity of decision makers, who work within the constraints of a reason-demanding constitution, that society can better achieve its social, economic, and environmental goals than with the present system. Our basic task at this conference should be to create fundamental changes for a positive relationship between the ocean's inhabitants and users.

At the heart of governance is the human obsession to control our future on this planet. Since humans alone have the power to significantly alter this earth, we have the primary responsibility for its future care and protection. Our system of fishery laws has been developed by extension of the same unique abilities we possess that created abstract concepts like equality and justice. Only humans, not the aquatic creatures, are responsible for the quality and performance of these laws. It is one of our major ethical responsibilities to improve the governance institutions we have created and know to be inadequate. (Simonitsch 1997 and 1998).

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Questions

Ted Ames: has there ever been a survey of fishermen and their feelings toward the council in New England?

Heidi Glaesel: Mark could probably answer this better than I. I spent about a month in New England and had some informal chats with the fishermen there. There was not a single fisherman who was satisfied with the council. At best, the fishermen were resigned to working with the council. People took time off work to attend their meetings.

Saudiel Ramirez-Sanchez: You were criticizing the top-down approach because it is undemocratic. Is it possible, even at a local level, to exclude politics?

Heidi Glaesel: I think it'll be better if it were more local. That way, you hear more voices. Certainly, you will get some local squabbles. When I was working in Kenya, there were lots of small-scale groups, and certain folks weren't speaking up. One such group is the women, because it's not in their culture to do so. But at a local level, you hear different voices than from further up. It's not perfect, but it's a start.

The Role of Indigenous Knowledge in Depleting a Limited Resource – a case study of the bumphead parrotfish (*Bolbometopon muricatum*) artisanal fishery in Roviana Lagoon, Western Province, Solomon Islands.

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Abstract

This study highlights the way in which new technological and economic inputs into indigenous artisanal exploitation systems can have negative ecological effects on a fishery, and the fact that traditional ecological knowledge is not always used sustainably. The fishers of Roviana Lagoon (Western Province, Solomon Islands) fished Bumphead Parrotfish (*B. muricatum* or topa in the Roviana language) for generations, using a targeting strategy based on precise knowledge of its aggregating behaviour built up over centuries. During certain moon phases at specific shallow water sites where the fish aggregated to sleep at night, fishermen speared them from dugout canoes by the light of dried burning coconut leaves. Catch rates were well below the maximum sustainable yield. When the underwater flashlight became widely available in Roviana Lagoon, however, this traditional fishing method was quickly replaced by night-time spear fishing using goggles and a steel hand-held spear. With this method, fishers could easily take four to five times as many topa as before. In the late 1980's, new pressures were placed on the topa stocks when local markets developed, ironically under the umbrella of NGO sustainable development projects. Today artisanal spear fishers use their sophisticated indigenous knowledge of topa behaviour and ecology to move from one known aggregation site to another, spearing as many topa as possible in a night. A Catch-Per-Unit-Effort (CPUE) survey of night-time spear fishing trips in Roviana Lagoon reveals that this resource is heavily overfished, with the majority of topa caught today being juveniles. Extensive interviewing with past and current spear fisher's reveals that this modern fishing method has caused major declines in topa numbers. The introduction of simple but new technologies coupled with small scale economic restructuring has thus thrown the system out of equilibrium.

Introduction

The concept of a traditional marine conservation ethic existing among indigenous coastal people (Hviding 1996, Ruddle *et al.* 1992) is one that has been losing favor in recent years. An increasing amount of anthropological, archaeological and marine biology literature suggests that subsistence fishing communities are also implicated in the problems of environmental degradation and resource depletion (Foale and Day 1997, Jackson 1997, Aswani 1998, Foale 1998, Jackson *et al.* 2001, Wing and Wing 2001). In some ways this was to be expected, as the original romantic assumptions that all indigenous people had an intrinsic conservation ethic that allowed their societies to remain "in balance" with nature, is a naïve and somewhat patronizing over-simplification of indigenous life ways.

There is however, a real danger in lumping all subsistence fisheries back into the unsustainable basket. If we do this, fisheries biologists and managers, who are often pessimists by nature, may overlook many of the potential management values of Customary Marine Tenure (CMT) and Traditional Ecological Knowledge (TEK) systems that are a common component of many coastal subsistence communities (Johannes 1988, Foster and Poggie 1993, Hviding 1991, Johannes *et al.* 1993, Lalonde and Akhtar 1994 and Christie and White 1997). It would also be an over simplistic response to an extremely complicated situation. In the last 50 years globalization has brought new technologies and new markets to virtually every remote society on earth (Suzuki and Dressel 1999). This, coupled with an exploding global population has put unprecedented pressure on all the world's resources. It is little wonder then, that small-scale indigenous fisheries have also began to show signs of ecological stress.

In this case study, I focus on the Bumphead parrotfish (*Bolbometopon muricatum*) fishery in Roviana Lagoon, Western Province, Solomon Islands. An overview of this species biology and global conservation status is given, and an historical overview of the topa fishery in this region is provided. Particular attention is brought to highly detailed and elaborate body of TEK of topa that is contained within Roviana spearfishing communities, and the way in which this TEK is used by Roviana spearfishermen to capture nocturnal aggregations of topa. The current status of the Roviana topa fishery is assessed using a combination of ethnographic and scientific data. The issue of whether or not Roviana fishers possess a traditional conservation ethic and use TEK to ensure sustainability is addressed.

Environmental background

The Solomon islands are a double-chained archipelago lying east of Papua New Guinea that extend over 1,400 kilometers across the South West Pacific (Figure 1). The islands display remarkable diversity in both terrestrial and marine environments.

The Solomon Island archipelago comprises over 900 islands, mostly volcanic in origin. Extensive lagoon systems occur in the Western Province. The population of the Solomon Islands is approximately 400,000, the vast majority live in rural villages, with their livelihood depending on subsistence production.

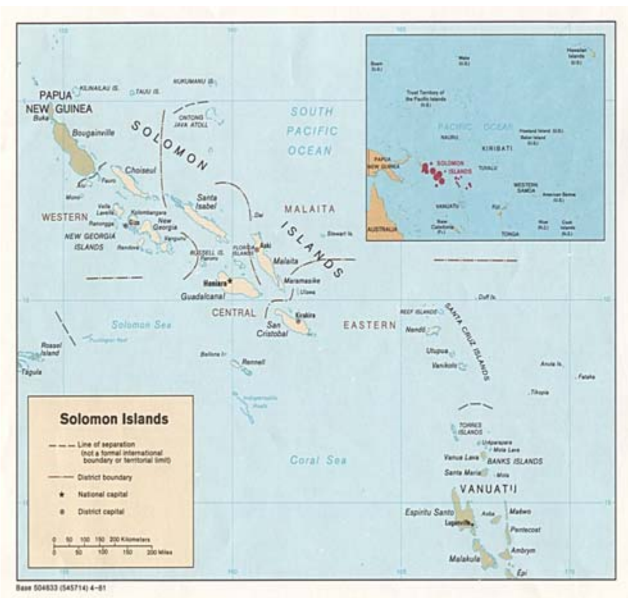

Figure 1. The Solomon Islands Nation.

The New Georgia Group, in the Western Province, is made up of 9 main islands that extend for approximately 270 kilometers. The largest island, New Georgia, is fringed by Roviana Lagoon to the southwest and Marovo lagoon to the northeast. The majority of this research was conducted in Roviana Lagoon, and studies were also carried out at the uninhabited island of Tetapare (Figure 2). The reason I focused on these two areas is that they provide an interesting insight into the ecological impacts of human subsistence and artisanal fishing systems. Roviana Lagoon represents a heavily fished area, while the uninhabited island of Tetapare represents a lightly fished area.

Roviana Lagoon where I was based, consists of a string of raised coral islands stretching for approximately 40km down the southwest coast of New Georgia Island. Between the outer islands and the mainland of New Georgia lies a shallow coastal lagoon of approximately two to three kilometers width (Sheppard *et al.* 2000). The lagoon system supports a high degree of biodiversity, through a wide range of habitats, such as: mangroves, coral atolls, barrier reefs, passages, marine lakes and sea grass beds. Scattered throughout the lagoon are a dozen small subsistence villages, whose inhabitants rely on the lagoon resources as a means of survival. The town of Munda is located at the western end of Roviana Lagoon, and is the only developed area in this region.

Topa (B. muricatum)

The topa, *Bolbometopon muricatum*, is the largest of all parrotfish, reaching over 50 kilograms and living to an age of at least 40. It is an herbivorous fish that feeds on corals. It forms mixed sized schools during the day and is extremely vulnerable to overfishing. Recent work by Dulvy and Polunin on this species' abundance in the Lau Islands in Fiji suggests that "the Bumphead parrotfish is highly vulnerable to exploitation and already extinct at some locations" (Dulvy and Polunin in revision).

Dulvy and Polunin attribute these local extinctions in the Lau group to overfishing by nighttime spearfishers, and reports that; "some young fishers (<25yr) had never seen an individual of this species and the last recorded captures varied from the 1980s to as long ago as the 1960s" (Dulvy and Polunin in revision). Topa is a highly prized food fish in Roviana Lagoon, and this is reflected both through the detailed ecological knowledge base of this species and the existing folk taxonomy for this fish. In the Roviana language, the Bumphead parrotfish is referred to as lendeke, kitakita, topa and topa kakara, where each respective name refers to an increasing size range of this fish.

Traditional ecological knowledge of topa

Previous research in the Roviana region has shown that TEK contained within Roviana Customary Marine Tenure systems is extremely detailed and precise (Aswani 1997, Hamilton 1999). The TEK of Roviana communities is directed towards identifying environmental and behavioral patterns that maximize capture success.

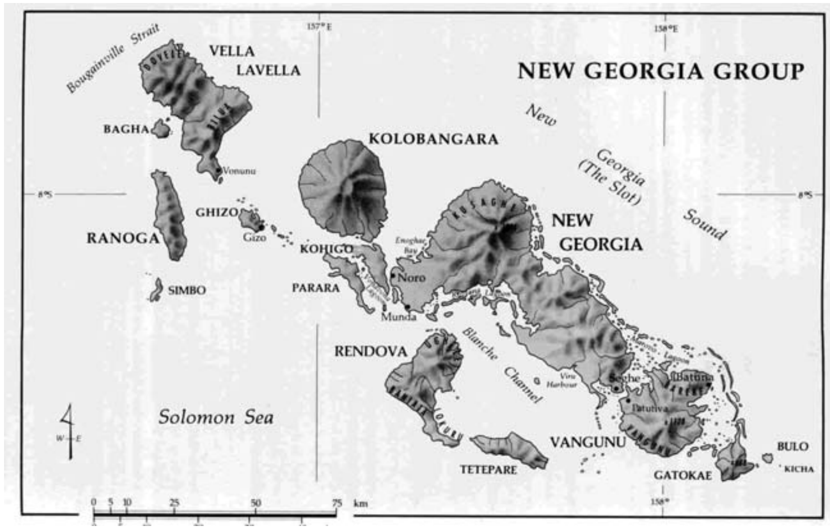

Figure 2. The New Georgia Group, with Roviana Lagoon to the North of Rendova Island, and Tetapare Island to the South East of Rendova Island.

Such knowledge requires an understanding of the influence that daily tides, tidal seasons, lunar stage and annual seasonality have on fish behaviour. This TEK is built up over generations and is cemented in Roviana culture through folk taxonomy, folklore and local place names. Roviana fishers draw upon this body of knowledge to decide when and where they will focus their fishing efforts (Aswani 1997, Hamilton and Walter1999, Johannes *et al.* 2000). The indigenous knowledge on the behaviour and ecology of topa is one such example. It includes knowledge on; diet, feeding times, schooling behaviour, juvenile nursery areas, spawning, the influence of the lunar stage on nocturnal behaviour, predation by sharks, nocturnal aggregations, individual color changes at night, spatial and temporal distributions, population changes over time and fleeing behaviour. A full description of Roviana TEK of topa is beyond the scope of this paper, but three aspects of this knowledge need mention, as they relate directly to the nighttime capture of this fish.

The most pivotal component of this knowledge, is the recognition that topa, which are a wary fish that are almost impossible to approach during the day, are easily approachable at night, when they are asleep up against coral structures. It is also well known that the spatial distribution of sleeping topa is not random. Topa fishermen understand that there are specific sleeping zones such as sheltered bays and certain passage areas where topa sleep.

Secondly, the lunar cycle is recognised as playing a very important role in topa behaviour. As in many parts of the Pacific, Roviana inhabitants have a traditional lunar calendar and many predictable fish behaviours are pinpointed using this (Aswani 1997, Hamilton 1999). Roviana fishermen know that several days immediately following new moon, and once the new moon had set, topa will be fast asleep up against coral, and thus easily approached and speared. Roviana fishermen also understand that if the moon is up, topa will not sleep properly. Instead they will be moving slowly about and are easily disturbed.

Finally, it is well known that topa do not normally sleep in solitude, but rather, a group of topa will sleep in the same small area. Roviana fishermen knew that the largest nighttime aggregations occurred during the new moon period, and that it is at this time that many of the topa sleep in very shallow water.

Traditional fishing methods

The traditional method of fishing for topa, hopere pana bongi, took place during tada sindara, the new moon period. Fishermen would paddle a wooden canoe to a shallow reef area where topa where known to aggregate to sleep. Once reaching their destination, fishermen would light one of many plaited dried coconut fronds that they had previously made and stored in the bottom of the canoe, and use the light to search for topa (Figure 3). This method needed at least two fishermen, one at the front of the canoe to hold the hand spear and burning coconut fronds and search for topa, while the fishermen at the rear of the canoe would paddle. Once a sleeping topa was seen, the paddler would position the canoe above the sleeping topa and the fisherman at the front of the canoe would throw his spear at the topa, attempting to strike it in the head.

Figure 3. The traditional method of fishing for topa.

This fishing method, which had been used explicitly for capturing topa for generations, harvested topa well below the maximum sustainable yield. Evidence of this is apparent from the fact that this fishing method stayed culturally stable over time and that the same aggregation sites were continually fished with no noticeable effect. One of the old topa fishermen that I interviewed said to me:

> *"In the old days, when we used traditional methods, no matter how many years we fished in the same places, there was always an abundance of topa there"*

(pers. comm., Ezara, Nusabanga village, December 2000. Translated from Solomon island Pidgin by the author). Of six older topa fishermen interviewed, all agreed that this method would capture less than ten topa in a night.

Changes in technology and markets

The first changes to this traditional method occurred following World War II. The Second World War left a big impact on Roviana Lagoon, with thousands of American soldiers and their war machines moving in and developing the area as an air force base in their fight for control over the South Pacific. When the war ended, most of the heavy machinery and ammunition was left behind or dumped in the sea. As well as leaving behind bombs and barges, the Americans also discarded large amounts of diesel. Hopere pana bongi fishermen quickly saw the potential of this diesel as a source of light, and discarded burning coconut fronds in favour of a piece of reinforcing steel that had an old copra sack wrapped around one end of it. Fishermen would soak the copra sack in diesel, and then set the diesel alight. Flames from the burning diesel were used as a light source to search for sleeping topa.

Fishing methods similar to this continued to be used up until 1970, when electric flashlights became readily available. These were not waterproof, but fishers found it easier to simply stand in the canoe with a flashlight and a spear, and search for topa in this manner.

The means for over-exploitation arrived with the introduction of underwater flashlights to Roviana Lagoon in the mid 1970s. Nighttime spearfishing quickly took off. Fishers interviewed reported discovering they could easily spear 50-70 topa a night around the new moon period with just a handheld spear, a pair of goggles and an underwater flashlight. The huge catches produced by this method effectively spelled the end of the traditional method of spearing topa at night from a canoe.

It is important to note that from the mid 1970s-right up until the end of the 1980s there were no cash markets for topa, so although a spearfishing party could take 50-70 topa in a night they rarely did, as this was far more fish than the village could possibly eat. Large catches of 50-70 topa where normally only ever made for special occasions such as weddings and funerals.
The slow but steady move of rural Solomon island communities towards a cash based society, and the provinces' desires for greater financial development, saw the opening up of a small, EEC-funded community based fishing centre in Munda in 1988. Although this development failed after several years due to financial problems, it set the way for numerous future fisheries projects in Munda and Roviana Lagoon. Pressure on stocks increased as tops became the most sought after fish in Munda. By the mid 1990's, topa fillets were being bought at a higher price than any other fish.

MATERIALS AND METHODS

Ethnographic data

The field component of the research was carried out from early August 2000 until late July 2001. During this period the author resided at Nusabanga village, where he participated in the daily life of the village and worked regularly with the local fishers, to gain as wide an understanding as possible of the topa fishing system. Formal interviews were conducted with 21 nighttime spear fishermen from the villages of Dunde, Nusa Roviana, Nusabanga, Sasavalle, Baraulu, Bula lavata and Nusahope in Roviana Lagoon. These fishermen were selected according to their recognized status of nighttime spearfishing experts within their respective villagers. When possible, the interviewer sought out older spearfishing experts that had lived in their respective villages for their entire life and remained active in nighttime spearfishing over a long period of time. These older individuals had some of the richest TEK bases on topa ecology and most importantly, older fishers were able to give detailed information on the changes that have occurred in this fishery over the last 30 years. The interviewer covered a set number of questions that pertained to the history of the subsistence topa fishery in Roviana Lagoon, fishermen's knowledge of the ecology and behaviour of this fish and changes in this fishery over time. All interviews were conducted in Solomon Island Pidgin. During this research period the author actively participated in over 50 nighttime spearfishing trips with fishermen from numerous Roviana villages.

Scientific data

Catch Per Unit Effort survey:

A CPUE survey of Roviana nighttime spearfishing trips was carried out from August 2000 to July 2001 in order to establish the importance of topa in the catch and the size distribution of the topa being captured. 82 nighttime spearfishing trips were recorded in Roviana Lagoon. Fish speared were sorted to family level and species level where possible and weighed to the nearest 10 grams. For all topa caught in the CPUE survey, fork length and total weight measurements were recorded, sex was noted, and gonads were weighed. In most instances otolith and gonad samples were also collected. A CPUE survey of nighttime catches was also carried out at Tetapare Island. The author recorded catches from four nighttime spearfishing trips at Tetapare island in 2001.

Size of female maturity in topa

To determine the size of female maturity, female gonad weight in grams was plotted against fork length for 169 female topa sampled in this study. A plot of gonad weight on size reveals an exponential curve. The point of inflection on this graph indicates the size at which maturity is achieved. (Howard Choat, pers. comm.). The size at maturity is to be checked through histological analysis.

RESULTS

Ethnographic data

All 21 spearfishermen that the author interviewed from throughout Roviana Lagoon reported major declines in topa catches in the past 10 years. Out of 15 current spearfishermen interviewed, all reported that the most topa they had ever caught in one night in the past 2 years was between 5-16, and that the average number of topa they caught on a topa spearfishing trip was around 2-8. This contrasts with the mid 1970s and early 1980s when spearfishermen sometimes took as many as 70 topa in a night. Furthermore, all fishermen mentioned a very marked decline in the abundance of topa kakara, the large terminal phase males in recent years.

Finally, several of the 15 current spearfishermen that were interviewed, reported that they have increased their spearfishing efforts in the inner lagoon, exclusively targeting juvenile topa that sleep in these inner lagoon areas. These inner lagoon areas were rarely fished in the past, and are being more heavily exploited now due to the marked drop in catches at traditional outer reef and passage areas.

Scientific data

Size of female maturity in topa

Female gonad weight (g) was plotted against fork length (mm) for 169 female topa (Figure 4). It is clear from Figure 4 that some individuals as small as 610mm have significant gonad development, and by 620mm, at least 50% of the population have gonads of a significant weight. Thus, the size of maturity for female topa in Roviana Lagoon can be taken to be 62cm.

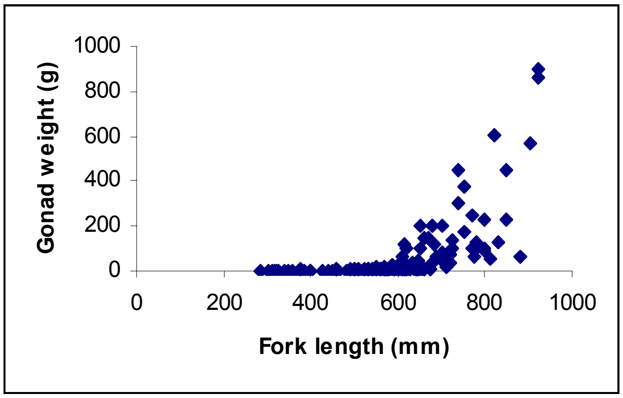

Figure 4. Fork length versus gonad weight for 169 female topa

Results of CPUE survey in Roviana Lagoon

The species that made up the most of the catch by weight was topa, accounting for 36.6 % of the total catch (Table 1). The size distribution of 239 topa recorded in the Roviana CPUE survey is shown in Figure 5. The mean size of topa speared in this survey was 63.2cm. Analysis of gonad data reveals that the size at which female topa mature is around 62cm, thus, 56% of all topa recorded in this survey can be considered juveniles.

What is also obvious from Figure 5 is that very few topa captured in this survey were over 100cm. Only 3% of the catch was made up of topa 100cm or more, a size range referred to as topa kakara in the Roviana language. In Roviana, the average number of topa shot on a nighttime spearfishing trip was 2.9. Figure 6 shows a good night's catch in Roviana Lagoon in June 2001. This particular fishing trip was organized to collect fish for a funeral, and it involved four spearfishermen who were diving for four hours. Most of the catch is topa and these topa are almost all juveniles, being between 50-60cm in length.

Results of CPUE survey at Tetapare

The species that made up the most of the catch by weight was topa, accounting for 86% of the total catch (Table 2). The size distribution of 65 topa recorded in the Tetapare CPUE survey is shown in Figure 7. The mean size of topa speared in this survey was 89.5cm. 5% of the Tetapare catch were juveniles and 35% of the catch were topa kakara, being 100cm or over. Topa 110cm or over where recorded at Tetapare 6% of the time. At Tetapare, the average number of topa shot on a nighttime spearfishing trip was 16.3. Figure 8 is a good night's catch at Tetapare in April 2001. This particular fishing trip was organized to collect fish for later sale at Munda town. The topa shown here were speared by four spearfishermen over a two hour period. In this short timeframe, almost 400 kilograms of topa were collected. This entire topa catch is made up of mature adult fish.

Table 1. Species that made up 1% or more of the Roviana CPUE survey.

Species	Percentage of catch
B. muricatum	36.6%
P. areolatus	10.9%
Naso lituratus	3.5%
A. nigricauda	3.3%
green turtle	2.6%
Painted crayfish	2.2%
C. undulatus	1.8%
hawkesbill turtle	1.5%
A. lineatus	1.4%

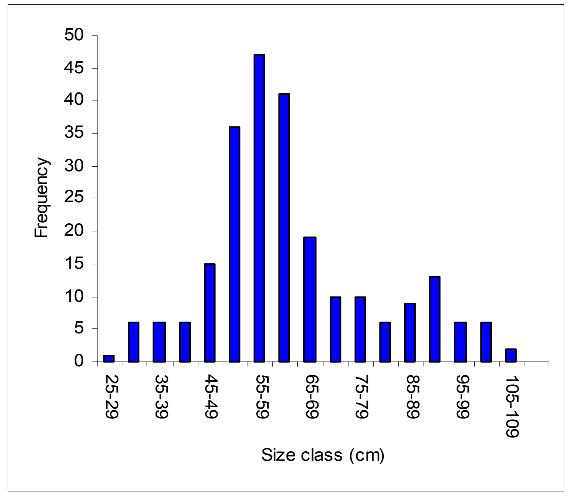

Figure 5. The size distribution of 239 topa recorded in the Roviana CPUE nighttime survey.

Figure 5. A good night's catch in Roviana Lagoon

Table 2. Species that made up 1% or more of the total catch at Tetapare Island

Species	Percentage of total catch
B. muricatum	86
Green turtle	3
C. undulatus	1.8

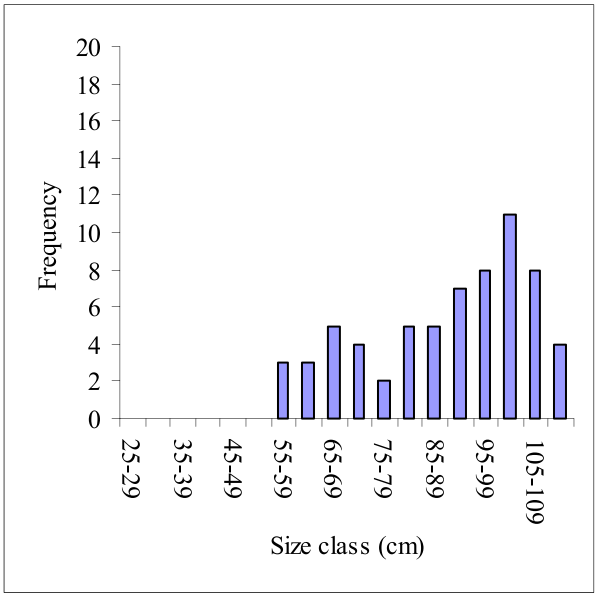

Figure 7. The size distribution of 65 topa captured at Tetapare Island.

Figure 7. A good nights catch at Tetapare Island.

DISCUSSION

The ecological impacts of new technologies and changing markets on topa populations in Roviana Lagoon have been profound. Roviana spearfishermen interviewed in this study unanimously agree that catch rates have declined strikingly in the last two decades, and topa kakara (large terminal phase males) which were once the dominant component of the night catch, are rarely captured these days. These changes have all occurred in only three decades, and coincide with the introduction of the underwater flashlight and the commencement of nighttime spearfishing in Roviana Lagoon. Scientific support for these anecdotal claims comes by comparing the heavily spear fished region of Roviana Lagoon with the only recently spear fished island of Tetapare.

In Roviana Lagoon, the mean number of topa caught on a spearfishing trip was 2.9, the majority of topa captured were juveniles (56%), the mean size of all captured fish was 63.2cm, only 3% of the catch was over 100cm and no topa in the 110-114cm size class were ever captured. In comparison, at the lightly fished island of Tetapare, the mean number of topa caught on a spearfishing trip was 16.3, only 5% of the catch were juveniles, the mean size was 89.5cm, 35% of the catch were topa kakara, being 100cm or over, and the size class of 110-114 cm was well represented, making up 6% of the total catch.

Large reductions in CPUE, a high number of juveniles in the catch, relatively few mature females and males in the catch and an absence of the largest size class, are all classical signs of an overexploited fish stock that is under stress. In short, all ethnographic and scientific data collected in this study points overwhelmingly at a fishery that is in need of management. In this study it was possible to evaluate the impact of nighttime spearfishing on Roviana Lagoon by comparing CPUE data from Roviana Lagoon with CPUE data from the lightly fished area of Tetapare. However, there are few places in the world where such a comparison are still possible. As more and more remote maritime locations become exploited, it will become increasingly important to draw on older fishers oral accounts as "sources of information on the histories of their fisheries, often the only link with marine environments and populations of times past" (Johannes *et al.* 2000).

The Roviana and Tetapare data presented in this paper supports research on topa in Fiji that shows that the abundance of topa is negatively related to fishing pressure, and that this is a species that is highly susceptible to overfishing (Dulvy and Polunin). Clearly, Roviana fishers possess a great deal of practical knowledge on topa, much of which is unknown to science, however this TEK of topa is used in order to maximize capture rates, and there is no evidence of a conservation ethic among Roviana spear-fishermen.

Although all fishermen interviewed raised concerns and disappointment over the status of the topa fishery since the commencement of nighttime spearfishing, many did not comprehend that overfishing could be a reason for the decline. The few fishermen who did attribute declines in catches to increased fishing pressure were among the youngest of the fishermen interviewed. They also stated that the financial incentives provided by night diving outweighed any environmental concerns.

The possibility that globalisation and changing market demands have suppressed a conservation ethic that once existed in Roviana fishermen cannot be ruled out, but I believe the answer is simply that Roviana people never developed a conservation ethic for their reef fisheries because they never needed one. Johannes (1981) defines a conservation ethic as an awareness that one can deplete or otherwise damage one's natural resources, coupled with a commitment to reduce or eliminate the problem. He points out that in the South Pacific, it is in areas where resources are scarce, and have been for some time, that conservation ethics and resource controls are most developed. "Some islanders, however, were fortunate enough to live in areas where marine resources greatly exceeded their needs; they literally could not deplete them. They were thus unaware that natural limits on the yield of their marine resources even existed" (Johannes in press).

Roviana Lagoon inhabitants have always had access to a large marine resource base as well as utilising large areas of New Georgia mainland for shifting horticulture practices. The current population of Roviana Lagoon and the nearby Vonavona Lagoon is 12,235 people (Government census 1999), with these communities having access to over 300 square kilometres of reef. The population numbers in Roviana Lagoon may have fluctuated considerably in the past (Aswani pers. comm.). However, given the limited efficiency of traditional fishing methods, and the absence of western markets, it is unlikely that Roviana fishers ever over-exploited their topa prior to the commencement of nighttime spearfishing. Thus, before the advent of nighttime spear-fishing, topa stocks appeared unlimited in the minds of Roviana inhabitants, and the need to practice conservation measures never arose.

The situation today in Roviana Lagoon represents a crossroad between the old and the new. The good old days when reef fishery resources were seemingly limitless and conservation measures was not required, are being replaced with the modern realities of one of the highest population growths in the world and the ecological costs of conforming to ever encroaching westernization. There is an increasing desire among Roviana communities to exploit marine resources for cash, so that they can pay their children's school fees, buy petrol for their outboard engines and access the wide range of western consumer goods now available to them. Interestingly, the scene appears set for the development and solidification of a conservation ethic in Roviana culture. In the case study here presented, the ecological changes in response to simple new technologies and market demands have been so dramatic and negative, that many Roviana fishermen have witnessed a magnitude of decline in this fishery in their adult life time. Negative impacts of Live Reef Fish Trade operations on spawning aggregations of grouper have been as dramatic and even more recent in this region (Hamilton 1999). Today there is an across the board awareness in Roviana Lagoon that marine resources are not nearly as abundant as they used to be, a growing realization (especially among the educated youth) that is over fishing that has caused this.

There have been several encouraging signs that Roviana communities are ready to practice more sustainable measures. The recent establishment of seasonal marine invertebrate refugia in Roviana Lagoon provides one such example (Aswani 2000). Another sign of changing times and changing perceptions is the efforts of the Dunde council of elders to place a complete nighttime ban of nighttime spearfishing around the Munda bar region in June 2001 (pers. comm.). Although the motivations for these conservation attempts may more accurately reflect power struggles between different entitlement groups then a conservation ethic *per se* (Aswani pers. comm.), it is the growing perception of limited resources that has brought these power struggles and their resulting conservation efforts about. On a broader scale, positive signs are also coming out of other parts of the Pacific, such as Vanuatu (Hickey, 2001), Torres Strait Islands (Mulrennan, 2001) and Samoa (Fa'asili, and Kelokolo, 1999), where traditional reef owners are implementing new management strategies in order to make their marine resources more sustainable.

Conclusion

Indigenous fisheries in Melanesia are based on a sophisticated traditional ecological knowledge system that has built up over thousands of years. Over time, these fisheries may have reached a point of equilibrium with the local environments. But it would be a mistake to assume that indigenous fisheries systems are inherently conservation oriented by design. It is frequently the case that customary practices result in conservation of resources, but as this study demonstrates, the concept of maximisation of returns is also an important factor in indigenous fishing systems. In Roviana the indigenous topa fishery was sustainable within the context of the economies and technologies that existed prior to 1945. But globalisation brought new technologies and new markets. The indigenous topa fishing system was so acutely tuned to the subtleties of topa behaviour and ecology that when the Roviana fishers continued the practice of maximising returns, including the expansion of the fishery to previously unfished areas, such as inner lagoon areas and Tetapare, this had an adverse effect on local ecologies.

To ensure the future sustainability of coastal resources in the Solomon Islands, there is a need for resource owners to develop management plans that take local fishing patterns, Customary Marine Tenure, local environmental knowledge and scientific expertise into account. The scope for developing fisheries management plans in this region is increasing, as Roviana fishers come to the realisation that their marine resources are limited. From a western fisheries management viewpoint, TEK provides an excellent source of basic data on ecology and the status of the fishery, parameters essential in the design of sound management strategies. But these systems must be understood within the context of contemporary economic realities, which include not only those parts of the economy that articulate with the west, but also the indigenous economic and kinship networks. The existence of CMT and TEK systems within Melanesian fishing communities should not be taken to imply sound management.

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Questions

Bob Johannes: Was there ever a population on Robiana Island large enough to put a stress on the marine resources? Was the fishery in enough trouble for them to develop a conservation ethic?

Richard Hamilton: I don't think so. They have a conservation ethic, but they were not at the point where they really stressed the fishery.

USING FISHERS' KNOWLEDGE GOES BEYOND FILLING GAPS IN SCIENTIFIC KNOWLEDGE – ANALYSIS OF AUSTRALIAN EXPERIENCES

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ABSTRACT

Most studies describing the nature of fishers' knowledge, and its value for fisheries research and management, have been concerned with small-scale fisheries in developing countries, for which conventional assessment and management techniques are usually not applicable. In industrial fisheries, accessing and using fishers' knowledge present new challenges. Fishers' interaction with scientists is influenced not only by economic imperatives and political lobbying, but also by the important changes that are currently affecting research and management practices.

In Australia, fisheries systems are increasingly based on a partnership approach, where fishers share responsibilities and costs for research and management through co-management and cost recovery mechanisms. Like many fisheries worldwide, Australian fisheries are facing serious challenges from community and government demands for greater protection of the environment. Traditional fisheries assessment and management methods are now seen as inappropriate and more holistic ecosystem-based precautionary approaches are being explored.

Three examples in Australia are examined to illustrate these changes and to show how, as a consequence, fishers' role also changes and expands (or should be allowed to expand) from simply filling gaps in scientific knowledge to providing expert advice on fisheries research and management. The partnership approach used in Australia is reviewed and difficulties in integrating fishers' and scientists' types of knowledge are discussed. Particular attention is given to the socio-cultural factors behind scientists' limited enthusiasm in using fishers' knowledge. In a partnership framework, both fishers and scientists have to realise that to acknowledge each other's knowledge and effectively cooperate is a necessity, not an option.

INTRODUCTION

There is a growing perception, worldwide, that conventional fisheries management is failing. Fish stocks are declining and some fisheries have already collapsed. Major problems include overfishing, by-catches and environmental degradation. To help improve the management of fisheries, there is an increasing recognition that more attention should be paid to fishers' knowledge and to the factors that affect fishing behaviour (Hilborn 1985, 1992, Hilborn and Walters 1992, Dorn 1998, Neis *et al.* 1999a, 1999b, Salmi *et al.* 1999, Neis and Felt 2000 and references therein).

Fishers' knowledge, and its communication to scientists, is influenced by the biological, socio-economic and cultural contexts in which fishers operate. Its value and usefulness is most often understood and studied in data-poor fisheries where conventional fisheries research and management methods are not applicable, such as small-scale indigenous fisheries in the tropics (e.g. Johannes 1998). Management philosophies and problems in these fisheries differ significantly from those in industrial fisheries. Indigenous peoples tend to have long standing association with a particular area and environment. In more recently developed industrial fisheries, fishers' association with the environment is more transient and is mediated by their tighter integration into technologically, socially, and economically capitalist societies (Neis and Felt 2000). Also, in industrial fisheries, formal procedures for the assessment and management of fish resources have been in place for some time and usually rely on scientific analysis of fisheries and biological data. This paper is concerned with fishers' role, and the use of their knowledge in Australian industrial fisheries.

Most Australian fisheries are under tight management controls, increasingly based on co-management, partnership and cost-recovery approaches and on allocating fishing rights to individual fishers. Fishers are now more involved in the scientific assessment and management of their fisheries, for which they pay a significant share, or even the entirety, of costs. However, in a context where fisheries assessment and management are dominated by science, what is the role and value of fishers' knowledge? What are the implications of the co-management, participatory approach for scientists and fishers?

Over the past decade, fisheries research and management have undergone significant changes, partly as a result of the inadequacy of traditional methods to respond to community demands for greater environmental protection. There are developing trends toward ecosystem-based and precautionary approaches to resource use and protection, along with greater and more open recognition of the uncertainty inherent in scientific results (Hilborn 1992). Both fisheries scientists and fishers have to review and adapt their philosophical beliefs and professional practices to these new approaches. In this paper, the implications of these changes for the role of fishers, and of their knowledge, in fisheries assessment and management are analysed using three examples from Australia.

EXAMPLE 1: FISHERS AS INFORMATION PROVIDERS

This example relates to a survey of the Australian south-east trawl fishery (SETF), which was carried out to collect information on, among others, changes in fishing gear and fishing practices. The SETF is a demersal, multi-species fishery in which catches of the most important species have been controlled by Individual Transferable Quotas (ITQs) since 1992. Trawl fishers' contribution to fisheries assessment and management formally began in 1986 when they started recording catch statistics in compulsory fishing logbooks[1]. Scientific stock assessments are done on a single species basis and rely for most species on catch-per-unit (CPUE) analysis using catch and fishing effort data recorded in logbooks. Both fishers and scientists have long questioned the validity of data recorded in logbooks, either because of potential mis-reporting by some fishers (especially since the implementation of the ITQ management system), or because of the influence of changes in fishing gear and fishing practices. Also, the single-species approach to stock assessment in this typically multi-species fishery, and scientists' reliance on CPUE as an index of fish abundance, have become a longstanding contention between fishers and scientists. It is well known that using CPUE as an index of fish abundance can lead to misleading results if changes in fishing gear and practices are not taken into account (Megrey 1989, Hilborn and Walters 1992, Tilzey 1999). Over the years, fishers' lack of confidence in scientific methods and advice grew, as they repeatedly demanded that scientists integrate changes in fishing technology and the influence of quota management and market demands on fishing practices into their analyses.

Eventually, in 1997, an industry survey was funded to collect this type of information. A questionnaire designed to collect a combination of quantitative information, e.g. vessel and gear description, and qualitative information, e.g. relating to fishing practice preferences[2] was used during face-to-face interviews with fishers, (see Baelde 1998, 2001 for more details). Much care was taken to keep the interviews flexible, extending the discussion beyond purely scientific conceptions (Johannes *et al.* 2000). Besides specific and practical questions, open questions were included to give fishers the opportunity to expand on their answers. The aim of the survey was to provide scientists with information that would help them improve their analysis of logbook data. Various validity and reliability checks, coding and ranking mechanisms were built into the survey questionnaire to assist scientists in quantifying and analyse the information collected.

The survey was a great success with fishers, all but two of the 47[3] fishers (skippers) approached agreed to be interviewed. Fishers provided a large and diversified amount of information including technical details of fishing equipment and description of how environmental, economic and management factors influenced fishing practices. Their perceptions and beliefs about the status of the fishery and the effectiveness of management were also recorded.

Qualitative analyses of the information collected identified significant changes in fishing practices following the implementation of ITQs (Baelde 1998, 2001). In summary, these changes included a general shift from maximising catch volumes to maximising quota holdings; catching smaller 'mixed-bags' of several species to satisfy market demand and quota restrictions. As part of their effort to diversify catches, fishers have modified the design of their trawl nets and are also fishing closer to harder, but more productive, grounds. In another developing practice, they tend to 'run away' from high

[1] Fishers also have a long, ongoing, but unappreciated and unacknowledged history of contributing to research and co-operating with scientists, often on a voluntary basis. For example, they regularly help with data collection during scientific surveys, take scientific observers onboard their vessels for routine catch monitoring studies, discarding studies, tagging experiments, and for fishing gear trials.

[2] Information on changes in environmental conditions (e.g. water temperature, winds, etc.) was also collected as fishers saw them as having a major influence on catches. Results are not presented here.

[3] This represented more than half of the skippers actively engaged in the fishery at the time.

concentrations of fish (also referred to as 'dodging the fish') to avoid over-catching their quota, or creating a fall in market prices (fishers described this as a very frustrating necessity). Such fishing practices have the potential to selectively drive down the CPUE of some species, with no relation to changes in their abundance (Baelde 2001). Communication between fishers has generally increased and, as observed in other fisheries (Allen and McGlade 1986), this influences fishing strategies and the dynamics of the fishing fleet. The survey also showed that assumptions about the direct relationship between technological improvement (e.g. access to global positioning systems) and increase in catches are not always justified (Baelde 2001). Similar observations were made by Maurstad (2000a) in Norway.

Despite the success of the survey, both in terms of fishers' willingness to participate and volunteer information and in terms of the wealth of information collected, things did not progress much further. Changes in electronic equipment and net design (the details of which scientists are mostly unaware), and quota- and market-driven changes in fishing practices have not been investigated further by scientists. These changes are not yet taken into account in stock assessments, despite their potential to seriously undermine the validity of these assessments. In fact, after initially welcoming the results of the survey, scientists then appeared to quickly lose interest. It became clear that they had unrealistic expectations and generally lacked an understanding of the quality and contents of fishers' knowledge. They failed to appreciate the need for dedicated and specialised work to turn this knowledge into a useful form for science. Institutional inertia quickly overcame their initial interest in favor of established fisheries science practices. Thus, single-species stock assessments and reliance on CPUE remain today a source of contention between fishers and scientists.

EXAMPLE 2: FISHERS AS ACTIVE COLLABORATORS

Example 1 described a direct interaction, albeit of limited success in this case, between fishers' information and conventional stock assessments. In Example 2, about the blue eye trevalla (*Hyperoglyphe antarctica,* Centrolophidae) fishery, quantitative stock assessment methods are not possible because of the limited data available and complex fleet and stock behaviour (Baelde 1995, 1996, 1999). However, there are important management issues, involving quota transferability and conflicts between several fishing sectors. These issues need urgent resolution and so another approach is to be taken shortly in an attempt to provide the best possible advice to management (a working group made of scientists, fishers and managers has been created and the process is about to begin).

The chosen approach for blue eye trevalla is partly based on the more holistic harvest and management strategy models that are currently developing in Australia and elsewhere (Smith *et al.* 1999, Punt *et al.* 2001). Broadly speaking, simulation-based operating models are to be built from hypotheses, or 'what if' scenarios. These scenarios will be identified using available data and expert opinion from scientists, various fisher groups and managers. In building the models, harvest strategies, stock assessment methods, performance indicators and research programmes are simulated and compared (Punt *et al.* 2001).

This approach to fisheries research and management presents three major challenges. The first will be to get members of the working group to accept and support the simulation approach and the concept of operating models. As Smith *et al.* (1999) pointed out, this type of approach is unfamiliar, complex and still experimental. To go from the principles and concepts of stock assessment methods to a simulation approach is difficult for everyone involved.

The second challenge will be to get the group members to commit themselves to the process. The success of this approach depends on genuine participation and input from, and collaboration between, scientists, fishers and managers. It is important that expertise and interests from all participants are taken into account in developing harvest and management hypotheses. Members must not only share their expertise and interests, but also be able to handle sensitive and/or controversial information in a transparent manner. Participants will also have to deal with the uncertainty inherent in their own knowledge.

The third challenge will be to get members to agree on how to use the results of simulations. Without quantitative stock assessments, operating models cannot answer questions regarding the size or current status of fish stocks and therefore cannot be used to set quota levels. This represents a major difficulty for managers. The operating models will test the performance of, and risks associated with, various management strategies. For example, 'what if' scenarios could involve proportional splitting of the Total Allowable Catch between fishing methods, or closing particular fishing grounds (both scenarios are already quite controversial). The group members will then have to work out, and agree upon, a set of decision-rules that trigger management actions based on these tests.

In this second example, the fishers' role is not simply to fill gaps in scientific knowledge (as in Example 1), but to cooperate with scientists and managers in assessing and managing the fishery. It will also be important that scientists and managers cooperate effectively. To develop meaningful simulation models requires effective industry participation and, as noted by Smith *et al.* (1999), these new trends in research and management fit better with the co-management approach adopted in Australia. However, as a note of caution, Punt *et al.* (2001) highlighted that hypothesis-based modelling approaches may not resolve contentious issues, but simply move them from being about the validity of data and assumptions in stock assessment methods, to being about the plausibility of hypotheses.

Example 3: Fishers' Role in the Development of Marine Protected Areas

In the face of growing perceptions that traditional fisheries management methods are failing, more and more attention is being paid, worldwide, to the establishment of Marine Protected Areas (MPAs) to assist fisheries (Attwood *et al.* 1997, Lauck *et al.* 1998, Parrish *et al.* 2000, Walter 1998, 2000, Pitcher 2001, Ward *et al.* 2001). Many fisheries problems are attributed to the lack of a precautionary approach by management and the implementation of MPAs, and of no-take areas in particular, is promoted as the most effective precautionary approach to protect both fisheries resources and biodiversity (Roberts and Hawkins 2000, Ward *et al.* 2001). In this fairly recent development in fisheries management philosophy, MPAs are not seen as substitutes for traditional fisheries management methods but as complements to them.

In Australia, the release of the Oceans Policy in 1998 included accelerated implementation of national and regional networks of multiple-use MPAs. This is currently being met with strong resistance from commercial fishers who are directly impacted by the establishment of no-take zones within these MPAs. Environmentalists often perceive fishers' opposition as resistance to changes and lack of care for the environment. However, in Australia, it is the lack of integration of MPA development with fisheries management which most contributes to fishers' resistance (Baelde *et al.* 2001). In this country, MPAs are specifically used for biodiversity conservation and not for fisheries management (ANZECC TFMPA 1998). They tend to be selected almost regardless of existing fisheries management systems and with very limited input from commercial fishers. Moreover, fisheries and conservation agencies show little willingness to cooperate on MPA issues or to accommodate their differing philosophical beliefs and legislative responsibilities.

In many Australian fisheries, management is evolving from a system of input-based controls (e.g. gear control, spatial management) to output-based controls (e.g. quota). As mentioned earlier, this is supported by the implementation of other mechanisms, such as co-management and partnership approaches, allocation of fishing rights, management and research cost recovery and, in some fisheries, collection of scientific data by industry. The granting of fishing rights is viewed as a means of providing fishers (and their financial institutions) with greater security of access to resources, thus promoting financial investment and development and long-term stewardship of the resources. By relying primarily on spatial management, the development of MPAs tends to conflict with these current trends in fisheries management. Whilst it is not the purpose of this paper to discuss the appropriateness, or otherwise, of Australian fisheries management systems or the value of MPAs, the point here is to highlight the uncertainty caused to fishers by the lack of congruence between the objectives of conservation and of fisheries management.

Governments' MPA policies fail to acknowledge, and properly assess, the potentially negative impacts of MPAs on commercial fisheries (Baelde *et al.* 2001). Mechanisms to address these impacts (e.g. more flexibility in designing MPAs, compensation to fishers[4], fisheries re-structuring, etc.) are not properly investigated.

[4] Australian governments are generally reluctant to pay compensation to fishers for loss of access to fishing grounds (and loss of fishing rights). Fishers now tend to use the compensation issue as a bargaining tool in negotiating with governments. However, government agencies and MPA advocates fail to recognise that for most fishers, compensation is a last option. Fishers would rather see more compromise between biodiversity conservation needs and use of fish resources in designing MPAs. The currently poor integration of conservation and fisheries management, as well as lack of consideration of socio-economic issues, means that the opportunity of MPAs being used as tools for re-structuring fisheries (i.e. to reduce fishing effort) is being missed (Baelde *et al.* 2001).

Fishers have to be content with unsubstantiated blanket claims that MPAs may benefit their fisheries and provide protection against stock collapse (Robert and Hawkins 2000)[5].

Another important consequence of the poor integration of fisheries and biodiversity conservation needs is that conservation agencies also fail to recognise and promote the role that fishers could play in the protection of the marine environment. A recent review of Australian governments' MPA policies and planning processes (Baelde *et al.* 2001) showed that fishers have little real say in the selection and design of MPAs and that their concerns and needs are generally overlooked or poorly addressed. This too is in conflict with current trends in fisheries co-management and partnership approaches. Whether MPAs are used solely for biodiversity conservation, fisheries management, or a combination of both, has major implications for their selection and design (size, location, level of protection) and expected benefits and costs for fisheries. This in turn influences fishers' share of MPA management costs (monitoring, compliance and enforcement) and their potential involvement in MPA processes (Baelde *et al.* 2001).

It is well documented that to achieve effective natural resource management and conservation with minimal conflict and long-term community support requires the involvement of those directly affected by management measures (Fiskes 1992, Crosby 1997, Neis 1995, Well and White 1995, Beaumont 1997, Johnson and Walker 2000). However, in Australia, as observed elsewhere (Beaumont 1997), while government policies and legislation on resource management never fail to mention the importance of stakeholders' participation, they rarely provide practical details and critical accounts of approaches taken (Baelde *et al.* 2001)[6]. There are generally limited resources and expertise, and sometimes limited willingness, within government agencies to design and engage in effective consultation with the commercial fishing industry.

Recent events in the state of Victoria, Australia, are a good, if disappointing, illustration of the situation (see Baelde *et al.* 2001 for details). On May 17, 2001, after a nine-year investigation, the State Minister for Environment and Conservation proposed to declare twelve MPAs in Victoria's waters (all MPAs were to be highly protected no-take areas where all fishing was to be banned) and tabled a bill in Parliament for their establishment. The hastily drafted bill instantly generated strong opposition from the fishing industry and various political parties because it included a controversial constitutional change. Fishers would have lost their right to seek compensation through the court for loss of property rights, whether or not this loss was related to the creation of no-take areas (the Victorian Government later claimed that this was a drafting error). On 13 June 2001, about one month after tabling the MPA bill, and after stormy street demonstrations, the Victorian Government withdrew the bill from parliament.

The Victorian Government's refusal to pay compensation to fishers has been said to be the major cause of the (temporary) rejection of the MPA bill. However, it more directly reflected a very poor handling of socio-economic issues in the design of MPAs and a lack of proper consultation with the fishing industry (see footnote 4). Better protocols to ensure effective fishers' input in the design of MPAs would have helped find a compromise and help mediate their impacts on fisheries.

In the Australian south-east trawl fishery examined in Example 1, fishers are now contributing to spatial management (Williams and Bax, this volume) by providing information on fishing distribution, type of habitats that exist on fishing grounds, and fishers' operational and socio-economic dependency on these grounds. This is precisely the type of information that was missing in this Example 3. It is hoped that this cooperative work between scientists and fishers will help avoid the difficulties experienced in Victoria.

Discussion and Conclusion

There is an increasing number of studies that describe the detailed knowledge that fishers have of fish stocks, their environment and their exploitation patterns. Most of these studies highlight the usefulness of fishers' knowledge in

[5] Ward *et al.* (2001) have clearly shown that the fisheries benefits from MPAs occur in quite specific circumstances (i.e. in the case of overfished and/or unregulated fisheries). Claims of such benefits in the Australian context appear largely unsubstantiated and therefore unnecessarily undermine the validity of the conservation message (Baelde *et al.* 2001).

[6] Moreover, government policies tend to expect more and more from consulting with fishers. Consultation is expected to resolve many different issues: e.g. provide expert environmental knowledge, provide socio-economic information and assist integrated management by reducing conflict between users. While the stated scope of consultation with fishers continues to expand, there is no dedicated research to design protocols that would lead to effective consultation and integration of fishers' interests and expertise.

filling gaps in scientific knowledge. However, as noted by McGoodwin *et al.* (2000), the integration of scientists' and fishers' types of knowledge remains difficult in practice. By comparison to scientific knowledge, fishers' knowledge is mostly of a qualitative and narrative nature, holistic rather than sectoral, and subjective rather than objective. It reflects not only the biological and the socio-economic contexts within which fishers operate, but also fishers' personal beliefs and values (Baelde 1998, Neis and Felt 2000, Maurstad this volume). Various techniques to check the validity and reliability of fishers' knowledge have also been described (e.g. Neis *et al.* 1999a, Purps *et al.* 2000).

Studies on fishers' knowledge have generally been concerned with small-scale artisanal fisheries in developing countries. In industrial fisheries, the competitive pursuit of profit and political lobbying partly drive fishers' behaviour and their interaction with scientists and managers (Finlayson 1994, McGoodwin *et al.* 2000). This does not mean that fishers' knowledge in industrial fisheries is less useful, but it creates new challenges in accessing and validating it. Also, fishers' knowledge and input are often sought only when fisheries management is perceived to be ineffective, that is when fisheries are already in difficulties. By that time, fishers themselves are under pressure from increasing regulations, and may face the ultimate prospect of a ban on fishing (as seen in Example 3). Crisis situations do not facilitate cooperation as scientists' and fishers' information can become political issues in times of conflict over management (Finlayson 1994, Maurstad and Sundet 1998).

In Australian fisheries, the partnership framework established by management agencies usually includes the formation of expertise-based (by opposition to representative) scientific and management advisory committees (for example, see Smith *et al.* (1999) for an analysis of the partnership approach in the case of federally managed fisheries). Membership on these two types of committees comprises scientists, fishers, managers and environmentalists. This framework is, without doubt, a significant step toward promoting fishers' involvement in fisheries assessment and management and facilitating collaboration between scientists, managers and fishers (see Smith *et al.* 1999). However, it is only partly effective. Problems are often attributed to fishers' vested interests 'capturing' the process, but Smith *et al.* (1999) question these perceptions.

Other problems are created by the fact that, on the one hand, the partnership framework gives fishers greater access to the assessment and management process, and thus greater opportunity to scrutinise and challenge scientific knowledge with their own knowledge and expertise. But, on the other hand the partnership framework has not been designed to facilitate the use of the knowledge and expertise that fishers bring into the process. In many fisheries, the scientific assessment process relies largely on conventional quantitative, single-species methods and is not adequately adapted to incorporate fishers' type of knowledge (as seen in Example 1). Scientists tend to believe that the usefulness of fishers' knowledge is limited because of the difficulties inherent in quantifying it. Whereas, fishers express growing frustration at scientists' inability to make direct use of industry information and views (Baelde 1998, 2001, Smith *et al.* 1999). Fishers' frustration during scientific meetings sometimes turns into confrontation with scientists. Also, the partnership framework does not facilitate access and use of broad-based industry knowledge. The communication of information between members of advisory committees and the wider fishing community is not effective and this generates some tension within the industry[7]. Additional structures that are better adapted to the specific nature of fishers' knowledge must be developed[8].

Possibly the greatest difficulty with the partnership approach is overcoming existing socio-cultural barriers that hamper communication and collaboration between fishers and scientists/managers. There is a great

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[7] McCay (1999) stated that current partnership practices based on advisory committees tend to create a new type of community, an interest-based community as compared to place-based community. These 'virtual' communities are defined by their management regimes (by species, area, gear type, etc.) and develop new social ties and identities. She suggests that such communities may be the only real hope for a participatory management that encompasses a wide diversity of interest groups. However, experience in Australia shows that they also tend to alienate non-member fishers and may create further divisions within an already divided fishing industry.

[8] In the case of the Australian south-east fishery, the management agency also funds a team of scientists and managers to conduct annual visits to major fishing ports. The aim is to give grass-root fishers an opportunity to interact with scientists and managers and raise issues about the fishery. However, it is obvious from the low attendance of fishers that this is not working satisfactorily. Individual fishers tend to be wary of public meetings (especially when there are conflicts about management issues) and one-day-a-year visits to their ports fail to attract their interest: they go fishing instead.

socio-cultural divide between the moral authority of science (collectively accepted by society and legitimised through rigorous objectivity rules) on the one hand, and the suspicion attached to fishers' information (subjective, non-tested and perceived as biased by vested interests) on the other hand. The lack of curiosity and interest that scientists showed in the wealth of information that was collected from fishers in Example 1 was surprising at first. However, it quickly became obvious that scientists' attitudes toward fishers' knowledge were influenced by the socio-cultural barriers so often described by social scientists (e.g. Finlayson 1994, MacCay 1999, Neis and Felt 2000 and references therein; Wilson, this vol). In a co-management situation, scientists have learned to respect fishers' political power, but they have remained sceptical of the validity of their knowledge. In his analysis of the northern cod fishery, Finlayson (1994) showed that scientists made a clear distinction between fishers' involvement in the scientific process and the incorporation of their knowledge in that process. Even the most sympathetic fisheries scientists are too perplexed by the structure, form, and scale of fishers' knowledge and prefer retreating into the security and familiarity of established scientific practices (McGoodwin *et al.* 2000).

Scientists tend to see themselves as possessors of universal knowledge and custodians of the sea (McGoodwin *et al.* 2000), as defenders of natural resources against an irresponsible fishing industry and an inefficient, or ambivalent, management (Finlayson 1994). When asking fishers to share their knowledge, scientists assume that they accept the purpose and methods of science, and that their role is to fill gaps in scientific knowledge. However, this science-driven approach fails to recognise fishers' own values, expectations and methods of gathering knowledge. Besides scientific understanding, other knowledge frameworks and value systems are gaining recognition as products of social, cultural and ecological contexts (McGoodwin *et al.* 2000). This increasingly challenges the central position of science. We need to explore and test fishers' own understanding and theories about biological processes and market or management-driven fishing behaviour (Maurstad and Sundet 1998, Baelde 2001).

By focussing on the technical difficulties of integrating fishers' knowledge into scientific methods, scientists maintain a narrow and prescriptive view of the nature and value of fishers' knowledge (Baelde 1998, Maurstad 2000b). McGoodwin *et al.* (2000) stressed that it is not longer enough to hire fishers as data-collecting technicians, or even to systematically collect their knowledge in a form that fits with the requirements of existing science. The type of fishers' input that is needed today for assessing and managing industrial fisheries is expanding well beyond simply filling gaps in scientific knowledge. This is because the principles and practices of fisheries research and management are also dramatically and rapidly changing. The three examples described illustrate these changes, from deterministic quantitative single-species stock assessment (Example 1), to exploratory, hypothesis-based simulation models (Example 2) to holistic ecosystem approach (Example 3). As a consequence, the role of fishers, and their input, also diversifies, from providing technical knowledge to providing advice and opinions on current and future harvest and management needs.

While the partnership approach is being increasingly adopted and promoted as a tool leading to better resource management, the social and cultural implications and constraints of such an approach are not well understood and appreciated by scientists. They fail to recognise that a truly effective partnership with fishers relies first of all on acknowledging the legitimacy of fishers' knowledge and actively developing ways of overcoming existing technical and socio-cultural difficulties[9]. This would require dedicated research, crossing the boundaries of fisheries and social sciences.

The sweeping changes that are taking place in fisheries assessment and management are partly in recognition of the limitations and uncertainty of traditional fisheries science. As public scrutiny of fisheries issues intensifies, community views and values on the use of common resources play an increasingly important role in fisheries assessment and management. Fisheries management and environmental protection are becoming matters of social debate and negotiations. A balance has to be found between environmental, social and economic values and this cannot be resolved on biological and technical grounds alone. Fishers are (or should be) active players in these social negotiations, contributing not only their knowledge but also their perceptions and values.

[9] Jentoft *et al.* (1998) also noted that, while income is important, the dignity and esteem that come from the occupation of fishing matter a great deal to fishers. Fishers' accumulated knowledge contributes to their pride.

Jentoft *et al.* (1998) point out that co-management is a process of social creation through which knowledge is gained, values articulated, culture expressed and community created. Scientists' reluctance to acknowledge, or at least test, the value of fishers' knowledge is anachronistic in today's circumstances. Like fishers, they are running the risk of being accused of resisting changes in order to protect their own entrenched professional interests.

This paper was concerned with scientists' responsibilities in ensuring effective partnership and effective use of fishers' knowledge. However, fishers do have responsibilities too toward the community, both as users of common resources and as food providers. They too must realise the extent of societal change with regard to the conservation of common resources and the consequences for their industry. They cannot operate with the same independence they once did and they must work on developing a more unified and credible voice. The well known divided nature of the fishing industry is an important factor limiting the use of fishers' knowledge. In the same way as too many scientists tend to retreat behind the comfort and familiarity of established science, too many fishers also tend to retreat behind the belief that resource protection and management is, ultimately, a government responsibility. This too is an anachronistic position, untenable in today's co-management approach.

Fisheries are in crisis and both fishers and scientists are under pressure to protect marine resources. Their ability to collaborate and find acceptable and workable solutions to fisheries problems partly depends on their ability to shift from their defensive positions to positions of leadership. Both fishers and scientists must now re-think their cultural and professional beliefs in order to accommodate each other's complementary knowledge and expertise and put them to best use.

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Questions

Melita Samoilys: Why weren't marine parks used for fisheries management?

Pascale Baelde: It was a legislative decision. I will challenge that.

Bruce Burrows: How do you define a marine park?

Pascale Baelde: A marine park is defined by use; it includes no-take areas.

Local Ecological Knowledge and Small-scale Freshwater Fisheries Management in the Mekong River in Southern Laos

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Abstract
Small-scale fishers possess a vast amount of local ecological knowledge (LEK) about the fish and fisheries of the Mekong River and tributaries in southern Laos. Between 1993 and 1999, a community-based co-management programme was implemented for the conservation and sustainable management of living aquatic resources in the Siphandone (4000 islands) Wetlands area of the Mekong River in Khong District, Champasak Province, southern Laos. In total, 63 villages established regulations related to living aquatic resources during the project, and local government has since officially recognised these regulations as constituting "village law". Independent evaluations conducted regarding the fisheries co-management system established in Khong report that local people believe that aquatic resources have benefited from the varied regulations adopted in individual villages, and it seems likely that the system will continue to function into the future, although the effectiveness of local management varies from community to community. The aquatic resource co-management measures established in Khong have been largely based on LEK, and LEK has played an important role in community fisheries monitoring activities, and in adapting management regulations to meet local conditions. This paper describes how LEK can be practically applied, disseminated, and strengthened for improving freshwater fisheries management in rural communities in Laos and other countries in mainland Southeast Asia. Particular techniques for utilising LEK in assessing fish diversity, and for addressing important fisheries management issues are also described.

Introduction
Small-scale fishers in many parts of the world have a vast amount of local ecological knowledge (LEK) about the fish and fisheries that they depend upon for their livelihoods (Johannes 2001; Poulsen and Joergensen 2000; Baird 1999b; IIRR, 1996; Johannes, 1981). While it is now generally recognised within the scientific community that fishers have a large amount of LEK, there has been little research specifically documenting the way local people use their LEK for fisheries management purposes, or how LEK can be adapted in order to improve the management of wild capture fisheries (Johannes 2001).

The purpose of this paper is to report on a community-based fisheries co-management programme of the communities living near the mainstream Mekong River in Khong District, Champasak Province, southern Lao People's Democratic Republic (Lao PDR or Laos), and the ways in which LEK has been utilised, disseminated and strengthened to improve the management of wild capture freshwater fisheries. A number of tools for improving fisheries management based on LEK are discussed, and methods for conducting fish diversity and behaviour studies using LEK are presented.

Background
The Mekong River, with a length of approximately 4,400 km, is the 10th longest river in the world, and the 14th largest in terms of total annual discharge. However, the Mekong is third (after the Amazon and the Brahmaputra) when it comes to maximal flows (Baran *et al.* 2001). The diverse habitats of Mekong River Basin support one of the richest fish faunas in the world, and more fish species than any other river basin in Asia. Approximately 1,200 species are believed to occur in the Mekong Basin, although many have not yet been taxonomically described (Van Zalinge *et al.* 2000; Rainboth 1996). Many species seasonally migrate long distances up the Mekong River to Laos and Thailand from as far away as the Great Lake in Cambodia and the South China Sea in Viet Nam (Baird *et al.* 2001a; Van Zalinge *et al.* 2000; Baird *et al.* 2000; Baird *et al.* 1999a; Warren *et al.* 1998; Lieng *et al.* 1995; Roberts and Baird 1995a). Other species are relatively sedentary or only locally migratory (Baird *et al.* 1999a; Baird 2000; Baird *et al.* 2001b).

Laos is a land-locked country in mainland Southeast Asia, sharing long borders with Viet Nam to the east and Thailand to the west, and shorter borders with China and Burma to the north, and Cambodia in the south. With a multi-ethnic population of approximately 5.5 million, most people in Laos are semi-subsistence rural-based farmers and fishers. The country, which is about the size of Great Britain, is considered one of the poorest in the world. The Mekong River is the hydrological life-blood of Laos, flowing for some 1,860 km through the country. Roughly 25 percent of the Mekong River Basin is located in Laos, which contributes 35 percent of the Mekong's total flow (FAO 1999).

The Mekong River and her tributaries are the main source of wild fish for local people, and fish constitute the most important source of both protein and cash income for the bulk of the population in Laos (Baird 1999b; Hubbel 1999; Baird *et al.* 1998b). There is a large variety of fisheries, each dependent on harvesting methods used, the particular habitats and seasons involved, and the ethnicity and socio-economic conditions of the fishers. The fishing methods used are also dependent on the species of fishes or groups of fishes being targeted, and the fishers' knowledge of the biology and behaviour of the fish (Claridge *et al.* 1997; Baird *et al.* 1998b). Certainly, the LEK of fishers contributes greatly to their ability to feed themselves and their families, and to generate income. In fact, fish resources and LEK are the basis for livelihoods (Baird *et al.* 1999a & b; Baird and Flaherty 1999). Yet, as human populations have grown, fishing implements have been modernised, markets have become more accessible, and development projects of various types have had a negative impact on fish populations (Baird 1999a & b; IRN 1999; Roberts and Baird 1995a; Roberts 1993a & b). Although there are few official data available on fisheries, there are increasing numbers of reports that individual fishers are experiencing significant declines in their catches (Baran *et al.* 2001; Baird *et al.* 2001a & b; Hogan 1997; Roberts and Baird 1995a; Lieng *et al.* 1995; Roberts and Warren 1994; Roberts 1993c).

The Siphandone (4000 islands) Wetland area, situated in the extreme south of Laos, is one of the most complex ecosystems found in the mainstream Mekong River. It is made up of large and small inhabited and uninhabited islands, channels, seasonally inundated forests, deep-water pools, rapids and waterfalls (CESVI 1998; Altobelli *et al.* 1998; Claridge 1996). The Siphandone Wetlands are largely situated in Khong District, which is in the southern-most part of Champasak Province (see Figure 1). The aquatic environment of the area is characterised by high biodiversity and productivity (Baird 2000; Baird *et al.* 1999a). So far, 201 fish species have been recorded from fish catches from the mainstream Mekong River just below the Khone Falls in Khong District, of which about 165 can be considered economically significant to fishers in the Khone Falls area (Baird 2000).

Figure 1 Lower Mekong basin

As of 1995, there were 65,212 people living in Khong, the vast majority being ethnic Lao rural subsistence-oriented peoples. For the most part, they are semi-subsistence wet rice farmers and fishers, and have a long history of inhabiting the area. The wild-capture fisheries of Khong may be more important to local people than in any other district in Laos. Of the 136 villages in Khong, 86 are situated on islands, and most of the rest are established along the eastern bank of the Mekong River (Baird *et al.* 1998b). Approximately 94 percent of families in the district participate in artisanal fisheries at a subsistence level or as a way of generating income. In 1996/1997, it was estimated that four million kg of wild fish were caught in Khong District, and that over US$ one million worth of wild fish and fish products originating from Khong were sold on the market. The average person caught 62 kg of fish (Baird *et al.* 1998b).

Fisheries Management in the Mekong River Basin

In the Mekong River Basin, including the mainstream river, wild capture fisheries management is faced with various obstacles and challenges. Scientifically documented information about the resource is very limited and fragmented (Baran *et al.* 2001; Kottelat and Whitten 1996; Roberts and Warren 1994; Hill and Hill 1994; Roberts 1993c). There are very serious gaps in understanding the many fisheries operating throughout the Mekong countries (Baird *et al.* 2001a; Ahmed *et al.* 1998; Hill and Hill, 1994; Roberts and Warren, 1994; Roberts 1993c). Furthermore, the Mekong system is characterised by having a large number of fisheries, some large and most small, each operating in different ways, adding to the complexity of management (Ahmed *et al.* 1998; Baird *et al.* 1998b; Claridge *et al.* 1997; Hill and Hill 1994). Many of these fisheries are located in relatively remote areas, making the possibility of government management extremely difficult and costly, and generally unrealistic (Cunningham 1998). The large number of highly migratory fish species in the Mekong basin that move between two or more countries also makes it difficult to manage many species at only a local level (Baird *et al.* 2001a; Warren *et al.* 1998; Roberts and Baird 1995a; Roberts 1993b).

Project development impacts

There are various development projects in the planning or implementation stage that have the potential to seriously impact natural aquatic resources. These projects are associated with a number of sectors, including hydro-electricity production, irrigation development and industrial expansion, to name but a few of the development sectors that have the potential to cause fish habitat degradation across international borders (Baird 2001; IRN 1999; Hubbel 1999; Roberts 1993b). For example, it has recently been documented that the Yali Falls dam in the Central Highlands in Viet Nam has caused major downstream impacts in neighbouring parts of northeast Cambodia (Fisheries Office and NTFP 2000).

Community-based Fisheries Co-Management

Centrally imposed natural resource management systems typically increase the monitoring and regulatory responsibilities of governments. Unfortunately, the fisheries departments in non-industrialised nations are typically understaffed and underfunded (Baird 1999b; Johannes 1998; Cunningham 1998; Kottelat and Whitten 1996; Cowx 1991). Given the pressing need for improved natural resource management, alternative decentralised management models, including "co-management" (CM) and "community-based natural resource management" (CBNRM), are being increasingly proposed in Southeast Asia and other parts of the world (Hirsch and Noraseng 1999; Masae *et al.* 1999; Johannes, 1998; Johnson, 1998; Pomeroy, 1998; Pomeroy and Carlos, 1997; Hogan, 1997; McCay and Jentoft 1996; Ali 1996; Clay and McGoodwin 1995; Kuperan and Abdullah 1994; Berkes and Kislalioglu 1993; Christy 1993; Berkes *et al.* 1991; Ghee 1990).

Natural resource co-management has been defined as, *"the collaborative and participatory process of regulatory decision-making among representatives of user-groups, government agencies and research institutes"* (Jentoft *et al.* 1998: 423). The term co-management (CM) is useful for demonstrating that fisheries management is often a joint effort between resource users and governments. However, some CM programmes remain strongly government dominated, with little real decision-making powers being given over to resource users (Simonitsch and Glaesel 2001; Glaese and Simonitsch, this vol). Because of the uncertainty of who controls management decisions when it comes to CM, some scholars and practitioners prefer to use the term community-based natural resource management (CBNRM), as it emphasises that the communities are the centre of management structures. However, the term CBNRM is limited because it does not imply the involvement or recognition of the government in management systems. Nor does it specify whether there are any partnerships or agreements between governments and users. In reality, most fishing communities require and desire some level of government support in order to be able to effectively defend community resource areas covered under local management regulations (Baird 1999b). Therefore, it seems preferable to use the term "community-based co-management" (CBC). This term is intended to convey the message that management systems and decision-making structures are centred in communities, with users having considerable management powers. However, the term also shows that the government is nevertheless participating in the process, and recognises the validity of the community-based management systems, and user tenure over resources. Essentially, the systems in Khong fit into the class of CBC. This type of management regime holds considerable promise for furthering local fisheries management in the Mekong Basin.

Community-based Fisheries Co-Management in the Khong District

Between 1993 and 1999 63 villages in Khong District, Champasak Province, southern Laos established CBC regulations to sustainably manage and conserve inland living aquatic resources, including fish, in the Mekong River, streams, backwater wetlands and rice paddy fields (Baird 1999b). The "community-based fisheries co-management" (CBFC) systems in Khong have been supported by two non-governmental organisation (NGO) supported projects, the Lao Community Fisheries and Dolphin Protection Project (LCFDPP), which was implemented between 1993 and 1997, and the follow-up Environmental Protection and Community Development in Siphandone Wetland Project (EPCDSWP), which was in operation between 1997 and 1999 (Baird 1999b).

Villages have been permitted to initiate the CBFC process, and choose what regulations to adopt based on local conditions and community consensus, but local government has endorsed the process, and the regulations of each village, with minimal interference. Moreover, communities are empowered to implement and enforce regulations, and they can alter them in response to changing circumstances. Recognised as "village law", the regulations established in each of the villages are different. Nevertheless, many communities have adopted similar regulations, with slight variations (Baird 1999b). The most commonly adopted regulations relate to:

1) The establishment of Fish Conservation Zones (FCZs) in deep-water (10 to 50 m deep) parts of the Mekong River. These areas are essentially "no take areas", for either all or part of the year. They are especially important as low-water fish refuges for protecting large brood stock in the dry season. In total, 69 FCZs have been set in Khong, with some FCZs being jointly managed by two or three villages, while some villages have established up to three FCZs under their management (Baird 1999b; Baird *et al.* 1998a; Baird and Flaherty 1999).

2) The banning of the blocking of streams with fish traps at the beginning of the rainy season in order to prevent the harvesting of fish making short spawning migrations into inundated rice fields and other wetlands. Locals want to encourage spawning before catching brood stock (Baird 1999b).

3) The banning of "water banging" fishing, where a long wooden pole with a metal piece at the end of it is used to bang the surface of the water in order to chase small cyprinid fishes like *Henicorhynchus* spp. *(pa soi* in Lao*)* and *Paralaubuca typus (pa tep* in Lao*)* into small-meshed gillnets. This ban has been implemented because it is believed that the method results in fish leaving local areas, leading to lower catches for those fishers who set stationary gill nets without chasing fish into them (Baird 1999b).

4) The banning of spear fishing with lights at night. This ban has been implemented because it is seen as being too effective a fishing method, catching large amounts of large brood fish. It is also unpopular because people who use this method sometimes steal fish from peoples' nets and traps at night when they encounter them, and have also been known to steal chickens and other things from villagers (Baird 1999b).

5) The banning of catching juvenile snakeheads (*Channa striata*) *(pa kho* in Lao*),* especially when they are less than about two weeks old and are still traveling in schools. These juveniles are very vulnerable to scoop-net fishing, but the amount of fish harvested is very small due to the small size of the fish. Villagers believe that it makes more sense to allow the fish to grow before harvesting them, thus increasing total production (Baird 1999b).

6) The banning of frog (*Rana* spp.) catching at the beginning of rainy season, when they spawn, and in some cases, at other times of year. The banning of frog harvesting during the spawning season is especially important, because frogs croak loudly at that time, making them very vulnerable to harvesting. Moreover, if frogs are harvested before they can spawn, recruitment may be reduced, leading to population declines. The banning of certain harvesting methods such as frog traps, frog hooks and lights at night is also mandated by many villagers due to the belief that frog harvesting for commercial sale is too intense, leading to population declines. Local farmers see frogs as important for controlling insect attacks on their rice crops (Baird 1999b).

7) The banning of tadpole (*Rana* spp.) catching at the beginning of the rainy season after spawning takes place. The principle of

protecting these small juveniles is the same as for protecting juvenile snakeheads, as explained in point #5 (Baird 1999b).

8) The protection of inundated forest habitat by encouraging villagers not to cut down wetland trees and bushes in the mainstream Mekong River (Baird 1999b).

While not all the villages have been equally successful in their aquatic resource management efforts, due to biological, geographical and social reasons, most villagers have widely reported increased stocks of certain aquatic animals, as well as increased fish catches, since the adoption of CBFC regulations. Some rare and endangered species of fish have also made comebacks due to the regulations, thus benefiting biodiversity. Improved solidarity and coordination within and between rural fishing and farming villages and the government, has also been observed. The costs to government of managing fisheries are minimal, since local people do most of the work. Therefore, the local government advocates the system, and hopes to expand the work to other villages in the future, although not all villages have opted to join the system, and some do not have appropriate habitat near their village for establishing FCZs. In any case, the initiative can be seen as being relatively successful to date, since both local people and the environment are benefiting (Baird *et al.* 2001b; Chomchanta *et al.* 2001; Baird and Flaherty 1999; Baird 1999b; Baird *et al.* 1999b; Cunningham 1998; Baird *et al.* 1998b; AIT 1997). In addition, two independent evaluations regarding the fisheries co-management system in Khong have both confirmed the above conclusions, especially in relation to the apparent success of FCZs (Chomchanta *et al.* 2001; AIT 1997).

Putting LEK to Work in Fisheries Management

LEK related to fish and other living aquatic resources in Khong is widespread, and most of the people in the district either live on islands or on the banks of the Mekong River, and spend a considerable amount of time on the water. Most people in the area have lived all their lives near the Mekong. Their lives are highly influenced by changing hydrological conditions in the Mekong River. Moreover, fishing traditions are strong. Fishing begins very early in life for many children, and especially young boys, and most are seasoned fishers by the time they are teenagers (Baird 1999b).

Local people in Khong have a highly developed folk taxonomy for fishes, and all medium and large sized species have specific local names, even when there are only small differences in outward appearances. These names are widely known within the general population, and discussions in communities are often centred on fishing activities. The average fisher is familiar with well over 100 local names, which are used to describe the approximately 165 species of fish that are economically significant to local people (see also Freire and Pauly; and Wiener, both this vol).

Photographs of fish found in Khong shown to children as young as five or six years old elicit many local names, indicating that many children of that age already have a vocabulary of 50 or more local names for fish. However, at such young ages, young children are not as easily able to match local names with fish photographs, compared to teenagers or adults.

As a testament to the accuracy of their folk taxonomy, when a foreign ichthyologist visited one village in Khong in 1993, he heard of three local names for fish in the genus *Micronema* (the names were *pa nang khao, pa nang ngeun* and *pa sa-ngoua* in Lao). At the time, the ichthyologist believed that these names indicated an over-differentiation of local names for describing the two species he believed actually occurred there (Roberts 1993c). However, it has since been confirmed that the villagers were right in that there are actually three species of *Micronema* in Khong, each species corresponding with a single local name (Baird *et al.* 1999a).

Local people in Khong possess a considerable amount of LEK about fish behaviour, including migration and feeding patterns (see for example, Baird *et al.* 1999a & b; Baird and Phylavanh 1999). However, in the past most people interested in LEK have been more concerned with documenting it than strengthening and disseminating it to make it more practically useful for local fisheries management by local people.

LEK has been of critical importance in the development of regulations as part of the community-based fisheries co-management program in Khong. In fact, it has been the basis for the establishment of all regulations, and the government and supporting NGO projects have provided additional scientific information to local fishers to augment their LEK.

Although the passing on of ecological information from the old to the young, and from generation to generation is a vitally important component of its development, LEK does not represent a stagnant state of knowledge. Importantly, LEK is also developed through the actual experiences of individual fishers, and therefore, LEK is not uniform within the population of fishers. Those who spend more time on the water may know more than others, but it also depends on the powers of observation of individuals, and the dispositions for learning of individuals, which may differ considerably. Differences in LEK are also certainly based on the particular habitats, species, and fishing methods utilised by different fishers. For example, some fishers who mainly only use fish hooks may have a considerable amount of LEK about those fish species that they target, but they may know much less about species that are not caught on hooks. However, most fishers in Khong use a wide variety of fishing gears and methods, based mainly on seasonal appropriateness and habitat diversity, and therefore have a considerable amount of LEK about a broad range of species and habitats. The diversity of fisheries that individual fishers engage in certainly helps ensure a generally high level of LEK amongst individual fishers.

Local fishers, even ones with vast amounts of LEK, are generally very eager to learn more, and are quite receptive to integrating new information into their LEK, provided that the source of new information is credible, and the information makes sense in the context of the LEK already in the possession of the fishers. In fact, often the fishers with the most LEK are the ones the most interested in learning more. That is how they got to know so much: by being inquisitive. Therefore, it is possible for scientists, government officials and NGO workers to contribute to and help build on LEK so that fishers responsible for managing fisheries can make better decisions. This is not to say that many fishers are not already making good decisions, but management is rarely perfect. The most enduring management systems are ones that can adapt to changing environmental, political and social conditions. Since LEK is often very locally relevant, while lacking a broad and regional perspective, it is often useful for outsiders to provide information of this nature to local fishers, as a way of helping to improve local fisheries management decisions. In this way, the LCFDPP and later the EPCDSWP have helped to support the CBFC programme in Khong. However, it is important to remember that fishers are unlikely to accept information from outsiders unless they respect the outsiders. Outsiders should make strong effort to learn from the fishers, so that they know what the fishers know, how they make use of their knowledge, and how they communicate LEK between themselves. This helps them to know what new information can be communicated in context with already accepted LEK (Baird *et al.* 1999b).

Another important way in which the LCFDPP and the EPCDSWP have helped to strengthen LEK and thus local fisheries management in Khong, has been by facilitating the exchange of LEK both within and between communities. Since fishers do not always know the same things, this type of activity has proven very useful, and it is usually very easy for fishers to accept information provided by other fishers who are in similar socio-economic and cultural situations, and speak the same language. In Khong, many of the regulations chosen by communities were adopted after other communities first implemented them. This can be clearly seen, as villages that entered the CBFC programme in Khong early on generally have much fewer regulations than those that entered later. The relative homogeneity of communities in Khong makes this process of information exchange relatively easy. Thus, the programme has evolved based on the dissemination and strengthening of LEK (Baird 1999b; Baird *et al.* 1999b).

"Peer review" is an aspect of the CBFC programme in Khong that relates to LEK, and it is of critical importance to ensuring the relevance of regulations. Since almost all villagers in Khong are also fishers (Baird *et al.* 1998b), LEK about fisheries is widespread in the villages in Khong. Therefore, during community consultations about regulations, it is difficult for anyone in the community to suggest regulations that do not make ecological sense, because others in the community are likely to quickly realise the deficiencies of such regulations based on their LEK, and object. Peer review is not just for academics, and the peer review process in the communities in Khong has helped to ensure high quality regulations (Baird 1999b; Baird *et al.* 1999b).

It is significant that most of the government officials responsible for fisheries management in Khong are of the same ethnic group as the fishers themselves, and most originate from rural villages in Khong. Therefore, the officials and the fishers have similar backgrounds, and hold the same LEK about fisheries. This is important, as it is generally easy for the fishers and local officials to understand each other, and officials can easily relate to the regulations that communities adopt (Baird 1999b).

One of the important reasons why CBFC has been successful in Khong is because the villagers have a strong sense of belonging to their communities, and a strong sense that their children and grandchildren will be living in the same villages in the future. This has helped to encourage a conservation ethic, and to ensure that many locals manage resources for the long-term and not just for the moment. A long-term sense of belonging often leads to good community-based resource management (Baird 1999b; Pomeroy 1998; Ostrom 1990).

ADAPTIVE MANAGEMENT AND LEK

Adaptive management is critical for successful natural resource management, especially over the long-term (Walters 1986). When fishers are involved in making management decisions, as they are in Khong, strengthening LEK is a critical part of supporting the adaptive management process. Adaptive management requires making management decisions; implementing them; monitoring and analysing the results of implementation; and then altering management decisions based on the results, gradually improving and adjusting them over time. This is commonly done by locals involved in the management of all kinds of natural resources, and is common in relation to fisheries management in Khong (Baird 1999b).

With regard to FCZs, it is been found that fishers monitor the success of FCZs in various ways, some of which are based on specific observations of natural processes. While observations regarding changes in fish species and quantities of fish caught are certainly very important, other tools for understanding FCZ success are more difficult for outsiders to understand. For example, fishers monitor the populations of some algae eating fish species like *Mekongina erythrospila (pa sa-i* in Lao*)*, *Morulius* spp. *(pa phia* in Lao*)*, and *Labeo erythopterus (pa va souang* in Lao*)* by observing shallow rocky areas adjacent to FCZs. If the rocks are covered with algae, they know that there are few algae eating fish in the adjacent FCZ. On the other hand, when the fish graze on the algae on the rocks, they can see what species have fed there, since the width of the grazing lines differ according to the species involved, and the sizes of individual fish. This method of observing fish populations is unknown within the scientific community (Baird *et al.* 1999b).

Another innovative and little known method of monitoring fish in FCZs by Khong people relates to fish rising to the surface of the water for oxygen, or other purposes. This is especially common during the height of the hot season, when water levels are at their lowest, and fish tend to concentrate the most in deep-water areas. Villagers have a considerable amount of LEK about what fish species rise up to the surface at what times of the day, and where, although this LEK is not understand by scientists. Villagers also exhibit a considerable amount of skill regarding their abilities to recognise those fish that rise to the surface, even though the non-experienced eye is unlikely to be able to identify them (Baird *et al.* 1999b).

Local people also monitor populations of the smallscale croaker *Boesemania microlepis (pa kouang* in Lao), which are important beneficiaries of certain deep-water FCZs in Khong. During their spawning season in the dry season, they make a loud croaking sound that is audible even out of the water. Local people gauge the amount of croaking that occurs each year, and in that way they have a sense whether populations are increasing or declining (Baird *et al.* 2001b; Baird *et al.* 1999b).

In Khong the EPCDSWP has helped to develop a more formalised data collection programme to monitor the results of management decisions related to the establishment of FCZs. This has been done to help communities improve their management strategies, but also to provide government agencies with quantitative data useful for assessing the value of FCZs (Baird *et al.* 1999b; Baird 1999b).

Initially, eight villages in Khong participated in the programme. In each village, locals themselves developed hypotheses regarding what fish species had already benefited from FCZs based on past observations. Once it had been determined what species locals believed had benefited from specific FCZs, each of which protects different micro-habitats of importance to different species, the communities determined what fisheries should be monitored to illustrate whether those species had really benefited or not. Then between five and twenty fishers were selected by the villagers to collect data regarding their daily fish catches in the selected fisheries, and the data were recorded in basic note books. After months of data collection, the data from different individuals was pooled and statistically analysed. Although not all the data was correctly recorded, most of the data were useable in the analysis. The data were then returned to the villagers to be reviewed and verified. It was found that the villagers were able to add a considerable amount of context and depth to the data, and the data were often altered due to this verification process. The data verification process acted as an important tool for helping the fishers to understand how effective management strategies have been for specific fish species, although there is still much more to learn (Baird *et al.* 1999b; Baird 1999b).

The data were also used to test the knowledge of the fishers regarding their understanding of the catch structure of particular fisheries. It was found that in Khong, most fishers were able to list the top ten species of fish caught in fisheries based on total weight quite reliably, thus showing their deep understanding of the fisheries (Baird *et al.* 1999b; Baird 1999b).

The process of adaptive management in Khong has also been strengthened through various other activities at the community level, the most important being periodic village meetings to review regulations informally amongst community members and discuss ways to improve regulations and their implementation (Baird 1999b; Baird *et al.* 1999b).

CONCLUSION

In cases where fishers are given a high level of authority over making management decisions, as is the case in Khong District, it is important to make maximum use of LEK to improve fisheries management, and in this context, it is often useful to disseminate and strengthen LEK in various ways.

However, the situation may not always be as straightforward as it may appear to be in Khong, especially when one is dealing with less ethnically and socially homogenous communities. But, even when less homogenous communities are the focus, CBFM may be the most viable option for improving management, especially when one considers small-scale fisheries with few scientific data situated in remote areas. The critical importance of LEK should be recognised, and has considerable potential for strengthening the local management of living aquatic resources.

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Questions

Eduardo Espinoza: Do you have any idea of the level of immigration in the fishers' communities?

Ian Baird: There are issues of upstream and downstream development that affect the Mekong. It may not be sustainable forever, but it's a good start.

Paul Fanning: In your talk, you left out two things namely how they identify their goals, and how they enforce or sanction the community when rules are broken.

Ian Baird: In the past, the fisheries had already declined quite a bit, so the people were already quite concerned about future decline. The big issue was increasing the amount of fish, bringing back fish that had disappeared, and resolving some conflict with other communities. In answer to your second question, the government had power over local people in Laos. People didn't have much management to begin with so they didn't have much to lose. Here in BC, so much is invested in the bureaucracy that no one wanted to lose it, so change is more difficult.

Paul Fanning: But what are the local sanctions?

Ian Baird: There are lots of meetings and discussions. We started the project by getting the locals to have meetings by themselves for two or three months, then we came in to talk to them and gave them questions to answer. Their agenda was already set before we arrived. Outside communities were consulted regarding any policy changes and if no one objected, it became village law. The village had power to confiscate gear, keep people out of there, and to manage the area. If it gets too much for them to handle, they can call in the municipal government for assistance.

Appendix 1

Some Comments on Conducting Rapid Assessments of Fish and Fisheries Based on Local Ecological Knowledge

As indicated in the main text above, local people living in the Mekong River Basin in southern Laos clearly hold a large amount of LEK about living aquatic resources, including finfish. At the same time, scientific information related to fish and fisheries is generally very limited. Therefore, it makes perfect sense to try to tap the rich LEK of fishers to improve the management of natural aquatic resources.

However, methodologies for collecting and analysing information based on LEK need to be developed and improved, as poor quality data have sometimes been generated in the region, along with good quality data. Essentially, the quality of data has generally been inconsistent.

Neither social nor natural scientists have all the answers. On the one hand, social scientists often lack sufficient understanding about biology and ecology related issues. However, natural scientists often lack knowledge about good interviewing methods or participatory approaches for working with local people. In reality, the skills of both social and natural scientists are necessary for getting good quality data, and for supporting the management of natural resources (Johannes 2001; Allut *et al.* this vol).

Interviewers need to have at least a basic understanding of the habitats, species and harvesting methods that they discuss with local people, and preferably much more than that (Johannes 1981). To illustrate this point, imagine that you are an electrical engineer with detailed understanding of various technical processes. Then imagine being interviewed by someone who knows nothing about electrical engineering. How would you, as an electrical engineer, respond to general questions about electrical engineering from a person who obviously does not understand electrical engineering? You would probably give simple and non-technical answers. You would certainly not provide many details, as you would know that details would go right over the interviewers' head. You might not even be that concerned with the exact technical accuracy of your responses, since you would know that the interviewer would not know enough to see any faults in the answer anyway. It certainly would not be worth your time to put much thought into your responses. And, if you decided to provide some technical details, your interviewer would be at great risk of either misinterpreting the details, or incorrectly recording them, since they would not really understand the context of the information they were receiving.

The above scenario is not so different than the situations researchers who interview local fishers are often faced with, although they are often burdened with additional cultural and language obstacles to good communication as well. Should anyone be surprised that the data collected on the LEK of fishers are often incomplete and incorrect? However, more often than not, researchers with inadequate interview methods blame locals for data that are later found to be inaccurate, rather than viewing their own deficiencies in collecting the data.

It is important for interviewers not only to understand the resources that they are interviewing local people about, but also to ensure that those being interviewed are aware of the knowledge that the interviewers possess. It is often best to try to let the interviewees know about the interviewers' knowledge during informal discussions before beginning structured interviews, but this may not always be possible for various reasons. Early on in interviews, it may, therefore, sometimes be necessary for interviewers to point out obviously inaccurate statements made by overly eager or unthinking interviewees who may be too quick to respond to questions, due to their lack of confidence in the abilities of the researchers, or because they do not think that the interview is important. Pointing out inaccuracies may embarrass interviewees, but if the mistakes are pointed out politely, and are recognised by fishers as mistakes once pointed out, it should make interviewees more serious about ensuring that their responses are well thought out and reasoned, and it will help the fishers to respect the researchers more. The author has used this technique successfully in Laos, but using it too much, or in an impolite or arrogant way is unlikely to be useful. It is generally only good to use this technique once at the beginning of some interviews, and only to make the point that the interviews should be taken seriously.

In recent years, the author has conducted a number of rapid fish and fisheries assessments, including biodiversity assessments, in central and southern Laos, and parts of Cambodia (see, for example, Baird 1994; Baird 1995a & b; Roberts and Baird 1995b; Baird 1997; Baird 1998a & b; Baird and Phylavanh, 1998; Baird *et al.* 1998b; Baird *et al.* 1999a; Baird and Sok, 2001). Various techniques and tools were employed for conducting these surveys, as it certainly makes sense to take advantage of all the useful tools available to researchers, especially in areas where little is known about biodiversity, and the learning curve is high. It is important not to be overly reliant in any one tool for conducting fieldwork of this nature.

The use of various methods to help verify the validity of data collected is called "triangulation", and the methodology that is used by the author is highly oriented in this way. When conducting field studies, five main tools are used, each being complementary to the others. They fall into both the natural and the social sciences, and involve both quantitative and qualitative methods. They include:

1) Conducting a background literature review in advance of fieldwork, looking into both peer reviewed and "gray literature". It is obviously important to know what has already been

documented about the biodiversity of an area before it is surveyed, in order to avoid having to "re-invent the wheel," as well as to know what information is still lacking, and so as to be able to concentrate one's efforts on poorly documented species or areas.

2) Using colour photographs of fish thought to either occur in the area, or occur in nearby areas, is important during interviews with local fishers. There has been considerable debate recently in Mekong countries regarding the usefulness of using photographs of wildlife, including fish, as a tool for identifying species or groups of species while conducting rapid biodiversity assessments. The answer is, "yes", it is worth using photographs, but photographs by themselves are not nearly enough to ensure good and reliable results. Fishers in Laos and other countries in Southeast Asia are often quite capable of identifying colour photos of fish, even if they are from remote areas where photos of fish have never been seen. However, there are also sometimes problems with fishers identifying fish from photos due to limitations related to changes in the scale and colour of fish, and of course, photos are only two dimensional, and do not reflect the context in which the fishes are obtained or viewed. Moreover, some groups of fish are more difficult to identify than others, and locally relevant identifying characteristics may not all be shown in photographs. Rare species that are not often seen will certainly be more difficult to identify than more commonly encountered species, and people often do not care much about the smallest species (Freire and Pauly this vol). The experience of the investigator is critical in helping to provide clues as to the types of errors that are likely to be common and investigators should be mindful of.

3) Using local names for fish identified in photographs is useful in order to provide an indication of whether fish identified in photos are in fact those that the fishers believe that they have identified. While local names often vary from place to place in Laos, even amongst members of the same ethnic groups, there are patterns of name use that can, nevertheless, help to indicate the accuracy of photograph identification. Again, the experience of the investigator is critical in helping to identify and pick up on common errors. Over time, as local names are recorded in the literature, and the local use of names becomes better understood, the pool of information will make local names increasingly useful for identifying species in particular areas. However, like photographs, names are not enough by themselves. In any case, it is critical to know local names for species, to enable the communication of useful management information to local people and government officials responsible for management, who generally do not know Latin names, especially of rare and unusual species. Many good reports about wildlife have remained unused by local managers due to confusion regarding what local names should be applied for species identified in technical reports without local names.

4) Using species-specific fish behaviour indicators for questioning interviewees, in order to help ensure that fish have been correctly identified, is another important tool for identifying fish, and especially for learning about the behaviours of different species. Combined with photographs and local names, this method can help improve the chances of accurate identification, but if the interviewer / interviewee does not understand the resource well, he or she will not be able to use this tool very effectively. This is because the researcher may not know the species well enough to ask specific questions about their behaviour, or understand the relevance of responses.

5) Finally, specimen collection remains a useful method for verifying fish species identified during interviews. The first four steps outlined above can help lay the groundwork for this, helping researchers target species worthy of particular attention. Specimen collection is done either by asking local people to help catch fish, or by the researcher collecting fish specimens, either alone or with colleagues. Specimens are generally photographed, and some are preserved in formalin and water solution for more detailed taxonomic investigations. This more standard research activity is important to confirm identifications, but again, it is not enough by itself for understanding the resource, as it does not provide contextual information about the species' behaviour, use or management by local people. Specimens also do not provide social information related to fisheries, or historical perspectives important for understanding changes in population structure and local utilisation patterns.

Hundreds of interviews with Lao fishers in various parts of the country over the years have helped indicate what fish species locals can generally easily identify, and what species they cannot. For example, it is virtually impossible to get reliable identification, local names and behavioural information about the smallest fish species, such as loaches in the genus *Schistura*. Therefore, the author rarely spends much time trying to collect such information during interviews. All the limitations must be recognised, and interview methods should only be used when there is a reasonable chance of getting useful information. Otherwise, one is simply collecting suspect data. One major problem is that many researchers are not aware of the limitations of interviews, or of other methods, or if they are aware, they may simply "throw out the baby with the bathwater". Extreme positions for or against interview methods are equally dangerous.

When conducting interviews with local people, the author prefers to interview between three and five fishers in small groups, instead of conducting individual interviews or large group interviews. Small groups help to ensure that there is "peer review" amongst the fishers before any information is provided, but avoids problems related to too many respondents during large group interviews. However, it is important for the interviewer to facilitate small group interviews well, in order to ensure that single individuals within the group do not dominate other members of the group. Fishers between 40 and 55 years old are generally the best to interview, because they have considerable experience by that age, yet are still active as fishers, thus avoiding having to test the more distant memories of older fishers who have largely stopped fishing.

Unfortunately, the validation of data in cooperation with local fishers is rarely done in the region, sometimes leading to the use of poor quality data. Data collected by local people should be brought back to local people for verification before its publication whenever possible. For example, before publishing the book on the Fishes of Southern Laos, Baird *et al.* (1999a) brought the data collected back to some local people for verification. However, full local data validation may not always be possible for various reasons.

Finally, it is emphasised that conducting surveys using the above tools is only fully possible when one has a reasonable command of the local language, as the author does in terms of the Lao language. One's ability to speak the language of those interviewed is critical for ensuring good communication with fishers.

Sciaenid Aggregations in Northern Australia: an Example of Successful Outcomes Through Collaborative Research.

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Abstract
Aggregations of the Sciaenid, Black Jewfish (*Protonibea diacanthus*), off Muttee Head in far northern Cape York Peninsula (CYP), have been exploited by Indigenous subsistence fishers for over fifty years. The apparent recent increase in effort targeting *P. diacanthus* in CYP's Northern Peninsula Area (NPA), has prompted concerns for the Injinoo Aboriginal Community, which has custodial responsibilities for that stock, and for the Queensland Fisheries Service, who must provide for managing fisheries in Queensland on a sustainable basis.

The tendency of *P. diacanthus* to aggregate annually in large numbers at well defined times and locations appears to facilitate the harvest of the species. In 1999, 96% of the recorded catch of this fish in the NPA (3.91 tonnes) occurred between April and August, the period in which historical accounts suggest they aggregate in the area. In 2000, 89% of the recorded catch (4.46 tonnes) occurred between May and September. Catches in 1999 and 2000 commonly exceeded 50 *P. diacanthus* per boat, with CPUE peaking at 224.5 kg boat h^{-1}. The relative ease of catching Black Jewfish when aggregating may render them susceptible to over-exploitation.

Based on length-age keys of Bibby and McPherson (1998), the predominant size and age represented in catches from Muttee Head during the aggregation period fell from three year old stock in 1999 to two year old stock in 2000. Historical records reveal that specimens close to the maximum size (>1500 mm TL) were being caught up until 1994. These data support the notion of a rapid change in the NPA Sciaenid resource, and justify concern for the state of the resource given that the fishery was previously based on adult stock.

Sexually mature *P. diacanthus* comprised only a small component (12 fish out of 270 = 4.4%) of the NPA catch examined in a sampling program that was biased towards the largest individuals available. The present study observed a minimum size at first maturity of 790 mm TL for female *P. diacanthus*. This represents a significant departure from the previous observed first length at maturity in Queensland waters of 920 mm TL, reported by McPherson (1997). A mark and release program, analysis of the diet, and examination of the genetic population structure contributed to the findings.

In response to the research findings of the present project, the Injinoo Land Trust (representing the Traditional Land Owner Groups of the Anggamuthi, Atambaya, Gudang and Yadhaykenu Aboriginal people), in cooperation with the Injinoo Community Council, have self-imposed a two-year ban on the taking of Black Jewfish. The area of closure incorporates the inshore waters of the NPA north of the southern boundaries of Crab Island (on the West Coast) and Albany Island (on the East Coast). The aim of the two-year ban is to allow local Black Jewfish stocks to reach a mature size so that prospects for the replenishment of stocks are improved.

With much consultation, this imitative has developed into a regional agreement with comprehensive support across the NPA. Representing each of the communities of the NPA, the Community Councils of Umagico, Bamaga, New Mapoon and Seisia, have undertaken to participate in the two-year ban on the take of *P. diacanthus*. In order to gain legislative backing for this species-specific ban, each of the Indigenous communities have expressed a willingness to forfeit their statutory exemption from the relevant catch restrictions. The implementation of the two-year closure presents new opportunities and obligations for research and management agencies alike to meet highly developed public expectations.

Introduction
Australian fisheries have a history of being managed and monitored in cooperation with commercial and recreational fishing groups, a process which has, until recently, neglected the values intrinsic to indigenous subsistence fishers. The expanding realm of cooperative arrangements is starting to ensure that contemporary environmental management includes cultural values. Although the value of a holistic approach to resource management is increasingly being recognised (see reviews by Alter 1996, White *et al.* 1994), the value of collaborative partnerships in fisheries research has often been ignored.

Collaborative research is based on the inclusion of the users of the fishery, i.e. the fishers themselves, in the process of the study. Such an approach facilitates the incorporation of their knowledge and experiences, and allows a broader assessment of the fishery i.e. integration of cultural and socio-economic values in parallel with environmental factors. As the people who spend the greatest amount of time interacting with marine ecosystems, fishers possess untold knowledge of the environment and its use.

Participative approaches to research not only lead to the more efficient production of results, but may also serve to increase the fishers' ownership of the process and its outcomes. Inclusive programs should increase the resource users' understanding and commitment at all stages, extending from the project's design through to development of management outcomes. This case study provides an example in which both indigenous fishers and scientific researchers have benefited from working together.

The research described in this case study gained tremendously from its participative approach and clearly demonstrates the benefits that may result from collaborative partnerships. Additionally, it is the belief of all project partners that the strong management outcomes which resulted from this research would not have been achieved without this interaction. This paper aims to present an example of the successful outcomes that can be achieved through collaborative research.

BACKGROUND

This case study focuses on a research project that concluded in 2001 after 2.5 years of close involvement with the Injinoo Aboriginal Community. Injinoo is situated 40 km from the northern-most point of the Australian continent (see Figure 1). The community lies over 1,000 km from the nearest city (Cairns), though there is a number of small indigenous communities nearby. The indigenous communities of Umagico, New Mapoon, Bamaga and Seisia are also located within the Northern Peninsula Area (NPA) of Cape York (north of the twelfth parallel).

The community was founded in the early 1900s, when the remnants of the clans whose customary lands occupy the NPA came together of their own accord to settle on the banks of Cowal Creek (Sharp 1992). The establishment of the community brought together five traditional owner groups: the Atambaya, Wuthathi, Yadhaigana, Gudang, and Anggamuthi. The population of Injinoo is presently less than 400 people (typically less than ten people of which being of non-indigenous descent), while the greater population of the region of the NPA is approaching 2,600.

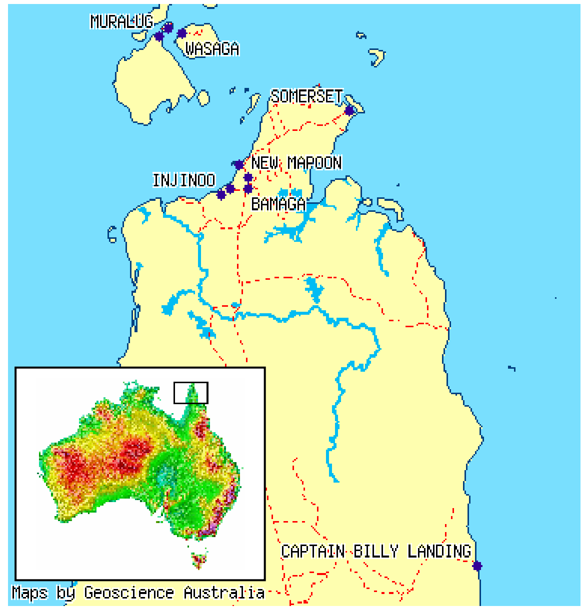

Figure 1: Map of the Northern Peninsula Area (north of the 12th parallel) of Cape York Peninsula, and the adjacent Torres Strait Islands.

The research focused on the biology and harvest of the aggregations of Australia's largest tropical Sciaenid, *Protonibea diacanthus* (see Figure 2). *P. diacanthus* may reach sizes greater than 150 cm in length and can exceed 45 kg in weight (Grant 1999). Aggregations of the fish form annually in the inshore waters of the NPA, and have also been reported at a number of northern Australia locations extending from Central Queensland (Bowtell 1995) to northern Western Australia (Newman 1995).

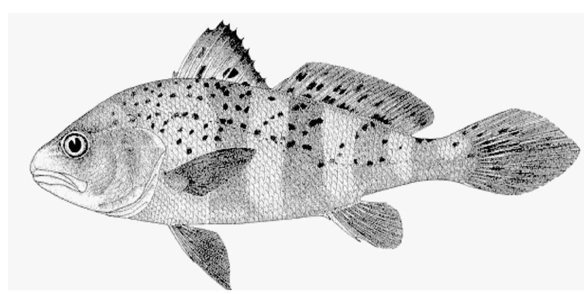

Figure 2. Juvenile *P. diacanthus*. (Source: FOA Fishbase.). Adult specimens do not show the distinct bands and spots on their scales.

Aggregations of fish, be they formed for the purpose of feeding, spawning or migrations, are renowned as vulnerable fishery targets (Johannes *et al.* 1999, Turnbill and Samoilys 1997). The largest member of the family Sciaenidae, *Totoaba macdonaldi*, is a relevant example. *T. macdonaldi* is considered to be critically endangered and is now listed on the IUCN Red List of Threatened Animals; a consequence of overfishing annual spawning aggregations (True *et al.* 1997).

Finfish of the Family Sciaenidae are widely distributed in tropical and subtropical waters (Sasiska 1996, Trewavas 1977). They commonly dominate epibenthic fish assemblages of near-shore waters of both regions (Rhodes 1998, Blaber *et al.* 1990), and often form the basis of commercial and recreational fisheries throughout the world (Gray and McDonnall 1993).

Catches of *P. diacanthus* form an important component of commercial, recreational and subsistence fisheries in several countries, including Australia (Williams 1997, DeBruin *et al.* 1994, Apparao *et al.* 1992, Mohan 1991). *P. diacanthus* is currently exploited in the NPA by local recreational fishers, and by domestic and international tourist anglers.

Need

One third of Australia's indigenous people currently live within 20 km of the coastline (Australian Bureau of Statistics 2001) (Figure 3). Many of the coastal clans of Australia's Aboriginal nations identify themselves as 'saltwater people', and their traditional estates typically extend beyond the coastal zone into the sea. In general, these coastal people view the sea as a cultural landscape, an extension of, but no different from, land, with similar inherent responsibilities (Tanna 1996).

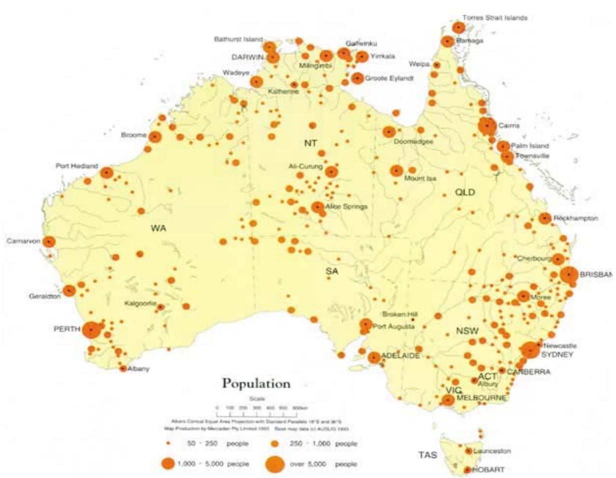

Figure 3. Distribution of Australia's indigenous population. Source: Australian Bureau of Statistics

In Australia, recognition of the importance of 'land' to Aboriginal cultures is a relatively new concept. It is still less than a decade since the Australian High Court decision (*Mabo -v- Queensland, 1992*), which acknowledged the native title rights of indigenous Australians. The legal validity of Aboriginal 'sea estates' is even more recent, having been recognised only in last two years (*Mary Yarmirr & Others -v- the Northern Territory of Australia and Others, 1999*).

Following these High Court decisions, the inherent rights and responsibilities of indigenous people under customary law are now recognised under Australian common law (Crisp and Talbot 1999). As a consequence, the rights of indigenous peoples to their traditional marine resources, and their role in the management of their customary estates, is of increasing relevance to coastal and marine resource administration in Australia.

In all there are about 100 coastal communities, mostly in northern Australia, occupying land under some form of Aboriginal or Islander leasehold or title (Smyth 1993). Indigenous members of these northern communities are largely exempt from Commonwealth and State legislation with regard to the utilisation of marine resources when they are harvested for traditional or subsistence use. However, there is presently a deficiency of datasets on the importance of the contribution of indigenous fish catch to the total annual catch (Tropical Finfish Management Advisory Committee 1998).

While indigenous people currently comprise less than two per cent of Australia's population, this figure is nonetheless growing rapidly. Since 1991 there has been a 45% increase in the number of people who identify themselves as indigenous Australian (Australian Bureau of Statistics 2001). The Aboriginal and Torres Strait Islander population has a much younger age profile than the non-indigenous population (see Figure 4), a reflection in part of higher fertility rates. For example, at Injinoo 49% of the population is less than eighteen years old.

It follows then that in the immediate future there is the potential for a rapid increase in fishing pressure place upon local resources. This appears more evident when one also couples in the improving economic situation among many of Australia's indigenous communities. At Injinoo, for example, there were five powered vessels in the community in 1990, ten years later the number had increased to 42 (at the same time there were 48 houses in the community).

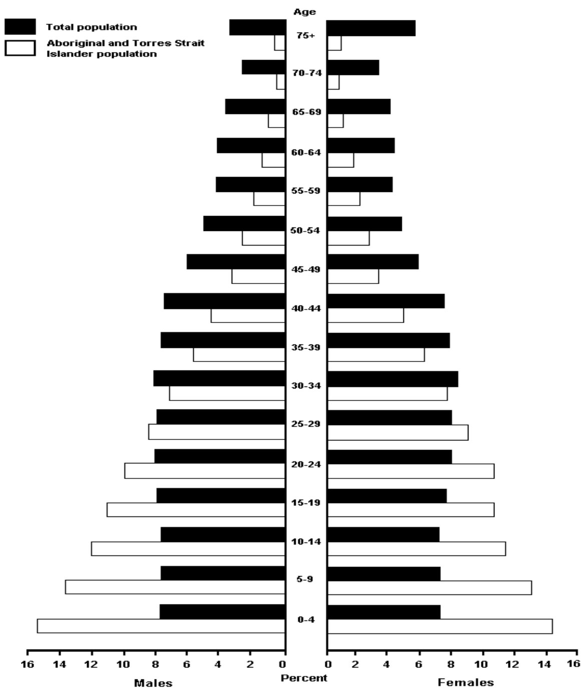

Figure 4. The age structure of Australia's indigenous population and the total population. Source: Australian Bureau of Statistics.

The research project was initiated due to concerns among the area's traditional owners of the impact of the perceived increase in fishing activity targeting aggregations of *P. diacanthus*. Aggregations of *P. diacanthus* that form off Muttee Head (~15 km south-west of Injinoo) have been linefished by indigenous subsistence fishers for over fifty years. The concerns of the traditional owners stem from an apparent rise over the last decade in fishing pressure sustained by the aggregations.

There is an extensive body of evidence derived from fish stocks around the globe that indicates target fishing of aggregations can rapidly undermine fishery production. Chronic effects of aggregation fishing include the truncation of size and age structure (e.g. Beets and Friedlander 1992), deterioration of the stock's reproductive capacity (e.g. Elkland *et al.* 2000), and altered genetic composition (e.g. Smith *et al.* 1991). Acute effects include the total loss of aggregations (e.g. Sadovy 1994).

As an example of the vulnerability of *P. diacanthus*, the once flourishing commercial fishery along the north-west coast of India has become 'non-existent' (James 1992). Anecdotal evidence suggests intensive fishing has also severely impacted several annual aggregations of *P. diacanthus* along the east coast of Queensland (Bowtell 1998, Bowtell 1994). Yet despite this there has remained a dearth of information on the species and the demands made upon those stocks by the various fishery sectors. In particular, the biological purpose and importance of these aggregations has yet to be demonstrated.

METHODS

Increasing awareness of the concerns held by the traditional owners led to presentations to the Queensland Department of Primary Industry (the state fisheries research agency) by Balkanu Cape York Development Corporation (an indigenous organisation representing the people of Cape York). Together they successfully sourced funding from the Fisheries Research Development Corporation (the principal fisheries research funding organisation in Australia). It is notable that this was the first time that this Corporation had funded research principally devoted to examining an indigenous fishery.

As far as possible, community members were involved in the design and implementation of the project, as well as the interpretation of results. The act of working together on all aspects of the project greatly enhanced the communities' trust, and hence their willingness to participate (See Rudd, this vol; Kwan, This vol). At all stages the project adhered to the protocols established by Balkanu for conducting research in indigenous environments. These were designed to allow individual communities to participate in scientific research in a manner that community members deemed culturally appropriate.

The continued involvement of local fishers was integral to the success of the project. Not only did they provide critical information on the spatial and temporal scale of the fishery, they also assisted greatly in providing biological samples. Limited employment opportunities were provided by the project, but the vast majority of their contribution was voluntary. It was the common goal of ensuring the sustainability of the resource, which provided for this demonstration of the feasibility of collaboration between indigenous fishers and scientific researchers.

Prior to the commencement of sampling, project staff had made a substantial commitment in time meeting the community residents and promoting the objectives of the project. A key challenge to persuading fishers of the importance of research is that fishers may perceive that the advancement of such knowledge may 'backfire' and ultimately diminish their rights. From feedback generated at later stages, this initial consultation was deemed critical to the success of the project. Although seemingly unproductive in terms of annotated results, this period was essential to gaining the understanding of community members. Initiatives undertaken to raise the profile of the project within the community included:

- the personal introduction of the project biologist to members of the community by a Balkanu staff member who had previously resided in the community;
- organisation of a drawing competition to create awareness of the project with the younger members of the community; and
- the introduction of the project's objectives and methods in an interview broadcast on the local community radio service, in a public meeting held in the community hall, and with posters displayed throughout the NPA.

There is no doubt at all that the project benefited greatly from the decision for the project biologist to reside in the community during most of the project. Like many other Australian indigenous communities, Injinoo is the focus of numerous studies each year. Researchers in almost all these studies 'fly-in and fly-out', and the community gains little understanding of the study and its findings. However, for the project biologist to reside in the community for such an extended period of time, considerable support was needed from the community, given the limited resources such as accommodation and office facilities.

By residing within the community, the biologist was able to achieve a stronger personal and working relationship with its residents, over time this generated a much greater understanding. This was not only from the perspective of the community's understanding of the research and results, but also of the researcher's understanding of the community. Adopting this method serves to bridge the skills held by biologists and those necessary to understand the ethnobiological information which Johannes (1981) advocates as critical for the integration of contemporary and traditional practices.

From the onset it was immediately clear that the indigenous fishers were not familiar with the methods and tools of western science. For example, while fish tags are very familiar items among recreational and commercial fishers in Australia, the indigenous people of Injinoo had never been exposed to such methods. This increased the importance of community awareness programs and called for slight alterations to some of the methods. The fish tags for example, were simply printed with a prompt alongside the normal contact details, which reminded the fisher to 'record tag number, date, place, and fish length'.

As there was no existing catch data on the fishery, oral accounts of traditional owners and long-term residents were collated in order to develop an historical profile. It is in such circumstances, when access to data is otherwise not available, that oral history proves an invaluable tool in establishing a retrospective analysis of resource use. Nonetheless, the acquisition of such information necessitated the same critical scrutiny that is applied to any other data set. In this investigation, only data verified by more than one source was adopted.

In order to maintain the high level of community ownership of the project, the community was consulted throughout all stages, with the results released as soon as they become final. The project staff liased directly with the community's Council Clerk, who also represented the interests of the community by serving on the project's steering committee. The steering committee was comprised of elected representatives of each of the stakeholder groups linked to the fishery, and guided the progress and direction of the project. The committee also ensured the transmission of the results to all stakeholder groups.

RESULTS

Oral accounts collected during the project provided a record of the fishery since its inception, and presented evidence of changes in the demographics of the fishery, the harvest levels, and stock condition. Very detailed information was available from members of the community, for example, elders were able to recall the very person and year in which *P. diacanthus* were first caught by the traditional owners. The indigenous fishers held a fine understanding of the spatial and temporal attributes of the aggregating behaviour of the fish stock. The seasonal, lunar and tidal patterns had long been common knowledge among fishers, but had never been scientifically documented.

Knowledge of the aggregating behaviour of the fish appears to facilitate the increased harvest of the species. Most of the recorded catch in 1999 (3.9 tonnes) and 2000 (4.5 tonnes) occurred during the aggregation season described by fishers (April to August) (see Figures 5 and 6). In contrast to their normal behaviour, *P. diacanthus* are exceptionally easy to harvest when aggregating. Catches of *P. diacanthus* typically exceeded 50 fish per boat, and catches of over 100 fish are not uncommon. Recorded CPUE ranged up to 250 kg per hour/boat.

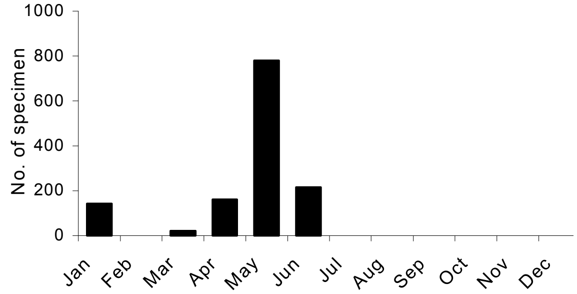

Figure 5. Number of *P. diacanthus* harvested each month of 1999 from the coastal waters and tributaries of the Northern Peninsula Area.

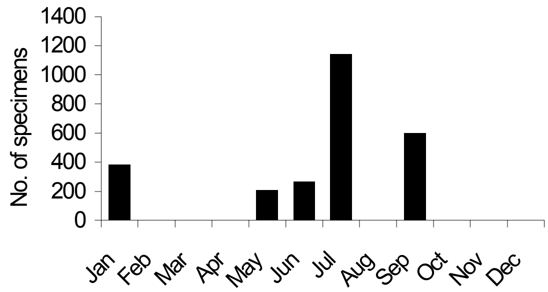

Figure 6. Number of *P. diacanthus* harvested each month of 2000 from the coastal waters and tributaries of the Northern Peninsula Area.

Data from the 4,000 plus fish observed in the catch revealed a decline in average size within the two years of monitoring. Catch records revealed that in 1999 the fishery was dominated by fish in the size range 75-80 cm (believed to be three year old fish), and in 2000, the dominant size class had decreased to 60-65 cm (believed to two year old fish) (see Figures 7, 8 and 9). Oral records reveal that specimens close to their maximum size (>150 cm) were caught up until 1994. These data support the notion of a rapid change within the fish stock, and warrant concern

Sexually mature fish comprised less than 1% of the catch examined in a sampling program biased towards the largest individuals available. This is a serious concern, given that estimates of the critical stock threshold for tropical fish range between 20% and 40% (Turnbill and Samoilys 1997). Among the fish showing evidence of sexual maturity, the development of their gonads coincided with the aggregation season. However, no hydrated or spent gonads were observed, so the exact timing and location of spawning could not be determined. Yet, the indigenous people of the Injinoo do eat the eggs of many marine species and state that ripe eggs were readily available during previous aggregations.
Another concern is a decrease in the age when first maturity was observed among females. From

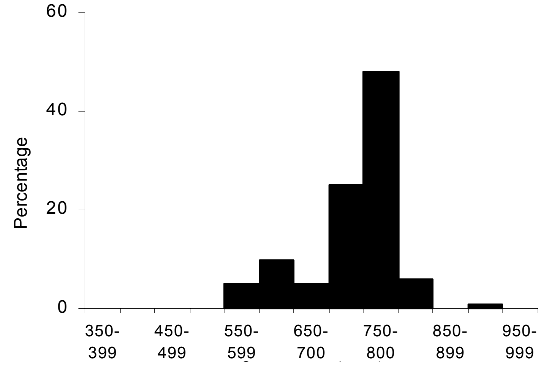

Figure 7. Composition of the size classes of *P. diacanthus* harvested off Muttee Head in 1999.

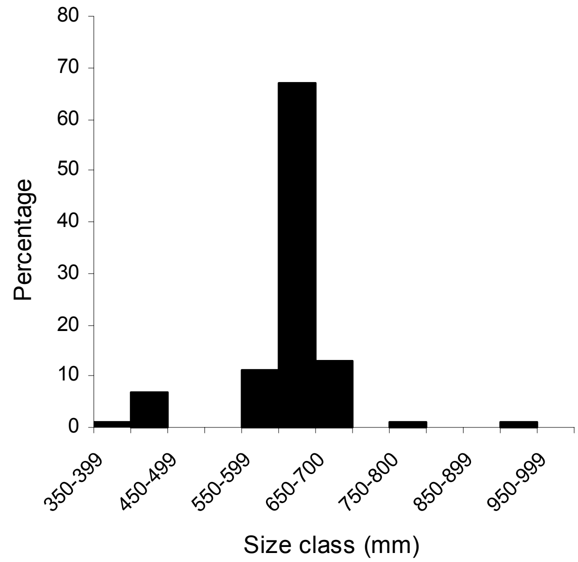

Figure 8. Composition of the size classes of *P. diacanthus* harvested off Muttee Head in 2000.

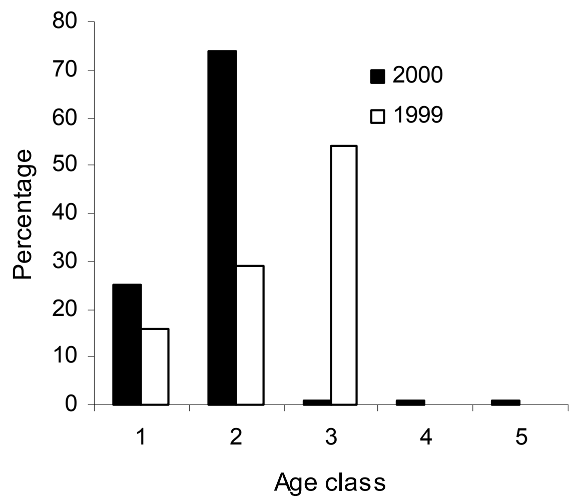

Figure 9. Composition of the age classes of *P. diacanthus* harvested the Northern Peninsula Area in 1999 and 2000.

the adjacent Gulf of Carpentaria waters, first maturity in females occurs at four years of age (McPherson 1997). Four year old fish were not present in the 1999 catch, and amongst the three year olds, no evidence of sexual development was observed in that year. However, in the following year, even though the three year old stock was greatly reduced, some of these displayed evidence of sexual maturity. Whether this was an artefact of increased sampling, or a direct consequence of the sustained fishing pressure, is currently the subject of further investigation.

Food items observed in the analysis of the diet of the fish included a variety of teleosts and invertebrates. The range of animal taxa represented in the prey items support the description of an 'opportunistic predator' attributed to the species by Rao (1963). The limited data gained in this project presented no evidence to support the notion that the seasonal migration of *P. diacanthus* was related to the increased availability of prey items in the inshore waters, as is suggested by Thomas and Kunja (1981). The occurrence and contents of stomach items observed between April and July did not contrast with that observed in the period outside which the aggregations form.

The tag and release component of the present project provided limited data on the movement patterns of *P. diacanthus* in the NPA waters. Tag returns prove that some of the fish remain at, or return to, the aggregation site at least into the following day. The recaptures also revealed the movement of an individual fish between two distinct aggregation sites. This was supported by DNA fingerprinting using the novel Amplified Fragment Length Polymorphisms (AFLP) technique. No significant genetic variation was found between fish sampled from the adjacent aggregation sites. As both sites are fished, their participation in multiple aggregations may increase their susceptibility to capture.

Resultant management outcomes

In response to the research findings, the Injinoo Land Trust (representing the traditional land owner groups of the Anggamuthi, Atambaya, Gudang and Yadhaykenu Aboriginal people), in cooperation with the Injinoo Community Council, have self-imposed a two year ban on the taking of *P. diacanthus*. The area of closure incorporates the inshore waters of the NPA north of the southern boundaries of Crab Island on the west coast and Albany Island on the east coast (see Figure 10). The aim of the two year ban is to allow local stocks of *P. diacanthus* to reach a mature size, thereby improving the reproductive capacity.

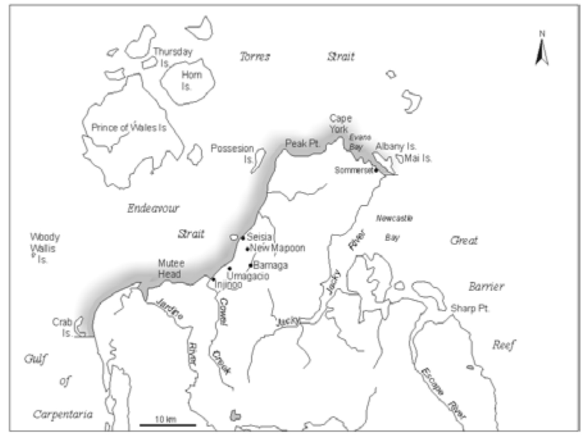

Figure 10. Location of the area within the Northern Peninsula Area that is closed to the harvest of *P. diacanthus* under the regional agreement.

Following extensive consultation, this community initiative developed into a regional agreement with comprehensive support across the NPA. Representing each of the communities of the NPA, the Community Councils of Umagico, Bamaga, New Mapoon and Seisia, have undertaken to participate in the two year prohibition on the take of *P. diacanthus*. Furthermore, Torres Shire and the Kaurareg Nation of the adjacent Torres Strait region are also signatories to the ban. Proprietors and operators of all tourist accommodation and fishing charter boats operating in the NPA region have also pledged their full cooperation with the initiative.

Adding to the uniqueness of this self-imposed management arrangement, the elected Chairmen of these indigenous communities have asked for legislative support for this species-specific ban. Each of the indigenous communities has expressed a willingness to forfeit their statutory exemption from the relevant catch restrictions. The relevant government institutions whose role is to provide for the management needs of the state's fisheries have been presented with a clear obligation to respond to these highly developed public expectations. As such the users of the resource have become empowered to assert responsibility for management.

Parties to the regional agreement of the NPA each recognise that the two-year closure may not provide adequate time for the complete recovery of the proportion of the adult fish in the population. All parties have requested continued investigation on local stocks, so that decision-makers will have sufficient information to review management needs at the conclusion of the two year period. The species-specific area closure that developed as a result of the research findings presents many unique opportunities and obligations for research and management agencies alike. Further funding will be sought to continue stock assessments, so that the appropriate persons can be informed of the stock's condition prior to the end of the management outcome.

Conclusion

Aggregation is one of the most widespread behavioural mechanisms used by marine fish to reduce natural predation (Die and Ellis 1999). Yet it is this behaviour that often promotes increased fishing effort and higher catches, as concentrations of fish are both easier to detect and more efficient to harvest (Turnbill and Samoilys 1997). This research has indicated that widespread knowledge of the spatial and temporal attributes of the fish's aggregating behaviour, has facilitated the increased catch of this species.

While the geographical setting of the project was within Queensland, the results should have widespread application to fisheries for *P. diacanthus* and other aggregating fish species. The arguments for collaborative research have been advocated as they apply in Australia, yet they are predominantly universal to indigenous fisheries in developed nations and may also apply to other fishery sectors. Undoubtably, the ongoing cooperation of indigenous fishers in the project greatly enhanced the outcomes.

The fine scale of fishers' knowledge of the aggregating behaviour of the fish stock proved very useful in developing monitoring and sampling programs. This type of assistance is particularly useful in remote waters that are frequently used by local fishers but rarely visited by researchers. The assistance of fishers in also providing specimens and samples allowed the more efficient use of project resources. The voluntary nature of much of this work demonstrates the willingness of fishers to contribute to scientific research where tangible benefits of the research have been demonstrated.

The guiding principles adopted in the project follow those explained in detail by other speakers of this conference. In brief, these principles provide recognition of the value of fishers' knowledge and allow for their greater participation at all stages. The process adopted in this project was to:

- Identify the issues of concern so as to ensure the relevance of the research outcomes;
- Ensure the transmission of clear and salient objectives so that the direction of the project is clear to all;
- Involve interested parties as far as possible in all aspects of the project;
- Provide recognition of the relevant cultural and social values held by the various groups, to, among other reasons, ensure the adoption of appropriate methodology;
- Liase with all of the stakeholders at all stages to ensure a politically neutral and open process;
- Ensure results are made available in a transparent manner acceptable to the various groups; and,
- Provide a forum for the input of users and stakeholders in development of management outcomes that may be necessary as a result of the research findings.

The comprehensive consultation process conducted throughout the lifetime of the project ensured the implications of the research have been recognised by both management authorities and the communities of the NPA. The implementation of the community-developed two year closure exceeded all expectations and sets a precedent for similar works. It is believed that this outcome was a product of the communities' understanding, participation and commitment to the research process.

The outcomes are unique among Australian fisheries, being the only example we know of in the modern context in which indigenous communities have initiated a long-term ban on the harvest of a fish species. This outcome serves to demonstrate that, provided with the appropriate opportunities and information, mutually beneficial relationships may be developed between indigenous communities and scientific researchers. This partnership between government institutions and resource users may serve to further enhance prospects of achieving the sustainable use of resources.

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Questions

Bob Johannes: How do you do a stock assessment during the ban?

Michael Phelan: It's still possible to continue what we did before. We know the size of fish at maturity, so basically if we measure the fish, we can determine the age structure of the population. Two years may not be long enough to get the fish back. We'll have to wait and see.

Bob Johannes: So it's a catch, measure and release study?

Michael Phelan: Yes.

Melita Samoilys: What about the commercial and other recreational fisheries?

Michael Phelan: The commercial fishing operations are still relatively young so the fisheries never expanded to that area. It is a relatively unproductive area anyway.

Tony Pitcher: Your talk and project are sensitive to the feelings and aspirations of the aboriginal people, which is laudable. This is why I'm surprised that the name of the fish that you use is gratuitously insulting to humans. The American Fisheries Society recently decided not to use that word or squawfish. Perhaps it is not a big issue in Australia, but in an international forum, you may wish to use another name.

Michael Phelan: This is common in Australia. The name comes from the tendency of the fish scales to blacken upon death.

Status of Research on Traditional Fishers' Knowledge in Australia and Brazil

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Abstract
This paper examines the status of research on indigenous Australian and Brazilian fishers' knowledge. In Australia, research involving indigenous ecological knowledge has been done mainly in terrestrial environments. The marine environment has gradually increased its profile and share of this research over the last 15 years, following research and management issues associated with indigenous use of marine resources, particularly in the Torres Strait and Northeast Australia. The development of such research is related to indigenous participation in marine resource management. The focus has been on threatened species – specifically dugong (*Dugong dugong*, Sirennia) and sea turtles rather than fish – and has now expanded beyond the domain of marine protected areas. Indigenous communities in Australia are increasingly valuing and protecting their knowledge as intellectual property. This involves strict controls of access and use, and adherence to culturally appropriate research ethics and methods. In Brazil, research involving ecological knowledge of artisanal fishers has been done mostly over the past ten years, focusing on marine and freshwater fish. Studies have been completed at the Southeastern and Northeastern coasts, and at the Southeastern and Amazonian rivers. Research findings show that fishers have a nomenclature system for fish species, usually classifying useful species in a detailed way. The classification of fish is influenced by their ecology and behaviour. Fishers apply their ecological knowledge while fishing and this knowledge is consistent with the relevant biological science observations. Despite its potential usefulness, application of this knowledge in a fisheries management context is yet to occur in either country. Environmental and socio-cultural factors threaten the maintenance of this alternate information base, and serve to highlight the need for increased research efforts to record this knowledge and realize its potential contribution to fisheries management.

Introduction
Human communities that rely directly on their natural resources for subsistence usually have a detailed environmental knowledge (Berlin 1992; Gadgil *et al.* 1993; Berkes 1999). There are several terms used to describe this type of knowledge, such as 'local', 'traditional' or 'indigenous', depending on the characteristics of the holders of that knowledge (Berkes 1999). Difficulties regarding this terminology have been addressed in the human ecology and ethnoscience literature (for example Berkes 1999). Ruddle (1994) argued that the term 'local' is less problematic, and thus a more practical description or identifier of the relevant people and their knowledge. Ultimately there may be no single terminology that is applicable to all circumstances. Australia and Brazil are indicative of this situation. Both countries have diverse Indigenous peoples and culture that have endured European colonization for generations. The immediate and prolonged effects of this are as diverse as the Indigenous cultures and the respective circumstances of their histories of colonisation. This diversity is linked to the range of terminology used to describe these communities today. The use of 'local', 'traditional' or 'indigenous' to describe a community and its knowledge often depends on the community's history and experience of colonisation. While acknowledging these differences, the knowledge held and applied by these communities in both countries has the common elements of being a part of their respective traditions or cultures, founded in practical experience and application. Therefore the term traditional knowledge is consistent in both an Indigenous Australian and Brazilian artisanal or local context. For the purposes of this paper the definition offered by Berkes (1999) is appropriate, with an additional note emphasising the fishery-related context of the discussion. Thus traditional fishers' knowledge (TFK) refers to the fishery-related component of the 'cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment (Berkes 1999:8). The terminology 'TFK' is used consistently throughout the text.

In the context of this paper, TFK research is ethnobiological research with Indigenous peoples, devoted to investigating, identifying and recording their fish, fisheries and related knowledge. This research is carried out in a variety of contexts and in a variety of ways. It ranges from the more direct ethno-ichthyological approaches where TFK is the main focus of the research, to more indirect approaches where a particular species or habitat, or its use, is the research focus and TFK has been incorporated as a result of Indigenous involvement.

This paper reviews Indigenous Australian and Brazilian TFK research. The main characteristics of the research are identified and results summarised. The paper concludes with some discussion of future TFK research effort and associated issues.

AUSTRALIA

In Australia, research involving TFK has been carried almost exclusively in the northern half of the continent and the Torres Strait Islands (TSI). Nietschmann and Nietschmann (1977) and Nietschmann (1985) detailed the complex classification system applied to dugong and, to a lesser extent, sea turtles by TSI fishers (see also Kwan, this vol). The system described was based on the parameters of age, sex, location, type, size and quality of fat and meat. A detailed environmental knowledge was also identified among those fishers. This included tide and sea conditions, such as identification of tidal cycle, moon phase, wind direction, island or reef exposure and time of season; and generic and specific names for large and small underwater features such as reefs, passages, channels, sandbanks, feeding grounds, shallow- and deep-water places, coral heads and various zones on reefs (Nietschmann 1977). Anderson and Heinsohn (1978) surveyed by questionnaire Indigenous perceptions of dugong abundance, population trends, behaviours and ecology across northern Australia and the TSI. This knowledge was found to be compatible with the then current hypothesis of year round dugong breeding. A specific purpose of this research was also to assist in future planning of dugong field studies. Collaborative research with Indigenous communities has occurred on sea turtles in Northern Australia (Kennett *et al.* 1997-a, -b; Bradley 1997; Yunupingu 1997, Munungurritj 1997) and has been planned for dugongs in northeast Queensland (Oliver & Berkelmans 1999). Some of this research has incorporated traditional knowledge of sea turtle populations at specific times of the year and nesting sites (Bradley 1997).

Literature on marine resource use by Indigenous communities in northern Australia, particularly in the northeast and the TSI also documents TFK to various extents (Smith 1985, 1987; Gray and Zann 1988; Johannes and MacFarlane 1991). Smith (1987-a, -b) completed an ethnobiological study of marine resource use in northeast Queensland. Aspects of TFK of fish, turtles and particularly dugong were documented.

Gray and Zann (1988) edited the proceedings of a workshop examining traditional knowledge of the northern Australian marine environment. This included accounts by Indigenous Australians from northwest to northeast Australia and the TSI of the type of traditional knowledge of the marine environment held within their respective communities. Also included were papers on Indigenous marine resource use, some which included TK. Bradley (1988) documented TK in the Gulf of Carpentaria including a glossary of terminology for dugong and sea turtle anatomy, hunting methods and associated environmental conditions. Davis (1988) contributed a revised version of earlier research (Davis 1984, 1985) which included ethnobiological information of seasonal use and associated TK of the littoral zone in northern Arnhem Land. Baker (1993) documented TEK in southwestern Gulf of Carpentaria. Classification of seasons, climatic conditions, environmental units from terrestrial to open sea, and animal and plant food calendars that incorporated fisheries and related information were outlined.

Johannes and MacFarlane (1991) described the traditional fishing in the TSI, including quantitative catch data, hunting and fishing areas including Customary Marine Tenure (CMT) and TFK. This included a substantial glossary of fisheries terminology employed by TSI fishers. The TFK documented varied in detail geographically throughout the TSI, and also included contributions by Poiner and Harris (1991) and Fuari (1991). The contribution by Fuari (1991) is indicative of the TFK included throughout the work of Johannes and MacFarlane (1991), and included TFK relevant to fish, turtle, environmental and seasonal indicators or environmental cues for fish species, and medicinal knowledge.

Peterson and Rigsby (1998) edited a volume on CMT in Australia. TFK of climatic, tidal and seasonal conditions, marine environments and associated classifications for parts of northern Australia is included (Sullivan 1998; Memmott and Trigger 1998; Bradley 1998; Palmer 1998 and Southen *et al.* 1998).

Aspects of southeast Queensland TFK have been documented (Ross *et al.* 1996; Ross and Pickering, in press). This research has been collaborative in nature with Indigenous communities, and has documented shellfish resources and their role in Indigenous culture and heritage, and the relevance of TFK to heritage and resource management.

BRAZIL

In Brazil the small scale artisanal and commercial fisheries are important sources of food and income both in freshwater (Petrere, 1989; Bailey and Petrere, 1989; Kalikoski and Vasconcellos, this vol) and marine (Dieques, 1999) environments. This importance and the number and diversity of fishing communities is reflected in the volume of research focusing on fisheries resource use. These studies have mainly addressed the fishing strategies and technologies, catch composition and use of fishing resources by communities from the southeastern coast (Begossi 1996; Hanazaki *et al.* 1996, Nehrer and Begossi 2000; Seixas and Begossi 2000), South and Southeastern rivers and reservoirs (Castro and Begossi 1995; Okada *et al.* 1996; Vera *et al.* 1997; Silvano and Begossi 1998, 2001), Amazonian rivers (Goulding 1979; Petrere 1978, 1986, 1990; Setz 1989; Ribeiro and Petrere 1990; Begossi *et al.* 1999) and Northeastern coast (Cordell 1978). Among the studies of use of fishery resources other than fish, Rebêlo and Pezzuti (2000) verified the use and consumption of freshwater turtles by Amazonian riverine people, while Nordi (1997) studied the energy allocation related to mangrove crab gathering at the Northeast coast.

LFK research in Brazil is almost exclusively ichthyological in content. Classification of fishes has been documented in communities from the southeast coast (Begossi and Figueiredo 1995; Paz and Begossi 1996; Seixas and Begossi 2001), south coast (Fernandes-Pinto 2001) the Amazonian Tocantins River (Begossi and Garavello 1990), and the northeast coast (Costa-Neto and Marques, 2000-a; Mourão, 2000; Freire and Pauly, this vol). Other studies focussed on the TFK of fish from the Mundaú-Manguaba estuary (Marques 1991) and the São Francisco River (Marques 1995) in the northeast, as well as by other communities from the northeast coast (Costa-Neto and Marques 2000-b, c), and the Piracicaba River, in southeast Brazil (Silvano 1997; Silvano and Begossi in press).

The literature illustrates the significance and value of TFK in Brazil. For example Marques (1991) conducted biological research about the diet of an estuarine fish (*Arius herzbergii*, Ariidae). The results corroborated the TFK of communities from the Mundaú-Manguaba estuary in the northeast, and included the identification of a trophic relationship in that particular environment unknown to western biological or ecological science. Another example is the TFK of migratory behaviour unknown by western fisheries scientists, of an important commercial fish species (*Prochilodus lineatus*, Prochilodontidae) in the impounded Piracicaba River (Silvano and Begossi, in press).

Collectively the literature indicates the existence of well developed TFK in Brazil, which includes details of fish ecology and behaviour. TFK has proven consistent with western biological scientific observations (Marques 1991, 1995; Silvano 1997, 2001; Silvano and Begossi in press). TFK about target fish species probably influences fishing tactics and fishery yields (Cordell 1974; Marques 1991; Silvano and Begossi, in press; Silvano 2001). Research findings also show that communities have classification systems for fishes, sometimes classifying useful species in a more detailed way (Begossi and Garavello 1990; Begossi and Figueiredo 1995), although other criteria besides utility may also influence classification (Seixas and Begossi 2001). These systems may be hierarchical, similar to that used by western biology or based on other criteria such as fish growth cycle, ecological and behavioural characteristics, and meat colour or flavour (Marques 1991, 1995; Paz and Begossi 1996; Costa-Neto and Marques 2000-a; Mourão, 2000).

DISCUSSION

The Australian and Brazilian research differs in a number of ways. Australian TFK research is dominated by a marine focus. TFK of non-fish species, most notably dugong and sea turtle is prevalent throughout the research. TFK research in Brazil is almost exclusively focussed on fish, and has included studies in freshwater regions comparable to those completed in marine areas. Another feature of some of the Brazilian research has been an assessment of the usefulness or validity of TFK as an additional source of ecological information based on its consistency with western biological and ecological scientific information.

There are significant geographical gaps in the research coverage for each country. In Brazil it is the great Amazonian rivers and the southern coast. However the gaps in the Australian research coverage are arguably more significant. With the exception of a pilot study planned for northern New South Wales (NSW), very little or no TFK research has taken place in the southern states of NSW, Victoria, Tasmania, South Australia or in Western Australia south of the Kimberley region.

The difference in research focus is attributable to the circumstances of each country. The coverage of northern Australia and TSI is, in part, a consequence of the dugong and sea turtle research focus, this being the geographic range of these species. It also reflects the importance of these species to Indigenous communities and marine resource managers in these regions. Research documenting TFK relevant to fish is also concentrated in these regions, a reflection of the relative importance of Indigenous communities in terms of fishery resource use. The southern, and especially the southeastern, states of Australia are more densely populated and Indigenous communities are a demographic minority. In these regions fishery resources are of continuing importance to indigenous communities despite the lack of research.

The Brazilian circumstances reflect the importance of fish as a food resource and the significance of small-scale fisheries in terms of food provision. Fishing for high conservation value species like sea turtles is strongly prohibited in Brazil by national environmental legislation. This limits detailed studies on TFK about such species, as fishers are unlikely to divulge information associated with illegal activities (but see Bird *et al.* this volume).

There is scope to broaden the TFK research effort geographically, especially in Australia, and in terms of the fishery and aquatic bio-resources in both countries. Studies addressing the TFK over broad geographical scales are also needed (Ruddle 1996), with few having been conducted with a simultaneous focus on different countries and fishing communities (Johannes *et al.*, 2000; Healey and Hunn 1993). Silvano (2001) conducted a comparative study addressing the TFK of Indigenous Australians from southeast Queensland and artisanal Brazilian fishers regarding the fishery and natural history of the Atlantic Bluefish *Pomatomus saltatrix*, (Pomatomidae), an important marine food fish species in both countries. Despite environmental and cultural differences, similar information about the diet and migratory behaviour of *P. saltatrix* was documented from both countries, suggesting the occurrence of some global patterns to the biology of this widespread fish species (Silvano 2001). Such patterns are consistent with observations from the ichthyological literature (Juanes *et al.* 1996), thus reinforcing the potential of TFK to provide additional insights and expertise to western fisheries science and management.

Consideration of the Australian situation also illustrates some other important issues associated with this type of research. Australian fisheries are dominated by well-developed, large scale commercial and recreational sectors (Baelde, this vol; Williams and Bax, this vol). Notwithstanding current and future commercial interests and opportunities (Tsamenyi and Mfodwo 2000), Indigenous Australian fisheries are founded in Indigenous cultural practise with subsistence a consistent feature. The priority that Indigenous fisheries have within the resource use, management, policy and research framework varies across Australia. In general this priority appears to diminish from north to south, and this is reflected in the concentrated research coverage for north Australia and the TSI. For Indigenous Australian communities, desired research outcomes include improved recognition of their human rights, increased participation in marine resource management and control, and recognition and protection of their knowledge as intellectual property.

Progress toward such outcomes is evolving through Indigenous participation in dugong and sea turtle management and conservation in north Queensland and the Northern Territory. Where such outcomes are difficult to achieve, TFK research may not be possible (Faulkner, 2000). The status of Indigenous Australian peoples that are a part of TFK and related research has and continues to develop, as evidenced by the gradual increase in collaborative research (Kennett *et al.*1997a, 1997b; Ross *et al.* 1996; Ross and Pickering, in press). The protection and Indigenous control of their intellectual property is now a major ethical consideration in Australian TFK research. The nature and measures of protection of Indigenous intellectual property and TFK have been widely discussed in an Australian context (Williams 1998; Janke, 1998; Dodson 1996; Fourmile 1996). One interpretation of the Australian experience may be that the most effective way to protect Indigenous intellectual property is for Indigenous communities to participate as partners in collaborative research.

There is now an established international recognition of the need for research on traditional biodiversity related knowledge, of which TFK is a part. This recognition is founded in the acknowledgment that such knowledge represents a substantial body of information and expertise that has contributed to, and is needed to continue, the protection and maintenance of the world's biological diversity. It is articulated in the Convention on Biological Diversity, and progressed by the Ad-hoc Working Group on Article 8j. To date a work plan has been developed that identifies the actions necessary to advance not only research, inclusive of TFK, but for its survival and continued application. Key elements focus on protecting the cultural practices from which the knowledge has evolved, intellectual property rights and equitable sharing of benefits accruing from the use of such knowledge to respective communities. The developments in Australia toward collaborations between TFK researchers and Indigenous communities are consistent not only with the established international objectives and standards for TFK research, but also with the domestic articulation contained in the *National Strategy for the Conservation of Australia's Biological Diversity* (Anon 1996).

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TRADITIONAL MARINE RESOURCE MANAGEMENT IN VANUATU : WORLD VIEWS IN TRANSFORMATION; SACRED & PROFANE [1]

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ABSTRACT

Much of the marine related traditional knowledge held by fishers in Vanuatu is concerned with enhancing their catch more than directly conserving the resources. However, the management of marine resources equates with the long-term survival of the community and thus a cosmology evolved over time to sustain these resources and hence the communities which depend on them. This system, enshrined in local custom, follows natural cycles of abundance for the various resources available and depends upon the respect for the rules of custom devised by their forefathers and passed down to the present generation. In addition, it is often the rules associated with the fabrication and deployment of traditional fishing gear and techniques that serves to manage the resources. The fabrication of these fishing devices also requires an extensive knowledge of the forest resources found far from the sea. A number of other customs, seemingly unrelated to marine resource management, also serve to directly conserve the marine resources.

Events associated with the arrival of Europeans and introduction of Christianity has initiated a process of transformation of these traditional cosmologies and practices related to marine resource use and management. More recently the forces of development and globalization have emerged to continue this transformation. The trend from a primarily culturally motivated regime of marine resource management is consequently being transformed into a commercially motivated system, that is from the sacred to the profane, in response to these external forces.

INTRODUCTION

Vanuatu is a Y- shaped archipelago roughly 1,000 km long located in the western South Pacific between 12 and 22 degrees South latitude (see Figure 1). Vanuatu means "Our Land" and was an appropriate name taken at Independence from the joint colonial rule of England and France in 1980. There are a total of 82 islands, mostly volcanic in origin, 70 of which are inhabited. Most of the islands are surrounded by narrow fringing reefs of limited size due to the steep nature of volcanic islands. There is only a limited number of areas with highly productive ecosystems such as mangroves, estuaries and lagoons. The reef areas, although limited, are non-the-less highly productive and support a high diversity of fish and invertebrates.

The population of 187,000 (as of 1999) is predominantly Melanesian. Approximately 79% of the population today lives in rural areas following a predominantly subsistence and traditional lifestyle. The term traditional used here is meant to refer to practices used prior to the arrival of Europeans in significant numbers starting in the mid-1800s. Root crops such as yam, taro, kumala and manioc are staples along with banana, pawpaw, plantain, breadfruit and numerous other fruits as well as various types of nuts. Wild birds, giant fruit bats, freshwater

Figure 1. Map of Vanuatu

prawn, fish and eels as well as domestic pigs and chickens introduced by the early colonists were traditional sources of animal protein in addition to various types of seafood. These include turtles, dugongs, numerous types of fish and shellfish, crabs including the large terrestrial coconut crab, as well as octopus, spiny and slipper lobsters, urchins, giant clams and many other marine invertebrates.

[1] The title and theme of this paper was inspired by the book 'The Sacred & the Profane, The Nature of Religion' by Mircea Eliade.

A number of factors affect food security on the islands. There are about 5 active volcanoes today in Vanuatu that may cover gardens and villages with ash and acid rains as well as molten lava on occasion. Cyclones are liable to occur from November till April damaging gardens, fruit and nut trees as well as impacting coral reefs. Tsunamis and earthquakes, floods and droughts are also a regular part of life in these islands. A number of systems was developed to provide food security in light of these threats in addition to keeping pigs and chickens, such as storing fermented fruits and sourcing a number of other foods not normally eaten except in times of need. The sea is also a source of much needed protein after a natural disaster has destroyed your food crops, provided it wasn't already over harvested. The regularity of these natural events impacting food security was perhaps also significant motivation to keep the reefs bountiful much like the idea behind 'saving for a rainy day'.

In addition, the practice of 'giant clam gardens' was also utilized in many coastal areas. This practice consisted of families gathering a number of giant clams into a small area in front of the village on the inside of the reef for their exclusive use in times of need. This practice is also considered to increase reproductive success by maintaining close proximity of the breeding population that depends on external fertilization. Thus, it may also be considered a management strategy.

There is great linguistic/cultural diversity found amongst these lush tropical high islands with currently 113 different Austronesian languages now spoken (Tryon, 1996). There were in fact more languages spoken in the past, but massive depopulation associated with European contact primarily through the introduction of diseases reduced this number. There are also numerous Polynesian Outliers, including the islands of Futuna, Aniwa, Mele, Ifira as well as three villages on Emae Island. Many other islands also exhibit varying degrees of Polynesian influences.

Each of the 113 language groups currently found in Vanuatu represents a people with different oral histories, cosmologies, customs and traditions. Based on these differences, each of the 113 linguistic groups represents a distinct cultural group within Vanuatu. With its relatively small population Vanuatu thus has the highest cultural diversity per capita in the world, and this often makes it difficult to generalize about the customs, including the various marine resource management traditions found throughout Vanuatu.

A new language, called Bislama, was invented during colonial times to help overcome the difficulties in communication with the first Europeans and amongst the different islands. It is a unique form of Melanesian Pidgin based mainly on English, but also incorporating French and some of the vernacular languages. Its name stems from its association with early contact with European traders, notably the Beche-de-mer (dried sea cucumber) traders. Bislama, one of the three official 'national languages' is the most commonly spoken language in the country's mixed urban centres, along with some English and French.

The use of the word 'custom' perhaps requires some clarification. In this context, it is used to denote the contemporary expression of the ancient traditions which of course are not static, but are in constant flux with the flow of new ideas and circumstances demanding adaptation of inherited traditions. The continuous flow and migration of people and ideas in Vanuatu throughout its history cannot be over-emphasized. Rather than leading to a homogenization of customs in Vanuatu it has probably been more responsible for its startling diversity through the admixture of various ideas, peoples, customs and traditions. '*Kastom*' is the Bislama term commonly used by ni-Vanuatu (people of Vanuatu) to collectively denote their inherited traditions and customs. The term is often used to contrast with recently introduced Christian beliefs.

Christianity was introduced slowly some 150 years ago, primarily via the Presbyterian, Anglican and Catholic faiths initially. Most islands in Vanuatu did not quickly embrace these new religions and many missionaries and Polynesian catechists employed in the missionization of Vanuatu met their demise in cooking ovens at the hands of islanders. Peter Dillion, an early 'man of enterprise' in the South Seas remarked on his visit to Erromango (also known as Martyrs Isle) in search of sandalwood in 1825 that "their general disposition indicates a more permanent attachment to barbarous feeling and habits than has hitherto been found in any part of the South Sea"(Davidson, 1956:103).

His comment indicates how deeply rooted the island *kastoms* were and foreshadows how their world view was not about to change so quickly for the benefit of a few trade items. More recently, numerous other more obscure Christian denominations (Assemblies of God, Seven Day Adventists, Holiness Fellowship) have become increasingly popular. In some areas, the two belief systems, *kastom* and Christian, are in open conflict with each other, in other areas they have managed to harmonize, as it is often said by those who speak of it, peace. In some areas people have only been converted in the last 30 years or less; in a few areas people have completely rejected converting to Christianity and choose to maintain only their *kastom* beliefs.

These recently introduced Christian beliefs overlie the much stronger *kastom* belief systems to varying degrees on the different islands. In virtually every community of Vanuatu and even in the urban areas, various aspects of *kastom* remain strong and are significant forces in people's lives. For example, the nature of people's relationships with others is still dictated largely by kastom protocol and the firm belief in sorcery, and the intervention of the spirit world is still very much alive and continues to influence peoples behavior.

One must consider that Christianity has only been received relatively recently, whereas *kastom* has been around for some thousands of years. Perhaps a useful metaphor is that *kastom* is like a deep ocean swell, powerful- almost immutable- and originating a long way off, a long time ago, while Christianity is like the small wind-driven waves or ripples found on the swell's surface. One is deeply rooted while the other is superficial. It takes a long, long time of blowing for a new wind direction to finally alter an ocean swell.

The traditional fishing methods of the islands varied somewhat amongst cultural groups. Most of the harvesting, however, was focused on the nearshore reefs. Reef gleaning for various fish and shellfish, octopus, giant clams, sea urchins, spiny lobsters and numerous other invertebrates provided a significant portion of the catch. Other methods including fish poisons, spearing and shooting fish with bow and arrow from the reef edge, as well as fish traps, leaf-sweeps, hook and line, nets and weirs, were all commonly practiced in different areas. However, it should be noted that the use of hook and line was apparently not known everywhere in former times.

There were also fisheries for turtles, and in some areas for dugongs, as well as the annual harvesting of the Palalo seaworm. In some areas offshore fisheries also occurred for deepwater snappers, bream and groupers, as well as for flying fish, tuna and tuna-like species, although the latter was mainly in areas of Polynesian influence. All of the various fishing methods were based on a significant corpus of traditional environmental knowledge (TEK) associated with these various resources to enhance the catches realized from their efforts. And all of these methods were embraced by a significant corpus of *kastom* as part of a group's oral histories.

The specialized TEK associated with the fabrication of the various fishing devices like traps, poisons, spears, bows and arrows, hook and line and canoes, etc. often took the fisherman far up into the islands interior where preferred plants were only found to grow. Its method of preparation and fabrication followed specific methodologies to isolate, strengthen, harden or preserve the materials. These methodologies were passed on via a group's oral traditions (with their own cultural-linguistic nuances) and were often encoded in *kastom* stories for the benefit of future generations.

Most of these various fisheries continue to be practiced today to varying degrees, however, the traditional nets and hook and lines have generally been replaced by their modern, introduced counterparts. Other introduced gear such as spearguns and underwater torches have also become increasingly common in the last few years, as has accessibility to outboard powered skiffs, now fairly commonly used for fishing and transport on most islands. The outrigger canoe still dominates in most coastal villages, however, and continues to serve local fishing and transport needs well. The use of dynamite to stun fish has stopped since the end of colonial times when dynamite was more readily accessible.

A number of small scale, village-based commercial fisheries was introduced with European contact, primarily for trochus (*Trochus niloticus*) green snail (*Turbo marmoratus*) and for dried sea cucumbers (Holothuroidea), locally known as beche-de-mer. These fisheries have provided access to early trade items of European manufacture to remote villages, and continue to provide access to cash for rural communities. In some areas they remain very important sources of income for rural areas, particularly trochus.

Johannes (1998a) notes that the tropical small-scale, multi-species fisheries practiced by the rural people today in areas like Vanuatu are prohibitively expensive and notoriously difficult to manage, except for a few high-value benthic species, using western models that require extensive data-collection. Johannes (1998b) suggested that the unrealistic emphasis on quantitative management ideals like optimum or maximum sustainable yields for tropical small-scale, multi-species fisheries could justifiably give way to a new paradigm, what he called 'data-less marine resource management', emphasizing that it is not management in the absence of information. The use of local knowledge (TEK) concerning the resources and their environment were invaluable to achieve the realistic management objectives of preventing serious over-fishing, ensure reasonably satisfactory allocation of resources and to minimize conflict.

The Vanuatu Fisheries Department emphasizes the fundamental role of traditional management practices in managing nearshore reefs but has also introduced some regulations, for example size limits for some commercialized invertebrates, the protection of turtle nests, prohibition of harvesting berried spiny lobsters, etc. However, the monitoring and enforcement of these regulations remains extremely difficult and virtually cost prohibitive in an archipelago such as Vanuatu. The main value of such regulations is to assist in controlling the export of commercial fisheries products like trochus and green snail and the flow of other resources with regulations such as lobsters and coconut crabs in and from the urban centres.

The main strategy employed today for managing the nearshore reefs is based on the ancient system of Custom Marine Tenure (CMT) and the following of traditional cosmologies or '*kastoms*' which impose additional restrictions on people's behavior towards the harvesting and consumption of marine resources. The fundamental principle underlying CMT is the ability of clans, chiefs and/or communities to claim exclusive rights to fishing areas and to exclude outsiders from these areas. The benefits of their restraint on the fishing grounds may therefore be realized by themselves at a later date and thus provides the motivation to do so in contrast to the 'tragedy of the commons' observed in areas with open access.

Under CMT, chiefs now commonly put certain resources, fishing areas or fishing methods under taboo for varying periods of time. These taboos are locally monitored and enforced by the chief and communities themselves. This system effectively de-centralizes management under custom tenure to the chiefs, community or even clan level, i.e. to those most intimately knowledgeable of the resource and the most motivated to manage well as they, and their descendants, will directly benefit, or suffer, from any management decisions.

The traditional cosmologies or *kastoms* that contribute to the conservation of resources evolved in these islands are driven by a need to protect their finite natural resources, and in so doing, to ensure the survival of the communities that depended on these resources. A prime example of one of these cosmologies is the belief in many areas of Vanuatu that if you eat turtles or turtle eggs and go to the yam garden then your yams' growth will be stunted. Since yams are a primary source of nutrition and are considered to have great *kastom* significance in Vanuatu, the consumption of turtle and turtle eggs during the yam growing season is highly reduced.

As the yam growing season coincides with the time turtles come ashore to lay their eggs, this *kastom* therefore assists to conserve their numbers during their most vulnerable period. This example, and others of cosmological beliefs or *kastoms* that contribute to resource management, will be elaborated on further below.

While many of these *kastoms* are not ostensibly concerned with management, their conservation value is apparent. This would suggest that they evolved in the remote past to fulfil a conservation purpose, thereby contributing to the food security and survival of the island peoples. One could postulate that at some point in the remote past, such customs arose over time under the guidance of the chiefs and high priests, (Melanesian 'Big Men'), that is, those most responsible for *kastom*. This would have been necessary once they had determined that resources were finite and that they had the ability to deplete them. This would not have taken too long once their numbers had grown sufficiently to populate these relatively small tropical islands.

Spriggs (1997:85), who has done considerable archaeological work in Vanuatu, notes "a 'pioneering' pattern of initial settlement followed by serious erosion of the local landscape, abandonment of an area for sometimes many hundreds of years, and a later more conservation-oriented reuse with continuing occupation." Archaeological data for Vanuatu and most other parts of Oceania show a similar trend in marine resource harvesting patterns after initial colonization. It would thus seem reasonable to propose that the introduction of conservation strategies would follow the same pattern with marine resources; once the impact of over-harvesting marine resources was observed then conservation measures would be introduced as a matter of self-preservation. It is after all the same pattern that is now being repeated on continents relatively recently colonized by Europeans and industrialized like North America, Australia and New Zealand - and even globally; that of severe resource depletion followed by the introduction of substantial conservation strategies.

Johannes (2002) argues that it would have been much easier to impact on and deplete many terrestrial-based resources on remote islands due to the occurrence of many species of flightless birds (due to the absence of large mammalian predators) which were vulnerable to over-exploitation due to being ecologically 'naïve' and also having very small clutch sizes. Additionally, the detrimental environmental and habitat impacts of the early effects of fire and land clearance by man would have introduced significant changes to island environments, including increased sedimentation. Finally, the introduction of the dog, pig and rat would have had a significant impact on island ecology, particularly on the nests and young of ground-nesting bird species.

Johannes also points out that the ability to deplete marine resources would not have been so great. There was no marine equivalent to the introduction of fire and land clearing, nor any known introduction of exotic marine fauna that could adversely affect the marine ecology. Also, the reproductive strategy of most marine fish and invertebrates involves the planktonic dispersal of thousands or millions of eggs and larvae from anywhere from a few days to a month. Larval dispersal is thus widespread and assists to replenish stocks that may be locally over-harvested, provided they are given some protection from further over-harvesting. It is thus reasonable to assume that it would take much longer to extirpate marine fauna than terrestrial, and thus people would have more time to recognize a decline and introduce measures to conserve them.

Indeed, archaeological excavations of Matenkupum, New Ireland, Papua New Guinea, have revealed fish bones and mollusc remains from 32,000 B.P. (before present). Allen et al, (1989) cite this area as being the world's longest continuously exploited reef and lagoon fishery and is the earliest evidence in the world for the human capture of fish. Midden excavations revealed the density of mollusc shells was greatest for the strata between 32,000 and 20,000 BP and that the shells deposited in the earliest strata were mainly large individuals from large species while the uppermost strata had the fewest large species and the smallest mean sizes of species. Gorsden and Robertson (cited in Allen et al) deduce that this indicates low levels of human predation on largely pristine mollusc populations and that some form of rotational harvesting of shellfish was practiced.

In a review of the archaeological record of anthropogenic effects on Pacific coastal fisheries, Dalzell (1998) concludes that mollusc resources were of prime importance for early Pacific island populations and that in some cases long-term exploitation can markedly reduce the average size and diversity of mollusc populations. Also, in some instances a decline in mollusc resources forced early human populations to turn towards other marine resources as well as to rely increasingly on agriculture. He also concluded that the archaeological record for subsistence fin-fisheries of reefs and lagoons indicated no strong evidence to suggest long-term effects on their populations.

However, we know of at least one sessile marine species extirpated in the past from Vanuatu waters, that of the largest of the giant clams (*Tridacna gigas*). We know this because their shells are now commonly found up above today's sea levels where they were transported through coastal uplifting. There has not been a confirmed sighting of a live *T. gigas* for many generations in Vanuatu. It has never been established when the extirpation occurred. One could speculate that they were heavily targeted by earlier residents due to their extremely large size and therefore the large amount of meat available from them for communal feasts. Just north of Vanuatu, however, in the Solomon Islands *T. gigas* can still be found.

One could hypothesize that these rules for conserving the resources necessary for the survival of ancient communities were thus initiated, encoded and enshrined into *kastom*, to be followed by the people as part of their cosmology. Melanesian society is characterized by numerous secret and Big Man societies that conceals the sacred knowledge associated with these elite groups from the uninitiated. Only through progressing through the rigorous prescribed stages of initiation is this knowledge slowly revealed to those deemed worthy. There is also an extensive use of metaphor and symbolism, understandable at its deepest level only by those initiated in the rich oral traditions associated with these societies and recording the island's histories.

Knowledge of the islands' histories is power, because it records who has primary rights to the land and sea and their resources. It is thus primarily held by the priestly and chieftain classes. The integration and obfuscation of resource management practices into the rules of *kastom* initiated by the ancients, to be then followed by rote by the general public is in keeping with this fundamental characteristic of Melanesian culture. This is why, if you ask an islander today, they follow certain rules associated with the fabrication of, for example, a fish trap, he will often simply respond that it is our custom to do so.

A COSMOLOGY EVOLVED TO SUSTAIN RESOURCES AND COMMUNITIES

The Lapita People

The first people known to have populated the islands of Vanuatu are now known as the Lapita people. They originated from somewhere in SE Asia (Kirch 1997). According to archaeological evidence, the earliest appearance of this people in Vanuatu was approximately 3,000 years ago (Spriggs 1997). By 2,800 years ago, the Lapita people had progressed through Vanuatu to New Caledonia, over to Fiji and on to Tonga and Samoa (Kirch 1997). This was a rather explosive expansion across a large area of the Pacific within a very short time period, when one considers that there were people who had progressed down through the large islands of the Solomon Islands as far south as San Christobal some 28,000 years ago. These much earlier coastal peoples have come to be known as Melanesians.

It should be noted that from mainland southeast Asia down to the southern Solomons there is a "voyaging corridor"; one can always see another island - but not when looking south from the southern Solomons. The success of the Lapita people in colonizing these pristine islands beyond the Solomons is attributed to their development of a superior seafaring tradition to that which had been previously known in this region, including more seaworthy canoes and navigation techniques (Irwin 1992). The cultural complexity of the Lapita people also included a well-developed repertoire of fish hooks, including trolling lures, and evidence for the use of a wide array of techniques including spearing, poisoning and netting fish as well as relying on the extensive shellfish beds. (Kirch 1997).

This rapid expansion of the Lapita people has been likened to a freight train that passed through the islands. It seems that these first colonists were not so interested in settling, but moving on once they had exhausted the large and often ecologically 'naïve' turtles, fish and land birds (many of which were flightless). Of course, without the initial benefit of crops (although these early settlers brought with them the plants and animals of their traditional economy), the Lapita people would have been almost entirely dependant initially on marine resources, especially the pristine shellfish beds and what could be hunted and gathered from the forests, primarily birds and fruit bats. There were also the domestic pigs and chickens that these early colonists brought with them. However, some 'boxcars' of this Lapita freight train remained and settled permanently in some areas.

The archaeological data available for these Remote Oceanic islands indicate a repeating pattern of marine (particularly turtle and shellfish) and avian resource extraction upon first contact, and in some cases numerous avian species extirpations and extinctions associated with these first colonists (Spriggs 1997; Kirch 1997). Although the archaeological data for Vanuatu remain relatively sparse, Bedford (2000:243) indicates there are "hints of a 'blitzkrieg-like' scenario on initial arrival" which will require further excavations for confirmation. He confirms the heavy exploitation of turtles and fruit bats and the extinction of some birds and a small, endemic land-based crocodile during the initial settlement phase. He also reports the dramatic reduction in size of some shellfish at some sites and an indication that some species may have been locally extirpated from particular areas on different islands. He also notes that "inshore and reef species of fish were targeted from initial arrival and continued to be so throughout the sequence, with no evidence for any change in preference or procurement strategies."

Arriving in what would have been a pristine 'paradise', these early arrivals tended towards a 'pillage and pull-out' strategy, in many cases needing only to move on to the next pristine bay around the corner to repeat the process. It appears that if the Lapita people had any sort of conservation ethic as part of their customs, it was apparently suspended while surrounded by such plentiful resources. This seems to be a common theme when resources appear to be infinite and seemingly inexhaustible. Europeans did the same thing when they viewed the endless expanse of rainforests and salmon on the coast of western Canada. Now, some 200 years later, both of these resources are severely threatened.

It was a different story, however, for the 'boxcars' whose people remained. The people who chose to remain in the islands of Vanuatu (and including the numerous subsequent waves of colonists from the north that arrived once the route was opened) would have been faced with the challenge of equilibrating with the finite space and delicate ecology of small tropical islands. One can imagine how the survival of these communities would depend upon the later inhabitants reaching equilibrium with their environment – or face the demise of their own people through a lack of resources to maintain a population. Indeed, the story of Rapa Nui (Easter Island) indicates that some Pacific peoples pushed their island environment to the brink of destruction which in turn led to the collapse of the islands culture and population. However, that this happened on one isolated island does not imply that the entire Pacific lacked a system of self-preservation, including a system of marine resource management.

One of the efforts to maintain equilibrium would have been the establishment and protection of a territory which a clan or group of clans would have control over. In Vanuatu, and throughout Melanesia, these territories included the nearshore reefs as a natural extension to the land. These territories provided the necessary resources for people – access to marine resources and gardening areas, fruits and nuts, wild birds, pigs and fruit bats. Also to natural materials for house and canoe construction, for fabricating fishing gear, weaving materials for mats and baskets, traditional medicines and the myriad of other materials used in island technology that are utilized to help sustain life on the islands. The management of these resources, once the population pressure became sufficient to threaten them, would be a natural progression for any group of people intent on survival.

Through thousands of years of observation, experimentation and close association with their environment, a body of traditional ecological knowledge (TEK) became part of a clan's heritage. This knowledge was continually built upon, refined, added to and modified through subsequent generations. Today we still find in Vanuatu a rich corpus of TEK associated with both land and sea.

These systems of CMT and TEK both served to enhance a clan's chances of survival in an otherwise uncertain environment where hurricanes, volcanoes, tsunamis, earthquakes, floods, droughts and warfare were a part of the annual cycle and human drama of these islands. These ancient systems of land and reef tenure, as well as environmental knowledge, continue to assist in the management and resource use and ultimately to enhance survival for people who still live a predominantly traditional lifestyle on the islands of Vanuatu today.

Ancient Traditional Marine Management Measures in Vanuatu – Ritualized and Sanctified

Background

A fundamental consideration in examining the ways in which marine resources were managed in pre-contact Vanuatu is to consider the context in which these measures, as well as the harvesting methods, were practiced. That is, within the framework of the traditional cosmology or belief system practiced in ancient times. Life in those days had an inherent sanctity that was maintained through a high degree of ritualization and based on the premise held true still today in Vanuatu that all things have a spirit. For most of us today it is difficult to imagine the degree of sanctity and ritualization of earlier times as well as the spiritual connection people felt with their environs. However, we must try to imagine if we are to approach an understanding of how things may have worked in ancient times.

For one thing, marine resource management was not an isolated body of knowledge neatly compartmentalized into one clearly definable element of early island cultures. Instead the rules of custom which contributed to the conservation of resources touched all facets of life (See also Purnomo, this vol) and formed a multi-dimensional web of support for resource management. This point will be elaborated upon further below. Also, much of the harvesting of fin-fish, particularly by people not directly living on the coast, was done before not by independent individuals looking for dinner, as is often the case today, but was more often done communally at seasonally prescribed times of the year and through the use of '*kastom*'. That is, it was often highly ritualized and involved the "spirit of *kastom*" or the intervention of the spirit world.

The communal nature of these fin-fisheries is evident in the main methods used to harvest fin-fish like coconut leaf-sweeps, fish drives and the use of fishing weirs, which at least today are owned by clans, not individuals. The harvesting of shellfish beds and other reef gleaning activities were more likely to be practiced on a regular basis, and would include small amounts of fish, but would still be controlled by local cosmological and seasonal restrictions (see below).

The spirits, including ancestral spirits, were omnipresent and could be used to people's advantage if done correctly. There were shamans capable of enacting the correct rituals to ensure a bountiful communal harvest. A taboo would be placed on the area to be fished for up to a year or so, which prohibited anyone from swimming or even walking by on the beach. This would serve to decrease the wariness of fish from entering that area as well as allowing for an increase in fish size. The timing of the communal harvest would then be divined by the shaman, who studied the tides. The villagers would facilitate the catch with a communal harvesting method such as a leaf sweep (a long net made from coconut fronds and used as a barrier) or a similar method using people with poles acting as a human barrier (fish drive).

These fish would then be shared amongst all clan members and perhaps traded to inland villages in return for resources from the island's interior. These practices would only be done on certain occasions according to the local *kastoms*, which appear to be timed to coincide with seasonal abundance or enhanced access of the target species, such as the season of extremely low tides. (see section below on 'Seasonal Considerations in MRM').

Traditional Marine Resource Management Measures: Taboos and Kastom Beliefs

There was formerly a number of different traditional marine resource management measures (MRM) practiced in Vanuatu. These practices varied between the numerous different cultural groups found throughout the islands, and reflect this cultural diversity. Some of these practices are still found today; others have survived only through oral history. Others have no doubt been lost.

Some of the traditional MRM measures resulted in fishing area closures, as outlined below. Other cosmological beliefs that manifested as rules associated with *kastom* contributed to the management of marine resources in less obvious ways. For example, the numerous rules associated with the fabrication and deployment of traditional fishing gear and techniques often contribute to the management of marine resources.

The most widely known example of this is the taboo against engaging in fishing after indulging in sex. One is given a choice - you may indulge, but if you do, it is taboo to go fishing for the next day or two, the actual duration varying with the area. Given that a certain proportion of the village population will indulge on any one night, it is easy to see how this taboo would contribute to reducing fishing pressure on the reefs the following day or two. It is easy to see that these rules also had something to do with birth control, in that devoted fishermen would not make love to their wives so as to be able to go out fishing the following day. Sexual abstinence is also required for those involved in the fabrication of fishing traps, weirs, canoes and most other fishing devices. This would further limit fishing pressure given that not all men would choose abstinence.

Other examples of cosmological beliefs or *kastoms* that effectively limited fishing pressure were that when you went on a fishing trip, you cannot be seen departing by others, or at least they must not be aware that you are joining a fishing expedition. Once seen by others as you prepare to depart for fishing brings nothing but 'bad luck' and so the trip is aborted. Another example is that any man with a pregnant wife is automatically excluded from any fishing activities. Both of these taboos relate to the belief in the negative intervention of the spirit world on fishing activity if these taboos are not followed.

It is also taboo to eat certain foods and to go to certain places when one is constructing fishing devices. If a fisherman is unable to respect these taboos, he must excuse himself from the fishing group, as he will ruin the fishing for all concerned. In most areas, there are ways to find out who has not followed the rules. This will put the offender to great shame within his clan, and so is to be avoided.

As noted above, in some areas it was taboo to eat turtle or turtle eggs if you planned to go to your yam garden. In some areas this was also the case with octopus, lobsters, certain fish and other foods including certain fruits. In some areas, it was taboo to go to the garden if your leg had so much as made contact with the sea. Thus, if there was work to be done in the garden (and there often was), one could not be involved in fishing, or in the consumption of certain seafood. Given the high priority to the production of food through agriculture in Vanuatu, it is apparent that these numerous rules of *kastom* also served to reduce fishing pressure.

During the season of preparing the new yam gardens there is much labour involved in planting and caring for the yams, necessitating frequent trips to the garden. Also, the production of yams was a central aspect of food production and in the *kastom* of most areas of Vanuatu and was thus treated as a serious endeavor. There were also numerous other taboos in addition to drawing upon the power of the spirit world to be followed to ensure a good crop.

Many other *kastoms* resulted in the direct conservation of marine, and other, resources. An example of this is the tabooing of a favorite food of a deceased clan member such that the family shows respect to the memory of the deceased by not eating that type of food for a specified time. For example a certain type of fish, spiny lobsters, octopus or a type of shellfish or a fruit may be tabooed in honor of a deceased clan member for a year or more. The time period is generally commensurate with the sorrow of the loss. This would take fishing pressure off that resource within the clan's area for that time period.

Another example is the practice of people not eating their ancestral or family totems for essentially spiritual reasons. This may be a certain type of fish, turtles, giant clams, or any other number of totems used. Again, this significantly reduces the fishing pressure on a given resource within a given area.

In fact, there were numerous rules of custom governing much of the activities and behavior not only of fishermen, but of all clan members engaged in any of the traditional arts of life from weaving baskets or making ceremonial carvings or headdresses to the preparation of traditional medicines. These numerous and various rules of *kastom*, which permeated all aspects of island life, combine to form a multi-dimensional lattice or web that provides a blueprint to life on the islands - including the management of resources - as well as all other aspects of life. These blueprints, encoded and enshrined in *kastom*, were often derived from the ancient gods and cultural heroes and thereafter sanctioned by the ancestors as 'The Way', and passed on to the next generation through the oral traditions and *kastoms* of a cultural group.

In all areas of Vanuatu there were also numerous secretly guarded customs associated with using spiritual powers, mediated through shamans, to ensure an ample supply of all resources. This was also a critical part of any taboo used to close an area to fishing, to use the power of the spirit world to increase resources. Reef taboos were never just set and left 'static', but were always accompanied by ancient rituals sometimes recited in languages long lost that drew upon the 'spirit of *kastom*' to proactively increase the resources.

These activities reflect a fundamental belief held by ni-Vanuatu in the spiritual connections between themselves and the rest of the natural world. This belief extends to the ability of people, through the power of *kastom,* to influence the natural world around them. This was frequently employed in all aspects of life, from agrarian and fishing practices to the cutting of a canoe, or in the preparation of natural medicines. These practices served to acknowledge, support and harmonize with the spirits and sanctity of the island world.

Examples of some of the cultural practices found throughout different areas of Vanuatu that resulted in a taboo being placed on a reef that allowed reef resources to rest and recover for varying lengths of time are outlined below. In most cases, taboo leaves specific to the cultural group are erected to indicate clearly the area covered by the taboo.

Death of a "Big Man"
In some areas, the death of a Big Man (or High Priest) meant that his memory would be honoured by the putting of taboo on his area of reef. This total closure to the harvesting of reef resources may last for many years, depending on the degree of respect held for the Big Man. This taboo is associated with the enactment of many rituals including the killing of pig(s), dancing, kava drinking and communal feasting. Upon the opening of the reef, a final communal feast is held to honour the deceased, using the fish and other marine resources harvested from the closed area.

Death of any Clan Member
In other areas, the death of any individual of the clan - man, woman or child - may mean that their clan's area of reef will be put under taboo, or closed to all harvesting for a year or so – this taboo is also associated with customary practices following ritualistic protocols.

Figure 2: A taboo indicator showing the fishing area closed as a memorial to a deceased clan member on Epi Island.

Grade Taking of a "Big Man"
In some areas, the practice of grade taking as part of ascending a social and spiritual hierarchy is accompanied by taboo being put on terrestrial, freshwater or reef resources for anywhere from 1-4 years. This is also associated with very strong custom practices like multiple pig killings, kava drinking, dances, songs, feasting and other rituals.

Yam Season
In many areas, the reef is annually closed to harvesting of all or some resources during the summer months at around the time of yam planting, and opened for New Yam Celebrations

approximately 6 months later. See discussion below on 'Seasonal Considerations in MRM'.

Circumcision
Circumcision rituals were also associated with putting taboo on an area of the sea; this was generally for a short duration, as short as 1 month.

Taboo Areas
In virtually every area of Vanuatu there were formerly numerous coastal taboo places of spiritual significance for which people had the greatest reverence and would respectfully avoid the area and not go fishing or collecting there. These taboo places were also found in the bush and in freshwater areas and were often areas associated with high biodiversity.

"To Allow Resources to Regenerate"
In some areas it is said that in the old days, there were taboos placed on the reefs to allow some specific species, such as a preferred type of shellfish or octopus to recover. However, these taboos were never 'static', but were accompanied by the use of ritual and *kastom* to draw upon the spirit world to ensure the resources would increase.

In Preparation for Specific Feasts or Other Customs
In many areas there were specific feasts or other customs arising, such as the harvest and exchange of fish or other marine resources to inland villages, which were preceded by a taboo being placed on the reef. During this time, the shaman would perform elaborate rituals invoking the power of the spirit world to make the fish plentiful and thus ensure a good catch.

The common theme to all of these closures was that they were highly ritualized and intertwined with the spirit world. It was this spiritual context that primarily ensured compliance by the people with these taboos. Punishment for breaking these taboos included retribution from the spirit world as well as the Chief imposing fines of pigs, kava, woven mats and other culturally significant articles or even death as an additional deterrent.

It can be seen from the number of *kastom* related area closures listed above that there would have been quite a few areas closed at any one time. When travelling through north Pentecost in central Vanuatu a few years ago, the author was informed of a total of eleven marine closures associated with grade taking ceremonies. These closures formed a mosaic of spatial-temporal refugia across the top end of this island that protected various types of marine habitats.

Given that there were always people taking new grades this mosaic of refugia and thus their management value would continually be perpetuated, varying in space and time. The same would be true for all other areas of Vanuatu that practiced the other culturally related taboos given above. Perhaps this was the traditional counterpart methodology to achieve the modern scientific concept of optimum sustainable yield through controlled harvesting rates in that through this system all areas would be fished but also be periodically closed in order to recover.

Seasonal Considerations in Marine Resource Management
In most areas of Vanuatu, much of the nearshore marine resources harvested came from reef gleaning or other fishing activities on low tides. Therefore an important environmental constraint regarding the harvesting of intertidal resources is the seasonal variation of the tides. The tides in Vanuatu occur twice daily (i.e. are semi-diurnal - two lows and two highs) while the height difference between the two highs and lows is markedly different. The overall maximum range of the tides is roughly 1.5-m.

The tides in Vanuatu reach their annual lows during the southern winter months and are at their highest during the summer months. The spring low tides of the winter months, peaking in June/July, are generally down to zero in height, or are negative tides, and this low occurs at midday. The tides never get as low as they do at the spring tides of the winter months at any other time of the year, either by day or night.

The reefs are therefore exposed optimally for gleaning purposes during daylight hours in the winter months. Thus, the environmentally determined season for reef gleaning is during the winter months, starting in April/May and finishing in September. These annual lows are also the optimal time for employing communal fish harvesting methods using the traditional leaf sweep, fish drives and use of fish poisons as these techniques also depend upon good low tides.

These annual winter daytime tidal lows are also coincident with the months of the ripening and harvest of Vanuatu's most esteemed root crop, the yams. The ripening of the first yams are celebrated annually in New Yam Ceremonies, (which are analogous to the European New Year celebrations) and are still a significant part of the annual cycle of island customs. The annual New Yam Ceremonies serves to ritually open the yams to harvesting, which will then continue throughout the winter months. A preferred method to prepare the yams for these communal Celebrations is to make traditional puddings by grating the yams and baking them in the earth oven, often sweetening them with coconut crème. Included in these puddings are delicacies such as octopus, giant clams and other shellfish, lobster or fish, depending on the area, gleaned from the reefs with the annual return of the low tides.

The coincident timing of the lowest annual tides and the maturation of the yams led many areas of Vanuatu to have the custom of closing their reefs, or at least most of its resources, at the time of planting yams (September/October) until the harvesting of the new yams in April or so. The actual time of closure varies from area to area from clearing the yam gardens in preparation for planting, to planting time, to when the planted yam first shoots. This annual half-year closure is a management strategy to ensure a good harvest from the reefs for the New Yam Celebrations and for use in preparing yam puddings during the subsequent months of harvesting later maturing yams through until September.

This annual half-year closure of the nearshore reefs also coincides with the hot summer months, the time at which it is believed most of the fish and invertebrates targeted for subsistence from the reefs are at their spawning peaks. This annual closure thus has obvious and highly significant management value for the marine resources.

Some areas would then turn to the wild birds and fruit bats found on the islands as a source of meat during these hot months when the reef was closed. Also, during the hot season while the nearshore reefs were inaccessible for reef gleaning, flying fish would come inshore and thereby become more accessible. There are a number of methods used to catch these pelagic fish, from hooks and gorges in the Banks Islands down through the islands of Pentecost, Ambae, Maewo to traditional lights (burning coconut fronds) and small dip nets on the southern island of Futuna. Some of the southern islands would also target the other pelagic fish, the tunas that followed the flying fish inshore during the hot season. These pelagic fish offered an alternative source of fish protein during this time when much of the nearshore reef was closed.

On other islands there was no blanket taboo, *per se*, on the reefs during the hot season, but as the tides were not low enough for effective reef gleaning, very little if any was done, thus taking the pressure off the reefs during this season. Besides, this was the season to focus on the all-important production of yams and other garden staples. The hot season is also the rainy season and therefore the time when everything in these tropical islands, including garden crops, grows prolifically. The hot rainy months when the tides weren't very low were thus the time to focus on food production from the gardens.

An important factor which also contributes to this seasonal management strategy is the aforementioned taboo to eat if you intend to go to the yam garden, including certain types of fish, octopus, spiny lobster, turtle and turtle eggs.

Another consideration in this annual closure is that many areas of Vanuatu note an increase in ciguatera reef fish poisoning (caused by a proliferation of the epiphytic dinoflagellate *Gambierdiscus toxicus*) during the hot summer months. Serious cases of fish poisoning are highly debilitating, and as the toxin accumulates in an individual over their lifetime, people become more and more sensitive to it. This consideration may well be part of the reason it was prudent to avoid eating fish from the nearshore reefs during the hot summer months and may have contributed to the initiation of an annual taboo on nearshore reefs during this time.

Also, the occasional unexplained occurrence of ciguatoxicity in reef fish not normally affected remains enigmatic in many areas. Outbreaks may occasionally occur and affect not only the usual species known to be affected (generally the larger carnivores of particular species) but smaller herbivores as well. Some areas have had inexplicable ciguatoxicity affecting almost all reef fish and lasting for many years. This situation ultimately results in a forced closure or a ‘natural taboo’ on harvesting reef fish in the area until the ciguatera event is known to have passed. It thus imposes a severe restriction on fishing pressure during these events resulting in the conservation of fish resources.

In some islands, for example on Tanna, it is said today that people were 'vegetarians' and that they only ate meat ritually on special occasions. They consider that to eat too much meat regularly is unhealthy and results in a shorter life. This sounds much like the modern medical advice that we hear today. Deacon (1934:16), an early ethnographer comments on what he observed on Malekula, “The principal occupation of the people is gardening, for their diet is predominantly a vegetarian one, yams being the staple food-stuff. In the coastal villages, however, fish are caught and shell-fish and crabs are collected, while everywhere wild pig is hunted; but the products of these activities are regarded as tasty extras to the usual vegetable dish, never as a basis of a meal."

FACTORS AFFECTING COMPLIANCE WITH TRADITIONAL TABOOS.

Ritualized Sanctification of Traditional Closures

One of the striking features of these ancient *kastom* taboos is that there is a high level of respect for them. The main reason for this level of respect is the strong cultural context of these taboos including the deeply rooted belief that the breaking of a taboo will result in the supernatural intervention of the omniscient ancestral spirits resulting in the demise of the transgressor, or of someone close to them. It is as if the ancestors remain in spirit form to ensure that the '*kastoms*', (and therefore the conservation of resources) are maintained by the following generation; the ancestors remain as a sort of conscience for subsequent generations. These beliefs are still part of the island consciousness in many areas of Vanuatu, despite over 100 years of Christian influence.

While the traditional cosmologies continue to shape much of Vanuatu's cultural landscape, there has been some erosion of many of these *kastom* beliefs and practices in most areas. This has consequently had a detrimental effect on the management of resources. Comments by Elkington (1907:181) who traveled through Vanuatu around the turn of the last century illustrates this process underway at that time regarding northeast Malekula "Turtle fishing is not gone in for much, as the natives are superstitious about the turtle, and civilization has not yet been able to dispel their fears. One of the chief ones is that the eggs are sacred and may not be eaten. But one by one their superstitions are going, for they see how the white man prospers in spite of scorning all their sacred ideas, and that now and then makes them courageous enough to break through the barrier and when once a superstition has been found untrue, they are not slow in testing another, if by challenging it they can see any gain for themselves." This process of the gradual erosion of traditional beliefs is still underway today in Vanuatu but is far from complete. The ocean swell of *kastom* still runs deep in most areas of Vanuatu.

The initiation of these ancient closures or taboos are accompanied by elaborate custom rituals, including pig killings, kava drinking, dancing to traditional drum rhythms and songs, and the erection of taboo leaves, all of which have a deeply rooted and heavy cultural significance for island people. These rituals all serve to invoke the power and the blessing of the ancestral spirits in their participation in these taboos. These taboos are thus in the realm of the sacred, as they involve the power of the spirit world.

In fact, the word 'taboo' is a vernacular term from Oceania and is translated locally into English as 'sacred' or 'holy'. (The OED defines Sacred as 'consecrated or held dear to a deity....made holy by religious association, hallowed...sacrosanct'.) These consecrations, through the enactment of elaborate rituals and invocation of the power of the ancestral spirits to initiate and oversee these taboos effectively consecrate the taboo, (make it holy, sacrosanct)., and are no doubt responsible for the high level of compliance found for these taboos still today.

Historical Impacts Which Affect Traditional Management Practices

In many areas, some of the ancient customs associated with the initiation of marine taboos have been lost or severely eroded, primarily due to the impacts of European contact. There are a number of historical factors which have contributed to this erosion since European contact and are outlined briefly below. Although they may be broken down into separate categories many of them were occurring simultaneously and thus were all closely interrelated with potentially synergistic effects in undermining ancient traditional ways.

Massive Depopulation

Massive depopulation of Vanuatu occurred as a direct result of the arrival of Europeans. Coastal people were generally the first to encounter the Europeans, (the whalers and Sandalwooders who arrived by ships starting in the early 1800's) and thus were the first to be exposed to the new diseases (smallpox, diptheria, whooping cough, influenza) that they had no immunity to. The 'Blackbirders' (labor traders) also targeted coastal areas starting in the 1860's to recruit labor for the cane fields of Queensland and other places like Fiji, Hawai'i and New Caledonia and thus contributed further to depopulation.

Those that returned from Queensland were often Christianized and spoke Pidgin or a bit of English. By the 1920's, the population of Vanuatu had dropped from an estimated pre-contact figure ranging from 500,000 to 1,000,000 inhabitants to only 40,000 due to the combined effects of European contact. This massive depopulation had an enormous cultural impact due to the loss of entire settlements (and cultural groups) in many areas as well as well as having a severe impact on the normal process of transmission of *kastom* knowledge between generations.

This dramatic drop in population starting in the early 1800's would have consequently resulted in a significant overall decrease in pressure on resources, including marine. The last two to three generations would have known relative times of plenty due to this prolonged reduced population pressure on resources. The old people of today all speak of the remarkable abundance of marine life in their youth, and the ease with which one could fill a canoe with fish and other seafood including turtles, giant clams and other shellfish. It is often under their guidance in their communities today that is highlighting the need for tighter management controls (taboos) so that future generations will also know what rich and diverse reefs are like. It is this older generation that has seen the abundance of the past and sparseness that is the future, if steps are not taken now.

Missionization and Christianity

Most of the early Christian missionaries, particularly the Presbyterians were highly intolerant of *kastom* and banned kava, numerous *kastom* ceremonies, dancing, and all other activities relating to *kastom* (Paton, 1911). The *kastom* use of the spirit world, which is a fundamental part of the taboo system as well as everything else in ancient times was labeled as the 'work of the devil' and outlawed by these early evangelists. Many forms of cultural expression were thus diminished and eroded in areas of strong Presbyterian influence. Anglican and Catholic, the other two main early denominations were often more tolerant of many traditional practices and the level of erosion was reduced in areas dominated by them. However, as noted previously, many of the underlying cosmological beliefs associated with *kastom* were not entirely eradicated, but their outward cultural expression often was. After all, the missionaries may have had great influence over what one did, but not over what one thought.

Traditional grade taking rituals, for example, a practice formerly central to the cosmology of much of northern-central and northern Vanuatu has been lost in many areas, with the exception of the islands of Ambrym, Pentecost, Ambae, Maewo and parts of Malekula where there has been an active revitalization of these practices since Independence in 1980. Big Men, who acted as High Priests in traditional society were sanctified and achieved their high status through very elaborate pig killing grade taking ceremonies, and as outlined above, the tabooing of marine (or freshwater or terrestrial) areas was in some areas a part of these rituals.

Also, it was these High Priests who had the right in most areas (in that they were sanctified) to set the taboos for all of the resources, including freshwater and terrestrial. With the loss of this Priestly class system and of grade taking ceremonies in many areas (which resulted in taboos being initiated in some areas) there was thus a void created in the setting of taboo and therefore the management of resources (as well as in numerous other aspects of traditional life).

Today in some areas, as observed on Gaua in the Banks Islands, the actual practice of raising tusked boars has dwindled to the point where the lack of pigs is the limiting factor in enacting the traditional setting of the reef taboos, as they were often an integral part of the initiation ceremony and/or the removal of the taboo. This lack of available pigs would indicate the general erosion of traditional practices, as the raising of tusked boars was a highly significant cultural practice for most areas of northern-central and northern Vanuatu in the past. It also means that the ancient traditional rituals, for example those required to properly initiate or remove, according to the rules of *kastom,* a marine taboo can no longer be performed.

Massive Migration

The introduced and mysterious diseases introduced by Europeans that rapidly decimated the population were interpreted by the people in context of the local cosmologies and thus believed to be the work of sorcery. The remnant populations of villages were then induced to consolidate to coastal missions where they were promised they would be safe from further sorcery and would have access to European medicines to combat disease.

Consequently, almost all of the coastal villages found today in Vanuatu are composites of remnant populations of numerous different *nasaras* or clans, which formerly lived in widely dispersed settlements consisting of extended families on their own ancestral lands. By formerly maintaining such a decentralized pattern of settlement, clans lived close to optimum gardening areas within their traditional territories, where they also had exclusive access to various terrestrial and freshwater resources.

This pattern of settlement would have significantly dispersed the pressure on terrestrial, freshwater and marine resources over the entire area of an island. However, by the majority of the island's residents of the interior areas migrating to the coast, the demand on resources was, and remains, significantly concentrated in relatively small coastal areas. These modern, translocated, composite villages now often share common access to waters considered communal in the immediate vicinity of the village while the lands and reefs surrounding the village are under the tenure of the *kastom* owners. The interior of most of the islands, the exception being Tanna, remains virtually uninhabited today. In some areas today, people have begun moving back to their ancestral homelands in the interior of the islands to avoid this coastal crowding and the attendant competition for good gardening areas and land disputes.

These changes in demographics also had serious impacts on the *kastoms* of these translocated villages. The numerous *nasara* which were grouped together as a result of this migration did not always share the same dialects, languages, customs or leaders. The homogenization of these composite villages often results today in a lack of cooperation and conflicts involving land and resource access as well as over leadership within these communities that in turn affect the respect for taboos and the management of resources.

Changes to chiefly lineages

In many areas, the chiefs of an area were replaced with a new chief appointed by the early missionaries. As the early missionaries often sought to undermine and destroy the traditional chiefly and priestly classes, (as it was often them whom opposed the missionaries and strove to uphold *kastom*), they found it expedient to replace them with one more to their liking. They would typically choose someone who had embraced the newly introduced Church as the new chief, as he was someone they wished to elevate in status. Those whom knew a bit of Pidgin or English and had adopted some Christian ways such as those returning from the Queensland sugarcane fields were sometimes chosen.

This new chiefly system often became hereditary and is a source of conflict in numerous villages today, where the new chiefly line appointed by early missionaries is being disputed by the original chiefly lineage. These internal community disputes often result in the taboos set by them today not being well respected (Hickey and Johannes, 2002).

Colonial Land Alienation

Starting in the 1870's numerous copra traders and planters, both English (from Australia) and French, (often from the nearby French possession of New Caledonia) arrived to purchase land, often for a couple of axes, some stick tobacco and some calico (cotton cloth). The individual who put an X beside his name on the contract may have had some *kastom* rights to the land in question but it is not likely they would have understood a European's concept of land alienation. Some French interests including the Government of France bought up vast tracts of land trying to tip France's claim to the island group in their favor. By 1905, this group had highly questionable claims to over 55 % of the islands (Van Trease 1984). The subsequent sub-division and sale of these lands to new French settlers led to numerous land disputes with these opportunistic interlopers, with more than a few of these settlers being killed.

In part due to the increase in violence relating to land disputes, also on the rise between European settlers, a Convention was signed in 1906 by the two colonial powers to jointly administer the islands. In 1914, this was amended to establish a Joint Court, also called the Condominium, primarily to deal with the land disputes including the registration of European land claims. This system of registration favored and legitimized the often dubious claims of the Europeans (Von Trease, 1984).

As these settlers favored the flat coastal plains for their plantations in addition to safe harbors for exporting their copra, cacao and coffee it was primarily the flat coastal areas which were initially alienated. These areas were often the areas of greatest fringing reef development, as opposed to the steep volcanic slopes that supported very limited nearshore reef development. Although they did not legally have control over the reefs (they in fact had dubious legal claims over the land) many of them apparently asserted their authority over them effectively alienating many reef areas. This large-scale alienation of land and extensive clearing for coconut plantations (for the production of copra) would have also had a significant impact on the reefs and freshwater systems themselves through erosion and sedimentation as well as on the traditional use patterns and *kastoms* associated with the management of them.

Many of these plantations also ran their own small ships around the islands to recruit labor for their plantations, as labor from other islands could not so easily return to their own land when they tired of plantation work. This helped the plantation owners overcome local labor shortages for labor intensive copra production. This presence of migrant workers in turn created additional problems as these people had different *kastoms*, yet would also look toward the reefs for subsistence needs. A number of the larger islands in Vanuatu today still have large remnant populations of the descendants of plantation workers from other islands from this period. These 'migrant populations' are sometimes a continuing source of conflict regarding the access and management of reefs and other resources on islands, lands and reefs not their own.

It was these ongoing and escalating conflicts over land, particularly when the European colonists eventually began to clear the islands interiors for plantations that led to the Independence of the New Hebrides and the creation of Vanuatu, which translates as "Our Land". The land and reefs were at that time returned to the indigenous custom owners and their descendants as well as provisions made for them to lease their land to non-custom owners (other ni-Vanuatu or foreigners) for development or other purposes. There is to this day no freehold title of land in Vanuatu.

The western concept of an individual owning land thus remains in the legal framework of the Republic as the legally binding leasing of land requires **a** 'custom owner' to sign over the land to whoever is leasing it. This western notion of individual ownership conflicts with the customary practice of clan custodianship of a territory and its resources with an inherent responsabilty to look after it for ones descendants. This results in considerable conflict and division amongst families within a clan as to who has the right to lease the land and thereby receive the economic benefits. As leases are normally from 50 to 75 years, these leases may also affect subsequent unborn generations.

Contemporary Transformations of the Ancient Marine Management & Taboos

The contemporary transformation in historical times of the management of marine (and other) resources including the use of taboos has been an ongoing process of adaptation since the historical impacts documented above began and continues into this more recent period of the Republic of Vanuatu's nation-building. It is truly a testament to the adaptability, resilience and capacity of this ancient system of resource management to have continually been transformed throughout the process of upheaval associated with the arrival of Europeans and on into today's pressures of development and even globalization.

These transformations emerged in response to massive demographic shifts which occurred while many aspects of traditional cosmologies were being eroded and displaced by Christian beliefs and traditional economies of barter and exchange were gradually displaced with the cash economy ushered in by the arrival of the Europeans. Consequently, these taboos have gradually become increasingly associated with the quest to earn money from the commercial harvest of reef resources. This represents a marked shift from the original predominantly cultural context use to manage reefs, a context that was found to significantly enhance compliance.

Some of the earliest transformations of taboos were associated with the management of the islands first commercially exported commodities of dried sea cucumber (beche-de-mer), trochus and green snail when European, American and Asian traders entered the region and initiated the era of commercial fishing for overseas export. Beche-de-mer, never a popular food item in Vanuatu or other parts of the Pacific was purchased in the region for export since the early 1800's. Trochus on the other hand, has been targeted for subsistence purposes since the Lapita people's arrival some 3000 years ago and at some later point became popular as well for making decorative armbands with cultural significance. It began to be targeted commercially for export sometime in the early 1900's. Today, it is the single most commercially significant reef mollusc sold in Vanuatu by villages for export; it now sells for around 300 vt/kg (about CDN 4.50/kg). Green snail, a larger marine gastropod used for inlay in Asia, until recently fetched 2000 vt/kg (about CDN 30.00/kg); one good-sized green snail can weigh a kilogram. With the recent Asian economic decline this price has dropped off significantly as has its demand.

The motivation to manage these resources well in order to generate revenue in the rural areas is thus quite high. It is not quite clear how these resources were managed in the late 1800's, early 1900's, but older men in areas where these resources have been fished for many generations relate how taboos were used to help them recover after continuous harvesting left the stocks depleted. Today these taboos for commercial purposes are no longer accompanied by any pig killings or other rituals of cultural significance, except in some areas the posting of a taboo leaf indicator, typically a *namele* (a cycad frond) used in the central and northern islands to indicate a taboo. In some areas the *namele* will be placed with a trochus shell on it to indicate that it is trochus being banned. In many areas today the use of the *namele* is no longer used for trochus closures but the reef is left unmarked after a verbal declaration.

In areas of Vanuatu where the ancient traditional taboos are still practiced today, people state that they have observed their conservation value over time. That is, that when an area was closed to harvesting during a traditional taboo, resources, including trochus, beche-de-mer and green snail were later observed to become larger and more abundant, as well as fin-fish being more easily caught as they were "less wild". That is, that the fish tend to lose their wariness of fishermen during periods when the reef is under taboo and therefore not being fished. When the fishermen return, the fish are much more easily caught.

For island people intimately associated with their environment, it is not too surprising that the effect of these taboos would be clearly observed and recognizable. In fact, it would be surprising if they did not notice the effect. They then took that knowledge and applied it to the conservation of commercial resources such as sea cucumbers, trochus and green snail that were being harvested and exported starting in colonial times.

Thus, the ancient system of putting a taboo as a customary practice rather than expressly a conservation one, was transformed into a modern management method to expressly protect particular marine resources in the quest to earn some cash. The context had changed from a cultural one to a commercial one. The way the taboo was initiated and implemented was also gradually transformed. Less emphasis was placed on the ritual formerly associated with the ancient custom taboos (such as pig killings) and the fines for breaking these taboos became mainly monetary, not items with cultural significance such as woven mats, kava or pigs as with the *kastom* taboos.

Essentially, a new custom was being invented through the transformation of an ancient one, one deeply rooted in peoples' cosmologies, to adapt to the social and economic changes that resulted from the arrival of European influences. Unfortunately, the respect for these more profane taboos, now normally referred to as 'bans' in many areas to denote this transition, has also significantly declined.

This also is a point made by older chiefs knowledgeable in *kastom*, that the system to protect commercial resources used today is like 'playing' with the power of *kastom*, i.e., the proper ritualization and spirit of a taboo. These chiefs are concerned because these contemporary taboos or bans are being so regularly broken compared to the ancient ones, that they serve to undermine the true power and respect of *kastom*. These *kastom* purists no doubt fear the eventual loss of respect for the ancient taboos as well, as a consequence of this gradual process of transformation from the sacred to the profane.

Since Independence in 1980 there has been a significant increase in the use of taboos to restrict harvesting of commercial products like trochus and in the use of introduced fishing gear to manage the reef resources in Vanuatu. This in part was due to the land and reefs going back to the indigenous landowners at Independence and this being enshrined in the new Constitution. In fact, as discussed above, the main issue behind the independence movement was land alienation. The increase in population and the consequent increase in competition for resources has also provided the impetus to gradually increase management efforts.

Newly independent Vanuatu was also a period when people were again proud to revive and transform some of their ancient customs and to openly express them, once the shackles of colonial rule and oppression had been cast off. One must remember that there was very little, if any, appreciation of the value and merits by Europeans of traditional knowledge and practices during colonial times. Even most 'New Hebrides natives' at that time had been convinced that the European ways were superior in all regards, and that their *kastoms* were part of their heathen past, a time still referred today as "the time of darkness", a term obviously imposed by missionaries.

Cooperative management initiatives

In the early 1990s the practice of putting taboos or reef bans received a significant boost when the Vanuatu Fisheries Department endorsed them in order to enhance the level of community management of trochus. In part, this was to protect transplanted juvenile trochus on select reefs as part of the Department's trochus hatchery program. The research section of the Department initiated a program of cooperative management for trochus whereby they would provide biologically relevant information such as growth rates, lifecycle information and size at sexual maturity to villagers (Amos, 1993).

This information was made available to local communities such that they could draw upon it to improve the timing and duration of their trochus taboos while, at the same time, appreciate why the Department had introduced minimum size limits. Understanding the rationale behind the size limits was found to greatly enhance compliance with them, once villagers understood that respecting the size limit allowed their trochus to spawn for many months before being harvested.

This cooperative management approach rapidly expanded to cover green snail and beche-de-mer to assist villagers with the management of their other most commonly commercialized nearshore resources. Following Johannes' (1998a) recommendations, the Department's Extension Services were used to broaden the scope and delivery of these cooperative management efforts. The Vanuatu Environment Unit, Cultural Centre and some NGOs also became actively involved in promoting the use of traditional and 'contemporary' taboos (i.e., those used for the protection of commercial resources) and in furthering cooperative management efforts to reach more remote communities. Through this process, because it was based on *kastom* and *because it works*, the use of taboos on fishing gear and areas to manage virtually all resources of the nearshore reefs, including those used in subsistence, has become very common, very popular and generally very successful in managing nearshore marine resources in virtually all areas of Vanuatu.

The success of this form of community-based management may be attributed to the fact that; a) resources **will** recover as part of a natural process if left undisturbed for a sufficient period (provided they haven't been completely decimated and the environment remains stable; b) CMT is formally recognized by the Government so communities have the legal right and autonomy to make their own management and enforcement decisions based on their local knowledge of the resources and environment; c) under CMT, the benefits of sound management decisions and restraint on the fishing grounds are realized by the resource owners themselves thus providing the incentive to manage well; d) respect for *kastom* and traditional authority upon which this system of management is based although it is showing signs of stress, is still relatively high in most areas of Vanuatu; e) the well directed assistance of government and ngo's in furthering cooperative management; ie, providing access to biological information relevant to management for villagers to draw upon and integrate with their local knowledge; f) the village and their chiefs decide in the end what the management regime will be taking into account their own unique kastoms, marine resources and socio-economic needs and they monitor and enforce it themselves; this system must represent the ultimate in decentralized management;

A survey of the villages originally surveyed by Johannes in 1993 and surveyed again in 2001 by Hickey and Johannes (2002) indicated that the number of village-based marine resource management measures (taboos) more than doubled in the 8 years between surveys. And the trend is continuing. Of concern however is that an increasing number of these taboos no longer have much or any *kastom* association or ritualization to anchor them in the deeply rooted traditions of the past. As mentioned, many islanders now refer to them simply as 'bans' to make this distinction.

In fact, this trend has more recently taken yet another step away from the protection of resources with the inclusion of *kastom* as its cornerstone. The concept of a MPA is well known to most whom have spent time in an industrialized society. These are generally 'no-take zones' designed to compensate for often extreme over-fishing and environmental degradation which now characterizes most if not all industrialized country's waterways. Locking up a bit of nature in a museum-like no-touch area is meant to maintain a bit of real nature in the form of Marine Parks or MPA's while the rest can often be degraded and over-fished.

A large regional environmental organization now sponsors workshops in Melanesia, and other parts of the Pacific to promote MPA's as if they are oblivious to the context of thousands of years of marine resource management in the Pacific. Even the term CMT, which was closer to describing the reality of marine resource management in Melanesia, as described above for Vanuatu, and a popular term only a few years ago has been left behind for the new and very foreign concept of a MPA.

More recently in Vanuatu, well-meaning overseas volunteers have arrived and attempt to set up MPA's as well as terrestrial protected areas. The idea of simply reviving and supporting traditional practices relating to resource management seems to be sometimes overlooked, and instead inappropriate models from industrialized countries are sometimes imported and supported by overseas donor agencies more comfortable and familiar with these models. Truly, from the sacred to the profane.

Consequently, chiefs are facing new challenges in the maintenance of respect for their leadership and for the taboos used to protect the resources. These challenges are greater in areas where internal community disputes remain unresolved. In fact most of these disputes stem from the colonial impacts outlined above. In summary, they are most often related to;

Land Disputes - relating to the massive depopulation

and migration of peoples to the coastal settlements or missions many generations ago means actual territory borders are not always apparent today; also when it comes to leasing land, conflicts arise from the gap between customary law and western law, namely one individual signs the lease (and gets the benefits) from land customarily held by an extended family of larger group;

Leadership Disputes – relating to missionaries changing the chiefly lines many generations ago that are no being challenged in many areas wishing to re-instate their ancient chiefly line; as well the translocation of many different nasara's (clan based settlements) into composite coastal villages during the missionization process often manifests in internal rivalries over chieftainship;

Religious and Other Divisions - many communities are divided amongst different Christian faiths, particularly with the recent advent of numerous new faiths, many of which openly scorn *kastom*; some communities are also internally divided due to different political affiliations; some communities also have internal divisions relating to predominantly Anglophone or Francophone alliances as vestiges of the condominium colonial rule by France and England;

'Independence' Disputes - when the land and reefs were given back to the customary owners at Independence some families took this to heart and interpreted this to mean that the chief no longer could make any management decisions regarding their land or reefs including the placement of taboos, as was done in the past; in fact there is an additional article also enacted at Independence that states " The rules of custom shall form the basis of ownership and use of land....".; this would still 'legally' keep the chiefs in the management loop in areas where this was the *kastom*;

The peri-urban areas of Vanuatu face perhaps the most serious challenges for maintaining respect for resource management related taboos in that they are generally more exposed to the cash economy and western education; two additional factors cited in undermining this respect. The Fisheries Department has thus seen a dramatic increase in the number of requests for assistance from chiefs in enforcing their taboos in the last 5-6 years.

The need to back up the rulings of the chiefs in Vanuatu is not isolated to the use of conservation taboos. Numerous other issues affected by the erosion of traditional leadership and cultural practices have begun to affect other areas of life, especially in the urban areas. The Government is thus contemplating introducing some sort of legislation to formalize support for the chiefs' rulings from their traditional village courts, but a clear path for Government to follow has not yet emerged.

One approach the Fisheries Department is considering is the passing of a "Closed Area Act". This would, upon a community's request, allow the Director of Fisheries to enact a legally enforceable closure for conservation purposes. The Department feels that this will serve the function of backing up the chiefs and their peoples' wishes to maintain a closure or taboo in areas where it is not enforceable through traditional means. The Environment Unit has included a 'Community Conservation Area' in a new Environment Act recently passed (but not gazetted) to also provide formal state support to community's wishing to protect areas but are not able to do so soley through customary means.

The increasing gap between the ancient taboos with a strong cultural context that clearly correlates with greater respect for compliance and the contemporary transformations or modern 'bans' (particularly the imported concepts with no cultural context) and an increasing trend in non-compliance reveals a clear trend from the sacred to the profane. This has resulted in some areas initiating a counter-trend back towards *kastom* in an effort to maintain respect for taboos.

These communities have undertaken to revitalize, transform and invent rituals associated with the placing of reef taboos, and thereby keep them in the realm of the sacred and rooted in the beliefs of their ancestors and thus ultimately more respected. This is done by re-enacting some of the elaborate rituals upon the initiation of these taboos, including the killing of pigs for a communal feast and placement of the taboo leaves associated with the cultural area.

Such a taboo initiation would be presided over by all of the local chiefs and witnessed by all of the villagers in the area. A custom fine for breaking the taboo is also specified at the outset; this would consist of pigs, mats, kava, shell money or other articles of custom significance. This is in contrast with the cash fine normally levied for many of the commercial taboos. However, if pigs are killed at the initiation, then following most areas customs, pigs will also be part of the fine. Fining people for breaking a taboo in articles of custom significance is obviously much more profound than people being fined in cash.

Another modern transformation seen is the use of Christian blessings on a taboo. Often there will be a combination of both custom and Christianity involved. This will help to appeal to all, no matter which belief system individuals in a community may lean towards. It also facilitates the inclusion of both powers, making it more powerful, whilst endeavouring to satisfy all community members. Some areas also integrate modern administrative protocols to help formalize and ritualize the initiation of a taboo.

For example, on southern Malekula, a Memo of Understanding between all nearby clans was used to help ritualize the initiation of a long term reef closure, and as a means to maintain cooperation and respect from the clan members the MOU included, "That all marine wildlife in the Sanctuary belongs to God" and further, "That the Sanctuary is like a church, to maintain the Christian faith in the creator and everyone should value what it stands for."

The initiation of this Sanctuary also included blessings from a church elder and a pig killing ceremony, kava drinking and involved the placing of traditional *namele* leaves to indicate and oversee the taboo. The initiation of this long-term tabu was indeed a grand fusion of *kastom*, christianity and administrative protocols. Respect and compliance for this Sanctuary has remained high, as have the management and fishing benefits, after many years of operation.

The emergent trend is that there now appears to be four ways of empowering taboos in Vanuatu. The method used depends on how much respect for custom and/or the Church there is in the area. These four methods of empowerment / enforcement include the *kastom* way, the use of both *kastom* and Christianity, the use of just Christianity (rare) and the emerging use of the state to enforce the taboos. There is also the potential synergy of using all three incentives, *kastom*, Christian and state to empower taboos. The inclusion of the state may assist in compliance, but decreases the degree of decentralization and autonomy communities have enjoyed for centuries in managing their own affairs, including resource management. It also incurs significant financial burdens to the state, which it previously never had.

The use of the state has already begun unofficially, with the police often lending a hand to persuade repeating transgressors of the taboos to pay more respect to them. This is most commonly occurring in the peri-urban areas where custom has been the most seriously eroded and there are police available to take this sort of action. Most rural communities have no police readily available nearby; in fact most islands have no police on them at all, a tribute to the chiefs and the capacity of their customary laws in regulating the island societies, as they have done for thousands of years.

Vanuatu today is increasingly facing a crossroads in trying to reconcile both traditional values and the ancient rhythms of life and its emergence into the economic development expected of modern statehood in a rapidly changing global arena. For example, structural adjustments were recently introduced starting in 1997 funded through 'soft-loans' by the Asian Development Bank to reform Government policies and attempt to usher Vanuatu into the realms of globalization. At the same time there is enormous external pressure for accession to the WTO.

The pressure to 'develop' and join the cash economy under the banner of globalization is finally being felt even in rural Vanuatu; an area of the world that had been close to self-sufficient for 1000's of years. Now even island people living off the land are expected to compete on even terms with the industrialized nations of the world as governed by the WTO. These factors are sure to increase the pressure on the limited resources and fragile environment of these small tropical islands as well as putting further pressure on the traditional systems of management that have served so well for so long.

Whatever fork in the road Vanuatu decides to take, it seems clear that if the customs and values associated with the ancient traditions can be supported and maintained by some means through this process of westernization and globalization, that the management of resources and therefore the people of Vanuatu will be that much better off, as will their descendents. If Vanuatu can manage to maintain its relatively pristine islands, vibrant cultural diversity and smiling, genuinely happy people into the future, the people of the wealthy industrialized nations will no doubt pay handsomely to come and visit one of the few remaining places on the planet where this is so.

PARALLELS IN CANADA – FROM SACRED TO PROFANE

By way of comparison, there would seem to be a parallel with what has happened in Canada where the resources of this country were formerly managed by the First Nations. They too seemed to follow a natural rhythm of harvesting and consumption based on their cosmologies, which also embraced a conservation ethic based on respect and on the limits of nature, and which are also in the realm of the sacred. This contrasts starkly with the profane approach undertaken by the Canadian Government which apparently relies primarily on scientific models of management and often seems to ignore much of the richness and usefulness of the TEK held by the First Nations regarding their resources. It would seem that the conservation of resources in Canada could benefit significantly by the adoption of a cooperative management approach, as seen in Vanuatu. This involves the integration and application of both scientific and traditional knowledge like the rich corpus of TEK available to the cooperative conservation of resources. It also involves the devolution of much of the decision making and data collection to the communities residing in the area, and thereby to the ones most intimately associated with and dependant upon the resources. It seems rather wasteful to ignore the thousands of years of knowledge acquired by the First Nation peoples about the resources that could be put to work to conserve them.

The advantages of this synthesis of traditional and cooperative management approach found today in Vanuatu can be summarized in the seven C's.

The Seven C's

Communities - This system of traditional management is community based. Those most intimately associated and knowledgeable and dependent on the resources have autonomy over management decisions. This is common sense!

Conservation - Most island people of the Pacific have been successfully managing the limited fragile resources of small tropical islands for thousands of years. Their conservation methods have proven themselves through the test of time. Europeans living on large continents have only discovered the limits of the resources and the need for conservation in the last 40 years or so. Science, while a powerful tool, is only beginning to get a handle on the environmental impacts of human activities and is still struggling to find workable methods to conserve resources. The cooperative management approach helps traditional conservation methods to adapt to contemporary issues like modern gear, changing social conditions and the commercialization of resources.

Counterparts - In fact, all of the traditional methods have their counterparts in the modern western approach. Closed seasons, gear restrictions, closed areas and limited access were all traditional methods. Europeans have just started to learn to use these relative to Pacific Islanders.

Capacity - It is clear that the traditional system has the capacity to manage and conserve the marine resources while reducing conflict amongst resource users and ensuring a reasonably equitable distribution of benefits. This is clear from the relatively pristine nature of the reefs still found in most areas today after three thousand years of use.

Cooperation - This system is based on the collective cooperation of the community members, fishers and resource owners for a common goal. Also, in cooperative management there is good cooperation between the rural communities and the Fisheries Department. This has been achieved through the development of respect and trust over time. This then allows for the two to work together to refine the traditional system and to adapt it to the modern reality of commercial exploitation, social changes and the introduction of modern fishing gear.

It's Cool - because it's by the people for the people, and it's free. It costs the government very little in terms of monitoring and enforcement as the communities do this.

Canada Seems to Lack the Last Two

Cooperation seems to be replaced by *Conflict* in Canada for the most part. The recent news item 'Burnt Church in New Brunswick' over lobster fishing rights would highlight this. A police boat literally drove over a small First Nations boat forcing the occupants to jump into the cold waters in fear for their lives.

That's Cowboy…

After some hundreds of years we really have not progressed much beyond the old Cowboys and Indians mentality. It's time for the Canadian Government to reassess its management approach, and to initiate the necessary steps to build trust and respect with First Nations communities and get it back to cool and cooperative. We would all benefit, and so would the resources.

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ACCOUNTING FOR THE IMPACTS OF FISHERS' KNOWLEDGE AND NORMS ON ECONOMIC EFFICIENCY

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ABSTRACT
Developing the theoretical links between the knowledge of fishers and socieconomic outcomes of its use is important if fishers' knowledge it to be taken seriously by policy makers. Having a theoretical basis that accounts for fishers' knowledge allows for rigorous approaches to marine ecosystem-based policy development that incorporates both social and ecological variables in management experiments. Social interactions that facilitate the development and communication of fishers' knowledge can improve aggregate economic performance by increasing productivity, reducing the risk of 'free-riders' engaging in opportunistic behavior, and encouraging the development of norms that support mutually beneficial collective action. The combination of (1) the social structures and protocols that facilitate predictable cooperative behavior and (2) the values that individuals hold, which predispose them to cooperate with each other, is known as *social capital*. Social capital theory is useful for addressing pragmatic questions about how to target and strengthen social structural variables that most increase the likelihood of successful collective action. When considered as a variable affecting fishery sustainability, social capital can also be used for comparative policy assessments and help address questions of how to devolve governance to comanagement systems that maximize efficiency.

INTRODUCTION
The use of fishers' knowledge has been hypothesized to facilitate effective fisheries management by utilizing context-specific information not readily available to external fisheries managers (e.g. Johannes *et al.* 2000) and increasing the legitimacy of, and compliance with, fishery management rules (e.g. Costanza *et al.* 1998). The need to incorporate fishers' knowledge seems to be especially important in tropical reef fisheries where our knowledge of ecological systems is relatively rudimentary (Jennings and Kaiser 1998; Johannes 1998) and where management organizations are perennially short of resources and expertise (e.g. Chakallal *et al.* 1998; World Bank 2000).

To be taken seriously in fisheries policy decisions, there needs to be a solid theoretical construct that explicitly links fishers' knowledge to social and ecological benefits that arise as a result of its use. In particular, it is important to link the use of fishers' knowledge to economic performance, because of the emphasis of economic performance in public policy decisions. A theory relating fishers' knowledge to economic outcomes would allow the development of testable research hypotheses and further the possibility for taking an experimental approach to fisheries policy development. Thus, an economic theory incorporating fishers' knowledge would facilitate the use of adaptive management approaches which are so important to marine ecosystem-based management (Walters 1997).

Social capital theory has been developed and refined by social scientists in a variety of disciplines to account for the effects of social context on economic performance (Putnam 1993; Woolcock 1998; Ostrom 1999; Rudd 2000; Woolcock and Narayan 2000). Increasing levels of social interaction tend to lead to: (1) increased knowledge about the world (which can reduce the costs of transforming ecological services into commodities for which humans hold economic value – food, recreational amenities, ecosystem resilience, etc.); and (2) increased knowledge about other people (which can increase trust or identify untrustworthy 'trading partners'), thus helping constrain individual opportunism. A variety of recent research has demonstrated the empirical effects of social networks and interaction on economic outcomes (Knack and Keefer 1997; Narayan and Pritchart 1999; Burt 2000; Uphoff and Wijayaratna 2000; Krishna 2001). Social capital theory offers a potential link between fishers' individual and collective knowledge and experience, and economic performance via social structure.

Knowledge about the world and the behavior of others affects economic outcomes by different paths, but both ultimately depend on fishers' knowledge. The importance of fishers' local ecological knowledge (LEK) has been increasingly recognized by fisheries scientists and managers (Johannes *et al.* 2000; Neis *et al.* this volume) for fisheries planning and management. While there is recognition that the active engagement of local fishers can increase the legitimacy of management rules, and hence compliance (e.g. Costanza *et al.* 1998; Russ and Alcala 1999; Mascia 2000), the importance of the role of fishers' knowledge in the behavior of others is probably not fully recognized by most fisheries ecologists or managers. Knowledge about the behavior of others increases the likelihood of successful collective action needed to solve social dilemmas such as the 'Tragedy of the Commons' (Ostrom 1999; Rudd 2000), potentially reducing the transaction costs of fishery management and making community-based and comanagement governance systems economically more efficient than 'top-down' State management.

The purposes of this paper are twofold; firstly to provide an overview of social capital theory, emphasizing how social capital links fishers' knowledge to economic and ecological outcomes, and secondly to briefly examine how social capital theory can be applied to tropical inshore fishery policy analyses and research. My main conclusion is that social capital provides a theoretical foundation for accounting for the impacts of fishers' knowledge and norms on economic efficiency. As such, fishers' knowledge, and the social structures and institutions that facilitate building and communicating that knowledge, should become a much more important focus of policy research.

SOCIAL CAPITAL – BACKGROUND AND FOUNDATIONS

Social Dilemmas and Collective Action

Social dilemmas occur when it is in the short-term self-interest of individuals to behave in ways that result in sub-optimal benefits at the aggregate social level. There are incentives for individuals within society, for example, to 'free-ride' by consuming public goods and maximizing short-term self-interest at the expense of longer-term social interests. This problem often arises in fisheries. While it would be in society's best interest to maintain environmental quality – a public good – that provides a long-term flow of valuable ecosystem services such as reef fish production, collective action is needed to counter short-run incentives for individuals to overfish or engage in destructive fishing practices. Where collective action cannot be achieved, the results are often the devastation of the fishery and, in the worst cases, the destruction of the environmental base that could sustain future fishery productivity (e.g. McClanahan *et al.* 1997; World Bank 2000).

Public goods have two important characteristics: (1) society does not produce enough public goods because it is not in any individual's short-term best interest to do so; and (2) society as a whole would be better off if more of the public good were produced. Solving social dilemmas and conserving important ecosystem goods and services requires individuals to comply with formal or informal behavioral rules, incurring some short-run individual costs for long-run societal gain. Compliance with these rules by individuals can be viewed in terms of internal cost-benefit calculations that are influenced by the physical environment, market prices for products, formal rules and enforcement mechanisms, and social norms (Crawford and Ostrom 1995; Ostrom 1999). Institutions – systems of formal management rules and informal social norms (North 1990; Ostrom 1990) within which resource users function – influence incentives and, thus, compliance with fishery management policies.

The idea that social context matters for socio-economic performance is not new (see Portes 1998), but there has been a recent surge of research in the field, much of it with very important policy implications. Much of the interest, and controversy, can be traced back to a study of regional economic development in Italy by Putnam (1993). Putnam claimed that there were positive economic externalities – spillover effects – from mundane social interactions such as participation in choirs. Putnam argued that choir members tended to have increased levels of 'general trust' (i.e. trust for people who are not personally known) as a result of their social interactions within their choirs. Having trust for strangers can make it easier to engage in transactions with them and, in aggregate, can even enhance the economic performance of regions or countries, so the argument goes.

While the nature of causality linking social interactions, trust and economic performance have been a source of debate (see Woolcock 1998; Rudd 2000), there is widespread recognition within the social sciences that social networks and institutions have an important impact on economic performance (North 1990; Nee 1998; Ostrom 1999; Burt 2000; Woolcock and Narayan 2000). Engaging in social transactions and trade is ultimately a matter of trust because agreements can never be made to cover all possible contingencies. There is always some risk that a trading partner will cheat on an agreement and engage in short-term opportunistic behavior. Institutions based on trust and reputation can help constrain opportunism, solve social dilemmas and, hence, increase the economic efficiency of producing public goods.

Social Capital – A Fisheries Example

Tropical reef fish stocks are a type of public good known as a common pool resource. They are subtractable – capture of fish means that there are less available for capture or consumption by others – and non-excludable – it is very difficult to prevent a person from using the resource (see Ostrom 1990). Tropical inshore fisheries are particularly complicated to manage because of the multiple species, myriad fishing technologies, and the difficulties inherent in monitoring and enforcing regulations (e.g. Dalzell *et al.* 1996; Chakallal *et al.* 1998; Johannes 1998). Maintaining environmental quality and the productivity of reefs that supply humans with a variety of ecosystem goods and services is a public good transaction and is, therefore, vulnerable to free-riding and individual opportunism. In tropical developing countries, where formal institutions may be relatively weak, social networks remain important for controlling opportunism and solving social dilemmas in the inshore fisheries (e.g. Sutherland 1986; King 1997; Cooke *et al.* 2000; Mascia 2000; World Bank 2000).

Consider the well-known case of Apo Island, Philippines (Russ and Alcala 1999), where a small community was able to implement a successful marine protected area (MPA). A community-based management initiative was developed in 1982 with technical support from Silliman University and, by 1985, the Apo community had endorsed an MPA for the entire reef. A Marine Management Committee, comprised of local community members, developed a management plan and met regularly. Between 1989 and 1990, a community education center was built with assistance from Silliman University and an Earthwatch expedition. Russ and Alcala (1999) note that "the planning, construction and frequent use of this building have been critical factors in maintaining the enthusiasm of the residents for the [MPA] concept. It has provided the community with a useful venue for meetings…" (p. 312). The MPA has enjoyed long-term, strong local support and compliance, and has met virtually all of the original objectives set forth by the community members.

Biologically, the result was an increase in fish density and biomass within the MPA and, according to local fishers, improved fishing adjacent to the MPA. There have also been tourism benefits for the local community, as Apo has developed into a popular dive destination. One can argue that the Apo community solved a social dilemma by establishing their MPA. The ecological services the MPA provides has resulted in a long-term stream of economic benefits to local residents that they would not have otherwise enjoyed. Without social capital – the rules and social norms that prevented opportunism on Apo – it is virtually certain that all economic rents would have been dissipated under open access conditions.

At nearby Sumilon Island, Russ and Alcala (1999) document the experience of developing and managing another MPA. The Sumilon MPA, which was established in 1974, experienced alternating phases of compliance and management breakdown over 25 years. The densities of large predatory reef fish decreased during the management breakdowns and any long-term benefits of the MPA have been virtually eliminated. The breakdowns in management – caused in part by a lack of trust between the community and outsiders (Silliman University and the Philippine national government), and in part by local politicians engaging in opportunism – led to depletion of fish stocks and the dissipation of resource rents that might have been collected through ongoing cooperation. Unlike Apo Island, the Sumilon MPA never gained genuine community-level involvement and support. Local rules and social norms were unable to prevent free-riding (in the form of destructive overfishing) and long-run economic performance has suffered as a result.

Social Capital Theory – Linking Fishers' Knowledge to Economic Performance

A number of disciplinary perspectives on social capital have emerged within the social sciences. Sociologists tend to hold a narrow view of social capital and concentrate on how one can use social networks for personal economic advantage by drawing on resources within the network (Nee 1998; Burt 2000). The emphasis is on narrow trust, prudence based on personal experience or on the basis of another person's reputation within a social network. Political scientists tend to emphasize civil society and how it can enhance the level of general trust in a society. Having trust for strangers can make it easier to engage in transactions with them and, in aggregate, can enhance regional economic performance (e.g. Putnam 1993). Economists tend to think of social capital in even broader terms, as the institutional infrastructure that facilitates trade with strangers whom one might not trust at all. Property rights, money and banking, insurance, and the legal system reduce our reliance on personal trust, thus reducing the transaction costs of trading (Williamson 1985; North 1990).

Investments in social capital entail an opportunity cost but permit people to become more productive in fulfilling human aspirations. As Uphoff and Wijayaratna (2000) emphasize, social capital is associated with *mutually beneficial collective action*. Social and kin networks (e.g. organized crime, gangs) can be close knit, but the overall societal results of their actions can be negative because these social networks benefit one group at the expense of society as a whole. Such networks should not be considered social capital. For example, at the beginning of lobster fishing season in the Turks and Caicos Islands (TCI) a local phenomenon known as the 'Big Grab' occurs (Béné and Tewfik 2001; Rudd *et al.* in press). Many people take leave from their regular employment in other regions and come to South Caicos, the center of the local fishing industry, to go lobster fishing. These fishers, who are usually not skilled divers, target undersized lobster in shallow areas. As many as 95% of lobsters landed in some fishing grounds are under legal size limits. Constraint on the part of visiting fishers would allow more lobsters to reach a larger size, benefiting the resident fishers and TCI society as a whole. Tight kin networks, in this case, actually facilitate the plunder of the lobster resource because relatives are given access to accommodation, supplies and access to boats that are needed for fishing. Clearly, the social relationships used in this situation lead to personal gain (fishers can earn hundreds to thousands of dollars per day during the Big Grab), but do not lead to mutually beneficial collective action and should not, therefore, be considered social capital.

Uphoff and Wijayaratna (2000) define two types of social capital. Structural social capital consists of the rules, procedures, and protocols that make it easier for people to work together to achieve mutually beneficial collective action. Cognitive social capital consists of the norms and values that people hold, which predispose them to cooperate with each other and work for mutually beneficial collective action. Veitayaki (1998: 52) provides an illustration of how structural and cognitive social capital coexist in traditional Fijian fishery management:

> *"Traditional management arrangements are enforced through traditional authority, which means that there are protocols to be followed. The social structure and close-knit units in Fijian communities demand that people strictly follow tradition and respect each other. Decisions made by the group are often conveyed through the social channels of communication, which ensures that all those involved are made aware of the group's decisions. Consequently, the traditional system of retribution is an effective way of ensuring compliance. Nonconformists are treated harshly, and this is an effective deterrent to others…"*

How does social capital work? First consider reef fish as an economic commodity such that output $V = v(L, K)$, where L is labor input and K is capital input (e.g. boat and motor). Increasing L and K will, initially, lead to an increase in output. As inputs increase further, reef fish landings typically exhibit decreasing returns and, eventually, total dissipation of economic rent under open access. If social interactions can constrain opportunism and help society avoid the open access equilibrium, then investments that encourage social interaction will increase societal economic returns.

At Apo Island, for instance, there was a relatively small financial investment in a Community Education Center. The process of developing a management plan and vision for the Apo community, and the general exchange of fishers' knowledge (which undoubtedly led to positive non-fishery spin-off benefits) were facilitated by the financial investment in the Center. If fishery output is now viewed as $V = v(SI, L, K)$, where the additional input (SI) is the social interaction needed to maintain community enthusiasm and compliance, then the value of the social interaction is the net return once the costs of the other inputs (i.e. Center construction) are met. The long-run returns to the fishing community would not have been possible without the durable effects of social interaction and the overall returns have certainly exceeded the modest financial investment in the Center.

Flows of information, whether formal or informal, have three possible effects. First, increased knowledge of the behavior of others reduces the risk of free riders, hence reducing costs imposed by cheaters depleting the resource (e.g. 'known thieves' in the Belizean lobster fishery are closely monitored and socially marginalized – King 1997). Second, increased knowledge about the non-behavioral environment improves productivity and reduces both risks and transaction costs (e.g. productivity increases as a result of some fishers engaging in innovative behavior, with others learning by example). Finally, collective action and coordination increase overall social benefits by helping to maintain compliance with social norms or formal rules.

Rudd (2000) summarizes by noting that informal or formal social interactions help solve social dilemmas by reducing transaction costs and increasing knowledge about both the world and the trustworthiness of other individuals. Economic performance can be enhanced by quantity-increasing measures (increased knowledge about the world and the transformation processes involved in production), cost-reducing measures (a reduction in production and transaction costs) and/or revenue enhancing measures (via gains from trade or increased knowledge about other trading partners). Social capital is a function of social interactions and social structural variables that may, on the surface, serve no explicit instrumental economic function.

When fishers imitate the innovations of another fisher or pool information about fishing conditions on the local dock at the end of the day, they are engaging in a type of social interaction, which increases knowledge about the world and has durable effects. Fishers who gain knowledge about the behavior of others through personal experience or reputation are in a better position to assess trustworthiness. If fishers trust other fishers, they may be able to exchange favors that help reduce fishing costs. On a broader scale, if there is trust between fishers and government, there may be more informal cooperation in developing fishing regulations and less need for costly enforcement or litigation.

Functions of social capital

Social capital can function on two levels, as an asset that can be used for either 'bonding' or for 'bridging' (Woolcock and Narayan 2000). Bonding occurs when strong intracommunity ties give kin and communities a sense of identity and common purpose. Bonding social capital is especially important for the rural poor because it serves as a substitute for the State when citizens are deprived of basic services. Bridging occurs when communities are endowed with diverse intercommunity ties, and as such are in a stronger position to confront problems and take advantage of economic opportunities.

For example, the Fijian government plays a relatively limited role in the management of inshore reef fisheries in many parts of Fiji due to their limited resources and inter-governmental jurisdictional conflicts (Cooke *et al.* 2000). Many communities in Fiji are left more or less on their own; even though they possess high levels of social capital (e.g. Veitayaki 1998; World Bank 2000), this asset is used for bonding purposes, helping communities to cope and manage local Customary Fishing Rights Areas without strong government support. In Samoa, on the other hand, the government worked closely with village councils to develop national legislation that supports local fisheries management (Zann 1999), and provided the services of extension officers to assist village councils in developing local management plans (King and Fa'asili 1999). The rapid adoption of village management plans and the implementation of a surprisingly high number of village MPAs is indicative of bridging social capital. Ideas and knowledge have flowed rapidly between villages. All villages that are part of the network benefit, increasing their capacity for solving local social dilemmas by accessing fishers' knowledge from other regions regarding successful MPA design experiences and how to effectively monitor and enforce village rules.

Community and Institutional Capacity

Fishers' knowledge plays a key role in the development of community-level social capital and solving local social dilemmas. The transaction of interest in inshore tropical fisheries management is the maintenance of environmental quality, a public good. The economic goal is to capture long run benefits, the ecological goods and services that flow in perpetuity from a healthy reef ecosystem, for human well-being. This is a transaction that normally has a high degree of specificity; that is, local knowledge is very important for understanding the unique aspects of the system. Broader cultural, institutional and ecological contexts all influence the degree to which LEK is transferable beyond the local level (Ostrom 1990; Ostrom *et al.* 1993). While local social capital may serve a useful bonding function, it should be clear that achieving broader scale sustainability for reef fisheries also depends on the institutional capacity of national or regional governance organizations. Community-level social capital alone will not be enough to solve all social dilemmas; the institutional infrastructure that the 'New Institutional Economics' emphasizes (Williamson 1985, 1994; North 1990) also has a role to play.

If communities don't have legally entrenched management rights, for example, they may not be able to exclude outsiders from fishing in their local grounds and depleting stocks (e.g. World

Bank, 2000). Evidence suggests that social capital can sometimes act as a substitute for government, but that social dilemmas are most effectively solved when strong governance organizations are present in combination with vibrant, capable communities (Uphoff and Wijayaratna 2000; Woolcock and Narayan 2000; Krishna 2001). Institutional capacity depends on factors like the strength of the legal system, property rights, the degree of government corruption, research and extension capacity, and the awareness of fisheries problems of bureaucrats and elected officials. There is certainly an ongoing need to account for fishers' knowledge in the education and government decision-makers.

Applying Social Capital Theory to Fisheries

Using social capital theory in a fisheries management context permits policy research that would be difficult or impossible using standard economic approaches. Three areas of particular importance are outlined below: (1) identification of key social structural variables in which investments can be made to build social capital; (2) comparative policy analyses that account for various combinations of community and institutional capacity; and (3) analysis of efficiency-maximizing co-management systems for maintaining environmental quality and long-run fishery production in inshore reef systems.

Social Structural Variables

Linking fishers' knowledge and economic outcomes using social capital theory makes it possible to hypothesize about the effects that specific social structural variables might have on the flow of fishers' knowledge, the development of trust and cooperation, and the transaction costs of producing public goods. Substantial guidance on the effects of various structural variables affecting cooperation and collective action is available in the common property literature (see Ostrom 1990, 1998, 1999). Ostrom (1998) outlined a theory of behavioral rational choice where a self-reinforcing 'core relationship' between trust, reputation and norms of reciprocity leads to increased levels of cooperation and, hence, net benefits. For any particular situation there might be a mix of salient structural variables, some of which could be used to build social capital via their enduring structure (e.g. the availability of meeting places for community members as in Apo Island) and some of which could build social capital via their enduring effect (e.g. the availability of transparent information about the past actions of community members).

From a policy perspective, the State faces a number of choices for managing fisheries, each of which has costs. Top-down management by the State ('command-and-control') has generally proven ineffective for tropical artisanal fisheries management (Johannes 1998). The question arises as to whether government might be best spending scarce resources on other non-traditional policy options rather than trying to enforce rules that are essentially unenforceable. Social capital theory suggests that fisheries management might be improved far more by targeted spending on specific social structural variables. For example, the construction of meeting halls, sponsoring visits of fishers to other communities, or the provision of facilitators and extension agents for community management planning are relatively modest investments may have substantial impact on long-run tropical inshore fisheries sustainability.

One insight of particular importance has emerged from social capital research. That is, that the process of working together on projects can be more important than achieving 'successful' results. O'Brien et al. (1998) found that the horizontal social linkages characteristic of successful communities led to benefits even if the specific project that volunteers worked on was a failure. The process of local people working together is more important than the accomplishment of a specific project objective. An implication of this is that the process of developing a community fisheries management vision can be seen as a key social structural variable affecting social capital. The vision-building process of identifying alternative policy options and deliberating about their relative merits builds social capital, helping to create shared understanding and generalized trust that has positive spin-off effects in other aspects of community life (Rudd 2000).

Comparative Policy Analysis

It is now widely recognized that any single policy goal can be achieved using a variety of tools (e.g. Ostrom *et al.* 1993). Transaction costs (i.e. gathering information, reaching agreements regarding the harvest and allocation of resource flows, and monitoring and enforcing those agreements) will vary according to the level of social capital that a community or region possesses and according to ecological, cultural and institutional context. The costs of different policies that might achieve a given end can, in fact, vary greatly.

When community level and state level capacity are considered jointly, a number of situations might be encountered. In northern Belize, relatively high social capital exists in combination with relatively high institutional capacity (Sutherland 1986; King 1997; Mascia 2000). Fishers have a history of collective action going back to the 1960 formation of the Northern fishery cooperative. Government is quite strong by Caribbean standards and is supportive of cooperatives. Local fishers, as a result, have been able to collect substantial economic rents from fishing over the past 40 years. Coastal Belize is not pristine, but compared with much of the Caribbean, is relatively ecologically intact despite export-oriented commercial fisheries.

This is in contrast to the situation in the Turks and Caicos Islands, where a centralized government department manages fisheries using conventional tools (e.g. total allowable catch, size limits, seasonal closures, etc.). Community capacity in the islands is low. There are strong kin ties, but 'The Big Grab' demonstrates that there is little mutually beneficial collective action (Béné and Tewfik 2001; Rudd *et al.* in press). In general, community apathy is high, and effective enforcement of top-down rules is limited by limited government resources and low compliance.

In Fiji, some strong traditional fisheries management systems are still intact. The government, while generally supportive of the traditional management system, can be somewhat irrelevant for local communities (Veitayaki 1998; Cooke *et al.* 2000; World Bank 2000). Local community management capacity is high, but there is limited input or support from government. Poaching is a major concern for local people except in areas where communities highly dependent on local marine resources have adopted strong (perhaps illegal) independent enforcement mechanisms.

Finally, consider situations where both community and institutional capacity are lacking. While there are remnants of traditional fisheries management systems in Kenya, population pressure, widespread adoption of destructive fishing practices, and cultural changes have eroded community capacity in many areas and have led to severe overfishing (McClanahan *et al.* 1997). The Kenyan government has limited resources and has encountered major challenges in dealing with fishers who don't trust them. Conflict, rent dissipation and ecological degradation are widespread as a result.

Why does social capital matter in comparative policy analysis? Consider the example of MPAs as a policy option for sustainable tropical reef fishery management. MPAs are widely advocated as an important policy tool for implementing adaptive marine ecosystem management at the community level (Costanza *et al.* 1998). The argument made by community-based MPA advocates usually revolves around three transaction costs: information costs are lower for MPAs compared to traditional management; the costs of monitoring fisher compliance are lower because it is simple to see, yes or no, whether someone is fishing inside MPA boundaries; and enforcement costs are lower when MPAs are locally implemented. Compliance is more likely when the community has a vested interest in the resource. In addition, cheaters can be punished immediately and internally rather than waiting for the more lengthy and costly process of court litigation.

When considered in light of social capital theory, it becomes clear that the conclusions above will only hold under a certain set of assumptions about community and institutional capacity. When there is a high level of local social capital and an institutional backstop that provides legally binding sanctions when necessary, the arguments in favour of MPAs are likely valid. So, perhaps MPAs would be a preferred policy tool in Belize, but what about the Turks and Caicos, where community capacity is weak, or Fiji, where institutional capacity is limited? Where there is community apathy, as in the Turks and Caicos, an MPA is likely to revert to open access due to low compliance (i.e. social norms are not sufficiently strong to prevent widespread individual opportunism). When institutional capacity is low, as in Fiji, local leaders may feel powerless trying to use traditional sanctions on fishers from outside their own community. The only general policy conclusion that can be drawn is that there will be no simple blanket policy prescriptions from country to country, or even from fishing ground to fishing ground in some cases. Understanding social capital will be crucial for choosing policy instruments that can increase the likelihood of ecological and economic sustainability. This requires that we understand and account for fishers' knowledge about the world and the behavior of other resource users.

Co-management and the Proper Scope of Governance

Social capital also plays an important role when considering government decentralization (transfer of authority to local government agents) and the devolution of fisheries management authority to local communities. The key question is how management authority can be decentralized or devolved so that overall fisheries transaction costs are minimized. Answering this question is contingent on the level of social capital in the region.

Determining the proper scope of governance is a major new research focus in the New Institutional Economics (e.g. Williamson, 1999; Knight 2001). A strong argument can be made that pure market approaches are unsuitable for tropical artisanal fisheries (they are subject to market failure because of the public good nature of the ecological base that supplies valuable ecological services). Thus the question becomes one of determining an efficient co-management balance between the 'State' and the 'Community'.

The discriminating alignment hypothesis (Williamson 1985) postulates that transactions have certain attributes and that governance systems have certain competencies. Minimizing societal transaction costs requires that these two factors be aligned. In tropical inshore fisheries, the transaction of interest is the maintenance of reef environmental quality and productive capacity. One attribute of this transaction is the high degree of uncertainty it entails, as our understanding of fishing impacts on complex reef ecosystems is limited (Jennings and Kaiser 1998; Johannes 1998). Aligning governance systems when there is uncertainty in artisanal fisheries depends on the degree of predictability of fish in time and space. Management by the collective action sector is usually more appropriate when resource users work in a predictable local environment, have higher levels of social capital and exhibit a high degree of dependence on the resource. Decentralized State governance may be more appropriate, however, if local management input is required for the resource but the collective action sector is weak. If regional management is important (e.g. there is widespread downstream dispersal of larvae important for fisheries recruitment in other regions), then co-management tipped in balance towards the State will be more suitable.

CONCLUSION

To be taken seriously in fisheries policy, there needs to be a solid theoretical construct that explicitly links fishers' knowledge to the economic benefits arising from collective action. This can be accomplished using social capital theory.

From a policy perspective, there are also important pragmatic issues. If the use of local knowledge increases resource sustainability, how can policy interventions target key social structural variables that build and share local knowledge? In many cases in tropical developing countries, it is likely that the most economically efficient policies are those that build community and institutional capacity for extended periods before even dealing with fisheries management *per se*. The success of devolution depends on local participation and the ability of the collective action sector to overcome individual opportunism. The likelihood of success increases as fishers' knowledge is increasingly taken into account. Social capital is, therefore, an appropriate indicator of the extent to which State and Community can work together to manage fishery resources.

Caution must be exercised, however, to ensure that the concept of social capital is not applied simplistically in cursory policy analyses. While there are strong theoretical reasons as to why fishers' knowledge and community capacity will have an impact on economic outcomes, there are equally strong reasons why social capital alone cannot solve all tropical inshore fisheries management problems. Effective conservation and fisheries management policies must consider ecological and cultural realities to minimize fisheries management transaction costs. In some cases, when fish stocks are highly mobile or inherently unpredictable, or when local communities have low internal capacity to solve social dilemmas, there may still be an important role for State involvement in fisheries management. Even in these cases, however, accounting for fishers' knowledge will be important, as effective State management will also depend upon context-dependent knowledge until local capacity for co-management is increased.

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QUESTIONS

Maria Mangahas: How exactly do you measure social capital? Isn't it something individuals possess?

Murray Rudd: In an ideal situation, you go into a community and do surveys. The World Bank has been very active in this. There are a number of very general questions that you can ask.

Maria Mangahas: My understanding of social capital is that if I have more relatives and friends than others do, then I have more social capital.

Murray Rudd: We look at the social capital held by the local community and not by individuals. In studies on farms in Tanzania for example, they are looking at differences in economic performances based on their values, norms and social context.

Maria Mangahas : Are you proposing to measure a community's social capital?

Murray Rudd : We are taking things from there. We are also using World Bank data.

THE USE OF FISHERS' KNOWLEDGE IN THE MANAGEMENT OF FISH RESOURCES IN MALAWI

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ABSTRACT
Until recently the management of fisheries in Malawi has been based on the policies and development objectives of Government alone. This took effect from the early stages of the colonial era and was formalized with the setting up of the Fisheries Department in 1971 as well as enacting of specific fisheries legislation in 1973. Unfortunately Government fisheries initiatives, in the form of management and development programmes, were not always successful. Among the many factors for the failure of the Government policies, was the 'sidelining' of the fishers in the planning and implementation of the fisheries programmes. Ironically, fishers were supposed to be one of the main beneficiaries of the Government's fisheries activities. Despite not being fully involved in the official programmes, the fishers, particularly from the artisanal sector, which is by far the major component of the country's fisheries, continued to rely mostly on their traditional knowledge for their fishing businesses. The fishers' knowledge can be categorized into a number of areas. Some still use traditional fishing methods and gears, others have established fishing seasons or control measures based on their local beliefs, long before Government started to get involved in the country's fisheries. The fishers also have a keen understanding, via their indigenous technical knowledge, of the resources they catch; and they accurately decipher the geo-climatic patterns in the areas that they work in. Co-management initiatives in the fisheries sector, introduced and formalized by Government in the mid 1990s, are starting to strengthen the importance of fishers' knowledge in the effective management of the fisheries in Malawi. Even technical areas such as monitoring of the fisheries can benefit from traditional practices and knowledge.

INTRODUCTION
The fish resources in Malawi have been exploited since people first settled areas adjacent to lakes, rivers and other water bodies and applied traditional methods. Government attention to fisheries as an important natural resource sector however, started with the advent of the colonial era: 1891-1963, the legacy of which lingers in present-day Malawi. Government regulation of natural resources began with the institution of the Protectorate of Nyasaland by the British in 1891. Research or recording of fisheries started in 1938 (Lowe 1948). Fisheries activities were carried out more systematically as a Section in the Department of Game, Fish and Tsetse Control from 1947. A fully-fledged Fisheries Department (FD) was established by an Act of Parliament in 1971 to manage fisheries in the country. In spite of the long Government involvement, the majority of the fishers, who are artisanal, continued to be guided by traditional knowledge. This covered all steps of fish resource production including harvesting, processing, marketing or distribution and consumption. The influence or impact of the Government policies on fisheries development has been somewhat limited (GOM 1989; ICLARM/GTZ 1991; Hara 1993; Chirwa 1996; Banda and Tomasson 1997; Dawson 1997; Scholz et al. 1998).

From an historical perspective, the situation is complicated by the difficulty of evaluating models of progress practiced by the local societies (Chanock 1972). Further, a general colonial Government approach of legislating agricultural and natural resource development (Lamport-Stokes 1970), largely disfranchised the people (Derman and Ferguson 1995; Chirwa 1996; Murombedzi 1999), as opposed to demonstrating preferred practices (Chilibvumbo 1969). For the southern African countries in similar arrangements, Katarere (1997) notes that

> *"...colonialism brought with it complex legal and administrative systems to regulate and control the use of natural resources by local communities. This significantly altered relationships communities had traditionally had with their environment..."*

SADC (1997) also presents the repercussions of the situation graphically by stating that

> *"...Africans for millennia managed their resources responsibly, and that it was only with the advent of colonialism that things deteriorated. Access and ownership were withdrawn, alienating the people from traditional means of sustenance. In response, they exploited resources ruthlessly and opportunistically. However, rationality prevails...inherent to their way of life..."*

Despite the survival of indigenous ways, disastrous encounters resulting from promotion of progress continue in rural Africa, even though many forms of impacts through foreign influence on local inhabitants have been documented

(Mitchell 1951; Chilibvumbo 1969; Krishnamurthy 1972; Phiri 1977; Robertson 1984; Dichter 1989; Hulme and Turner 1990; Ferguson et al. 1993). However, it is now abundantly clear (and understood) in development circles that rural people have a lot of knowledge on many subjects that affect or are associated with their way of life, particularly of their local environs (Berlin 1992; Chambers 1993, 1994; Matowanyika 1994). Chambers (1993) further notes that "...The apparent ignorance of rural people is an artificial product of 'outsiders' ignorance of how to enable them to express, share and extend their knowledge". Rapport through appropriate attitudes and behaviour, as a result of this recognition, is achievable.

Currently, the FD implements fisheries policy through six divisions: research, extension and development, training, fish farming, management and administration, and the coordination of inland fisheries[1] in the Southern African Development Community (SADC) area (Ngwira et al. 1996). The FD has many offices and field stations near or along the major water bodies in the country in addition to its headquarters in the capital city, Lilongwe. The policy objectives of the sector are to maximize the yield from fish stocks in national waters. They include improving efficiency of exploitation, processing and marketing; and exploiting all opportunities to expand existing, and develop new aquatic resources. However, care is taken to protect endemic fish fauna as scientific and educational assets; and because fish represent a particularly vulnerable major economic resource (GOM 1989; Ngwira et al. 1996; Scholz et al. 1998)[2]. The sector also complements the national development policy in its objectives of (i) poverty alleviation - through providing employment and thus financial income (GOM/UN 1992; Scholz et al. 1998); (ii) reduction of disease or improved health - the sector provides 70 % of the protein intake from animals and 40 % of protein intake from all sources (GOM 1989; ICLARM/GTZ 1991); and (iii) income re-distribution - through involvement in both direct and indirect fisheries services.

As a responsibility of FD, legislation for fisheries as a sector on its own was first enacted in 1973. The regulations are contained in the Fisheries Act in the Laws of Malawi, Chapter 66:05 1974 and amended or supplemented in 1976, 1977, 1979, 1984, 1996 and 1997. Regulations include: licensing; closed seasons; prohibited methods of fishing; prohibited fishing gear and dimensions; and minimum size or length of fish (Ngwira et al. 1996; Scholz et al. 1998; Mapila 1998; Nsiku 1999). Although these are viewed to be adequate measures for the management of fisheries in the country if appropriately applied, they have been largely ineffective in Malawi due to various factors (Scholz et al. 1998). The situation exemplifies crises in Government-controlled fisheries that prompt some form of stakeholder involvement or fisheries failures seen all over the world (Pitcher and Hart 1982; McGoodwin 1990; Sen and Nielsen 1996; Tailor and Alden 1998).

There were some negative experiences in the early stages where community involvement had been actively pursued (Hara 1998; Scholz et al. 1998). There is now, however, a big shift by Government towards encouraging involvement of user communities in management and conservation of natural resources. The Government has amended its fisheries legislation to recognize the roles of and empower fishing communities in the decision making process (GOM 1989; Turner 1995; Ngwira et al. 1996; Scholz et al. 1998; Mapila 1998). There is some apprehension as to its effectiveness but it is a commendable starting point (Dobson 1996). This sets the stage on which fishers' knowledge can be harnessed to enhance the conservation of the fish resources.

This paper sets out to describe indigenous fishers' technical knowledge of both fish resources and geo-climatic conditions in the localities in which they operate. Secondly, possible ways will be explored in which the knowledge may be used in fish resource management and in which it may be applied to the development of new community involvement processes in order to enhance fisheries resource conservation.

CATEGORIES AND EXAMPLES OF INDIGENOUS TECHNICAL KNOWLEDGE BY MALAWI FISHERS

Traditional techniques are still prevalent despite gradual changes in fisheries practices during the history of Malawi, (GOM 1989; ICLARM/GTZ 1991; Chirwa 1996; Banda and Tomasson 1997). Fishers' knowledge is seen in all steps of fish production, harvesting, handling or processing, marketing and consumption. Central to this is the learning system. Folklore, which serves as one of the channels along which knowledge can flow to future generations, is rich in beliefs, customs and practices, in many communities such as the

[1] This arrangement of implementation of the SADC's programmes of actions is being phased out and the SADC Secretariat in Gaborone, Botswana will carry out all the plans and activities of SADC (SADC 2001).

[2] The sector's policy objectives were being reviewed in 1996 to closely reflect the national priority policy of food security and poverty alleviation. The sectral policy goal is thus "to sustain the contribution of the national fish resources to the upliftment of life in Malawi by conserving the resources for the benefit of the future generations (Matiya 1997).

Chewa (Kalipeni 1996). Information is usually transferred orally in stories and song related to experiences of daily life. Fishing is thus learnt informally, as is common with the livelihoods of rural communities, and passed on to subsequent generations through practice (Berlin 1992; Matowanyika 1994; Dawson 1997). In shoreline communities, fishing has strong links to transition into adulthood. Hoole (1955) describes one such form of instruction for the Tonga people of Nkhata Bay District along the northwestern shore of Lake Malawi:

> *"...The male Tonga is wedded to the lake almost from the day he is born...learns to tumble in it, to swim like a fish, to exult his skill on it, and love it in all its moods. His main ambition in life then becomes to own his own net, and paddle his own canoe. In the hot season the boys of the village build themselves 'mphara', roofless shelters of reeds on the shore and at all times they are assisting their elders, and learning from them the many details of the fisherman's craft. In the kindergarten stage they become adept at catching small fish with a matete reed for a rod..."*

Local fishers, therefore, have detailed knowledge of fish types in their area, fishing methods and gears, as well as how to interpret climate and other factors such as wind, rain, clouds, temperature, vegetation and animal life to determine suitable times and places to fish. Similarities or large differences in fish are appropriately distinguished through assigning names to individual or group(s) of species (FM Nyirenda, *pers. comm.*). Other factors that fishers use to predict whether or not fishing will be successful include fish movements or migrations, feeding areas and times, breeding seasons and colours, and predator-prey relationships. Fish ecology is thus learned, although not in a scientific sense or methodology (Matowanyika 1994). Fish utilization tended to correspond to the level of prevailing techniques of fishing. Until recently, local fishers focussed on meeting their subsistence needs and those of their community. Banda and Tomasson (1997) report 1938-42 observations by Ricardo Bertram and others on operations of indigenous fishers:
"...The fish caught was mainly used to provide food for the owner of the gear and his dependants...". Some trading also took place. Earlier, fish, especially fresh products, would certainly have been bartered and distributed near fishing communities or stations. Fish handling or processing to reach distant areas was limited to sun-drying for small species, boiling or roasting and drying, and splitting and then smoking on open fires for the large species (Hara 1993; ICLARM/GTZ 1991).

In the past, fish resource management has not been a matter of daily concern for fishing communities. Traditional fishing operations were sustainable for a number of reasons, notably gear limitations and low population in many areas. On fishing gear, Chirwa (1996) notes that there are "some positive elements and some weaknesses in traditional fishing methods" and further observes that:

> *"...It was the adoption of new, and especially imported fishing technology such as nylon gill-nets, trawling nets, and narrow-meshed beach seine nets, which put fish stocks at risk...".*

Examples also abound, particularly in the terrestrial zone, that indigenous production processes tended to have "balanced use of ecosystems" so that the actions were "...deliberate natural resources management systems which mimic the natural cycles in local ecosystem" (Matowanyika 1994). Specific to Malawi fisheries, Munthali (1997) contends that:

> *"...legislation does not recognize the importance of traditional controls in promoting sustainable exploitation of the fish resources. Prior to the colonial era, the fish resources in Malawi were governed by traditional controls, through chiefs and village headmen who regulated all fishing pitches within their territorial units. Also ritual prohibition of fishing certain areas, magic and taboos relating to certain fish species regulated the number of fishers in each ground. Besides these traditional controls, there were technical inadequacies in the fishing gear used, and human population was small. Thus the fish resources resiliently absorbed the fishing pressure exerted by the local communities."*

Customs, beliefs and practices also have a big role. GOM/UN (1992) states that "...For the majority of rural based Malawians, traditional value systems still influence and guide their day to day life..." For the management of natural resources, the current situation is very different. Conservation of fish resources, for instance, has become important to local fishers and other players in the fisheries industry (Sen and Nielsen 1996; Scholz et al. 1998). It would thus be prudent to look critically at the folklore and related practices to encourage positive aspects while leaving out the outdated ones (GOM/UN 1992). The fish ecology and geo-climatic and other resource knowledge of fishers, which has been accumulated through traditional practices over centuries (Hoole 1955; Msiska 1991; Berlin 1992; Matowanyika 1994), has to be used in ways that are cognizant of current realities of life and protect fish resources from depletion. Some specific details of fishers' knowledge of fishing methods, gears and craft, closed seasons and areas, fish ecology and geo-climatic conditions are as follows.

Fishing Methods

There are many traditional fishing methods in Malawi. Most fall into five categories, namely netting, trapping, line fishing (hooking), simple manual techniques and using fish stupefacients or piscicidal plants. Some methods are further improved in their effectiveness to attract, encircle or congregate fish by use of baits, dams, barriers or weirs, light and other aids (Hoole 1955; Mzumara 1967; Mills 1980; Ojda 1990; Tweddle et al. 1994; Brummett and Noble 1995). Additional information on methods appears in the next section on gears and craft. The way some gears are used may vary within or between water bodies. ICLARM/GTZ (1991) notes that:

> *"...There is considerable variation throughout Malawi in the fishing methods traditionally employed, as there has been in the rate and type of technological modernization accepted by fishing communities. Without exception, however, all techniques traditionally employed have been closely adapted to the local details of fishing grounds as well as the behavioral patterns of the species present..."*

There are also very specialized fishing methods or techniques that occur only in some specific fisheries in the country. Magalaji (translated as "garages") is a technique used by fishers on Lake Chilwa usually employing line fishing methods and targeting catfish *Clarias* spp. (mlamba) so that they remain alive for many days. Mzumara (1967) describes it as follows:

> *"...the fish caught...are kept in floating baskets suspended in the water near to the [gear used]. The 'mlamba' remain in the basket up to a week or even longer depending on the degree of success of the [fisher]. They are fed on maize meal or small 'matemba' (barbs, Barbus spp.) during their captivity before being taken ashore and offered for sale..."*

Lake Chilwa fishers use zimbowela (floating islands) in their fisheries. This is a direct result of adapting to ecological and climatic conditions existing in the lake region. Some parts of the lake are fringed by an extensive and dense growth of macrophytes, particularly majedza (bullrush *Typha capensis*), extending up to 15 km from fishing villages to access the open water area. There is a problem of floating weeds being "cut off from the marsh areas by strong winds which clogs beaches, landing points, jetties and fishing grounds, sometimes for long periods" (Landes and Otte 1983). Fishers of Lake Chilwa use floating manjedza to make a platform on which they build a temporary hut. These structures, called 'zimbowela', can be built as a deliberately planned fishing camp or temporary shelter when stranded in a windstorm. A small number of fishers in Nkhata Bay specialize in utilization of vuu (precarious stands on rocky ledges on falls or rapids), in association with Khombe, a specialized scoop net used at falls or rapids to target anadromous fish species, sanjika (lake trout *Opsaridium microcephalus*) and mpasa (lake salmon *Opsaridium microlepis*), particularly during their upstream migration to spawn from Lake Malawi. Khombe was especially used at Chiwandama falls on Luweya River in Nkhata Bay District, but is not common nowadays. Hoole (1955) has the following narration of vuu:

> *"...The rapids are formed by a band of hard black rock cutting across the softer rock of the country above, and it is on ledges no more than a few square inches in extent that the jealously guarded vuu are situated..."*

and khombe operation:

> *"...It is a narrow scoop net, somewhat like those used by 'elver' fishers and is fixed to a narrow frame to which is attached a long pole...Notwithstanding the wild rush of water downstream, the bulge of the nets on poles point upstream...The fishers stand on somewhat precarious footholds on ledges projecting over the main falls, and dip their nets into the eddies and pools at the foot of the rocky ledges..."*

Virundu (sing. chirundu) are rocky prominences, pinnacles or 'reefs' that occur in some fishing grounds, protruding from the lakebed. They are usually rich with stocks of species such as utaka ('happy', *Copadichromis* spp.). The Chilimila, an open water seine, was developed to target such habitats. ICLARM/GTZ (1991), based on a final report in 1983 for a fisheries development project in the north, provides the following:

> *"...Utaka shoal above a chirundu and orient themselves toward the current, which concentrates their planktonic food around the rocks. The regime of these currents fluctuates, both annually and diurnally. Hence a thorough knowledge of the current pattern and bottom topography is essential to successfully use the open water seine...Over smooth, shallow bottoms ,...chilimila ...functions as a diver-operated lift net..."*

Fishing gears and craft

Net fishing gears used by fishers in Malawi include gillnet (machera, ndangala, chilepa); open water seine (chilimila, nkacha); shore seine (mkwau, [n]khoka, ukonde); scoop/dip net (chiu); and cast net (chabvi). Machine-made nylon netting materials started to appear probably long after the First World War on Lake Malawi and in the late 1950s and early 1960s in other water bodies such as Lake Chilwa and Lower Shire River. Before this, all nets were made from fibres of different shrubs and barks of trees, and creepers (Mzumara 1967; Mills 1980; Ojda 1990; ICLARM/GTZ 1991)[3]. The most popular source was a cultivated evergreen shrub *Pouzolzia hypoleuca* (variously known as mulusa, muluza, t(h)ingo, lu(i)chopwa, lukayo, (b)wazi, gavi, khonje). Preparation of the fibre is described in Hoole (1955):

> *"...The outer back is scraped off, and then they [net fibre shrubs] are dried in the sun. Later they are soaked in water and then partially dried, which allows the white inner bark fibre to be peeled off easily. From this inner fibre when dried out, the string is made by rolling out strips of it with palm of the hand on the thigh. The various lengths are then spliced and rolled together into one long skein of string. This string is made in many variations from fine to thick, according to the purpose for which it is required..."*

Most of the net gears have an active mode of operation. The gillnet falls into both passive and active modes. Fishers in Lake Chiuta and sometimes in the Lower Shire Valley dye their gillnets brown or reddish brown with bark or root preparation (usually boiled in water) from local trees or herbs such as chan(i)lama (*Newtonia* sp.), chanima (*Elephantorrhiza goetzei*), chirima (*Acacia macrothyrsa*), and chilusa/chirusa (*Lannea stuhlmanni; Lannea* sp.; *Commiphora* sp.; *Fagaropsis* sp.).

Traps are the second most common fishing gear after gillnets (ICLARM/GTZ 1991; MFD 1996). The main types are basket trap (mono, chisako) and fence trap (psyailo, beyu). Mono is made from split bamboo canes, reed stems or thin branches (twigs, wicker) held together by twisted palm leaves (milaza), bwazi/khonje fibres or creepers, and then tied to hoops of staves or lengths of supple branches (nthepa) as frames to give mono its shape and full size. It may be tapered with a valve placed on the larger front end to allow fish in but not escape. The back end is closed when the trap is set and opened when removing the catch. Mono may be used either singly or in association with weirs. Weirs are constructed using poles or other vegetation materials to close a section of a river or other water body. Basket traps are set in gaps left within the weir. Singly set traps are usually baited with other smaller fish or meal remains. In Lake Malawi, the mono is weighted to enable it to be set at the bottom while attached by a rope of a tree creeper held to a buoy or large float (sila) that has a stick fixed to it and serves as a marker called 'bingo' in Tonga (Hoole 1955). Psyailo or beyu is an encircling fish fence made of bangu/o (*Phragmites mauritianus*), nsenjere (*Pennisetum purpureum*) or other reeds and grasses such as manjedza (*T. capensis*), and stakes or poles. The materials are bound together by milaza -leaves of ngwalangwa (*Hyphaene crinita*) palm, or stems of chilambe (*Helichrysum chrysophorum*), a common creeper. Each is operated by six to eight people in shallow water of about a metre (ICLARM/GTZ 1991; Brummett and Noble 1995). Mills (1980) observes that:

> *"... the method requires a team of eight or more men. Essentially, a long sectional fence made of closely fitting reeds set vertically and about five feet high is set up on supporting stakes set into the shallow water areas of the marsh. The fence is normally set early in the afternoon in the form of a square or oblong with one end left open...to take up the most productive parts of that particular spot. Later in the day the men drive* the fish in the area into the fence

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[3] Local plant materials for construction of traditional fishing gears include bango/matete reed grass *Phragmites mauritianus*; (n)duvi/nsanje/ (m)sali Hippo grass *Vossia cuspidata*; mulusa/t(h)ingo/ lu(i)chopwa/lukayo/wazi evergreen shrub *Pouzolzia hypoleuca*; lulisi climber *Tinospora caffrara*; (naka)bwazi/chosi/chiguluka/njefu/muluka/mu-uruak tree violet *Seciridaca longendunculata*; mbibu/msololikoko/nkoloso chashew nut *Anacardium occidentale*; chiumbu/sidyatungu livelong *Lannea discolor*; msaula/malandalala creeper *Ipoma pes caprae*; and mlambe baobab *Adansonia digitata* (ICLARM/GTZ 1991; Nsiku 1999).

> *by beating the water and then rapidly closing the opening with further lengths of fencing. Early next day the sides of the fence are moved inwards so as to form a dumb-bell shape, one end being larger than the other. Finally the smaller end is collapsed inwards completely driving the contained fish towards the other from whence they are scooped out..."*

Another form of fish encircling is used at Bangula Lagoon and Ndinde Marsh in the southern part of the country. It involves making banks of aquatic weed *Ceratophyllum* sp. and mud scooped out to form an enclosure. Traps are set in the gaps left in vegetative walls and fish escaping from the 'fishpond' is thus caught (ICLARM/GTZ 1991).

Hook fishing (kuwedza, kuweja) is in three forms; long line (khuleya), single line (chomanga) and pole-and-line (mbedza). Khuleya is a long main rope with 50 to 800 short sidelines, each with its own hook (Mzumara 1967). A khuleya line is held in place by poles fixed in the water at each end. A few staves (zichili) are sometimes included at distances between the two ends. Anchored floats or weights set at the bottom and tied to a float by a string are used in some areas used instead of the poles. Chomanga is a single hook on a short length of line attached to an anchored float or fixed stake. A chomanga fisher may set several of these on the fishing ground. Pole-and-line is also a single hook set on a hand held rod of about a metre and a string twice as long. A small float is usually attached so that the bait is around 30 cm below the surface. Pole-and-line is also used as a partial harvesting technique for fish ponds (Brummett and Noble 1995). Baits are used in all hook-fishing techniques. Baits vary according to the species targeted and water conditions, and include small fish such as usipa (*Engraulicypris sardella),* matemba (*Barbus* spp.), worms, insects, frogs or other amphibia, pieces of meat, and remains of the local meal (nsima). On Lake Chilwa, pieces of tablet soap are reported among the baits for mlamba (Mzumara 1967). Simple manual fishing techniques include plunge basket, spear (mkondo), and bow (uta) and arrow (mubvi). Plunge basket is constructed like a mono but it does not have a valve and is conical in shape with an opening on the side of its apex. It is mainly found in the Lower Shire Valley. It is operated in shallow water by driving or plunging it downward at random, over an observed fish or disturbance in the water. Spears, and bow and arrows are common in the marshes and flood plains of Shire River (for both) and Lakes Chilwa and Chiuta (for the former). A spear is a hard metal blade, usually sharpened that is fixed to a thin but strong stake about a metre and a half in length. The blade may, in rare instances, be winged or have barbs at the tip. The gears are used in very shallow water mainly for subsistence fishing during the dry season as well as wet season when it is flooding and mlamba, the main target species, is on spawning migration. Spear fishing may be conducted during both day and night (Mzumara 1967; Mills 1980; Ojda 1990; ICLARM/GTZ 1991).

Lastly, fishing by using stupefacients and piscicidal plants or fish poisons has been utilized mainly along seasonal rivers with pools that dry late, small and isolated swamps and marshes. This fishing practice was banned during the colonial administration. Hoole (1955) notes "...The use of poisons for catching fish is prohibited under the Game Ordinance, but it is still occasionally used surreptitiously..." This was in 1934, long before the Fisheries Ordinance was formulated or enacted in 1949 (ICLARM/GTZ 1991; Matiya 1997). Instances of excess use of stupefacients and poisons were associated with certain ceremonial occasions, particularly during the dry season. The large fish kills were to provide fish for whole communities. The method is still outlawed, but occasional cases come to the attention of the Fisheries, which intensifies its campaign against the technique during the dry season. There are many plants common in the country used for this purpose (ICLARM 1991; Nsiku 1999), some of which are indeed very potent[4]. Brummett and Noble (1995) report on recent research on piscicidal plants or fish poisons by three professors at the University of Malawi:

> *"...Fifty potential candidates were investigated by Chiotha et al. (1991). Of these, 14 (Agave sisalana, Aloe swynnertonii, Bridelia micrantha, Breonadia microcephala, Ensete, livingstonianum, Erythrophleum suaveolens, Euphorbia (unidentified species), Neorautenenia mitis, Opuntia vulgaris, Phytolacca dodecandra, Sesbania macrantha, Swartizia madagascariensis, Tephrosia vogelii, Xeromphis obovata) were found to kill 95-100 % of Tilapia rendalli and Oreochromis shiranus within*

[4] The potency of some of the plants was observed first hand by the author in 1992. Unscrupulous individual(s) poured a mixture of plant fish poison in a pool with slow moving water on one of the rivers stocked with trout on Zomba Plateau in the southern part of Malawi. Fish were stunned in a very short period of time and began to die soon after. A few tens were lost on the occasion. Luckily the river was flowing and flushed the site of application with no further disasters reported down stream.

> *24 hours at a concentration of 100 mg·l-1. The potential risks to humans of eating fish killed in this manner have yet to be determined..."*.

At least four species, in ICLARM/GTZ (1991) where stupefacient plant materials used to kill fish in Malawi are detailed, appear in the above list. The local communities in which these plants grow naturally have long known of the potency of these plants, and may even be aware of the effect on people of eating the dead fish.

Fisheries in Malawi have made some progress since the inception of modern fishing - a modest number of two European operators on Lake Malawi in 1938, and introduction of the plank boat as well as promotion of use of gillnet in 1951. Traditional craft, canoe (wato, bwato, ngalawa), have prevailed as the main fishing vessels, despite predictions they would long ago be replaced by other types of craft (Emtage 1967). The canoe commanded a proportional mean of 78.3 % for all traditional fisheries craft in the country between 1985 and 1995 (Nsiku 1999). On Lake Malawi, the proportion of canoes in 1994 was 81 % (Banda and Tomasson 1997). The simplicity in design and limited investment cost seemed to bolster the canoe's resilience despite declines in life span and size due to the unavailability of tree species most suitable for making canoes (ICLARM/GTZ 1991). Emtage (1967) describes one of the so-called technical designs of a canoe:

> *"...It is these in-curved lips of the hull that make the well-made dugout virtually impossible to turn over. To the uninitiated it may seem the most unsuitable craft; especially if one tries to sit facing straight forward, with the backside perched on both lips of the hull, spanning the central opening. The fact remains that a dugout can roll through 90° to lie on its side and recover, without shipping water. A slight lift to stem and stern acts as a stop to rolling, and greatly helps recovery..."*

Besides the two square projecting knobs at the prow (mushyio) and stern (chisiuka, matambi), the only other essentials are paddles (nkhafi), a pole (mchonjolo), and a baler (lupu) depending on the water body the craft is to be used on. Lupu used to be wooden, but a tin can or pail is now common. A special feature which can be added to a canoe, and used to transport a fisher's catch, is a ziwo. This is a compartment created by compressed and tied bundles of grass or creepers to form the required size so that the fish or other items are confined in one place and not stepped upon (Hoole 1955). The best hardwoods for canoe making include chonya, mung'ona (*Adina microcephala)*, Mlombwa (*Pterocarpus angolensis*), mbawa (*Khaya nyasica*), mvunguti (*Kigelia* sp.), mkuru (*Pterocarpus stolzii*), muawanga (*Afrormosia* sp.), nsangu (*Acacia albida*), mtondo (*Cordyla africana*) and ntondo-oko (*Sclerocarya caffra*). These were favorites because they have long life spans and relatively high oil content. Mills (1980) notes of Mulanje cedar (*Widdringtonia whytei*), the now most popular wood in Malawi for boat construction: *"...a particularly oily and long-lasting wood requiring little protective maintenance..."* Canoe makers now resort to using inferior trees such as softwoods, acacia and blue gum; palm tree; and even mango fruit tree among others.

Closed seasons

Although not very well known in recent times or accounted for by Government fisheries authorities, closed seasons were and still are common in smaller water bodies such as lagoons, dambos[5] and other wet lands. Rural communities generally regard the areas as common property (Brummett and Noble 1995). Closures usually coincide with seasonal changes in agricultural activities. Areas may therefore be closed to fishing, watering animals, or swimming during the planting season, the ban being lifted when crops have been harvested. The seasonal closure of areas used as reserves by individuals or the community, particularly those used for cultivation of crops, is very common (Chipeta 1971; Chirwa 1998). There is a proposal to promote community fish stocking and management of one such area in the Lower Shire Valley which has two extensive marshes, Elephant and Ndinde, and several lagoons including Gumbwa, Kanjedza, Makhuthu, Chitimbe and Nyazuluko (K. Katambalika *pers. comm.*). This will probably be extended to many other similar water bodies. The best known example of a locally instituted closed season in Malawi is that of Mbenji Island located in the central part of Lake Malawi in Sub-Chief Msosa's jurisdiction within Salima District. The season is marked by elaborate ceremonies for its closing and opening which include offering nsembe, sacrifice to the ancestral spirits. Of the closed period Scholz et al. (1998) write:

> *"...mainly comprises of a closed season from December to March to allow stocks to recover. During the closed season no one is permitted to remain on the island or to fish in the surrounding waters..."*

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5 These are 'pocket' wetlands; marshy channels that drain surrounding higher ground (ICLARM/GTZ 1991; Brummett and Noble 1995).

Closed areas

There are many examples of marine and terrestrial closed areas. Unlike the latter areas, the basis for establishing the former ones are usually not clearly defined (Matowanyika 1994). They do, however, seem to revolve mainly around tenure or usage rights, similar to those of Japanese village fisheries, as presented in Ruddle (1989), as well as the Pacific Basin (Ruddle 1988). In Malawi there are some closed areas based on belief and the magico-religious systems of the communities. One such place is Phiri la Mtsatsi (hill of castor oil), one of three small islands on Lake Chiuta. There is no fishing or any other activity on the island and its surrounding area, due to the myth that spirits, probably of the land, live there. Compliance is total because of the strongly held belief that anyone who trespasses simply vanishes, and there is no one who has ever returned to say otherwise (Donda 1998). A similar situation exists near the western shoreline of northern Lake Malawi, where fishers avoid a very small island, sometimes just referred to locally as Mizimu ('spirits'). It is believed that an overabundance of monkeys sometimes seen from a distance is a disguise for the mizimu. It is however permitted to shelter there from bad weather. On these occasions no monkey has ever been seen anywhere (F.M. Nyirenda *pers. comm.*). Yet another place is Chileka, a very tiny island connected to Chisi, the largest and most densely populated island on Lake Chilwa. It is not used as a fish landing point, and resources such as firewood, poles, small game, thatch grass, soil and stones are also not used. The place was and probably still is, believed to be a landing site for witches. The place named 'Chileka', after Malawi's ever first international airport in Blantyre, probably as a joke about the witches' flying spot on the island[6].

Other closed areas not based on belief and magico-religious systems are found along Dwambazi, Luweya and Upper Shire Rivers. The right to set biyo, a fish fence fitted with basket traps on the Dwambazi is restricted to the traditional rulers, from Chiefs to village headmen. Two village headmen, Mkoma and Mpute have that right. On Luweya, vuu (noted in fishing methods section), for setting khombe to catch anadromous species at Chiwandama falls - is the preserve of the traditional leaders as well. Vuu associated with pools known as Mkwache and Chinteche at the falls belong to Headman Mambo and Chief Ngombo respectively. These two, however, allow two other people to fish to a limited extent. Those given the opportunity are another Headman Kahinja and an individual, probably an influential figure in the community, Mateyu Nkunkha (Hoole 1955). Chirwa (1998) points to the existence of a controlled area on the Upper Shire River, although this is no longer operative due to commercialization of fishing, when he notes:

> *"...there is historical evidence of chiefly control over fishing activities at certain times of the year...in parts of the river/lake traditionally used by the families in the area for domestic purposes..."*

Ecology and geo-climatic conditions

While traditional fishers in Malawi may have extensive ecological knowledge of the fisheries and areas they work in (as noted above) it is almost impossible for them to share it in systems of international science (Chambers 1993, 1994; Matowanyika 1994). There are nevertheless many broad areas that can be pointed out. They know the many different species they see or catch, and give them names. Of the more than 700 fish species identified and described in Malawi waters (Nsiku 1999), the majority have been given local names by the fishers, or at least a label for the group to which the species is perceived to belong (Berlin 1992). Some fish groups such as chambo (*Oreochromis* sp.) and utaka (*Copadichromis* sp.) have actually been accurately distinguished to the species level, including stages of growth judging from the names assigned (Msiska 1991; Smith 1998). It can also be safely said that local fishers are far better at identifying fish species than Government fisheries personnel, as there are so far only a few people with any form of training in formal ichthyology in Malawi. The fishers are aware of some species' breeding seasons, colours and sites (F.M. Nyirenda *pers. comm.*). Lake Malawi fishers have long observed chambo and other mouth brooders, although their understanding may be faulty. Lowe (1948) describes a case in point when she says:

> *"...In spite of the belief among many African fishermen that the young are born through the mouth, the eggs are probably always laid and fertilised in a sand scrape 'nest' and then picked up by the female...*"

Fish migrations (feeding, spawning, etc.) are known to cause corresponding movements of fishers (ICLARM/GTZ 1991; Munthali 1997). Fishers know the bycatch species of their fishing gears; influence of lunar cycles on their catch; qualitative stock status (i.e. when they are experiencing declines or increases in general);

[6] This is from accounts of the locals during the author's visits to Chisi Island, between 1987 and 1995.

and feeding relationships at least of their target species' predators (Munthali 1997; Smith 1998; F. M. Nyirenda, *pers. comm.*). Specialized feeding relationships between some species such as *Corematodus shiranus* and chambo *(Oreochromis squamipinnis)*, in which the former feeds on tail fins of the latter (biting small pieces), are keenly observed by local fishers. Since the *C. shiranus* follow the other species it is aptly named kapitawo, supervisor of chambo (Lowe 1948). The fisherfolk from the northern region of Lake Malawi know a lot about anadromous species, which spawn with the first rains, particularly those that migrate to upstream tributaries, such as sanjika (*Opsaridium microcephalus)*, mpasa (*O. microlepis)*, chimwe/ngumbo (*Barbus johnstonii)* and kadyakolo/kuyu *(B. eurystomus)* (Hoole 1955; F. M. Nyirenda, *pers. comm.*).

As with other aspects of indigenous knowledge discussed above, fishers in Malawi have acquired the ability to interpret geo-climatic signs and thereby enhance the effectiveness of their fishing operations over time. Some of the specific skill areas are as follows. In N. Lake Malawi, the combination of rising clouds and winds from the western mountains that follows a period of chimphungu (absolute calmness) is a sure sign of an impending heavy downpour or windstorm. Mupungu refers to evening (between 5 and 8 pm), and early morning (from around sunrise until 10 AM) rains brought by easterly (east to west) winds starting from the Mozambican shore of the lake. The winds may be short-lived; blowing for an hour or less. Winds that blow in the direction of home are studied carefully. If they are not too fierce, the fishers continue their work and 'ride on the winds' as they paddle home exerting little or no effort. If the winds are strong or blow away from home, the fishers rush for safety. Rising water level in swamps or water level in wells, particularly in areas of clay soils, which usually crack during the dry season, indicates the onset of 'm(u)wera' (southerly trade winds) which can bring rains for several weeks (F. M. Nyirenda, *pers. comm.*).

Other fisheries related traditional beliefs and practices

In some areas in Malawi certain fish species are not preferred, or are forbidden based on taste, looks or colour, because of traditional taboos or religion. Taboos and religious beliefs that prohibit people from eating certain fishes are also common in West Africa (ICLARM/GTZ 1991). In the case of taste, most people from the shores of Lake Malawi do not eat fish from rivers and ponds, particularly those that are layered with mud at the bottom. The people have such an acute sense of taste that they differentiate fish from the lake and other places with ease (F.M Nyirenda *pers. comm.*). Looks impact the utilization of nkunga (eel, *Anguilla nebulosa*) and dowe (lungfish, *Protopterus annectens brieni*) in some parts of Malawi. Many people do not consume nkunga because it looks like a snake. Dowe is not liked by others, particularly in the Lower Shire Valley, simply because its features and colouring are horrible. In certain areas it is believed to be a bad omen if fishers find snakes, dead frogs or other small animals, and fish species such as nkunga in their fishing gears. In those areas such animals are, in most cases, taboo to catch. A related dislike or taboo is for nyesi (electric catfish, *Malapterurus electricus*). Its skin in particular, is believed to have mangolomela, magical properties against opponents in duels when a dried piece is tied to the body or a powdery preparation from a charred piece is administered to one's skin[7].

An example of the influence of religion is the forbidding of mlamba (*Clarias* spp.), bombe (*Bathyclarias* spp.), kampango (*Bagrus meridionalis*) and related species (nkunga again falls in this group). This belief is strong in communities of Judeo-Christian background, particularly those of Zion and Apostolic Faith congregations. This is based on one of the Bible Laws in the Old Testament, which forbids eating fish with do not possess scales[8] (Carroll and Pricket 1997). ICLARM/GTZ (1991) quotes Grove and others on the case of mlamba being prohibited by taboo in West Africa. The role of religion in Africa is "all pervasive". Matowanyika (1994) makes the point clear when he writes:

> *"...African religion is founded on all aspects of people's livelihoods and has been very much responsible for shaping their character and culture. Religion is embedded in local languages and is transmitted orally...IKS [indigenous knowledge systems] also depends on this process.*

[7] This was a common belief in the Lower Shire Valley during the author's childhood.

[8] From Leviticus 11: 9-12 which states "These shall ye eat of all that are in the waters: whatsoever hath fins and scales in the waters, in the seas, and in the rivers them shall ye eat. And all that have not fins and scales in the seas, and in the rivers, of all that move in the waters, and of any living thing which is in the waters, they shall be an abomination unto you: They shall be even an abomination unto you; ye shall not eat of their flesh, but ye shall have their carcases in abomination. Whatsoever hath no fins nor scales in the waters, that shall be an abomination unto you"; and Deuteronomy 14: 9-10 reads "These shall ye eat of all that are in the waters: all that have fins and scales shall ye eat: And whatsoever hath not fins and scales ye may not eat; it is unclean unto you."

> *Religion reinforces the transmission process...*"

The types of relationship between people and the environment, often seen in the "animistic beliefs" of African peoples (ICLARM/GTZ 1991), come out of the cosmological (myths, legends and other forms of folklore) aspect of religion. Changing the pattern of resource use does not sit well with these beliefs, and taboos are instituted which affect the timing and means of resource extraction (Matowanyika 1994). Similar beliefs also seem to influence people's attitudes in Malawi on whether they may eat fish from ponds or small swamps or other water bodies that have been fertilized by manure from chicken, cattle, pigs or humans (Brummett and Noble 1995). A non-fish magico-religious practice involves the making of a dugout among the Tonga of north Malawi. Hoole (1955) describes such a ritual:

> *"...When a man who is searching for a canoe finds a suitable tree, he then approaches the "owner" of the land for permission to cut it. A price is agreed upon, and a small sum in addition...so that he may address the spirits of his ancestors to ensure that all may go well in the making of the canoe, and that it may be free from cracks, and other faults. The tree is then felled, and before the adzing of the canoe commences the "owner" of the land comes again, kills a chicken, and sprinkles the tree with blood. When the adzing of the canoe is completed and before it is hauled away, the "owner" of the land again addresses the spirits of his ancestors that all may be well with it on its journey to the lake."*

This is not common nowadays probably due to depletion of suitable canoe-making trees and forestry legislation that regulates use of trees.

APPLICATION OF THE KNOWLEDGE IN FISHERIES MANAGEMENT OR CONSERVATION

The Indigenous knowledge of fishers and their communities is not yet used in a systematic way for the management or conservation of fisheries in Malawi. There are, however, some examples of fishing communities taking action with respect to fisheries practices taking place in their areas. The actions or reactions in most cases seem to be based on the knowledge or belief system strongly held in those fishing communities. The measures can also be categorized into the knowledge areas discussed in the above section, i.e., fishing methods, gears, closed seasons and areas, and fish ecology and geo-climatic conditions.

Control of the fishing methods

In the lakeshore District of Nkhotakota along Lake Malawi, some chiefs (traditional authorities) prohibit the chiombela, although FD researchers have not found any evidence that the method is solely responsible for depleting the fish stocks in their areas (Msiska 1991; M. Hara *pers. comm.*). In the chiombela method, fishers drive fish into nets or other gear by beating the water surface with poles or paddles to make noise (Ojda 1990). The chambo fishery, which is the most lucrative in the country, collapsed in Lake Malombe at the start of 1990s. Through co-management initiatives launched in 1994, traditional leaders and fishers of the lake propose to restrict 'kauni', a fishing method that uses light as an attracting device, among many other measures (Chirwa 1998). The unintentional consequences of using the canoe, which is the most common fishing vessel in the country (ICLARM/GTZ 1991; Banda and Tomasson 1997), is its inability to access the offshore regions of large lakes, particularly Lake Malawi. This has the advantage of restricting offshore fishing. Although the inshore areas may be heavily impacted, the overall effect in the lake may be minimized.

Prohibition of certain fishing gears

Chief Kawinga, Sub-Chief Ngokwe, village headmen and the fishers of Lake Chiuta, where the main gears of the fishery are traps, gillnets and longlines, now prohibit use of nkacha (open water operated seine) and other small meshed seines on the lake (Donda 1998; Scholz et al. 1998).

Establishment of fishing seasons based on the local traditional beliefs

There is an effective closed season on Mbenji Island under Sub-Chief Msosa. As a result there is a thriving fishery of utaka (*Copadichromis* sp.) and the stocks are generally healthy. Other prohibitions include beer drinking, gambling, and chamba (marijuana). Women are also not allowed to visit the island, particularly during the fishing season. Penalties for flouting the rules are stiff, including expulsion from the area under the Sub-Chief's jurisdiction (Donda 1998; Scholz et al. 1998).

Establishment of closed areas based on the local traditional beliefs

The magico-religious systems of the areas surrounding Lake Chiuta forbid fishers from exploiting fish and other resources found at Phiri la Mtsatsi Island (Donda 1998). This enables the island to act as a natural fish sanctuary in the lake.

Use of fishers' ecological knowledge of fish resources and geo-climatic conditions of the local areas to enhance conservation

Based on their knowledge of the mpasa fish including its upstream spawning migrations, its role in their communities as well as experience of declines in catches of the fish in recent years, some local leaders are taking measures to protect the species. Msiska (1991) reports that:

> *"...Some traditional chiefs are reported to have been policing against fishing for mpasa during its breeding migration into rivers...Conservationists should be encouraged to tap this traditional knowledge for regulating the fishery..."*

Fishers try to select for size and protect young fish (it is mainly young children that eat these when caught). They look for flavour, eggs in certain species, and large table size fish. Flavour is an issue in target species such as ntuwa/nchila (African carp, *Labeo* spp.), nkholokolo (squeaker, *Synodontis njassae*), and mbumbu/bombe (large catfish, *Bathyclarias* spp.) which is especially targeted for its eggs. The species are sometimes found in the lake and connecting rivers. When fish traps are set at the river mouths, they face in the lake direction to catch only upstream going fish. For fishers mwanga, the period after spawning, is not good for fishing, the fish (including masanga *Oreochromis karongae*, mgong'u other cichlids, mpherere/sanjika *O. microcephalus* and mpasa *O. microlepis*) are thin and not tasty. The fish are however very easy to catch because they are usually hungry and are taken by hook and line. For lakeshore people, even mwanga fish offer a better alternative in meals that have only mphangwe/masamba (vegetable) relish. Changes in seasons bring in factors that fishers learn to take into account. Rain or flooding is sometimes followed by an increase in fish food (algal or plankton blooms), which may in turn be followed by an increase in the presence of crocodiles, which restrict fishing grounds in some areas (F.M Nyirenda *pers. comm.*). Chirwa (1996) provides the following conservation aspects of some traditional fishing methods:

> *"...weirs and traps could only be used in shallow waters, and especially during the dry season. In the rainy season when the rivers, marshes and lagoons flooded, the traps were removed for fear that they might be washed away. They were also constructed in such a way that fish fry could easily pass through. Fish poison could only be used in still or slow moving waters and its effectiveness was limited to a short period of time. The amount, depth, and flow of water could easily reduce its strength. As for the traditional nets, they were designed to catch specific fish species in their habitat."*

Gear maintenance is an important activity. Apart from repairing them, fishing nets are kept in dry places with good air circulation. Khumbi huts (small round thatched shelters with no walls) are sometimes constructed for this purpose (Hoole 1955). As a result of their knowledge of fish, weather and climate in their local areas, fishers tend to devise specific and sometimes elaborate tools, and ways to conserve as well as catch the fish for both their own use and sale.

THE WAY FORWARD

There are many facets of indigenous knowledge systems (IKS). Matowanyika (1994) notes one of the problematic aspects that: "...IKS are often differentially distributed within groups". Apart from knowledge, there are also other differences ,such as relationships and influences, that exist within communities (Robertson 1984; Murphree 1993). Advocates of progress or agents of developmental change need to be aware of the issues even in the context of promoting IKS. When it comes to effective management of fish resources, full involvement of all stakeholders has to be at the forefront. Experience and advice e.g. for example, FAO (1986), Ruddle (1986), Mills (1990), Chambers (1993, 1994), Matowanyika (1994), Taylor and Alden (1998), Pinkerton (1999) and many others on the participation of different stakeholders of fisheries and other natural resources are important. The bringing on board of the rural poor, like most of Malawi's fishers, who have a lot of indigenous knowledge, will have dividends, although it may be slow at the start. Through this process, transformative learning (Pinkerton 1999) will be created for the target groups or stakeholders as well as change agents. There is thus potential to use the indigenous knowledge of fishers in Malawi more effectively. Two areas where the knowledge can be applied are in strengthening user involvement in the decision-making process for the management and development of fish resources, and the setting up of a monitoring scheme that is both less expensive and robust.

Co-management

It is widely realized now that management of resources, especially fisheries, must include all users. Fisheries management thus requires a mutually agreed system of controls with appropriate forms of enforcement to ensure responsible use of the resource (FAO 1986; Tailor and Alden 1998). Co-management initiatives in Malawi began in 1994. Dialogues between fishers, and Government and other interested parties are on-going for Lakes Malombe and Chiuta (Dawson 1997; Chirwa 1998; Donda 1998; Hara 1998; Scholz 1998). For the rest of the water bodies in the country, the dialogue process is in the early stages. To show willingness to proceed with the co-management initiatives, Government has enacted new legislation that calls other stakeholders of the resources to take part in decision-making (Mapila 1998; Scholz et al. 1998). There is also support from external agencies, playing a role in sensitizing the local fishers who also have to accept and acquire transformative learning (Pinkerton 1999) as noted above, like the rest of the stakeholders. It is hoped that the experiences at Lakes Malombe and Chiuta will serve to catalyze crucial aspects of the process in the rest of the country's water bodies. Regional CBNRM (community based natural resource management) experiences like those of CAMPFIRE in Zimbabwe and ADMADE in Zambia (SADC 1996) are also important to learn from. When sustained dialogues are in place and functional co-management developed, IKS issues discussed in above sections will have an appropriate base and be used effectively.

Monitoring

The FD's major monitoring tool for traditional fisheries is annual frame surveys and monthly data collection organized in ten management zones associated with the fisheries of Lower Shire Valley, Lake Chilwa, Lake Chiuta, and Lake Malombe together with Upper Shire. The remaining six zones relate to fisheries of Lake Malawi. For the allocation and management of commercial fisheries, which only occur in Lake Malawi, the lake is also organized in fishing areas. There are nine areas where entry is regulated, at least in principle (ICLARM/GTZ 1991; Tweddle et al. 1994). The tenth zone is mainly inshore, available to traditional fishing operations, and is open access. Two systems of data collection, Catch Assessment Survey (CAS) and Malawi Traditional Fisheries (MTF), are currently in place. The MTF is applied in the Mangochi area, the most fished part of Lake Malawi, while CAS is used in the rest of the country. These systems entail elaborate recording and relatively huge costs, which unfortunately sometimes result in under-funding of FC in Government budget allocations. Designing and implementing an alternative data collection system along the lines of that proposed by Smith (1998), i.e., determining species composition from surveying drying racks and identifying fish found by using their local names (known to fishers), would bridge gaps that are inevitable in some other methods. Fishers' knowledge of fish species, bycatch, processing practices, and other aspects of the fisheries will therefore play an important future role in their management. In any case, fishers already help to identify species in their catches in the CAS and MTF data recording systems. The involvement of fishers in providing information for an alternative monitoring scheme can only strengthen their role in the appropriate management of fish resources, and the development of co-management practices.

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QUESTIONS

Heidi Glaesel : There was an MPA set up in that area about fifteen years ago. How much community involvement is there in the management of that area?

Edward Nsiku: It is different in the Lake Malawi National Park where there is no co-management and it is more of a government initiative. In the Lake Malawi National Park there are a few villages left. All management is top-down instead of bottom-up. A committee on natural resources has recently been set up to cooperate with the locals.

Jim Enright: You mentioned that the funding agencies were promoting traditional knowledge. How much do the local people want to participate in a top-down system?

Edward Nsiku: With this understanding, and also in the case of co-management, they are really very sensitive. The first case was funded through GTZ, a German funding agency, which was promoting co-management in Lake Malawi. It started as a government initiative, but during the process they are trying to balance it by bringing in more participation from the locals. Another example is Lake Chuta. Here the initiative came from fishers themselves and they set up a committee. These are some of the examples. In localized, small places it is the community itself that takes the initiative through a local process. They use the island model and co-management.

Agus Heri-Purnom: How confident are you about implementing the TEK?

Edward Nsiku: There is that potential through the funding agency. The majority of the fisheries is small-scale and still uses the traditional gears. The government wants to incorporate these fishers in programs and policies. There is the potential that their knowledge will be incorporated in order to sustain the fisheries. It is not there yet.

Scott: You mentioned that some traditional practices involved closing the fishery. Was this closing an area or closing down fishing for a species? Is this traditional practice complimented by scientific knowledge?

Edward Nsiku: In the case of Embenji Island, the main species of fish is called *utaba* and the closures were effected for it.

Scott: Following up from the previous presentation, are there ways to punish people if they don't follow the rules?

Edward Nsiku: In the smaller lake, there were traditional beliefs which were in existence, and the people believe that the spirits will punish those who infringe the law. The lake is like a natural sanctuary. In the case of Ebenji Island, there is a local committee that works on the regulations. For example, there are regulations for joining the fisheries operations. There is also a rule that drinking is prohibited. Some regulations are set up from time to time depending on what they are paid for etc.

Sheila Heymans: Does the chief set up the rules?

Edward Nsiku: There is a sort of fishing committee and it is the committee that decides together with the chief. They try to inform everybody and the people in the village will follow the rules, otherwise they will be subject to the local sanctions and penalties.

Kerry Prosper: This is like a value system within a community. Is it passed down through the community through education, like a spiritual thing?

Edward Nsiku: Their knowledge system is learnt through daily life. It is passed on from the older fishers to the younger fishers.

Kerry Prosper: How do you tackle the world changing, for example young people wanting new things and new technology?

Edward Nsiku: It has been a problem. When government came in and set the objectives, they tended to concentrate on economic criteria. A number of these programs have had limited impacts and it is only now that the government has realized it is not enough. Yes, certainly there is that conflict. The regulations of the bay have not focused on the values system. Co-management will try to balance that.

Examining the Two Cultures Theory of Fisheries Knowledge: the Case of the Northwest Atlantic Bluefish

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Abstract
Many accounts have relied on a general contrast between fishers' knowledge and scientists' knowledge. This 'two cultures' theory suggests A) that both training and experience lead fishers and scientists to think in systematically different ways about fish and B) that breakdowns in communications caused by this difference in knowledge cultures is a primary reason for fisheries management failures. The case presented here qualifies both of these suggestions. The research combines a participant observation study of scientific decision making, with a discourse analysis of debates around the management of Atlantic bluefish (*Pomatomus saltatrix*) from 1996 through 1998. The paper traces seven disputes over bluefish science and argues that institutional factors, rather than differences in understanding, were more important influences in five of these seven disputes. Fishers and scientists did not think differently about most of the central facts in the debate over the condition of the bluefish stock. In fact, they were in broad agreement. The final outcomes of the debate, however, involved a wholesale and specific rejection by the scientists of the "anecdotal" information that the fishers considered important. This happened in spite of the fact that most of the scientists involved believed that the anecdotal data accurately reflected the condition of the stock. The reasons for this outcome, which satisfied no one, are to be found in institutional factors that constrained and distorted the scientific debate, rather than in differences in culture among the parties concerned.

Introduction
Discussions of the differences between local ecological knowledge (LEK) and research-based knowledge (RBK) often reflect, more or less consciously, a “two cultures” theory that emphasizes how and why scientists and fishery workers see the resource in different ways (Berkes 1993, Felt 1994, Pinkerton 1989, Smith 1990,1995). Berkes (1993) sees LEK as beliefs associated with indigenous societies that have been handed down through generations and suggests that these systems of knowledge share among themselves characteristics distinct from Western RBK (Berkes 1995). Others have made similar observations about people of European extraction. Finlayson (1994) in his book on fishers’ knowledge and the collapse of the Canadian cod argues that Department of Fisheries and Oceans scientists "willfully dismissed" the insights of the inshore fishermen because of dissimilar cognitive cultures. Because they used alien rules, norms, and language in the negotiation of validity, "Knowledge claims by members of each culture were literally heard as incoherent by the other” (p. 103). Smith (1995) also argues that both fishers and scientists see the other as violating "plain common sense.” For example, both Smith (1995) and Pálsson (1995) found the same reaction to transect surveys amongst fishing skippers in separate studies: the scientists don’t seem to realize that fish swim! Roepstorff (2000) suggests that fishers in Greenland "focus on fish as a living being" and think of them as “mass nouns” while scientists see the fish as a “count noun,” meaning that the individual fish is a representative of the stock in the sense that the stock is the arithmetic sum of the single fish.

While appreciating the importance of these insights, I believe that this “two cultures” approach to the differences between LEK and RBK needs qualification. One problem with contrasting LEK and RBK as two cultures is simply that there are many more than two knowledge cultures in both categories. As even a short review of the sociology of science makes clear, science is made up of many communities with different scientific cultures and standards of validity (Barnes *et al.* 1996). Different local communities also have their own knowledge cultures. Nor is it useful to hold a position, while conceding ‘of course, there are more than two knowledge cultures,’ that there are still enough essential differences between LEK and RBK that they are useful as ideal types. As Agrawal (1995) argues, this will likely stereotype LEK while idealizing RBK. Good cultural explanations of LEK and RBK within a particular management situation begin with an empirical approach to uncovering communities of common understanding among both professional scientists and fishery workers.

An institutional approach to social influences on fisheries knowledge may yield more useful insight and be more empirically accurate than a cultural one. Here a cultural explanation is one that focuses on how one group shares meanings that another group does not share. When Finlayson (1994) makes the argument mentioned above about dissimilar cognitive cultures making fishers and scientists mutually incoherent, he is offering a cultural explanation. An institutional explanation focuses on the way in which interactions within and among groups are structured, and how institutional attributes block or distort arguments that would otherwise be mutually understood. These structures include formal laws, operational rules, fora for discussion and decision-making and social networks. When, elsewhere in his book ,Finlayson (1994) argues that the data produced by offshore fleets was privileged over data from inshore fleets, he is offering an institutional explanation.

Drawing a distinction between culture and institutions has some very artificial aspects. The best understandings of institutional maintenance draw heavily on the concepts of culture and cultural embeddedness, where shared understandings are institutional products (Jentoft *et al.* 1998). The reason for using the distinction here is that fisheries social scientists have overemphasized the idea that fishers and scientists see the world differently. Not only does this threaten a reification of the categories of "scientist / RBK" and "fishery worker /LEK ," it leads us to underestimate the degree to which the rules governing management and stakeholder interactions create these apparent gaps in how the world is seen.

I ground this argument through an examination of the roles and beliefs of various stakeholders and how they affected their determination of the "best available science" with respect to the management of Atlantic Bluefish (*Pomatomus saltator*, Linnaeus 1766) during the period from the fall of 1996 to the spring of 1998 in the United States. The case study begins with a description of the methods used and a brief background discussion about bluefish management. Then each of the seven disputes about bluefish science is described in turn.

Case Study Background Methods

The case study presented here is part of a larger study of the tensions between science and public participation in fisheries management. This study includes two other Northeast Region species case studies and two random sample surveys, one of marine fisheries scientists and the other of the general population of people active in fisheries management in the Northeast Region. Information for the case studies was gathered in a number of different ways. Formal key informant interviews were carried out with 24 scientists, 21 fishers (many of whom served on advisory panels), nine activists in, or active observers of, the fisheries management system, and four administrators. Approximately 200 management-related documents were reviewed, including ten complete transcripts of the Council and/or Commission meetings, of which four related directly to bluefish. We also observed a total of 43 meetings.

Background on Bluefish

In 1976, the US Congress redesigned federal fisheries management and created eight regional Fisheries Management Councils (see also Glaisel and Simonitsch, this vol). Representatives of the fishing industry sit on and hold voting rights on the councils, which have certain powers over the creation of fisheries management plans (FMPs) in federal waters. These councils are only one part of a complex "alphabet soup" of agencies and other institutions. Table 1 overleaf provides a guide to help the reader navigate this soup. The regional council responsible for bluefish is the Mid-Atlantic Fisheries Management Council (hereafter the Council). The Council works very closely, indeed regarding bluefish it usually meets around the same table, with the Atlantic States Marine Fisheries Commission (the Commission), which is responsible for bluefish management in state waters. The third major government actor in bluefish management, the National Marine Fisheries Service (NMFS, pronounced nymphs) implements FMPs in federal waters and must ensure that they meet certain national standards.

US marine fisheries management between 1976 and 1996 was generally not a success. The dominant explanation given by observers was that the council system, and a history of close NMFS - industry cooperation, has put the 'foxes in charge of the hen house' (Safina 1994). In 1996, changes in Federal Law addressed the 'foxes' problem by both strengthening NMFS's powers vis-a-vis the regional councils and by more precisely defining the 10 National Standards that all federal FMPs must meet. During 1997, NMFS developed guidelines for implementing the new laws. Some of the most important related to specifying "objective and measurable criteria" for overfishing. These guidelines allow an overfishing definition to contain either a maximum rate of fishing mortality or a minimum acceptable stock size. In practice, for many FMPs including bluefish, both of these components of the overfishing definition are required (MAFMC and ASMFC 1998). This language also makes the creation of an FMP for

Table 1: Bluefish Management Jurisdictions and Institutions

	State Waters	Abbreviation Used in Text	Federal Waters	Abbreviation Used in Text
Area	0-3 Miles		3-200 Miles	
Jurisdiction	Individual States		US Federal Government	
Ultimate Decision Maker	Individual state legislatures		The Secretary of Commerce	
Responsible for FMP design	The Atlantic States Marine Fisheries Commission Bluefish Board	The Commission	The Mid-Atlantic Fisheries Management Council	The Council
Available Scientific Staffs	Individual state fisheries agency scientists Commission scientists		Council Scientists Northeast Fisheries Science Center at Woods Hole, Massachusetts	Woods Hole
Basic scientific work	Bluefish Technical Committee		Northeast Fisheries Science Center at Woods Hole, Massachusetts Stock Assessment Workshop	Woods Hole SAW
Peer review of basic scientific work	Commission Scientific and Statistical Committee	S&S Committee	Stock Assessment Review Committee	SARC
Monitoring and Enforcement of FMP compliance with national standards	National Marine Fisheries Service	NMFS	National Marine Fisheries Service	NMFS
Monitoring and Enforcement of fishers compliance with FMPs	State Fisheries Management Agencies		National Marine Fisheries Service – United States Coast Guard	NMFS

an overfished stock a legal requirement and this FMP must rebuild the stock to the minimum acceptable stock size (or often to a somewhat higher target value) within ten years. The most critical difference between the pre-1996 and post-1996 fisheries management regime is that, if a Regional Council fails to produce an FMP acceptable to the Secretary of Commerce (meaning in practice to NMFS) NMFS now has the authority to impose its own FMP.

Figure 1 (overleaf) is a schematic representation of the scientific institutions involved in bluefish management. Above the black line is the picture of the natural world that these institutions construct, below the black line is the social context in which the institutions operate. The upper left hand box is the unknowable actual condition of the bluefish stock. The upper right hand box is the legal condition of the bluefish stock that will be used for management. The bottom half of Figure 1 depicts the major fisheries management groups and how they relate to each other. On the right hand side is the Federal system made up of NMFS and the Councils. The arrow from NMFS to the legal condition of the bluefish stock box represents the Secretary of Commerce's final acceptance of the FMP. Arrows between boxes represent influence and /or authority. It is notable that the main entry points to the process from the fishing public are through the state level administrators or through the industry representatives on the Council, who are appointed at the state level. The arrows from the agencies to the fishing public represent the combined influence on fishing behavior of the perceived legitimacy of fisheries management, and the available surveillance and enforcement powers. The arrow going up the far left hand side represents the fact that the fishing behavior of the public is the only link from all of this back to the actual condition of the bluefish stock.

The states and the Commission, the Council and NMFS all have scientific staff. Representatives of these staff groups come together regularly in various fora, come to know each other and each others' work very well, and form a concrete scientific community, in the sense used by Barnes *et al.* (1996). They share a culture that includes a sense of shared responsibility of fisheries management, understandings of leadership, and criteria for evaluation of scientific work. Meetings of the ASMFC Bluefish Technical Committee (BTC) were the most important fora where these scientists interacted in this particular case study. In spite of this shared culture around bluefish, important differences exist between scientific cultures at the state and federal levels. For example, state scientists work more directly with the fishing industry and tend to have a higher evaluation of LEK (Wilson 2000a, Wilson 2000b).

In Figure 1, the peer review process is placed on the intersection between the science boundary and the stock assessment model. Stock Assessment Workshops (SAW) are open meetings that take place at Woods Hole. The SAW's assessment is then peer reviewed by a Stock Assessment Review Committee (SARC), which is also an open meeting that includes a broader group of fisheries scientists. The findings of the SARC are then presented in Public Review Workshops, which are basically informational and the one observed here did not involve any modifications of the material. NMFS and other fisheries administrators view basing an FMP on the findings of a SARC as the strongest foundation for certifying that the legally required "best scientific information available" has been used.

NMFS pushed hard for severe restrictions on the recreational bluefish catch, negative public reaction was intense and the Amendment failed to pass the Council. Under the old system, NMFS could not force the issue by threatening to impose its own FMP. In the fall of 1996, SARC 23 (NEFSC 1997) started the second round in the creation of Amendment One with a new bluefish stock assessment. They found bluefish to be "over exploited," a term that now triggered a legal requirement for a plan to reduce fishing effort. This finding contradicted a previous finding by the BTC that the bluefish stock was "fully exploited." This stock assessment was greeted with widespread disbelief and anger. This was partly because changing the stock from fully to overexploited, especially with the legal ramifications of the change, was seen as high-handed. But there was also a strong sentiment

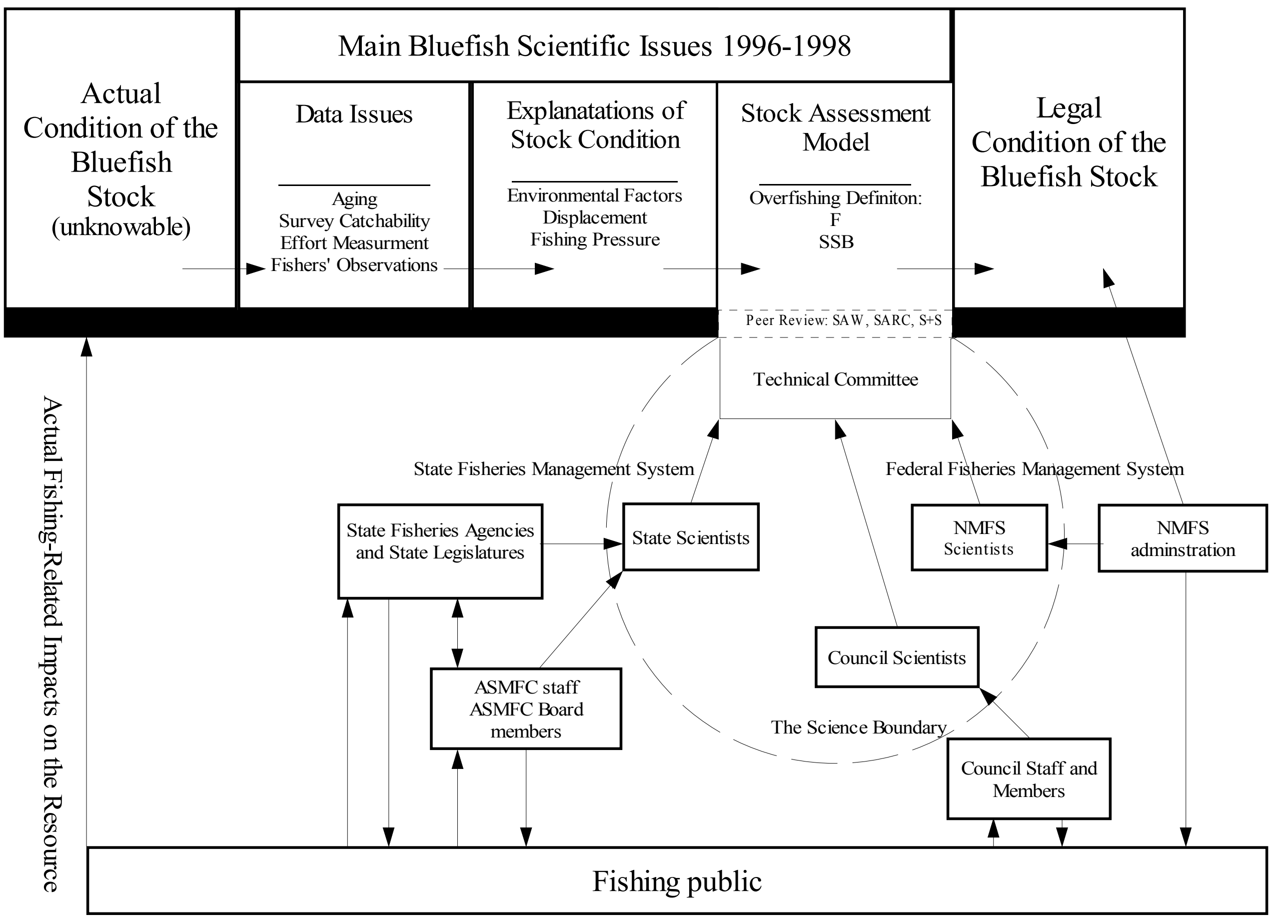

Figure 1: Schematic representation of the scientific institutions involved in bluefish management

The process of creating Amendment One of the bluefish FMP began in December 1994 (when SAW 18 found serious problems with the condition of the stock), and ended in the fall of 1998. The first two years of the Amendment One process, 1996, took place under pre-1996 rules.

that the SARC's decision was simply wrong and it had recommended drastic measures based on very shaky evidence. The case study traced seven major scientific disputes around bluefish science in the period from SARC 23 assessment to the official designation of the "best available" scientific knowledge that would be the basis of Amendment One. Each of these disputes is presented in turn, and evaluated in terms of the degree to which cultural or institutional factors (as defined above) were the driving force in the course taken by the dispute. Table 2 lists the disputes according to the outcome of this evaluation.

Table 2: Important Scientific Disputes in Bluefish Management

Type of Dispute	Disputes Mainly Rooted in Cultural Differences	Disputes Mainly Rooted in Institutions
Data Issues	Aging of Bluefish	Usefulness of Survey Data
	Effort measurement	Usefulness of Fishers' Observations
Competing Explanations for Observations about Bluefish		Environmental Factors
		Fishing Pressure
		Offshore Displacement

DISPUTE #1: THE AGING OF BLUEFISH

The problem of aging bluefish is one that received relatively little attention among nonscientists concerned with bluefish, but which the scientists considered very important. Knowing the age of individual fish is critical because the more sophisticated ways of measuring fish populations are based on tracing year classes, which are cohorts of fish of the same age. It takes time to figure out how old a fish on a lab bench was when it died. It is done by looking at the fish's scales or its otoliths (hard formations found in fishes' inner ears) and counting the rings in them as you would do to age a tree trunk. Because aging fish takes so long, samples of fish are used to make "age-length keys" which give the probabilities of a fish being a particular age if it is a particular length.

SARC 23 (NEFSC 1997) used age-length keys for bluefish that came from the North Carolina Division of Marine Fisheries (NCDMF). In August 1997 the Mid-Atlantic Fisheries Management Council received a letter from the South Atlantic Fisheries Management Council. They were concerned that keys estimated from winter commercial catches in 1995 had not been used with information from recreational catches being used instead. Fish caught in the winter commercial fishery are twice as big as the summer, recreational fish. They also raised a new issue. The NC data was based on scales and not on otoliths, which their S&S Committee feared might lead to inaccuracies of as much as three years.

The NCDMF addressed this second concern with a study of bluefish aging techniques. They reported their findings at the Bluefish Technical Committee (BTC) meeting in February 1998. They had found that whole otoliths are not reliable for aging bluefish beyond age three. The reporter described aging a bluefish older than age six as a "crap shoot" and suggested that many ages in the past had been assigned by guess. They recommended that when analyzing the bluefish stock, fish over age six should be lumped together into a "six +" age category. The use of such 'plus' groups in these models is standard practice, but the question of the age at which to set them is an important one.

At the March 1998 BTC meeting, Woods Hole was represented by a scientist deeply involved in assessing bluefish. Almost immediately, as the minutes for the February meeting were being read, he began to object to the "unsubstantiated rumors that you can't age fish" based on the NC report. In a tense moment in the meeting, the state scientists reacted defensively that nothing in the minutes should be construed as an endorsement of the NC presentation. The federal scientist insisted that this be made clear because he "does not want to get blindsided by this stuff." Later, he presented two bluefish stock assessment models. One was based on the currently used 9+ as the oldest year class, the other on 6+. The 9+ gave an initial stock size in 1982 of 379,000 tones and a 1996 size of 158,000 tones. The 6+ model decreased the stock size by half in 1982 and by a factor of four in 1996. To understand the implications of this, remember that the new law required that a minimum stock size be established and that management measures must rebuild to that level, whatever it is, in ten years. The choice of the final model of the bluefish stock was strongly influenced by the desire of the scientists to avoid using unreliable aging data.

Government scientists were the only stakeholders involved in the dispute about bluefish aging. They were certainly not interested in publicizing this powerful ammunition for stakeholders who would like to delegitimize government science. The 10-year rebuilding requirements added particular urgency to the question as well. Therefore, there were institutional reasons why the dispute unfolded in the way it did. However, all of these proceedings and associated documents were open to the public and more or less scrutinized by the interested parties. That other stakeholders did not make a major issue of the aging problems is most likely because they did not fully realize how bad and how crucial the scientists thought they were. This suggests that the progression of the aging dispute is better explained by cultural factors, i.e. a lack of fully shared understanding among some of the stakeholders, than by institutional factors. That these differences in understanding are related to statistical modeling is important, because that is true of almost all failures of mutual understanding found during the case study. Differences in understanding rooted in statistics exist among scientists as well as between scientists and other stakeholders.

DISPUTE # 2: EFFORT MEASUREMENT

Members of the bluefish fishing public are very concerned about how fishing effort is handled in assessments. The issue was raised in nearly every interview with fishers in which bluefish were discussed. Sitting in the recreational fishing communities, they have seen the degree to which anglers have shifted from catching bluefish in the 1980s to catching striped bass in the 1990s. They believe that this drop in effort is a major reason for the drop in catch and do not believe that this is adequately considered in the scientists' models.

Most of the scientists acknowledge some problems with effort measurement but feel that the models they are using handle it adequately. The model that SARC 23 used is based primarily on the relative number of fish caught in the various year classes, but a measure of catch per unit effort (CPUE) is used based on the Marine Recreational Fishery Statistics Survey (MRFSS). This survey includes both intercepts of anglers returning from fishing and a general population survey of coastal states that gathers information about catches. SARC 23 (NEFSC 1997) acknowledges that the intercept survey does not measure the lengths of an adequate sample of fish. As their measure of effort, SARC 23 uses the number of "trips that caught bluefish plus trips in which bluefish was the target species and in which some fish (of any species) were caught" (NFSFC 1997a p 156). At the Public Review Workshop for SARC 23 held in February of 1997 at a Council meeting the following exchange took place:

State scientist: The last issue I have deals with effort. There are no tables here dealing with fishing effort particularly on the recreational side, and I'm just curious if you considered trying to use that or use boat trips as some surrogate for fishing effort.

Federal scientist: Actually it doesn't show up in this one, but in the last assessment we went through what I would characterize as extensive discussions on effort. Looking at various ways to appropriately use the recreational data and the commercial data, we looked at that in a really hard way, there was no real modification done at this time .....we had done such extensive analyses in the last round, so we are sort of using that up to the present.

Council member associated with recreational fishing: Let me see if I understand what you are saying. In response to the question I asked earlier, you pointed out that it was something new that happened since the last SAW that helped you fine tune this assessment. Are you now saying that you did not take into consideration in that same time period anything that changed in the recreational fishing performance? We all know that that has changed significantly with respect to the targeting of bluefish and the lack thereof.

Federal Scientist: I just answered your question. We have taken into account the additional information, the additional years, the rec [recreational] index that we used again from the extensive analyses we did in the last assessment. We used that again, and added the new information to it.

Council member: Do you see a dramatic downturn in the participation in bluefish fishing recreationally? Any downturn? Do the lower catches, in fact, addressing [the state scientist's] point, in any way reflect less participation?

Federal Scientist: That's hard to say. We've looked at the effort data. I mean, I think probably, yes, that's true.... yes the recreational catch has declined. It's possibly due to less participation; we haven't quantified that to a great degree.

Council member: Okay, explain something to me, the extent to which you would use lower catches to help drive some of the conclusions about SSB, how then can you use that number if it isn't in some way fine tuned with effort? It suggests to me from what you are saying that the effort isn't as important in the calculation as the use of the number itself.

Federal scientist: I'm sorry if we got cross wired here. We're using an effort index to tune and we've incorporated the new information that is available up to the present through 1995, which is the terminal year of this assessment.

At first the Council member thought that the scientist was saying that they had not updated the effort data itself, when he had meant that they had not changed the way that data was modelled. This is perhaps because the Council member was focussed on the question of whether or not the change in effort was being considered. The federal scientist's need to double check the answer, implies that he was not aware before this interchange, of the degree to which the fishing public was concerned that changes in effort were being ignored. The opaque language he chose to use in his last remark suggests that he still may not have sensed the degree of concern.

In addition to the fear that changes in effort are being ignored, members of the fishing public frequently expressed three other criticisms of MRFSS as a measure of effort. The first is that the general telephone survey does not cover Pennsylvania, and a great many of the customers on party and charter boats come from the Philadelphia area. The second is that in the intercept survey, work is only done during the day, while a lot of bluefish fishing is done at night. They also believe, and I have heard a scientist express this belief as well, that the CPUE is higher at night than it is during the day. These things are seen to be correlated as night anglers are often from Philadelphia.

The third criticism is that the growing number of anglers who catch and release their bluefish rather than keeping them is not considered. As one sports fishing organization put it the "methodology becomes even less dependable when you consider that the recreational community has, in most recent years, been releasing the majority of its catch. This brings into question the use of recreational "landings" and recreational "catch" in the assessment. It almost appears the two are interchangeable in places when in actuality, the figures are different by orders of magnitude" (JCAA 1998). This criticism does not accurately apply to either the SARC 23 assessment (NEFSC 1997) nor the stock assessment adopted for Amendment One (Gibson and Lazar 1998). Both of these explicitly considered the release of fish and used figures that reflected the increasing trend toward catch and release. Recreational effort measurement was addressed by both the SARC and the BTC as a serious technical issue, especially once larger issues of model and raw data selection were becoming clarified.

Even more than the aging, effort measurement is a good example of how a lack of shared understanding between the recreational fishing community and the fisheries scientists can drive a fisheries science dispute. On the one hand, the anglers had difficulties understanding when and how the scientists were incorporating effort data into the models, while the scientists had a difficulty understanding the sources and degree of the fishers' concerns. On the other hand, the recreational people's knowledge of who fished and when led them to be much more critical of the ways effort was measured.

Dispute #3: The Status of Fishers' Observations

Fishers believe that they have considerable information to contribute to bluefish management. In interviews, fishers pointed to their knowledge about how different combinations of changes affect the bluefish stock, and particularly tracing the movements of the fish. Examples they gave of their knowledge of bluefish involved both what they were seeing and what they were hearing from different kinds of fishers around the coast. The observations they found important involved the behavior of both bluefish and species that the fishers associate with bluefish, e.g. striped bass, menhaden, and sand eels. These behaviors were most often seen as driven by environmental changes, particularly water temperature. What emerged from these discussions were not simply "anecdotal data," but "anecdotal hypotheses" (see also Stanley and Rice, this vol) about what is happening to the stock. None of the fisheries scientists interviewed, nor the fisheries scientist who accompanied us to some of these discussions with industry members, found these not yet systematically tested hypotheses, unreasonable. Anecdotal hypotheses for what was happening in the mid-1990s took various forms, but all suggested that the bluefish had moved offshore.

Fisheries scientists that we spoke with agree that using fishers' observations to improve stock assessment would be a good thing. At the state level in particular, there have been many instances of scientists working with fishers to address local research problems and to collaborate in research efforts that involved more than just using fishers' *ad hoc* observations. Both fishers and scientists learn in these small scale interactions.

The most critical problem, especially for NMFS, is one of scale. It includes both the logistical issue of processing detailed information from across the breadth of the Northeast Region, and the conceptual problem of translating local observations into meaningful information at a larger scale. One attempt to use logbook information from party and charter boats was overwhelmed just by data entry demands. This led to loud resentment from the people who provided the data. Over the course of the case study, many presentations of LEK by fishers were made to scientists in public fora. A typical response to such presentations was "you're right and we looked at that question, and additional work is needed."

The use of fishers' observations in stock assessments is a charged issue. At one meeting, in response to a council member's raising the question of the degree to which fishers' observation did not jive with the SARC 23 assessment, the Regional Director (RD) of NMFS began by pointing out that anecdotal information is very difficult to use because fishers' observations in one place often don't agree with observations in other places. Then he said the following:

> 'Anecdotal is not a pejorative description, neither is analytical, although people are very happy to throw rocks at the analysis and are offended if people say 'that is anecdotal.' That seems to me to be silly. Nobody ignores anecdotal information .....Anecdotal information is used in the way that you can use anecdotal information, the same with analytical information. There is nothing pejorative about it.... I have never felt that it is not used in the assessment. It is used in the analysis when people are examining tuning indices and trying to explain why certain things occur in diagnostics. That is exactly what they used. It is used extensively.'

Two things are interesting in the RD's statement. The first is the defensiveness, he wanted people to understand that this is not some bias he or anyone else at NMFS has against the knowledge of fishers. The second is the assertion that fishers' observations are used as background information in putting together an assessment model. As will be clear, this case study suggests that this role as background information is a very problematic one.

The treatment by different stakeholders of fishers' observations, characterized by the use of the term "anecdotal data" by scientists, has important cultural elements. To some extent, different groups have different understandings of what makes a fact valid. Arguably these differences are more formal than substantive, by which I mean the "common sense" that lay people use to understand nature is often very similar in content to the method of the scientist.

NMFS' basically positive response to using fishers' observations, and the real attempts they have made to do so, suggest that institutional problems run deeper here than cultural ones. We simply do not know how a government agency can make more than *ad hoc* use of fishers' observations, the response "you're right and we looked at that" is often the best they are able to do under the rules they have to operate under.

DISPUTE #4: SURVEY CATCHABILITY.

Two basic types of data are involved in stock assessment, information about the catches of fishers and "fisheries independent" data from surveys. Fisheries independent data is a critical source of information because the same gear is used in the same place year after year. Effort, i.e. the amount of time that the gear spends in the water, can be accurately measured, and the hauls are placed across the ocean according to a deliberate, mathematically designed plan. The Northeast Fisheries Science Center at Woods Hole does two surveys of the ocean between Canada and Cape Hatteras, which is approximately the mid-point of the US east coast. Because the most important commercial fish species are groundfish, the NEFSC surveys are done by pulling a trawl net along the bottom. Bluefish is a migratory, pelagic species that spends most of its life swimming quickly through the water high above the bottom. The catches of bluefish in the spring survey are so sporadic that it is not even considered in evaluating the stock. Data from the fall survey, however, is used in evaluating the stock.

Scientists point out that this poor catchability is not sufficient reason to dismiss the data. As long as the same gear is always used in the same way, the results are usable if the variance in the catch is not too high. Of course, 'too high' is a matter of judgement and an important one in the bluefish assessment. The fall survey is divided into geographical areas and there is an important distinction between the inshore and offshore areas. The inshore survey catches are of the order of fifty times as many fish as the offshore survey. This huge difference comes almost entirely from the number of young, age 0 and 1 fish that the inshore survey catches. In the offshore survey, the majority of hauls show either 0 or 1 fish, and so it becomes very difficult to arrive at statistically valid conclusions. The inshore and offshore contrast is very important in light of the dominant anecdotal hypothesis that the bluefish had moved offshore.

Much of the fishing public perceives these surveys as inadequate and many of them do so for sophisticated reasons. All of the interested public, for example, seem to be aware of the problem of the bluefish being too high in the water column to be caught. In July 1997, leaders from recreational and commercial bluefish interests from one important bluefish state, including three Council members from the "industry representatives" category, met with scientists from their state to discuss how to respond to SARC 23. The content of the meeting was a review of the scientific arguments involved and a marshaling of counter arguments. Many were offered, including several related to survey catchability. One raised the point that the bluefish swim faster than the survey trawls move through the water. Another suggested that the surveys assume greater consistency in fish behavior than was justified. A council member argued that the survey moves north to south while the bluefish were moving south to north.

These issues were echoed in the meetings of the ASMFC Bluefish Technical Committee (BTC). As the federal scientist that attended the second meeting put it: "First of all, our trawl gear can't catch big bluefish unless it runs into them when we are hauling back because the damn things can outswim a trawl that is only this far [holds hand out] off the bottom and second, out on George's Bank or out on most of the shelf the trawl is down here and the bluefish are some 50 fathoms up there." His conclusion: "we need a bluefish survey, that is what we need."

At the conclusion of this BTC meeting two new stock assessment models were selected to be added to the one already created by SARC 23, and all three were sent to the Council Science and Statistical (S&S) Committee for a final determination. The first was an ASPIC[1] model. This model does not rely on aging, only on the number of fish caught, but accurate effort data is important. It cannot use the NEFSC offshore trawl because those were the only data that showed that the number of bluefish was increasing, and the model cannot accept data with contradictory trends. The validity of the ASPIC model depends on the assumption that the NEFSC inshore survey accurately reflects all of the bluefish available to the fishery. This fact is critical to understanding the present case study because it means that the ASPIC model relies on the assumption that the hypothesis that the bluefish had moved offshore was false. The other new model they considered was an *ad hoc* model created by a state scientist. He used both inshore and offshore data and melded several accepted approaches together. One of the justifications for the final selection of the ASPIC model as the "best scientific" characterization of the stock was that it did not use the less statistically tractable offshore data.

The dispute over the survey catchability was clearly driven by institutional factors. All stakeholder groups shared a common understanding of the problems with the survey. Therefore, it was institutional constraints, particularly driven by the expense of doing surveys and decisions about the allocation of fiscal resources, which lead to trying to assess all species with a single survey designed for the most commercially important species.

DISPUTE #5: THE EFFECT OF ENVIRONMENTAL FACTORS ON THE BLUEFISH STOCK

The issue of environmental factors such as habitat damage and predator - prey interactions played a relatively minor role compared to the offshore displacement and fishing pressure issues. The perceived need to manage fisheries as part of a broader ecosystem is intuitively appealing, especially to fishers. It resonates with their common argument to focus more on non-fishing related causes of declines in fish stocks. In interviews, several academic fisheries scientists were proponents of the ecosystem approach and no scientist denied its theoretical validity. There was skepticism about its practical relevance to management.

In April of 1996, the Subcommittee on Fisheries, Wildlife, and Oceans, of the House of Representatives Resources Committee, held a hearing on the decline in bluefish. At that hearing the NMFS representative attributed the decline in the stock to overfishing while other witnesses, including the Council, the Commission, and angler groups emphasized environmental factors (NOAA 1996), particularly a decline in bluefish prey species (JCAA 1996). Later the same year, NMFS produced a very short paper relating environmental variables to bluefish abundance (Terceiro 1996), which was later incorporated as a SAW 23 working paper. The paper found that many environmental variables do indeed correlate with bluefish abundance. The paper does not purport to test any theories; its main purpose seems to be to demonstrate the complexity of the question.

[1] ASPIC < www.fisheries.org/cus/library/cuslib39.htm> is a non-equilibrium implementation of the Schaefer stock-production model that can handle up to 10 simultaneous or sequential fisheries or indices of abundance for the same stock. The model can be fit conditional on the observed fishing effort or on the observed yield, and in the latter configuration, can handle missing values.

During the Public Review Workshop for SARC 23 the following statement was made by a fisher on the Council. It is representative of a common criticism of management.

> 'We're protecting all of the predators, fluke, striped bass are recovered, we're protecting the weakfish, we're protecting all of the predators, how about everything else? We're trying to protect the butterfish, the squid, everything in the ocean, but there has got to be a natural balance somewhere.'

A few minutes later:

Another council member: One of the things that we've discussed in the few years that I've been on Council, and in other meetings prior to being on Council, was a greater understanding of the migratory patterns and the relationships to ocean conditions and water temperatures and bait [fishers often refer to prey species as "bait"] availability for this species. Has there been any additional work done on that, because it could be a significant contributing factor to the presence in our waters?

To whom came the response:

NMFS Scientist: The other paper we looked at was one where we had a correlation matrix with about 25 environmental and biotic variables reviewed in that paper [note: this is the paper mentioned above] and, of course, the problem with a correlation analysis is that you don't know which ones are spurious.. the recommendation as a subcommittee... to do more work in that area.

Another comment made at the meeting:

Industry representative: That seems to be the approach sometimes, that we want an ocean full of bluefish and we want an ocean full of striped bass and those things may simply not happen. The problem is, in the process, what [The NMFS scientists] said is correct, the fishing pressure is the only thing that anybody can do anything about, but that makes the fishing industry the lowest common denominator in that attempt to maximize simultaneously or multiple variables. I disagree with the idea that fishing is the only thing that you can do anything about because certainly one of the greatest benefits to the bluefish resource might very well be to reestablish a greater commercial fishery on striped bass.

This statement shows another important aspect of the political complexities of considering species interactions, because the appropriate extent of the commercial fishery on striped bass was the most contested question in striped bass management. Many in the bluefish recreational community mirror this issue by arguing that a cause of the decline of bluefish is commercial fishing on prey species, particularly menhaden. The reduction or elimination of the menhaden fishery has been a priority of several recreational fishing groups.

As in other disputes, the dispute over the role of environmental factors reflects some cultural differences based mainly in scientific training. Scientists want to be able to model something before they start treating it as real. This is especially true when that treatment has a legal basis. The reason I have not classified this dispute as rooted mainly in culture, or even as rooted more or less equally in culture and institutional factors, is that all stakeholders basically agreed that environmental factors are important. The real differences were in possible responses to these factors, the law that NMFS in particular is mandated to carry out is designed to control the activities of fishers. The new laws do emphasize the importance of habitat, and require FMPs to identify areas of essential habitat for the species, but all NMFS is able to do with this information is to write letters to other agencies asking them to consider the protection of this habitat. To take into consideration all of the potential interactions may be academically appealing, but it is a poor fit with legal and political realities. This theme carries over into the next dispute.

DISPUTE # 6: THE EFFECT OF FISHING PRESSURE ON THE BLUEFISH STOCK

The second explanation given for the stock condition was that it was being overfished. SARC 23 concluded that fishing mortality has exceeded the appropriate biological reference since 1991. Critical reactions to these findings mainly took the form of highlighting the problems with the data discussed above. The varied reactions of other scientists to the model also focused on the data problems, particularly the aging issue.

During this year and a half period between SARC 23 and the creation of alternative findings by the BTC, NMFS put up a sprightly defense of the SARC findings and the need to take the management actions that they called for. Early on, NMFS cast the disagreements with the stock assessment as coming from "the sentiments" of people who were not willing to face reality. At the council meeting that followed the Public Review Workshop in February 1997 for SARC 23 the following exchange occurred:

Council Member (an academic): I believe that when this and these additional analyses go out to public hearing, there will be tremendous discussion, tremendous public concern on

> what's occurring here, and perhaps once that public comment is completed, this Council may wish to take very careful note of that comment and reconsider some of the actions that it's taking.

NMFS Regional Director: This has come up a number of times now about the concerns that the public will have .Clearly, it will be controversial, but sometimes the need to do such things is controversial, the issue is what is needed to try to rebuild this stock. So, I think that regardless of the public outcry, sentiment and so on, it is important to be clear that that is what is apparently needed.

NMFS' application of the FAO Code of Conduct for Responsible Fisheries and the precautionary principle (FAO 1995) is at the heart of their vision of management and fishing pressure is what NMFS is best empowered to control in a precautionary way. NMFS scientists tend to conceptualize fisheries management as a technical problem and fishing pressure plays a key role in this conceptualization (Wilson and Degnbol 2001). During the initial presentation of SARC 23 at the Public Review Workshop, for example the NMFS scientists said

> 'So, again, I repeat that the focus of the SARC was more on, how do you get out of the current dilemma of, say, doing things that are within man's control, and the only thing you can do is really to lower catches.'

Other stakeholders are less comfortable with this assumption, as in this quote from an interview with an industry representative:

> 'Biologists are starting to acknowledge that there is less impact now, but they are saying "oh, maybe there's not but we still have to protect them and this is the only way we can do it, we can't deal with environmental factors, we can deal with you so we are going to screw you guys". I don't think it is going to have a great deal of impact biologically but ... It will destroy more human beings and small businesses who cannot survive this and who are not the cause of the problem.

The conflicting interests in fisheries management means that there can be no final, objective criteria that determine where the burden of proof lies. The issue in the final analysis is about the distribution of gains and losses from assuming or avoiding the risks of overexploitation. Those who are going to lose business now from a cutback, and who may or may not be the ones who enjoy its potential future benefits, are going to be much less sanguine about considering other causes of stock decline that cannot be responded to with changes in fishing pressure as irrelevant. While nearly everyone gives lip service to the precautionary principle, many people resist, and not always unreasonably, its stark demarcation of what the null hypothesis should be. As a council member put it at the special bluefish meeting:

> '[With all due respect for the precautionary principle] I think you will have a very hard time convincing people that it is wise to take actions that will put people out of business today because if we get squared away two years from now that we really didn't need to do that in the first place well now you can tell them to go back in business. Once they are gone they're gone.'

The dispute over fishing pressure clearly stems much more from institutional than cultural sources. All parties acknowledge that the size of a fish stock is a function of both environmental factors and fishing pressure. It is the law that requires that a target fishing mortality be identified, and the reason it does that is because that is what is most feasible to control legally. The dispute over the relative emphasis on fishing pressure versus environmental factors is driven by interests and by the rules that have been set up to adjudicate those interests. This is as much true for the government, which has a strong interest in emphasizing aspects of nature that are amenable to bureaucratic manipulation, as it is for the fishers.

DISPUTE # 7: THE DISPLACEMENT HYPOTHESIS

While there were many issues and problems with the bluefish assessment one disagreement stood out. Many people involved in the bluefish fishery, including scientists, believed that the observed decline in the bluefish stock was an illusion created by a large and sustained movement offshore of larger bluefish. The bluefish had moved away from where they had been caught in the past and the methods of catching them, both those of fishers and scientists doing surveys, had not followed them.

Among fishers the idea that the bluefish had moved offshore was close to a consensus. Longliners who targeted swordfish complained that bluefish were stealing their bait much more than in the past. Others told me that they had heard the same thing from tilefish and wreckfish fishers who fish in deep water canyons. This was the typical nature of the information. One fisher's observation was reinforced by that of another until a picture of the position of the resource was built up that was entirely coherent, in the sense of being an internally consistent explanation, but not systematic. Thus a consensus emerged based on a great deal of information, but in a way in which information challenging that consensus could easily have been dismissed as not fitting the "common sense." A few typical statements are presented here. The first, from February 1997, is from a recreational fishing activist who served as chair of an advisory panel for another species and later became a member of the Commission:

Recreational Fishing Activist: I talk to offshore guys who see huge schools of large bluefish 60-100 miles offshore. The assessments we are getting are based on looking in the same places they always looked. These assessments say we are in deep trouble. I think we are but not to the degree that they are stating.

At the bluefish industry leaders' strategy meeting in July of 1997:

Council member: The 1996 year class was weak according to NMFS. Surveys are done in estuaries while the bluefish are offshore. Offshore the bluefish are giving fishermen a hard time but they are not seen inshore.

Another participant: They are not inshore down south.... Commercial Bluefish fisher: We are seeing half pound fish 10 miles offshore.

Council Member: Cold water runs down the coast along the beach to 12-13 miles off and bluefish don't like this.

The inshore water temperature theory was repeated by several fishers in different contexts. Water temperature figures frequently in fisher's observations. The importance of temperature is also reflected in the business of the Council member, who said the following at the Bluefish Monitoring Committee meeting in August 1997:

'To add a little anecdotal information onto the record...one of the businesses I am involved in provides satellite temperature chart service to recreational fishermen from New England through North Carolina. As part of that service people that receive our charts phone in fishing reports for their trips. They call them in to any one of six reporters who work exclusively for us. And that information is provided back in weekly reports to our customers up and down the coast. For the week of July 9th to July 15th I went back and read through the reports that were broken down by (50,000 reports) inside the 50 fathom curve areas and also by the canyons. What I found didn't surprise me but it might shed some light on the offshore distribution in these fish. I broke these down into canyon areas, and remember, keep in mind these are people who are not fishing for bluefish. They are fishing for yellowfin tuna...[tape is turned over]... There were bluefish harassing and believe me some of the reports said they could not get away from them. Bluefin tuna fishermen off Montauk, off Shinecock Inlet 45 miles, [the outer tip of Long Island] the sea buoy to the dip off Mariches [?] Inlet about 50 miles, the Texas Tower and Triple Wrecks area that's 50 -60 mile off NJ. The Slough Area, Little Italy, those areas are 16-28 miles off New Jersey, the Chicken Canyon, the Hambone and Sausage Lumps off of Delaware, the Fingers off Indian River, and 28 Mile Hill off of the Delaware-Maryland area. Those are all in one week period. That is a lot of bluefish covering a lot of area offshore.'

In spite of the number and coherence of the fishers' observations, some scientists did not find these arguments convincing. The response from one federal scientist when displacement was raised at the Public Review Workshop for SARC 23 was as follows:

'Actually in the subcommittee we did address some additional work that has been done in both of those areas [predator-prey and displacement]. We did look at a paper that suggested that perhaps there has been some movement of larger fish offshore, so that, in some way, addresses the availability thing you are talking about. It's weak evidence at this point, but we looked at it.'

The paper he referred to was written by a state scientist who was convinced that the displacement hypothesis had merit. The paper (Crecco 1996) is cited in SARC 23 as stating that "there is some evidence in the pattern of commercial landings and effort that adult bluefish have been displaced further offshore in recent years" (NEFSC 1997 p 161). That document did not use the word "weak" to describe the evidence. The paper argued that there had been a gradual shift, beginning in 1988 in commercial bluefish catches from state to federal waters, suggesting a shift in the stock.The federal scientist at the Public Review Workshop referred again to the displacement hypothesis a little while later in answer to another question about the "dome shaped partial recruitment vector," a statistical pattern showing that there were fewer older bluefish in the data than should be expected:

'In this case, since we have this funny fishing pattern, which we would characterize as a dome shape, where the older ages aren't recruited to the extent that the age ones are... The reason for using this pattern is because it

> has repeatedly shown up in the analysis that the Committee has done, it's not the usual one and in fact, most of the time you have a hard time justifying using this kind of relationship, but in this particular case we reviewed the evidence, both in terms of the analysis that you normally use to look at the fishing pattern. Also, as I mentioned before there is some, albeit weak evidence that larger fish are moving offshore and they may not be available, that would be a plausible mechanism why you would have a dome shaped curve.'

So while this scientist continues to characterize the evidence for the displacement hypotheses as weak, it is the only explanation he offers for why the "funny fishing pattern" keeps showing up in the data so often that they feel they have to go ahead and use it in the assessment in spite of the difficulty they have in justifying such a decision.

The displacement hypothesis became the central issue in the deliberations of the Bluefish Technical Committee. As described above, one of the models they were considering used the NEFSC off-shore trawl data and showed that bluefish was not overfished. Meanwhile, the other ASPIC model showed that the bluefish were overfished. The ASPIC model did not use the offshore data and its key assumption was the stock was fully available to the fishery. Bluefish is a recreational fishery which takes place near the shore; if the displacement hypothesis had any merit at all this assumption was not valid. Many, if not most, of the scientists that spoke at the meeting, however, believed that the displacement hypothesis had merit. One scientist, when accused of not believing it, responded that he had been catching bluefish far offshore just like other people (Wilson and Degnbol 2001).

The ASPIC model had a number of advantages, both scientific and institutional. It did not rely on aging fish. It yielded both a measure of standing stock biomass and fishing mortality, both of which are required by law if it is possible to obtain them. The management advice it triggered was not nearly as drastic as that from SARC 23, but was more conservative (more conservative = more restrictive of fishing) than the other model. Its being more conservative was definitely considered a plus by some, as a state scientist said,

> 'I don't know if we can spin it that way [chosen for being more conservative] but we should keep this in the back of our mind.'

Another scientist responded that one could call it conservative, or biased low. Finally, it was more scientifically standard than the alternative model, hence it would stand up to the kinds of peer review that are concerned with maintaining standards in science for public policy (Wilson and Degnbol 2001). The committee did not want to make a final decision. They decided to pass the final decision on to the Council's Scientific and Statistical Committee. They did this knowing that the ASPIC model would be chosen. As the presenter of the *ad hoc* model that accepted the displacement hypothesis said *'I don't think that my analysis will pass* [the Scientific and Statistical Committee] *as well as the ASPIC, I just think it is the right answer.'*

In May of 1998 the newsletter of the Atlantic States Marine Fisheries Commission announced their decision with the following comment:

> 'The S&S committee recognized the shortcomings of the assessment but concluded that it represents the "best scientific" characterization of the Atlantic bluefish stock given the currently available data. An important caveat is that the assessment does not consider the possibility that the sharp declines in landings and abundance indices may be due to migration of adult bluefish to offshore areas.'

The displacement hypothesis was the center and essence of the LEK about bluefish and supported by many scientists. Just as the RD had said, this "anecdotal data" was seriously considered by the scientists charged with making the stock assessment. That is was specifically rejected by the adoption of the ASPIC model as the *"best scientific characterisation of the Atlantic bluefish stock"* was even acknowledged in the announcement of that adoption. In spite of the scientists' awareness that the models key assumption of availability was questionable, valid scientific reasons, such as avoiding unreliable aging and survey data certainly contributed to the selection of the ASPIC model. But from the perspective of the social influences on the scientific process, cultural differences did not drive this dispute; the mutual understanding of the parties was nearly complete. It was the institutions of fisheries management, i.e. the legal requirements for specific types of answers, the administrative need for a peer review process that does not use "ad hoc" judgements, and the political need for an outcome which was precautionary but not too draconian, that made the ASPIC model the best science available.

Conclusion

The seven scientific disputes around the management of Atlantic bluefish in the mid 1990s are listed in Table 1 and evaluated in terms of whether or not they are best explained as driven by culture, defined as the degree of shared understanding among the various stakeholder groups, or institutions, defined as the rules and practices governing management and stakeholder interactions. Most of these disputes contained both elements, but five of the seven seemed more clearly driven by institutional factors than by issues of mutual understanding.

These categorizations should not be overdrawn. As was conceded in the introduction, this strong distinction between what is "cultural" and what is "institutional" is an artificial analytical distinction made to drive home a specific point. Even as defined here, the distinction is hardly mutually exclusive as cultural and institutional factors can be found in all of the disputes. Nevertheless, the basic point is an important one: institutions have the power to *"*systematically distort communications*"* (Habermas 1987) involved the social construction of nature even in situations where the stakeholder groups understand each other well.

As do other social scientists involved in arenas of policy where science is important, fisheries social scientists face a difficult task as we try to understand social influences on the knowledge base used for fisheries management. We have recognized the importance of different worldviews in the process of building this knowledge base, and this case study suggests that we need to pay close attention to the distorting affects of rules and institutions as well. We can draw on tools to accomplish this from a number of areas. Many studies exist of the use of science in legal and regulatory areas (e.g. Jasanoff 1990, Salter 1988). A literature is emerging on the relationship between bureaucracy and quantification (e.g. Porter 1995). Various Habermasian concepts are also available to analyse the effects of social structures on human communications from a general perspective (Habermas 1987, Wilson *et al*. 1999). The application of these tools to fisheries management may well help us better understand how to develop a sound knowledge base for management within our disagreement-ridden policy arena.

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THE VALUE OF LOCAL KNOWLEDGE IN SEA TURTLE CONSERVATION: A CASE FROM BAJA CALIFORNIA, MEXICO

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ABSTRACT
The use of sea turtles by many coastal communities worldwide remains a part of their traditions and culture despite evidence of decreasing turtle numbers and strict laws prohibiting their harvest and use. There have been great advancements in our understanding of sea turtle biology and behavior, and the science of conservation is continually developing new tools. Unfortunately "science" does not always translate into "conservation" on the ground. As researchers become increasingly aware of the cultural motivations involved in sea turtle exploitation, it becomes critical to shift conservation efforts towards local communities, particularly to the fishers often in the position to make choices directly impacting the fate of turtles. While the ways that fishers have negatively impacted sea turtle populations have been documented, what is often overlooked is how these same individuals can contribute to their conservation. A major goal of community-based efforts in sea turtle conservation is to develop practices which will protect sea turtle populations and habitats that are also compatible with the socioeconomic system and cultural ecology of local resource-dependent communities. Within a conservation mosaic, the incorporation of both biological and social research methods and communication are critical. Analysis of a case study in sea turtle recovery efforts within Baja California, Mexico indicates that community-based research can result in locals actively participating in conservation and providing the knowledge and information necessary to create successful long-term conservation plans. Formation of partnerships through local education, informal conversations, and community meetings are shown to be a fundamental part of sea turtle conservation. By combining the knowledge gained through scientific investigations, with the insights of the local population, we stand a much better chance of succeeding in recovery efforts, particularly if adaptive management techniques designed through community-based research and action are advocated.

INTRODUCTION
Coastal communities worldwide continue to utilize sea turtles according to their traditions and culture despite evidence of decreasing turtle numbers and strict laws prohibiting turtle harvest and use (Frazier 1995; King 1995; Kowarsky 1995; Nietschmann 1995; Parsons 1962; Tambiah 1989; Tambiah 1995). In northwestern Mexico, and specifically the Baja California peninsula, turtle use originated as subsistence harvest, but over time this use broadened into a directed fishery (Clifton *et al.* 1995; Caldwell 1963). In addition to the food that turtle meat provided for an individual fisher's household, there were increasing economic benefits associated with the sale of turtle meat in the market, both regionally and internationally. Although legislation is now in place to protect Mexican sea turtles, enforcement is prohibitively expensive in such a vast area and fishers have devised elaborate methods of eluding existing enforcement. As such, laws and enforcement have not adequately abated harvest or declines in sea turtle populations, especially in rural areas like Magdalena Bay where laws have been misunderstood or disregarded. As Reichart (1999) suggests, marginalizing the participation of local stakeholders nearly always ensures the failure of such legislation.

Nichols describes the cultural significance of sea turtles in Baja California as having the food quality of filet mignon and the addictive quality of coffee, while possessing the traditional symbolism of Thanksgiving turkey (*SFS Center for Coastal Studies lecture* 2000). Whether you look at turtles from the perspective of cultural traditions, or as an economic or food resource, we believe that sea turtles are arguably among the most important species in northwest Mexican culture.

Of the five threatened or endangered sea turtle species known to inhabit the coastal waters of Pacific Mexico, two species most commonly frequent the waters within and adjacent to Magdalena Bay: the East Pacific green turtle -- or black turtle -- (*Chelonia mydas*), and the loggerhead turtle (*Caretta caretta*) (Clifton *et al.* 1995; Nichols 2001). These are also the species that are most commonly caught by the fishers of Puerto San Carlos, Puerto Magdalena, and Lopez Mateos, the largest communities on the shores of Magdalena Bay (Gardner and Nichols *in press*). The coastal waters around the Baja California peninsula serve as critical feeding and developmental habitat for these and other sea turtles, after they migrate from as far as Michoacan (Nichols *et al.* 1998) and Japan (Nichols *et al.* 2000b).

Site Description

The Baja California peninsula, which extends into the Pacific Ocean south of the U.S. state of California, is comprised of two states: Baja California and Baja California Sur. The entire length of the peninsula is about 1000 miles (~1,600 km). Magdalena Bay, a large mangrove estuarine complex on the Pacific side of the peninsula, is one of the largest bays in all of Baja and is bordered by several barrier islands. Due to its location between the Pacific and California ocean currents, which allows for a mixture of both warm and cold water species, and the relative protection that the barrier islands provide, Magdalena Bay is a highly productive ecosystem which boasts enormous biodiversity. Mangroves present in this bay are at the northernmost limit of their range; their presence is a unique feature of the coastal ecology which contributes to the high productivity of a bay that has been called "the Chesapeake of the Pacific" (Dedina 2000).

Many of the towns on the shores of Magdalena Bay were settled by *rancheros* (ranchers) from the Santo Domingo valley and surrounding inland areas. While Magdalena bay was first discovered by *Conquistadores* (explorers) in the 14th Century, migration to this region did not commence until the 1920s when inland agricultural projects began to fail and new means of subsistence - shell and finfish - were sought (Dedina 2000). More permanent settlement began in the late 1950's when the cannery and deep-water port projects were initiated in Puerto San Carlos. Since that time, people have continually been migrating to the town. Though many who currently inhabit Puerto San Carlos have lived there for a number of years and consider themselves residents of the area, their roots may lie in other states in mainland Mexico (Bostrom *et al.* 1999). Today, migrant fishers continue to come from the mainland and other parts of the Baja California peninsula in order to exploit the seasonal resources.

Currently, numerous, mostly seasonal, fish camps are scattered along the coastline of Magdalena Bay. There are also a few permanent settlements, most notably the towns of Puerto Adolfo Lopez Mateos, Santo Domingo, Puerto Magdalena and Puerto San Carlos, which is the largest settlement on the bay. The population of Puerto San Carlos varies seasonally with the fisheries, and ranges between three and five thousand people. The people of Puerto San Carlos have been called "the people of the mangroves" - they form a resource-dependent community (Dedina, *pers. comm.*), relying on marine and coastal ecosystems for their livelihood and survival. While there is a cannery, port and large-scale commercial fisheries, as well as a thermoelectric plant in the area, the community and character of Puerto San Carlos rests on the shoulders of small-scale artisanal fishers and their families. These fishers may be members of a fishing cooperative or one of many *pescadores libres* (independent fishers) in the region.

The Conservation Mosaic

Frazier posed the question: "is increased scientific [knowledge] production conserving turtles?", stating that "we are learning more and more about what is becoming less and less" (Frazier, *in press*). There have been great advances in our understanding of sea turtle biology and behavior and the science of conservation is continually developing new tools. Unfortunately "science" does not always translate into "conservation" on the ground. As researchers become increasingly aware of the cultural motivations involved in sea turtle exploitation, it is critical to shift conservation efforts to *actively* include local communities, in particular the fishers who are making choices which directly impact the fate of turtles.

Despite inadequate population estimates and utilization assessments, throughout the world fishers have been blamed for declining sea turtle populations, (Caldwell 1963; Clifton *et al.* 1995; King 1995; Parson 1962; Tambiah 1995). As a result, local "science" has historically been excluded from the conservation process and the active participation by fishers in sea turtle conservation initiatives was rarely considered (Nader 1996). Within a *conservation mosaic* (Nichols 2001), the incorporation of both biological and social research methods and communication are critical. Placing value in the opinions, experiences, and knowledge of the fishers, and involving them directly in the project from the first step may form strong conservation alliances.

Over the past decade, local involvement in turtle conservation has been increasing, though generally as directed by an outside "expert" organizing and/or overseeing community work by providing guidance regarding appropriate conservation techniques. Community-based strategies are not new to sea turtle conservation: (see James and Martin; Faulkner *et al.* this vol) such approaches take a variety of forms including community monitoring of lighting practices on nesting beaches, community-based stranding networks and beach patrols, self-enforcement by fishing communities, formal sharing of traditional knowledge (Nabhan *et al.* 1999) and the systematic consideration of interviews with fishers (Tambiah 1999). While such practices are increasing, community-based efforts are still not widely accepted as valid conservation tools (Frazier 1999; Tambiah 2000).

A major goal of community-based sea turtle conservation efforts is to develop population and habitat protection practices that are also compatible with the socio-economics and cultural ecology of local resource-dependent communities (Bird and Nichols, *in press*; Tambiah 2000). In general, however, many of the "community-based conservation" cases documented in the literature have been those in which external researchers have initiated conservation projects and in the process have integrated local community *participation* (Govan 1998; Hackel 1999; Tambiah 1995). Few of these case studies have actually integrated local *science* into the project. In many places around the world, external researchers only have the time and resources to make a snapshot assessment. The typical approach of a research project is to "get in and get out" - gathering as much data as possible as efficiently as possible. Once the data are collected researchers may never return. They may enter the host community with complete autonomy, for instance with their own boat, equipment and food. Alternatively, a special connection can be made through a certain dependence on the host community - for food, equipment, labor and guidance - which fosters trust and builds partnerships. We suggest that such partnerships lay the foundation for long-term successes in conservation.

Research Approach and Methodology

Research objectives have been twofold: including both conservation research and active community involvement. Our research consists of socioeconomic studies of current and historic sea turtle utilization within Baja California Sur, particularly in the Magdalena Bay region, as well as ongoing biological monitoring and ecological studies (Brooks, *et al. in press*; Garcia-Martinez and Nichols 2000; Nichols *et al.* 2001). A variety of data have been collected, including mortality information, diet analyses (Gardner and Nichols, *in press*; Hilbert *et al. in press*), and tissue samples for genetic analysis. Radio and satellite transmitters have been deployed in order to monitor the distribution, movements and long-distance migratory patterns of sea turtles (Brooks *et al. in press*; Nichols *et al.* 1998; Nichols *et al.* 2000b). Local fishers from the community have been involved in all aspects of this data collection, identifying optimal locations and times to set nets, assisting in captures, measurements and marking, as well as informally monitoring turtle movements while fishing on the bay (Nichols *et al.* 2000a). Through their participation, the fishers have learned about the techniques used and the motivation behind our biological investigations. Their sharing of detailed knowledge about the ecology of the bay, including the seasonal movements of marine species and the daily movement of the currents, has contributed immensely to our work by improving the accuracy of the information collected and providing a more complete picture of the sea turtle's natural history.

The partnerships formed with individual fishers have been integral to other aspects of research in the area. Several fishers have helped in the collection of surveys and interviews within their communities. Furthermore, much has been learned about the community's needs and interests related to sea turtle exploitation and conservation in the region. Qualitative research conducted by Bostrom *et al.* (1999) at the SFS *Centro Para Estudios Costeros* (Center for Coastal Studies) in Puerto San Carlos also yielded some important primary data related to the cultural and socioeconomic factors that affect a fisher's decision to capture a turtle, or impact the choice of keeping or throwing back a turtle captured incidentally.

Our research approach seeks to utilize local knowledge and to foster partnerships, which facilitate the exchange of information and active community participation. The following stepwise approach outlining general research considerations for the integration of local science into conservation initiatives was used in this project:

1. The first step involved getting to know who we were working with while allowing them to

know us as more than just an outside researcher: We built trust through friendships and partnerships within the local community and showed respect in our interactions to all individuals.
2. After we made our introductions in the community, we learned about community issues, cultural norms and beliefs. Showing consideration towards personal, local, and regional politics, we worked within the existing socioeconomic framework.
3. While it was acceptable to share the knowledge we possessed with local fishers, (particularly when it was specifically requested), we didn't do all the talking: we spent an equal amount of time asking questions and engaging in participant observation. Both "outsiders" and "insiders" had something to share with and learn from each other.
4. We integrated the local knowledge and information contributed with 'outside' science into an action plan, and implemented the plan with the support, knowledge and *active* participation of the local population.
5. Lastly, we monitored progress and maintained flexibility, following adaptive management strategies.

OUTCOMES AND LESSONS LEARNED

Several meetings have been held within various communities in Baja California and Baja California Sur, the majority being concentrated in the Magdalena Bay area, in order to identify community issues and generate conservation strategies related to sea turtle recovery efforts. Through both formal meetings and impromptu discussions aboard *panga*s (small fishing boats) and in the back of pickup trucks, both local fishers and outside researchers have been engaged in participant observation, learning from each other and incorporating local and outside science into their daily activities (Bird and Nichols *in press*).

Over the past several years, interest in sea turtle conservation has been on the rise due to informal education and outreach initiatives, initially implemented by outside researchers from the United States and Mexico. More recently, we have witnessed some of the local fishers who have been involved in the biological research taking on their own educational pursuits within the region, leading discussions or simply setting examples by releasing turtles that were accidentally entangled in their nets.

Cross-regional communication is also extremely important in sharing knowledge of the implementation of conservation initiatives (Trono and Salm 1999). In August 2000, representatives from several of the fishing cooperatives in Magdalena Bay accompanied outside researchers to exchange knowledge and information with members of the very successful, organized fishing cooperative at Punta Abreojos, BCS. The fishers from Magdalena Bay wished to learn how the Punta Abreojos cooperative was successfully guarding the rich resources of their concession, including sea turtles in Estero Coyote, from outside poachers. Members of the Punta Abreojos cooperative were interested in learning about aquaculture, in which several individuals in Magdalena Bay had been actively involved. Over the course of a few days, sharing meals and going out on the water together, much knowledge was shared.

This interest in sharing information has also helped in the collection of data in the form of recovery of flipper tags placed on sea turtles locally and at distant locations. As word has spread and fishers have become increasingly aware of sea turtle conservation initiatives, flipper tag returns have also increased. Although many of these tag returns represent a dead turtle, it is still a positive sign of the trust and cooperation present within the community. Of particular importance was a tag return from Japan. Because the tag had been on this fisher's key chain for five years, predating any of the results from satellite telemetry and molecular genetic studies, this tag represented the first piece of concrete evidence of the loggerheads' trans-Pacific migrations to Baja California. Awareness of the importance of the information collected created a strong sense of pride within the community.

In recent months, an organized network of sea turtle conservation and monitoring spanning the Baja California peninsula from the Pacific coast to the Gulf of California, including both Baja California and Baja California Sur, has been created (Nichols *pers. comm.*). Through the annual meeting of the Sea Turtle Conservation Network of the Californias (STCNC), started in 1999 and held in Loreto (Baja California Sur, Mexico), several fishing communities have stepped up to say that they are interested in contributing more towards sea turtle conservation efforts through systematic monitoring (Nichols and Arcas 1999). In the past, fishers have known the general movements and distribution of the turtles, but have lacked the support of numbers. Now, through the coordinated efforts of six dedicated communities, monthly monitoring will enable fishers to attach quantitative weight to their observations. The results of these studies will be shared between communities year round, with additional formal reports at the annual STCNC meetings in Loreto.

CONCLUDING REMARKS

An interdisciplinary approach allows for the utilization of many "sciences" and provides a more holistic view of how sea turtles fit into the grand picture. By avoiding a purely biological and "turtle-centric" approach, and instead investigating the overall turtle habitat, including the cultural and socioeconomic communities of which turtles are a part, our understanding may be greatly enhanced. The inclusion of local people in resource management can provide many benefits. Stronger conservation alliances based on the mutual sharing of knowledge, along with the combination of local science and structured monitoring, may produce the greatest conservation benefits. The objective behind "Western science" of external researchers is not too different from the "local science" of fishing communities. The integration of knowledge generated through quantitative approaches with the knowledge of local fishers may provide the most detailed information -- daily observations, leading to a 365 days/year account of turtle behaviors and movements. We need to contribute our knowledge and accept others'. Recognizing that outsiders and locals share the same goal of conserving sea turtles, we recognize that all involved have a right to be, and indeed, must be, part of the solution.

The foremost challenge remains in recognizing that "Western science" does not have all the answers, nor can it collect all the necessary information in order to make conservation plans materialize successfully (Nader 1996). By looking towards local communities to provide the "missing links" within the data, the time needed to develop the biological and social pieces of the *conservation mosaic* is tremendously reduced. Fishers and other members of local host communities will more readily share their intimate knowledge of their environment, including information on the daily movements and distribution of sea turtles, when friendship and trust are fostered through partnerships. Once the value of local fishers' knowledge is recognized, the next step is the active integration of that knowledge into marine conservation planning and management. In order for this to happen fishers must feel empowered to participate. In this way, the fishers are viewed, and view themselves, as an integral part of the conservation team contributing valuable knowledge and ideas, not just acting as boat drivers and guides for outside researchers within the host community.

Tambiah states that he would have to spend 365 days of the year living in a community for several years to derive even a fraction of the understanding and information that local people have shared with him in the 15 countries in which he has collaborated. Nichols often remarks that without the help and knowledge fishers have shared with him over his years of work in Baja California, he would have had a far more difficult time finding turtles and collecting information. Without the knowledge shared by local fishers, many attempts at long term marine conservation planning may have been met with minimal success.

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NOTE: For more information and on-going progress on sea turtle conservation activities discussed in this case study see web-site: www.wildcoast.net