PUTTING FISHERMEN'S KNOWLEDGE TO WORK: THE PROMISE AND PITFALLS

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ABSTRACT
Indigenous fishermen's knowledge often gets dismissed for being subjective, anecdotal, and of little value to today's fisheries and centralized management strategies. Yet, fishermen have spent much of their lives accumulating intimate, fine scale ecological information that is not otherwise available. Pitfalls encountered during efforts to access fishermen-based information during the mapping of historical Gulf of Maine spawning grounds of cod and haddock are reviewed and the strategies developed to overcome them are included. Current and future roles for fishermen's knowledge in managing coastal fisheries are examined. Various ways to integrate the local place-based information of fishermen into current management strategies and potential for introducing a new local management paradigm are explored.

INTRODUCTION
In New England, fishermen's knowledge has often been dismissed as subjective, anecdotal, and dealing only with local situations. It is usually further discredited by the argument that fishermen's reports are not only subjective, but they usually describe commercial stocks that were fished out decades ago and at best, are only historical footnotes describing a marine ecosystem that may no longer exist.

I tend to disagree. I have used fishermen's knowledge often in my life, not only in the traditional way of catching fish, but also as an important source of ecological information about a fishery. From this perspective, the accuracy and breadth of knowledge shared by fishermen is very impressive. Fishermen and their subjective, anecdotal descriptions have a pivotal role to play in the development and function of sustainable fisheries.

However, the question of whether fishermen's knowledge gets integrated into mainstream science to influence management ultimately depends on the ways it is used. Fishermen and their vessels for example, are currently being used to develop "real time" catch data for faster, ongoing stock assessments. Though useful in bolstering the status quo, this approach tends to employ fishing vessels rather than fishermen's knowledge, which deals with local populations and their seasonal habitats.

Fisheries science, involved as it is with the analysis of large population units, has not focused on local level phenomena, such as the changes in behavior and distribution of local populations associated with the collapse of a stock that are so often described by fishermen. The preoccupation of fisheries science with system-wide characteristics has left it without historical parameters that allow interpretation of fine-scale changes in stock distribution, behavior, or migration patterns over time. Consequently, management has lacked the ability to detect or interpret fine scale changes in abundance.

A New Role for Fishers' Knowledge
This lack of an historical perspective may have aggravated attempts to manage New England's commercial fisheries. We have all been so preoccupied by the depressed state of our fisheries that we may have missed some of the root causes of their depletion.

If we are to develop sustainable fisheries, we must, at the very least, understand how and why the stocks collapsed in the first place. While fishermen and scientists acknowledge that many stocks have declined because of high catch rates, the problem is far more complex than the simplistic rationale of "too many fishermen chasing too few fish". (National Academy of Science 1997) Declines in abundance have consistently been accompanied by local changes in distribution, migration patterns and species assemblages. Clues abound about the disruption of local interrelationships and changes associated with them. But fine-scale changes cannot be detected by today's system-wide fisheries assessments.

It is here that fishermen's knowledge can play an important and perhaps critical role. Fishermen are, in fact, the only available source of local, historical, place-based fisheries information. Just to survive, let alone succeed, each fisherman has become proficient at figuring out how local changes in a fish stock affect distribution and abundance. This creates a pool of people with unique experiences with local marine ecology.

Not only do they have special knowledge about what is presently there, but each generation of fishermen has developed its own particular fishing patterns that are attuned to the stock migrations and behavior present during that period. With a little effort, information can be retrieved about such factors as distribution, behavior, species assemblages and abundance that are unique to the period.

Information collected from several generations of fishermen creates a series of historical windows into a fishery's local ecology that can be used to identify long-term processes in the fishery (Hutchings and Meyers 1995). Compiling an historical database forms a timeline that allows those processes to be studied. If a relatively short time span is used to capture changes occurring before, during, and after the depletion of a fishery, the sequential effects of its depletion on the marine ecosystem can be analyzed. Linking the intimate, place-based knowledge of fishermen with scientists would help in the study of how highly productive coastal ecosystems functioned when they were more robust. This would also provide historical perspective into the fine-scale details so lacking in fisheries today.

The value of fishermen's historical insights into fisheries ecology goes beyond its benefit to research. Fishermen's knowledge is most powerful when it is applied to fisheries management. Fisheries management, based on an understanding of local, long-term details of a fishery's ecology offers a whole new paradigm. Alternatives such as community-based strategies using local knowledge and local participation to maximize productivity within sustainable fisheries could maintain local populations and forage stocks while at the same time protecting spawning areas and nursery grounds.

THE GULF OF MAINE COD SPAWNING GROUNDS PROJECT

A good example of the use of traditional fishermen's information surfaced during efforts in New England to revitalize the collapsed inshore cod fishery. Two fishing associations, Maine Gillnetters Association and Maine Fisherman's Co-op successfully petitioned the Maine State Legislature to form a Groundfish Hatchery Commission to study the feasibility of establishing one or more groundfish hatcheries. Raising the groundfish license fee to commercial fishermen funded the hatcheries. The commission found large areas of groundfish habitat along the coast that used to be highly productive, but were now abandoned. They concluded that, if hatchery production could be used to increase the number of active spawning sites along the coast by reintroducing groundfish into these areas, the resulting spawning success would drastically reduce the time depleted stocks would need to recover. The commission recommended that young cod and haddock be released near once-productive spawning grounds and nursery areas in an attempt to jump-start the process. Releasing juveniles in the right habitats would be a critical step.

Unfortunately, most of the inshore grounds that were suitable for such a project had been fished out decades before and had long been abandoned and forgotten by fishermen. With collapsed cod and haddock stocks, scientists were unable to locate spawning areas by conventional methods.

In spite of the fact that the Gulf of Maine had maintained a directed cod fishery for more than three centuries, few spawning grounds were known. Most of the spawning areas suitable for such a project had been "fished out" decades earlier and had been abandoned and forgotten. Few current fishermen were even aware of their existence.

A study was funded to locate and interview the few remaining fishermen who had fished those areas to identify coastal spawning and nursery areas of cod and haddock. It became my privilege and great pleasure to interview these older fishermen and to draw the spawning ground maps based on their knowledge.

Prior to the fishermen-based spawning ground study, very few coastal spawning locations for cod and haddock were known, causing researchers to raise important questions about whether either species had actually been year-round coastal residents. Fishermen, however, indicated quite the opposite was true. As the interviews proceeded, the number of confirmed spawning sites mounted.

It soon became clear that both cod and haddock once had spawning areas along the whole length of the Gulf of Maine's coast. By the time the study was over, nearly 700,000 acres of spawning grounds for cod and haddock were identified (see Figure 1), and numerous questions had been raised about what actually caused coastal fisheries to collapse. Their contributions have provided new insights into the causes of the collapse of Atlantic cod in the study area. (Ames *et al*. 2000)

An accompanying study, using side-scan sonar, (Barnhardt *et al*. 1998) found the spawning locations given by fishermen, including their descriptions of substrates and depths were exceptionally accurate. This reinforced general acceptance of the locations identified by fishermen as coastal New England's historical spawning grounds for Atlantic cod.

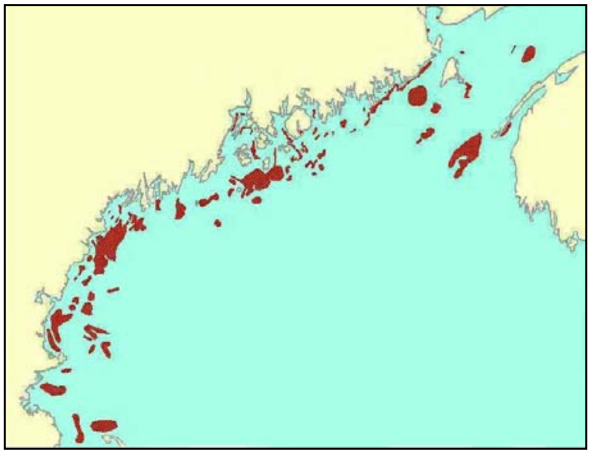

Figure 1. Map showing cod and haddock spawning grounds along the Gulf of Maine coast, identified in the study.

PITFALLS TO AVOID WHEN INTERVIEWING FISHERS

Collecting fisheries information about commercial stocks does not come without its own set of hurdles. Simply interviewing some fishermen and then cleaning up the data to make it presentable to the scientific community is only a small part of what has to be done to interview fishermen effectively. The process of figuring out who can best provide the information you seek can be formidable. The knowledge of a random fisherman may not be enough.

In addition, the majority of interviewers confirm that fishermen can be difficult to interview, their information is difficult to verify, and once verified, is very difficult to integrate into conventional fisheries information. A well-defined strategy for surmounting these hurdles is essential for good results.

Also be aware that different gear types may give quite different types of information. What is observed by one fishing technique alone can be very misleading. For example, an overview of coastal New England shows that hook fishermen caught cod in their feeding areas. Since fish do not feed when they are spawning, hook fishing may not provide good information about spawning locations. Otter trawlers and gillnetters caught fish whether or not they were feeding and so became a prime source for spawning ground information. Similar issues exist with each gear type.

A brief description of the problems that emerged during the spawning ground project, and the strategies used to resolve them, follows. Hopefully they will be of use to others:

1. When we started, we did not know the names or addresses of the fishermen who were part of the collapsed coastal fishery for cod and haddock. Most of them were retired and had not fished for decades.

We asked Maine's two coastal groundfish organizations to help us identify older fishermen to interview. Their members prepared a list of older fishermen for us who were well known locally and respected for their skill at catching cod and haddock in coastal waters.

2. Fishermen generally mistrust fisheries researchers and managers. To counter this, a local fisherman accompanied the interviewer, introduced him, and participated in the session. This proved to be an effective way to put everyone at ease.

3. In general, fishermen are not inclined to hand over hard-won knowledge that could threaten the livelihood of friends, family, and self by inviting competition or closures.

The project did not encounter this concern often because the fishermen being interviewed were older and were no longer groundfishing. They had little motivation to safeguard or falsify information about spawning areas.

In addition, the interviews focused on coastal spawning areas that had been fished out years ago, rendering their location relatively worthless.

4. Fishermen are often reluctant to answer questions if they perceive the interviewer to be collecting information simply for the sake of collecting it, or worse yet, collecting it for management purposes.

The survey addressed this concern by explaining that its purpose was to rebuild the fishery for the benefit of fishermen. The few remaining fishermen who had taken part in the fishery were the only ones who knew where the spawning grounds were located.

They were told that, if we could find them, funding would be available to support an effort to rebuild the stocks. In the end, fishermen themselves were to be the beneficiaries.

All recognized that restoration efforts were a long shot at best, but felt that it was worth talking with us anyway. And, if all went well, fishermen in their area would regain a fishery.

5. Fishermen feel especially threatened when asked to share information that may become public and often refuse to talk.

Interviewers should recognize the economic consequences fishermen face when their fishing secrets are revealed. Once made public, it becomes available to anyone, including competitors, fisheries managers, and anti-fishing interests. Facts so glibly asked for in an interview often form a key part of a fisherman's economic existence and they need to be reassured that they won't be misused.

The challenge to interviewers starts with thoughtful decisions about what to ask and how to handle the resultant information to minimize the detrimental consequences to those sharing it. Only then does it involve strategies for persuading fishermen to share their knowledge. These are not trivial issues.

PITFALLS TO AVOID WHEN PROCESSING FISHERS' INFORMATION

Traditionally, many fisheries scientists have brushed fishermen's information aside because it is so difficult to integrate into research's high-tech, statistics-based world. Even when fishermen's subjective observations can be confirmed, they will lack the reproducibility and precision of a carefully controlled experiment.

Given these concerns, controlling data quality becomes critical. Researchers who find ways to accommodate these limitations by developing ways to validate fishermen's knowledge, however, may find a treasuretrove of site-specific information about fisheries ecology.

Three different strategies for validating data were developed during the cod spawning ground project. The first came from recognizing that each spawning ground and its location had to be independently verified in some credible way before the results could be considered for peer review.

A protocol was developed to ensure that;
(a) each spawning site was identified independently by two or more fishermen,
(b) the presence of cod and haddock was established on-site during known spawning seasons, and
(c) the depth and substrate present at the site agreed with known species behavior.
This was adequate to validate the 30-60 year-old observations being described.

A second problem arose from our efforts to figure out exactly where fishermen said a given site was located. Some fishermen identified spawning grounds directly on nautical charts, but most preferred to simply name a fishing ground in an area, or gave marks and bearings leading to the bottom they had once fished.

With marked nautical charts, two independent reports confirmed the site, but the other cases required additional work. In addition to the criteria listed above, the location of grounds lacking bearings, but which had been named by two or more fishermen, had to be verified by additional fishermen or references.

Spawning areas identified by sets of landmarks required the marks to be found and then plotted by dead reckoning. Once the site was established, it then had to be correlated with the bottom types reported on a nautical chart. Finally, other fishermen had to be questioned to establish independent confirmation of the ground.

Of all parameters encountered in the study, timelines were perhaps the most difficult to establish. Fishing information collected during the spawning ground study was, by necessity, decades old. Even though fishermen were quite sure of the season or month they had caught ripe fish, they often could not recall the exact year when it happened. In these cases, supporting information occurring during the same period had to be identified and then used to determine the approximate year when the fish were caught.

NEW APPLICATIONS FOR FISHERS' KNOWLEDGE

The mapping project of cod and haddock spawning grounds displays only a fraction of the potential value found in fishermen's knowledge.

Two years ago it gave rise to my current work, a new project building a prototype database for Atlantic cod from fishermen's knowledge. The results of the spawning ground interviews became key components of the database. Combined with a 1920s data set of historical fishing information and basic habitat information, the database allowed closer examination of distribution and movements that was invaluable in untangling the historical stock structure of Gulf of Maine groundfish.

Fine-scale details of the distribution and behavior of Atlantic cod in the Gulf of Maine became obvious after placing the 1920s data set on GIS (Geographic Information System). Movement patterns to and from the historical cod spawning grounds linked them to historical fishing grounds identified from the reports and logs of fishermen from the same period.

Seasonal distribution patterns, migration corridors, and the fine-scale details of Atlantic cod stock structure were identified for the 1920s. Movement patterns associated with the spawning grounds identified several local populations of cod. Enough historical information was available on Atlantic cod in the Gulf of Maine to allow local, long-term behavior patterns to be compared with those found today.

A comparison that matched spawning grounds and winter fishing grounds of the 1920s (Ames, 1997) with recent distribution patterns of gadoid eggs (Berrien and Sibunka 1999), indicated that local populations of cod were still using the same spawning grounds. Another comparison relating recent tagging studies (Perkins *et al.* 1997) to historical movement patterns showed that the local population of cod inhabiting the area still followed the same routes.

Today's Gulf of Maine managers and fishermen alike are trapped by a system totally dependent on annual stock assessments, that cannot even detect local indicators of depletion, and must watch helplessly as one fishery after another is depleted to a fraction of its historical productivity.

Fishermen's knowledge can play a new and positive role in the restoration of commercial stocks. Their local, fine scale information offers a new paradigm based not solely on annual stock assessments, but on strategies that protect and enhance local spawning grounds, local nursery areas, and maintain local forage stocks and critical habitats. This provides an unparalleled opportunity to create an overarching historical framework that will allow assessment data to be linked to stock structures, abundance, migrations, distribution patterns, and a host of related ecological parameters.

Used in conjunction with historical references, fishermen's knowledge can provide valuable insights that may be pivotal to developing sustainable fisheries based on ecological principles.

Local, place-based historical information linking local populations, abundance, and critical habitats to stock assessment data can supplement, and perhaps even replace, management strategies based on today's stock assessments. Historical profiles of stocks and their seasonal habitats could even be used to guide the placement and character of Marine Protected Areas.

The linking of fishermen's knowledge to historical reports offers a new paradigm to fishermen, managers, and environmentalists in support of local and regional efforts to restore coastal fisheries. Similar studies should be initiated for other coastal stocks found today.

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QUESTIONS

Omer Chouinard: What kind of gear was used?

Ted Ames: Trawling, handline, gillnet, and otter trawl. One of the things that is really neat is that in one of the studies I was doing, by isolating the hook fishery from other fisheries, I was able to get the feeding habitat.

Jennifer Graham: How do you set boundaries for your plotting areas?

Ted Ames: Massachusetts Bay fishermen have known for a long time that fish move in a different way there. Their migration didn't appear to go back into the Gulf of Maine proper. Their behavior is different in Cape Ann. They come up the shore and back. We arbitrarily decided the area was big enough. It was arbitrary with a little bit of practical fishermen knowledge.

USING EXPERT KNOWLEDGE TO IDENTIFY POSSIBLE GROUNDFISH 'ESSENTIAL FISH HABITATS'

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ABSTRACT

Despite over a century of exploitation of fish in European waters, scientists know surprisingly little about the precise distribution of the major commercially exploited fish species, and their habitat requirements. This is the first European study that aims to identify essential fish habitats of commercially important fish species (cod, haddock, whiting, plaice, sole, plaice, lemon sole) in the Irish Sea and the English Channel (UK). Areas of the seabed that harbour the highest densities of these species were identified and mapped using an existing database spanning 12 years' data from national stock assessments.

Demersal fishers observe samples from the sea floor every time they haul their nets, which far exceed the sampling schemes that scientists can afford or mobilise. Experienced fishers may have decades of observations to bring to bear and keep detailed records of exactly where and when they fish and how much they catch. Although the ultimate goal of fishing is to provide income from the catch, rather than to test scientific hypotheses, many fishers seek to understand the very questions about the seabed that motivate our study. Therefore, we decided to liase with the fishing industry to refine our broad scale fish maps for future survey. Information was gathered in a pilot study through questionnaires filled in at a fishing exhibition. Through a process of informal presentations and meetings, fishermen have helped us to refine our studies by pinpointing fishing grounds of importance for the fish species in question. The co-operation with fishers has not only added to the credibility of the study and any management decisions that may depend on its findings, but has also highlighted once more the vast amount of knowledge that can be gained from this declining species.

INTRODUCTION

Habitats used by marine fish are generally 'hidden' underwater, and may, therefore, have received less attention from scientists than more obvious and accessible terrestrial faunas (Koehn 1993). As with terrestrial species, fish may be dependent upon the availability of certain habitat types, and alterations to such areas may be partially responsible for the recently witnessed decline in the world fisheries (FAO 1995), and should therefore be addressed in fisheries science and management (Benaka 1999). Despite centuries of intensive commercial exploitation of fish in European waters, scientists know relatively little about the variation in the small-scale distribution of the major commercially exploited marine fish species, and their habitat requirements. Freshwater biologists, by contrast, have an extensive tradition of research that has focused on the habitat requirements for fish (e.g. Keast *et al.* 1978; Ebert and Filipek 1988; Koehn 1993). In recent years, the wider ecological effects of fishing have become a global environmental concern (*e.g.* Dayton *et al.* 1995; Jennings and Kaiser 1998; Collie *et al.* 2000). Consideration (and mitigation) of the effects of fishing on marine habitats that are critical for certain life-stages of commercially important fish species became a legal requirement in the United States with the reauthorisation of the Magnuson-Stevens Fisheries Conservation and Management Act (1996). These habitats have been termed 'Essential Fish Habitats' (EFH) and would include areas that are spawning and nursery grounds, provide specific feeding resources and shelter from predators, or form part of a migration route (Benaka 1999). This new emphasis on EFH has resulted in a number of studies in North America (see Banaka 1999; Coleman *et al.* 2000). The present study is the first in Europe that specifically aims to identify the EFH for cod (*Gadus morhua* L.), haddock (*Melanogrammus aeglefinus* (L.)) and whiting (*Merlangius merlangus* (L.)) in the Irish Sea.

Haddock, cod, whiting and plaice (*Pleuronectes platessa* L.) accounted for 52% of the demersal species landed by UK vessels in 2000 (DEFRA 2000). National landings of haddock and cod have generally decreased from *ca* 90,000t and 75,000t to 53,000t and 42,000t, respectively, between 1996 and 2000 while landings of whiting and plaice decreased between 1996 and 1998, but have remained constant between 1998 and 2000. Fishing effort remains very high, while spawning stocks have fallen below the precautionary level, and the numbers of young fish have generally declined since 1990, raising concerns about the risk of stock collapse.

In general, the spawning grounds and nursery areas of many species of fishes are well known. In contrast, we know relatively little about the specific habitat requirements of fish during different parts of their lives. One component of essential fish habitats, which to date has received relatively little attention, would constitute those areas in which fish are able to feed effectively and reduce their risk of predation.

It is well known that certain fish species are associated with specific habitat features (*e.g.* reefs, sandbanks), a fact used by fishers to target particular species. Demersal fishers observe samples from the seabed each time they haul their nets, which far exceed the sampling schemes that scientists can sustain (Maynou and Sardà 2001). Furthermore, experienced fishers may have knowledge based on decades of observations, and that has been passed down from one generation to the next (Freire and García-Allut 1999; Sardà and Maynou 1998). In addition, they often keep detailed records of exactly where and when they fish and how much they catch. Present day ship-based electronic instruments permit fishers to see first-hand the link between different seabed types and textures. Although the ultimate goal of fishing is to provide income from the catch, rather than to test scientific hypotheses, many fishermen seek to understand the very questions about the seabed that motivate our study. Despite this obvious wealth of experience, and the fact that the Magnuson-Stevens Act requires the National Marine Fisheries Service (USA) to consult with fishers before submitting its advice, few studies, to our knowledge, have sought to consider or integrate fishers' views and knowledge on EFHs (but see Pederson and Hall-Arber 1999). The need to improve the collaboration between scientists and the fishing industry is widely recognised by scientists and fishers alike (*e.g.* Mackinson and Nøttestad 1998; Taylor 1998; Freire and García-Allut 1999; Baelde 2001; Maynou and Sardà 2001; Marrs *et al.*, in press). The involvement of the fishing industry in fisheries science might not only improve the credibility of fisheries science but also enhance the support for any regulations that may be based upon it.

In the present paper, two complementary approaches were adopted to identify possible EFHs. We used existing data from annual national groundfish surveys of fish abundance and biomass and compared them with fishing grounds outlined by fishers. Fishers marked grounds they considered to be important on nautical charts for a finer scale resolution of fish distribution (Taylor 1998). Information on habitat characteristics of target fish was also sought in a questionnaire format.

Materials and Methods

Identification of potential EFHs Using National GroundFish Surveys

Areas of seabed, which consistently harbour the highest densities of cod, haddock and whiting in the Irish Sea (ICES division VIIa), were identified using two databases spanning a decade of fishery-independent data from national groundfish surveys. The Centre for Environment, Fisheries and Aquaculture Science (CEFAS, Lowestoft) holds a complete data set from 1990 to 1998. Fish were sampled every autumn using a 4-m beam trawl at fixed stations (Ellis *et al.* 2000). The Department of Agriculture and Rural Development of Northern Ireland (DARDNI, Belfast) database spans a period from 1991-2000. Fish were caught by otter trawling at fixed stations every summer or autumn.

In our analysis, the abundance of each species for each station per year was ranked and a mean rank over time (per station) calculated to identify potential EFHs for further habitat survey (reported elsewhere). Plots of mean abundance or total abundance over a set time period were not considered useful to the identification of habitats that are used consistently from one year to the next. In addition, an exceedingly high abundance of fish in any one year could skew the results. We converted abundance to ranks within each year. Our rationale for using a rank score was that it is most relevant to know which habitat is consistently attractive to fish. These ranks were plotted using ArcVIEW GIS 3.2 software.

Using Expert Knowledge

We consulted with the fishing industry to refine our broad scale fish maps (from bottom trawl surveys) in terms of the seasonal and spatial distribution of fish. The project was first introduced to the fishing community through an article in 'Fishing News', the main national industry paper. It is often not practical to consult directly with individual fishers that spend most of their time at sea, often for more than a week at the time. Therefore, information was gathered in a pilot study through questionnaire-based interviews with maps (n=19) at an annual national fishing exhibition.

The interviews were designed to study fishers' perceptions of the relationship between fish and habitat features, perceived changes to habitats and to gain information about the location of potential EFH. Further information was gathered by sending out revised questionnaires with maps and more detailed information about the project to Sea Fisheries Committees and other relevant fisher's organizations with requests to circulate these among their members. Further interviews were conducted at a fish fayre in Lowestoft (English SE coast fishing port) (n=2) and a fishing exhibition in Newcastle (Northern Ireland) (n= 5). We collated a total of 39 questionnaires and 19 maps. These hand-drawn charts were digitized using ArcVIEW GIS and plotted in a chart format suitable for comparison with the charts generated from the scientific ground fish surveys.

The questionnaire (Figure 1) contained a total of 16 questions (following Pederson and Hall-Arber 1999), only six of which were analysed in this paper (see below). The responses were analysed by calculating the frequency of categories ticked and the frequency of statements made.

RESULTS

Fishing ground locations and distribution of mean ranks of fish abundance

Most fishers were very responsive and helpful during interviews. Following contacts with the Irish Sea Sea Fisheries Committees, the Fleetwood Fish Forum provided a high-resolution chart detailing the seasonal distribution of commercial fish species in the eastern Irish Sea (Fig. 2). Figure 2 represents the aggregated knowledge of 50 fishers that have outlined information gathered over a period of *ca* 50 years. More responses were obtained from contacts with Sea Fisheries Committees and Fisheries Producer Organizations but many of these 'mail shots' were answered by respondents that worked outside the Irish Sea or that targeted other species. Eighteen fishers out of 40 (excluding Fleetwood) plotted fishing ground locations on charts but only eight of these were located in the Irish Sea.

The geographical position of the fishing grounds outlined by fishers for cod, haddock and whiting were similar (Figs 3a-c). The main fishing grounds for these species appeared to be located between the north of the Isle of Man, southwest of Scotland and around the Solway Firth (NW England). It should be noted that several fishers highlighted areas in this region and north off the Welsh coast independently, which increases the confidence in these data. Some of these grounds are no longer visible in Figures 3a-c because they lie on top of each other. Further grounds are located off the Irish and Northern Irish coast and along the North Wales coast.

Similarly, fisheries survey data indicated that the highest mean ranks of cod from the two databases were situated off the Ribble Estuary (NW England), off Belfast Lough (Northern Ireland), off Colwyn Bay/Anglesey (N Wales), the Solway Firth (NW England) and in St George's Channel (Fig. 3a). The distribution of haddock mean ranks was similar to the distribution of fishing grounds (Fig. 3b). No

1. What do you regard as important ground features for your target species ? Please identify seabed structures (e.g. mud, gravel, boulders) or other characteristics of the grounds (e.g. sea weed, sponges) that you associate with your target species: ____

2. What do you regard as the most important factors that affect the grounds that you fish?
____

3. Do you think fishing gear has altered the grounds that you usually fish? ☐yes ☐no.
If 'yes' how has it affected the grounds? Please explain:
____

4. Have you noticed any changes over the time that you have been fishing?
☐target species ☐bottom animals and plants ☐habitat structure ☐fish health ☐bycatch ☐other changes.
Specify:____

5. Which of the following have you observed over time for the species that you target?
☐no change ☐increase ☐decrease ☐moved to other areas ☐replaced by another species ☐decrease in size
Please describe your observations:________________________

6. If you noticed a change to the grounds or species that you fish, please indicate what you think may be the cause(s): ☐climate☐pollution ☐changes in fishing gear ☐changes in prey abundance
☐habitat loss ☐overfishing ☐other
Please explain:_____________ ________________________

Figure 1: Questionnaire format used in interviews and mail shots.

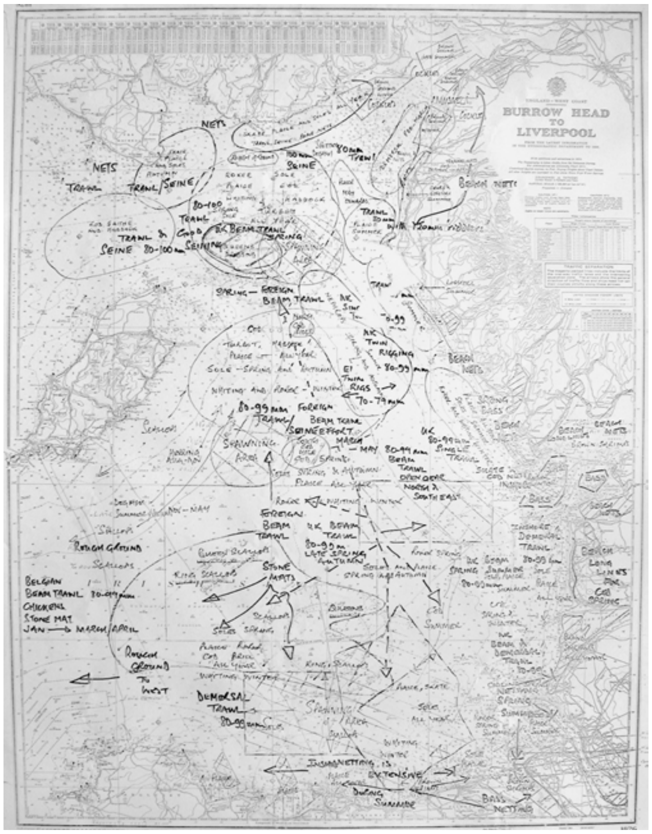
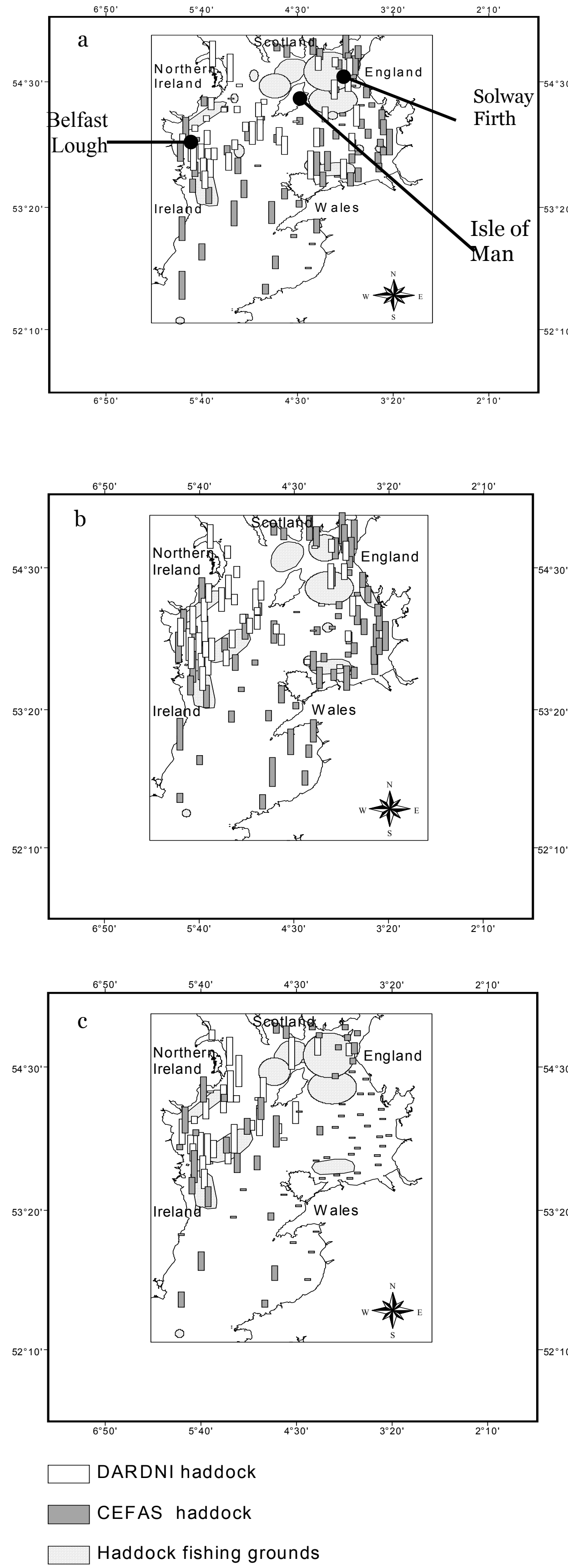


Figure 2. Chart with important fishing ground locations provided by the Fleetwood Fish Forum

haddock fishing grounds were outlined at the low abundance stations off the English coast. There was less consistency between the whiting fishing ground locations and the distribution of the higher mean ranks of whiting (Fig. 3c). For example, no whiting fishing grounds were outlined off the Ribble Estuary, an area with high mean ranks of whiting but this may be explained by a low mean size of fish.

Questionnaires

Question 1. Cod, haddock and whiting were targeted by 16 out of 39 total respondents. The most important ground types stated for cod included sand (56%), mud (56%), 'hard' ground (comprises the categories boulders, cobble, rocks, stones, 'rough') (44%) and gravel/shingle (31%) (Fig. 4). For haddock the most frequently stated ground types were hard grounds (69%), sand (56%), mud (50%) and gravel/shingle (38%) while important grounds for whiting comprised mud (56%), sand (50%), hard grounds (31%) and gravel/shingle (31%) (Fig. 4).



Figures 3a-c. Distribution of mean ranks of fish abundance (bars) in the Irish Sea from 1990 to 2001 and fishing ground locations as outlined by fishers.

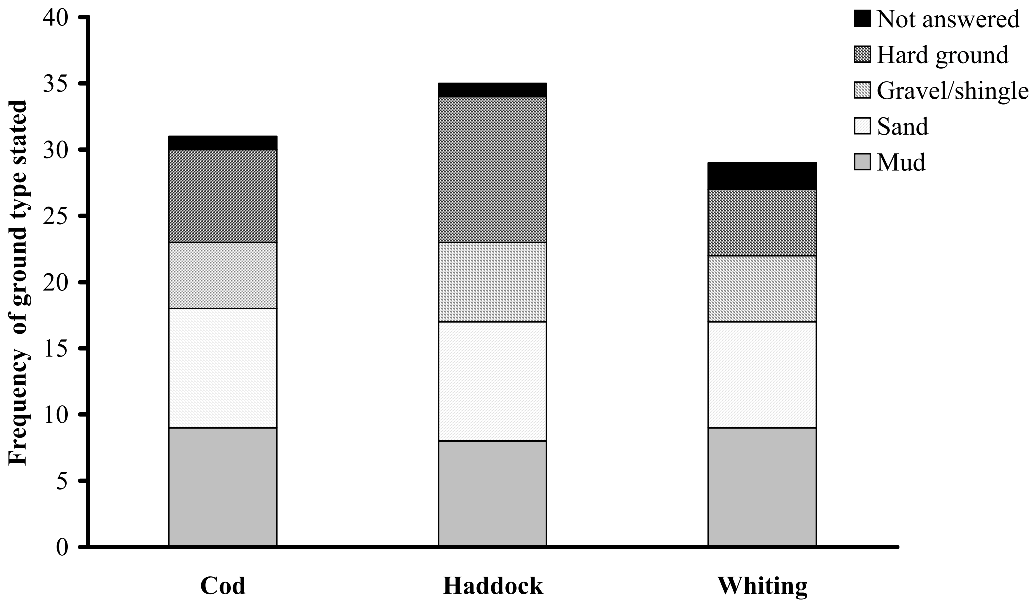


Figure 4: The most important ground types stated for cod included sand (56%), mud (56%), 'hard' ground (comprises the categories boulders, cobble, rocks, stones, 'rough') (44%) and gravel/shingle (31%)

The most frequent stated habitat features for cod were sand, feed (meaning the ground contained food for the fish), hard grounds (each 25%), wrecks, gravel (each 19%), mixed grounds and mussel beds (each 6%). Haddock habitat features included hard grounds (25%), brittlestar beds (19%), feed (19%), gravel, sand, mud (13%), seaweed (we interpret this to mean emergent growths of weed-like bryozoans such as *Flustra spp.*) and mixed grounds (6%). Sandeels (*Ammodytes spp.)* were perceived as important prey items of cod (67%) and haddock (80%), followed by 'small fish' (50% and 60%, respectively) shrimps (25% and 40%, respectively) and small crabs (38% and 20%, respectively). The most frequently stated habitat features for whiting were hard grounds (19%), mud, sand, gravel (13%), sea grass[1] and soft corals (*Alcyonium digitatum*) (6%). The response rate to this open-ended question was relatively low: 25% of the respondents did not comment on cod habitat features, haddock habitat (44%) or whiting habitat (69%).

Question 2. 21% of the respondents named heavy fishing gear such as beam trawls, scallop dredges and twin otter trawls as important factors that affect targeted habitats. Other factors stated included fishing (effort) (21%), feed (15%), weather (15%) and season (13%).

[1]Although the respondent used the term 'seagrass' we doubt that the angiosperm plant was meant. It seems more likely that he used this term for seaweed or weed-like bryozoans or hydroids.

Question 3. Fifty-six percent of the respondents thought that fishing gear had altered their grounds (96% response rate).

Questions 4.-6. A third of the respondents observed changes in their target species such as a decrease in numbers (74%) and size (35%), and only two percent stated that there was no change in their target species (Table 1). These changes were attributed to overfishing (56%), climate (38%) and pollution (36%), changes in fishing gear (28%) and prey abundance (23%).

Discussion

Fishing ground locations and distribution of mean ranks of fish abundance

Although many fishers volunteered to fill in questionnaires, fewer were willing to outline their fishing grounds on charts. This was largely for reasons of confidentiality and due to suspicion that such information might lead to negative management developments for fishers. For example, the information may inform the choice of potential areas for closure or the imposition of further limits on fishing practices (Pederson and Hall-Arber 1999). Furthermore, many respondents worked in areas other than the Irish Sea or targeted other species, which restricted the number of charts used in this paper to eight. The similarity of the fishing grounds outlined for the three different fish species reflects, to some extent, the fact that several fishers did not distinguish between which

Table 1: Results of three questions posed in questionnaires (*n*=39 unless stated otherwise; f= frequency of category checked; %= percentage of frequency)

Changes over time	f	%	Changes in your target species	f	%	Cause of change	f	%
Target species	12	31	No change	2	5	Climate	15	38
Bottom animals and plants	12	31	Increase	5	13	Pollution	14	36
Habitat structure	3	8	Decrease	29	74	Changes in fishing gear	11	28
Fish health	1	3	Moved to other areas	5	13	Changes in prey abundance	9	23
Bycatch	7	18	Replaced by another species	2	5	Habitat loss	3	8
No changes	5	13	Decrease in size (*n*=26)	9	35	Overfishing	22	56
Other changes	5	13	Other changes	1	3	Other causes	4	10
Not answered	9	23	Not answered	4	10	Not answered	7	18

species were targeted in the different areas outlined. In those cases, it was assumed that respondents fished for all of their target species in the area outlined although we recognize that it may have been a prime ground for one particular species.

At first sight, it would appear that areas of the highest fish densities obtained from databases do not always coincide with those given by fishers. For example, cod, haddock and whiting densities were generally high along the (Northern) Irish coastline according to the fisheries survey bases, whereas many fishers highlighted grounds off the Solway Firth (S Scottish and N English coast). This, however, may partly reflect a local bias in the port of origin of many of the respondents that attended the fishing exhibition in Scotland at which many of the interviews were undertaken. Owing to logistic problems, it was more difficult to reach (Northern) Irish fishers. It should be noted, however, that two Irish fishermen also outlined grounds off the Solway Firth. An attempt to interview more (Northern) Irish fishers at the Fisheries Co-operative meeting in Newcastle (Northern Ireland) yielded five questionnaires but no charts as many fishers targeted shellfish, or were unwilling to mark their fishing grounds. After closer inspection of Figures 3a-c, however, it is apparent that the highest mean ranks for haddock and cod coincided with fishing grounds off the Solway Firth (S Scotland and N England) and those off the N Welsh coast. A greater sample size, involving more fishers from (Northern) Ireland, would allow for a less biased comparison between the fishers' data and the groundfish survey data. It is possible that this spatial bias could be circumvented by restricting a spatial analysis of the ground fish survey data to subsets in the vicinity of respondents' ports.

The fishers' information has added to our confidence that high density sites indicated by the fisheries survey data are indicators of areas targeted by fishers, Several fishers highlighted the same grounds in the northern Irish Sea and off Ireland and off Wales. These areas presumably have features that consistently attract fish in sufficient numbers and quality to be of interest to fishers. Some of the discrepancies between the fishers' charts and the groundfish survey data may also lie in the fact that there were relatively few sampling stations located between the N Isle of Man, NW Scotland and NW England. This is probably due to differences in the gear historically used for the CEFAS ground fish survey, a beam trawl, the use of which would be restricted over the rough grounds around the Isle of Man. Recent studies from the NW Atlantic indicate that young cod and haddock prefer habitats of coarse sediment interspersed with rocks (Lough *et al.*,1989; Gotceitas *et al.* 1995; Gregory and Anderson 1997; Lindholm *et al.* 1999). On the other hand, the groundfish survey may include areas that fishers normally avoid because they would catch too much 'rubbish'[2] that may clog up their nets during the longer commercial tows.

Although it could be argued that no 'filter' was incorporated in our questionnaires to test if questions were answered truthfully (Johannes 1981; Maynou and Sardà 2001) we believe that most respondents answered the questions to the best of their knowledge. Maurstad (2000) highlighted that the publication of maps and other information given by fishers in a purely scientific context can put scientists into a dilemma in terms of intellectual property rights and confidentiality. Also the

[2] inert material and by-catch of non-target species

knowledge becomes separated from its sociological context. We decided to publish our results, however, as we feel that the quality of the charts presented here is not sufficiently accurate to pose a threat to any individual respondent's livelihood. Also, it is likely that the information volunteered is known by many fishers.

Questionnaires

Sand, mud and hard grounds were most frequently named as key ground types for all three fish species, although more respondents (69%) considered 'hard' grounds as important for haddock *vs* the other species. In a similar study in the US, fishers indicated that they preferably fished whiting on fine-grained sediments whereas other groundfish were targeted across all habitat categories (Pederson and Hall-Arber 1999). 'Feed' was named as one of the critical sea bed features for cod and haddock. Sandeels were reported to be important prey items of cod and haddock and many fishers were concerned about a decline in sandeels due to an increased effort in industrial fishing over recent years. Information on fish diet can be regarded as particularly valuable as fishers gut high numbers of fish and often observe their stomach contents. Pederson and Hall-Arber (1999) even suggested that trained fishers could sample and preserve stomach contents for scientific purposes.

Interestingly three fishers stated independently that 'wigs' (probably brittlestar beds) are an important habitat feature for haddock, especially after spawning. Although fishers suggested that haddock sought out brittlestar beds to 'clean themselves' after spawning it is known that haddock feed on brittlestars as a grinding substance in their stomachs (Mattson 1992). This emphasizes the potential value of apparently obscure observations made by fishers even though their conclusions may be partially inaccurate.

A few other fishers noted that weed (possibly hydroids or the wide-spread bryozoan, *Flustra spp*.) was often found in their haddock or plaice catches and one fisher also associated whiting with soft corals, *Alcyonium digitatum*. These habitat features may provide fish with shelter from predators or act as foci of prey species (*e.g*. pandalid shrimps). These features of fish habitats are currently the subject of further investigation (Freeman *et al*., unpublished data). Similar to the findings of Pederson and Hall-Arber (1999), few fishers commented on habitat features other than ground types (see above), and such features were given in interviews rather than in mail shot questionnaires. Fishers often do not know scientific names, especially those of non-target invertebrates, and seem unwilling to offer their own interpretation that may be proven incorrect (Mackinson 2001). It was easier to steer and expand questions during interviews through explanations and by showing images of marine animals that fishers would recognize. In a more comprehensive survey, the provision of a standard photo card showing common marine animals could help to increase the response rate and train fishers that are often keen to expand their knowledge of the marine environment.

More than 50% of the fishers believed that fishing gear has, in some way, altered their grounds. Many recent studies have shown that towed bottom fishing gears have altered the seabed (Jennings and Kaiser 1998). Fishers were also concerned about heavy mobile fishing gear such as scallop dredges, beam trawls and twin otter trawls. Similarly, Collie *et al.* (2000) showed that scallop dredging together with intertidal dredging has the greatest initial impact on benthic biota.

It should be noted that most fishers attributed habitat changes to gear types that were not used by them. Less than a third of the respondents polled in a study in the US believed that fishing gear had changed the grounds (Pederson and Hall-Arber 1999). This difference may be attributed to the fact that in Pederson and Hall-Arber's study fishers were asked if their own gear had altered the grounds. In the same study, more than 50% of the fishers identified mobile gear as the most important factor that affected habitats.

A third of the respondents observed changes in their target species such as a decrease in number and size, which reflect recent trends in the state of the fishery. Overfishing, climate change and pollution were perceived as the most important causes for declines in fish abundance. Again, many fishers complained about the decline of sandeels (due to industrial fishing) as an important food source for their target species, and an increase in seal populations that feed on their target species. The majority of fishers attributed changes to overfishing.

It should be noted that only a few fishers commented on habitat loss over time although many fishers stated that fishing gear smoothes seabed topography and 'damages the ground'. It is possible, that once stated, fishers thought it unnecessary to repeat the statement in subsequent questions of the questionnaire. Also, fishers may have been unfamiliar and therefore uncomfortable with the term 'habitat', although the meaning was explained either verbally or on enclosed information leaflets and the word 'ground' was used instead in most questions.

Although more time-consuming, questionnaire based interviews on a one to one basis yielded the best data as it enabled the essential establishment of trust between the scientist and the fisher and allowed for elaboration of specific questions when technical terms were unclear. Our consultation with fishers has not only added to the credibility of the study and any future management decisions that may rely on its findings (Maurstad and Sundet 1994), but has also highlighted how our current knowledge can be expanded. Further insights may be gained by an analysis of statements made in questionnaires which are then integrated with biological data using fuzzy logic (Mackinson 2000). The integration of fishers' knowledge into science and management is a potentially invaluable tool that should not be overlooked (Pederson and Hall-Arber 1999).

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INTEGRATION OF FISHERS' KNOWLEDGE INTO RESEARCH ON A LARGE TROPICAL RIVER BASIN, THE MEKONG RIVER IN SOUTHEAST ASIA

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ABSTRACT
The Mekong River is home to an estimated 1,200 species of fish and supports one of the most important freshwater fisheries in the world, vital for food security and employment among the 60 million people in the Mekong Basin. Many of the fish migrate seasonally between flood-season feeding, spawning and rearing habitats, and dry-season refuge habitats. Only limited, fragmented, information on these movements is available for individual species. Much more information is urgently needed in order to include such information into future development plans for the river basin. In order to start filling this knowledge gap, a survey of local fishers' knowledge was carried out. More than 350 local fishers along the Mekong were interviewed about the migratory and reproductive habits of 50 important fish species and the distribution ranges for another 120 species. Interviews covered a stretch of almost 2,500 km extending through four countries.

By merging data from different areas, migration patterns for 50 species were produced. We were also able to divide the Mekong into three distinct, but inter-connected regions, based on the pooling of the migration data. Further to this, the research produced considerable information on certain important fish habitats. Interviews revealed, for example, the role of deep pools within the Mekong mainstream. These appear to be very important dry season habitats for many species. Although this was not included as a specific subject during the interviews, fishers volunteered more than 230 records on the importance of the deep pool habitat. Our research demonstrates how fishers' knowledge can provide information that is vital for management, and help develop hypotheses that focus future research.

INTRODUCTION
This conference is the latest evidence that local ecological knowledge has finally entered into the mainstream of fisheries research and management. We have now reached a point where it should no longer be needed to argue for the use of local knowledge but instead aim for its wider integration into research programmes and management strategies.

The diversity of presentations on offer at the conference also reflects the diversity of issues and scales at which local knowledge has a role to play. This diversity will likely increase in the future as more fisheries researchers and managers embrace local knowledge in their activities.

In this paper, I will focus on the role that local fishers' knowledge has recently played in a research programme in the context of a large river basin, the Mekong River, in Southeast Asia. During the past three years, ecological studies, with emphasis on fish migrations, have been carried out as a joint effort between the four countries of the lower Mekong Basin: Cambodia, Lao PDR, Thailand and Vietnam[1]. These studies were based entirely on the systematic compilation of local ecological knowledge throughout the lower part of the Basin.

I will use a few key results to demonstrate how local knowledge can provide information at several scales. Not only can it provide a wealth of detailed and site-specific information at local scale, but by merging data from different places, crucial information at the regional, and sometimes ecosystem, scale can also be obtained. For a large system like the Mekong Basin, where it is almost impossible to obtain relevant large-scale ecosystem information based on conventional ecological research, this is perhaps the most promising result of this study.

The Mekong River.
The Mekong is the largest river in Southeast Asia. From its source at the rim of the Tibetan plateau to its outflow in the South China Sea, it covers a distance of more than 4,200 km and drains an area of 783,000 km^2. During its course, the river flows through six countries: first through the Yunnan Province of China, then for a short distance along the northeast of Myanmar, along the border between Lao PDR and Thailand, cutting through Cambodia until, finally, reaching its delta and discharging into the South China Sea in southern Vietnam (see Figure 1).

[1] Under the auspices of the Mekong River Commission (MRC), an inter-governmental river management organisation established by the four countries, Cambodia, Lao PDR, Thailand and Vietnam in 1995.

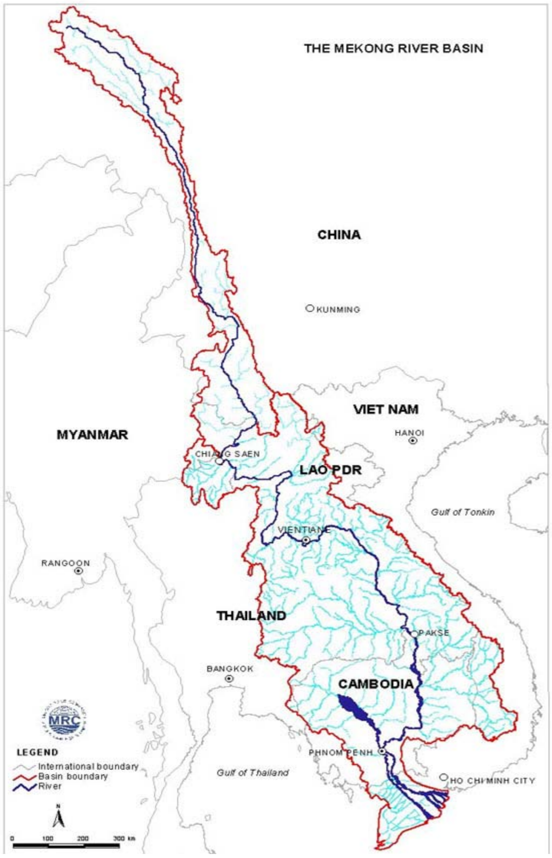

Figure 1. Map of the Mekong River Basin

The river basin contains a breath-taking biodiversity. It is home to an estimated 1,200 species of fish, which in turn represent the foundation for one of the largest and most important freshwater fisheries in the world. Conservative estimates suggest the total annual fisheries yield from the river basin to be 1 million tonnes (Jensen 1996). These fisheries are of critical importance for food security and income generation for the 60 million people living in the lower Mekong Basin (Ahmed *et al.* 1998; Sjørslev 2000).

The Mekong is a seasonal river, highly influenced by the monsoon climate of Southeast Asia. During the rainy season from May to September, a large amount of water is "injected" into the system as a result of both rain throughout the basin and snowmelt in the upper mountainous stretches. This flood-pulse inundates vast land-areas adjacent to the river. These seasonal floodplains are extremely productive fish habitats and they account for most of the fisheries production in the basin. Most fish species in the river have developed life cycles which are adapted to take full advantage of these seasonal habitats for feeding and rearing young. As a result, fish migrations between seasonal and perennial water-bodies are very common in the system. A large number of Mekong species are migratory, to a greater or lesser extent, and a large proportion of the fisheries activities target migrating fishes.

Fish migrations are a common feature in river systems (Barthem and Goulding 1997), and they have substantial management implications since they interconnect different parts of the whole system. Managing such resources thus requires management actions at both the local habitat scale and at the regional ecosystem scale. In some cases, the ecosystem encompasses almost the entire river basin (e.g. Barthem and Goulding 1997).

Through a long interdependence, fishers along the Mekong have become as intimately linked to the rise and fall of the Mekong waters as the fish. For example, migratory fishers follow the paths of migrating fishes during the year.

In order to be able to develop management strategies and development plans for the river basin, it is crucial to have more information about the extent of these fish migrations and their importance for the functioning of the ecology of the system.

The need for more and better ecological information about the Mekong basin led to the formulation of a basin-wide study of fish migrations, initiated in 1997 under the MRC fisheries programme[2]. The main objectives were to obtain information on migration patterns and spawning behaviour for a large number of important species, with a view to incorporating such information into future management strategies and development plans for the region.

Considering the size and ecological complexity of the Mekong River basin, this felt like a daunting task! Very early on in the planning process, it was recognised that the best, and possibly the only, way to achieve the objectives was to seek the assistance of local fishing communities, i.e. by compiling and merging their existing knowledge about fish migrations. These communities depend on the capture of migratory fishes passing through their area and have built up very detailed knowledge over a long period, which enables them to predict when they will

[2] The MRC fisheries programme is a sector programme under the Mekong River Commission, Its activities are implemented as a joint effort between the following line agencies in the riparian countries: Cambodia: Department of Fisheries; Lao PDR: Living Aquatic Resources Research Centre (LARReC); Thailand: Department of Fisheries, and Vietnam: Research Institute for Aquaculture No. 2 (RIA-2).

catch which species. They have a clear concept about fish migration and often liase with neighbouring villages upstream and downstream to send, or receive, the message that certain fish are on the move.

So, detailed knowledge about fish migrations in the Mekong River has existed for a long time, dispersed in local communities and in their fishing practices. The main issue then is to get access to that knowledge. The following section gives a brief overview of the process that was developed to access local knowledge about fish migrations in the Mekong River basin.

Overview of the Methods

The decision to carry out the survey through systematic compilation of local ecological knowledge was relatively easy to make. Given the objectives and the time available, we concluded that there were simply no alternatives. However, the next question was **how** to do it. Since hardly any previous experience was available to draw upon, at least not in the given context, we had to "start from scratch". At the initial planning stages, lots of brainstorming sessions were held in order to produce some rough outlines for a field method. From then on, we entered into a more formal process of methodological development, which included the involvement of all the future data collectors and interviewers from the four countries. The final outcome was a set of field guidelines, describing the process of defining the right people to talk with, creating the right conversational atmosphere, and designing a survey format for entering detailed ecological information emerging from the interviews.

The process and the method were described in detail by Poulsen and Valbo-Jørgensen (1999), and further discussed by Valbo-Jørgensen and Poulsen (2000). The following is a brief overview.

In each of the four countries, a team of 2 to 3 people carried out the survey. A number of workshops and meetings were held with the interview teams. During these workshops, the survey was designed through a process of field-testing, re-designing and testing again, before the final format was agreed upon. Other important objectives of the workshops were to ensure that the data obtained from different countries were compatible and, importantly, to gradually develop the skills and confidence of the interview teams, who in most cases had never before attempted this type of research.

The final survey format was quite rigid in its structure, reflecting the need to obtain specific data that could easily be merged between different interview teams in different countries. However, the need to "strike a balance" between rigidity and flexibility was strongly emphasised throughout the survey process. We tried to develop an atmosphere where the formal rigidity was kept on paper, whereas the interview process itself was carried out in an informal, conversational manner. Furthermore, we also tried to avoid a common danger of rigid survey questionnaires: they often miss crucial information that is not allowed for on survey forms (see for example, Johannes and Freeman 2000). As will be discussed later, crucial information was indeed obtained, which was not allowed for in the rigid structure of the survey format. Most fishers knew something, which did not have an entry field on the form. Such information was included as endnotes on the forms (i.e. "any other information").

For the target species, the following key data were obtained: 1) local name(s); 2) occurrence by month over the year; 3) sizes of fishes by month; 4) migration timing and direction (i.e. upstream or downstream) by month; 5) environmental indicators for migrations; 6) spawning (timing, behavior and habitat); 7) any other information.

Finally, I would like to emphasise a few important details. Firstly, as focal points of discussion during the interviews, photos of Mekong fishes were used in the form of a photo flipchart specially designed for the study. This tool proved invaluable, not only in order to minimize the chances of misunderstandings between interviewers and fishers, but also as an ice-breaker at the start of the interview. Secondly, the starting point for each interview session was a mapping exercise, where fishers were encouraged to draw a map of the fishing ground and include everything they believed was important. Apart from providing detailed habitat information for each site, this mapping process also helped fishers to focus on that particular fishing site in the subsequent interview session.

The survey was conducted at 51 sites along the Mekong mainstream during 1999 and more than 350 fishers were interviewed (Valbo-Jørgensen and Poulsen 2001). In 2000, the survey was extended into certain important tributary systems of the Mekong. The analysis of these data is not included in this paper. In the following section, I will discuss some of the key results that were obtained during the survey.

KEY RESULTS

Based on this survey, migration patterns for 50 important fish species from the lower Mekong Basin was described along a stretch covering almost 2,400 km (Valbo-Jørgensen and Poulsen 2001). In this paper, I will discuss three of those species in order to illustrate the nature of the information obtained. By pooling data, e.g. on all species and/or all sites it was also possible to reveal ecosystem patterns on a larger scale. This is perhaps the most significant outcome of the work. It demonstrates, for example, the degree to which the ecology of the system depends on the hydrology of the river basin, in particular the annual flood cycle. It further illustrates how the whole system is ecologically inter-connected by fish migration networks "criss-crossing" the basin. Finally, dry-season refuge habitats within the main river channel were identified as crucial habitats for many species and for the ecological integrity of the ecosystem at large.

Migration patterns for three species of river catfishes

The family of river catfishes (*Pangasiidae*) is important for fisheries in the Mekong basin. The family also includes some of the most "charismatic" species, such as the Mekong giant catfish (*Pangasianodon gigas*), and (*Pangasius sanitwongsei*). The family contains 21 species globally, of which 15 occur in the Mekong Basin (although the taxonomy of the family is currently being revised). In this paper, I will discuss the results for three members of the family: *P. krempfi*, *P. sanitwongsei* and *P. larnaudiei.*

The migration patterns for the three species are illustrated in Figures 2, 3 and 4, in Appendix 1 at the end of this paper. These migration maps are the result of data on the timing and direction of migration, combined from each station for each species. Black arrows indicate migration within the period October to February, white arrows indicate migration in the period May to September, and grey arrows indicate migration in the period March to May.

A comparison between the three migration patterns reveals both striking similarities and differences. Firstly, the only major waterfalls on the mainstream Mekong, the Khone Falls, influence the migrations of all three species. *P. sanitwongsei* does not appear to migrate over the falls and thus may consist of two separate populations, one above and one below the falls. On the other hand, *P. krempfi* and *P. larnaudiei* both migrate across the Falls during May to September. This observation is supported by several long-term sampling programmes near the Khone Falls (Baird 1998; Singanouvong *et al.* 1996). However, the Falls appear to separate two different migration patterns. For both species, fish migrate upstream above the Khone Falls during May-July, while at the same time below the Falls, fish of the same two species are migrating downstream. A look at the reported fish sizes reveals that juveniles mainly occur below the Falls, whereas large mature adults mainly occur above the Falls. For example, *P. larnaudiei* juveniles, ranging from 10 to 60 cm, are reported almost exclusively below the Falls, whereas adults ranging from 70 to 90 cm are reported from above the Falls. The two migration patterns may thus represent simultaneous but different life stages, i.e. upstream spawning migrations above the Falls, and downstream juvenile migrations below the Falls.

All three species appear to have a distinct migration pattern in the upper catchment, i.e. approximately from Vientiane and upstream. This may represent different populations of the same species from the middle and lower sections of the river.

Thus, in summary, there appear to be three distinct migration patterns for each species: 1) a lower Mekong migration pattern covering the stretch from the Khone Falls down to the Mekong Delta, and including the Tonle Sap Great Lake system of Cambodia; 2) a middle Mekong migration pattern covering the stretch from Khone Falls upstream to around the mouth of the Loei River tributary (approximately 100 km upstream from Vientiane); and 3) an upper Mekong migration pattern covering the stretch from Loei River to the border between Lao PDR and China (and probably further). These three migration systems emerge even more clearly when data for all the surveyed species are pooled (Valbo-Jørgensen and Poulsen 2001). Thus, by pooling local ecological knowledge from different sites along the river, ecosystem patterns on a much larger scale were revealed.

Hydrology and Fish Migrations

Fish species of the Mekong have evolved life cycles that are intimately adapted to the hydrological cycle of the river. Fishers know this very well and use hydrological indicators to make decisions about their fishing activities. For example, many fishers have learnt the sequence of fish species migrating in response to a hydrological event and are therefore able to adjust their fishing activities accordingly. Often, they use naturally occurring "hydrological gauges", such as rocks and trees in the river channel, to decide when the time is right to start fishing for a certain species of fish. When asked about what triggers fish migration, there is broad agreement between fishers from all over the basin that rapid changes in water discharge is the main cause, either directly or indirectly. As a result, large-scale migrations peak twice per year, at the beginning of the rainy season (May-June) and at the end of the floods (October-November).

Deep Pools as dry season refuge habitats

One of the issues which we did not anticipate at the beginning of the survey, and therefore did not include as a "question" in the survey formats, was the issue of certain stretches of the river serving as important refuge habitats during the dry season. However, many fishers emphasised that in certain deep pools within the river channel near their villages, a large number of fish species congregate during the dry season. Many fishers volunteered more than 230 records about the key role of deep pools. Importantly, certain stretches emerged as "deep pool hot-spots", while others appeared of limited use as dry season refuge habitats. As we will discuss later, this information may have important management implications. Had our survey not been able to accommodate this "unexpected" information, we would have missed it, and thereby missed a crucial factor in relation to the ecological integrity of the river basin.

Ecosystem patterns

To summarize the findings, local knowledge made it possible for us to: 1) identify three migration patterns along the lower Mekong River (covering a stretch of more than 2,400 km); 2) determine that migrations are closely linked to the hydrological cycle of the river and peak twice per year during rapid changes in water discharge, and 3) the importance of deep pools as dry season habitats.

If we put all this information together, we may define the three migration systems that were identified more precisely. What signifies them as 'systems' is mainly the relative geographic position between dry-season refuge habitats and flood-season feeding and rearing habitats. Thus, the lower Mekong migration system constitutes a migration between dry-season pool habitats in the upper stretch and floodplain habitats in the lower stretch. The middle Mekong migration system constitutes a migration between refuge habitats in the Mekong mainstream and floodplain habitats along major tributaries. Finally, the upper Mekong migration system constitutes a longitudinal migration between downstream refuge habitats and upstream spawning habitats (i.e. in this section of the river, very little floodplain habitat exists).

Concluding remarks on the results

The preceding results only constitute a small fraction of the data that were compiled. I hope they have illustrated the nature of the obtained information and thereby demonstrated how local knowledge can be applied in the context of a large river basin. It is hard to imagine that all this information could have been generated based on conventional biological/ecological research tools, such as sampling or tagging, particularly considering available funds, time and human resources. This is not to say that they do not have a role to play. Based on large-scale local knowledge surveys, conventional scientific techniques may be applied in a more focussed manner to test specific hypotheses on a smaller scale. For example, as illustrated by the three species discussed in this paper, we generated several hypotheses about population structures for many species (Poulsen and Valbo-Jørgensen 1999). Advanced genetic tools may then be applied to test such hypotheses.

LOOKING TOWARDS THE FUTURE

Based on our experiences from the Mekong River, we believe that Local Ecological Knowledge will play an increasingly important role in future activities related to river fisheries research and management. We also believe that it will play a crucial role as an important element of Environmental Impact Assessment (EIA) procedures related to development plans for the river basin. For example, existing EIA procedures for large-scale water management schemes such as hydroelectric dams could be substantially improved by incorporating local knowledge. In the following, I will briefly discuss the prospects for local ecological knowledge within 1) fisheries research and management, and 2) EIA procedures.

Fisheries Research and Management

It can be argued that the survey described in this paper has been a "one-way" study, where local fishers provided information, which was then used to reveal migration patterns and other ecological features of the river basin. It is thus important to emphasise that this was the beginning, not the end, of a process of increasingly involving local fishers and fishing communities in research, management and monitoring of river fisheries. The next step is to take the results of the research back to the fishers and discuss it with them, so that they are aware of, and accept, the use of the information that they provided. This process has already started, and some of the most motivated fishers from the survey are currently involved in a migration monitoring programme, where they monitor their catch daily over one whole annual cycle with a view to identifying any fish migration waves passing through their areas. Such a programme could, with a few modifications, be implemented for future monitoring purposes of targeted areas. For example, fishers living near deep pool hot-spots may be involved in monitoring these crucial dry-season habitats.

In a complex system such as the Mekong fisheries, research, management and monitoring should ideally be regarded as integrated parts of an *adaptive management* process. If such a process is to succeed in managing aquatic resources, local communities must play the central role throughout. The starting point should be to build upon the knowledge and practices that are already in place within local communities.

In the Mekong basin, traditional management systems are still common in many places (Sjorslev 2000). However, as has happened elsewhere around the world, traditional management systems have been abandoned in recent decades as globalisation slowly, but steadily, expands to every remote corner of the world. Since the globalisation process has happened relatively recent in the Mekong Basin, traditional management systems here can be "re-awakened". This has for instance been achieved with success in southern Laos where a large number of so-called fish conservation zones has been established within the river channels based on initiatives, which, although facilitated externally, largely originated from within communities (Baird, this vol). There is thus clearly a good foundation within the river basin on which to build future co-management strategies. Management systems which are locally rooted have a far better chance of success than externally imposed systems.

Migratory fish stocks pose a special management challenge in the Mekong River. Such stocks are shared between many local communities, in many cases even between communities in different countries. Thus, by nature, local management practices are not enough. Although management measures, in practice, are always implemented locally, higher levels of co-ordination are needed for migratory stocks. The nature of this co-ordination depends on the scale at which the resource is distributed. For transboundary stocks, for example (i.e. stocks which migrate across international borders), co-ordination is required at the level of national governments (for the Mekong region, this could potentially be through the Mekong River Commission). However, it could also happen at lower scales, e.g. between provincial or district authorities, or even between two or more villages, within a country. The details about how such a system could be established are beyond the scope of this paper. The main issue of relevance here is that, no matter how high up management co-ordination takes place; local communities should always be actively involved throughout the process. And, as we have seen, local knowledge **can** contribute significantly with information at even the largest of scales in the ecosystem.

Environmental Impact Assessment

Current EIA practices in the Mekong region are often based on external experts carrying out short-term field studies to establish species lists and site inventories for the particular area under assessment. The main shortcoming of this approach is that ecosystem dynamics are often disregarded. A particular site or stretch of river may inhabit few species at the time of the EIA field study, but may at other times act as an important habitat or migration corridor for many species. This is particularly true for large rivers with pronounced seasonal variations such as the Mekong and its seasonal hydrological cycle. Furthermore, most often only local impacts are considered. However, in rivers, upstream activities and events may have impacts that reach far downstream, either through changes in water quality or quantity, or timing of supply. Such impacts often extend beyond national borders. Thorough environmental impact assessments that take account of both seasonal variations and far-reaching impacts, can not possibly be based on field surveys covering only a few weeks of sampling in the vicinity of the project site. The incorporation of local knowledge into EIA procedures seems to be one of the few possible solutions to remedy this problem.

Johannes (1993) discussed the potential for incorporating local ecological knowledge into Environmental Impact Assessment (EIA) procedures. He suggested that one should focus on four essential frames of reference: 1) taxonomic, 2) spatial, 3) temporal and 4) social. 1) The taxonomic frame of reference should establish local names of plants and animals and establish their local significance, i.e. as sources of food as well as other uses (including religious). 2) The spatial frame of reference should establish the spatial distribution of living and non-living resources by mapping. 3) The temporal frame of reference should establish timing of ecological events such as spawning and migration periods. 4) The social frame of reference includes the way local communities perceive, use and manage their natural resources. This in turn may influence the way they would react to any environmental impacts of a development project.

The study on which this paper is based covered the first three perspectives: taxonomic, spatial and temporal. I thus believe that the applied methodology can be incorporated into EIA procedures with few modifications. Since it was carried out at the basin-wide scale, the information generated may best fit into more strategic environmental assessments, i.e. under a basin development planning process, which is currently on-going within the framework of the MRC. Each specific EIA for smaller scale projects, for example hydroelectric dams, will require additional studies, which can use the same approach and methodologies as this study.

Conclusion and Final Remarks

Local ecological knowledge is ideal for revealing ecological events and life history information, such as migration routes and spawning habits. It is based on daily observations made over many years, often reaching beyond the lifetimes of individual people. I believe that in the context of a large and complex, multi-species ecosystem, such as the Mekong River, local knowledge is particularly appropriate since, as we have seen, it can provide information at different ecological scales, which include many species and cover long time horizons.

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APPENDIX 1

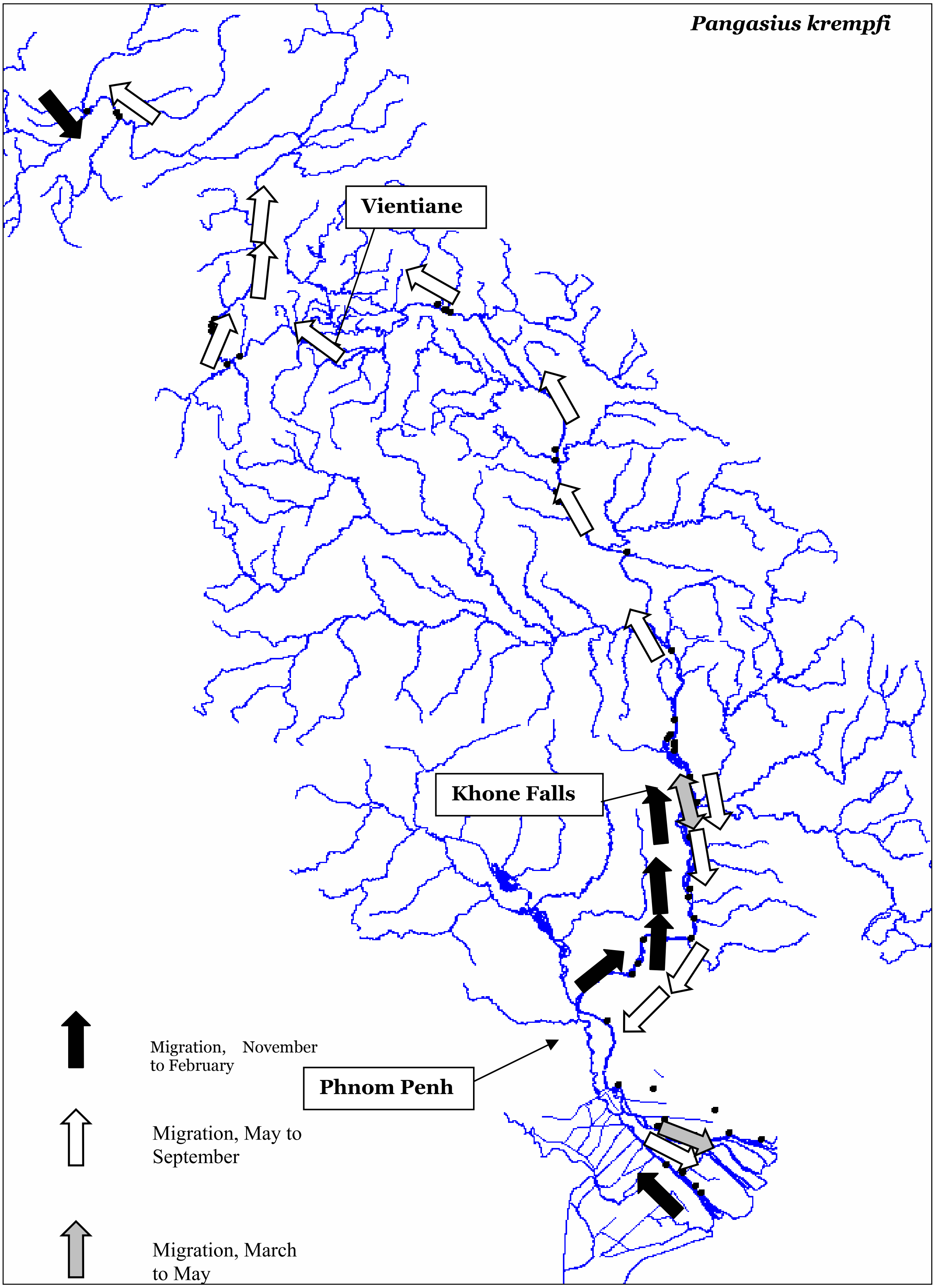

Figure 2: Migration data for *Pangasius krempfi*

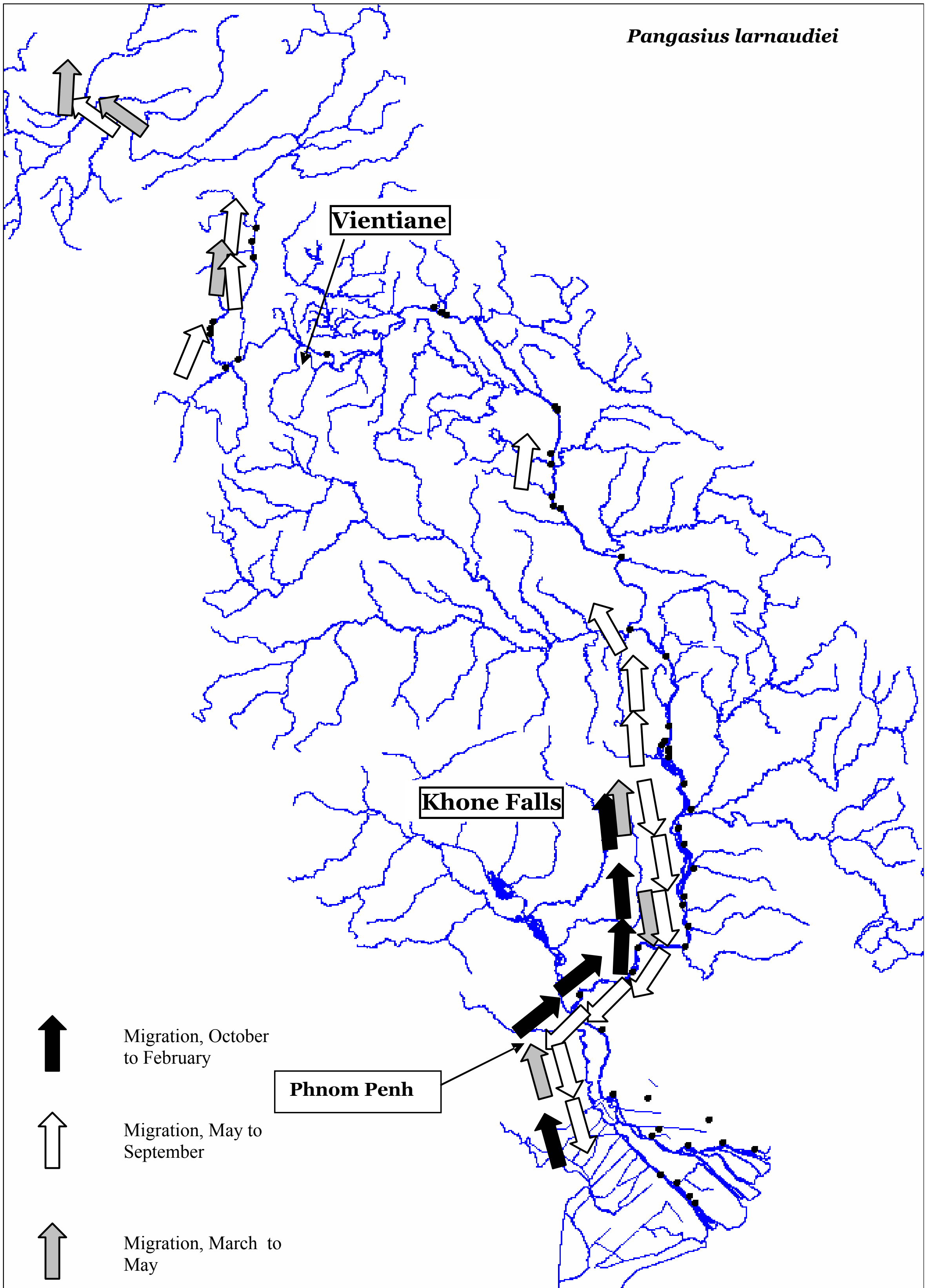

Figure 3: Migration data for *Pangasius larnaudiei*

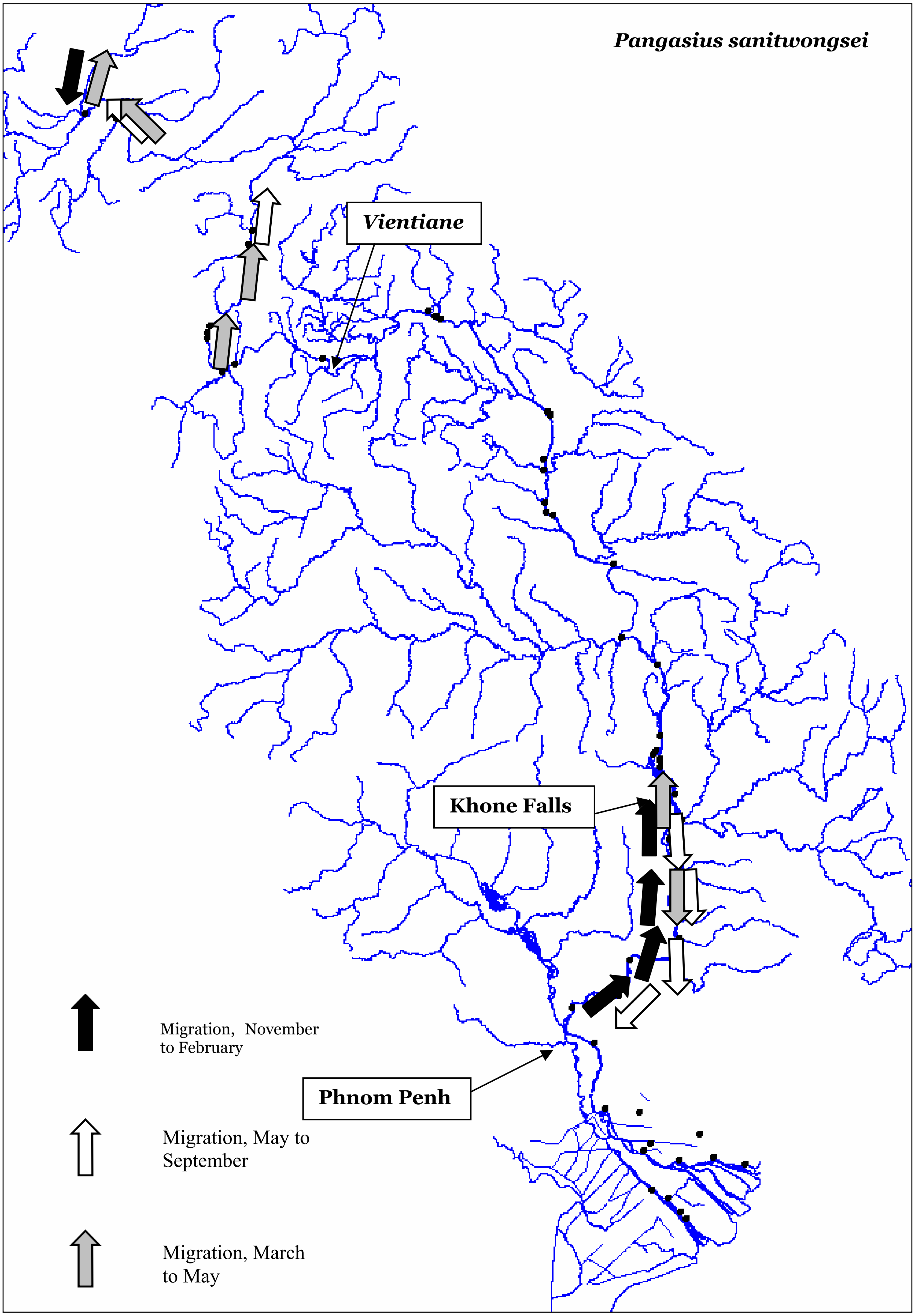

Figure 4: Migration data for Pangasius sanitwongsei

FISHERS' PERCEPTIONS ON THE SEAHORSE FISHERY IN CENTRAL PHILIPPINES: INTERACTIVE APPROACHES AND AN EVALUATION OF RESULTS

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ABSTRACT
We conducted a study in coastal communities in the central Philippines designed to involve seahorse fishers in research and conservation initiatives. The study comprised (i) an initial scoping survey to obtain data on the fishers and their fishery, including effort and habitat quality, and (ii) community meetings conducted as focus group discussions, in which results from the scoping study were fed back to the communities, questions were repeated, and information on fishers' knowledge and opinions with respect to the seahorse fishery, the state of their fishing grounds, and the condition of their livelihood were collected. Discussions on marine resource management were also held. Participatory methods using visual aids were designed to facilitate communication and discussion. The scoping survey collected information from 173 seahorse fishers in 19 communities on location and quality of fishing grounds, and fishing effort while the community meetings collected information from 117 fishers in 10 focal communities. Average effort was reported in the scoping survey and community meetings as 111 and 192 trips (nights) per fisher per year and 334 and 894 trips per fishing ground per year, respectively. Habitat quality of fishing grounds was generally assessed as good in the scoping survey and community meetings but live coral was not commonly perceived as the dominant habitat type. Responses differed markedly from independent ecological surveys of the same fishing grounds. A comparison of the answers provided by fishers in the scoping study and community meetings indicated that although absolute values differed, relative estimates of fishing effort per fishing ground and effort per fisher corresponded well across the two surveys. Fishers consistently described seahorse abundance, habitat quality and their livelihoods as in decline, and proposed a number of solutions. Through our participatory approach, seahorse fishers are playing a role in designing applied fisheries research, and in developing management plans for their fishery.

INTRODUCTION
Stakeholder involvement in the planning and implementation of conservation initiatives is considered fundamental to the achievement of resource management objectives (Akimichi 1978; Johannes 1981, 1982; Polunin 1983, 1984; Wright 1985; Zann 1985; Johannes 1989; Bailey and Zerner 1992; Ruddle *et. al.* 1992; Ruddle, 1994; Jennings and Polunin, 1996; Walters *et. al.* 1998; Neis *et. al.* 1999; White and Vogt 2000). Participatory approaches to resource management have a number of benefits: (1) stakeholders may have specialized knowledge relevant to resource management that is accessible only through collaborative approaches; (2) the process transfers knowledge and builds stakeholder management capacity; and (3) compliance with resource management decisions is more likely if stakeholders participated in their establishment. There are a number of examples of stakeholder involvement in the management of tropical marine ecosystems. Local knowledge of fish behaviour has been harnessed in the management of South Pacific fisheries (Johannes 1981, 1982; Jennings and Polunin 1996; Cooke *et. al.* 2000). Capacity building lies at the heart of community-based resource management initiatives in the Philippines (White 1988; Vincent and Pajaro 1997; Walters *et. al.* 1998; Alcala 1998, 1999; White and Vogt 2000; Alcala 2001). The integrity of community-based marine protected areas relies heavily on stakeholder compliance that in turn increases with understanding and agreement based on involvement in the process of establishing these areas (Johannes 1982, 1989; Gulayan *et. al.* 2000; Pajaro *et. al.* 2000; Alcala 2001).

Interest in participatory approaches in resource management in part reflects the failure of top-down, centralized approaches to manage natural resources alone (Murdoch and Clark 1994; Agrawal 1995; Maguire *et. al.*, 1995; McClanahan *et. al.* 1997; Sillitoe 1998; White and Vogt 2000). Bottom-up, community-based approaches (BOBP 1990; Walters *et. al.* 1998), involving stakeholders may be more appropriate where resource exploitation is diffuse as is typically the case with subsistence fisheries (Pauly 1997), and where human and financial resources are limited (White and Vogt 2000).

As part of a seahorse conservation program (Project Seahorse, www.projectseahorse.org) we initiated a participatory research-focused fisheries project in 1999. Our study focused on the seahorse fishery of Danajon Bank, Bohol, central Philippines (Fig. 1, overleaf). Danajon Bank is a double barrier reef stretching approximately 145 km along the northwest coast of Bohol (Pichon 1977). The reef system is shallow (approximately ≤ 10m), silty, and composed of scattered and patchy coral reefs interspersed with *Sargassum* and seagrass (pers. obs.). Fishing is the primary source of income for communities located on islands in this system. Seahorse fishing began in the 1960s as part of a subsistence food / cash income fishery termed the lantern fishery. Fishers free dive at night on shallow (1-5m) fishing grounds, using a kerosene lantern strapped to the front of their small boat (4 m outrigger canoes called *bancas*) to illuminate prey items (see also Mangahas, this vol). They spear fish, catch crabs and hand pick seahorses and holothurians (sea cucumbers) that they find. This is the primary method used to collect seahorses in this region (Vincent and Pajaro 1997), though not all lantern fishers collect seahorses. Hookah divers also catch a limited number of seahorses incidentally.

We developed a participatory approach that involved the exchange of information about marine resources on Danajon Bank between lantern fishers and researchers, and among fishers. Stakeholder inclusion was incorporated in the fisheries research program to achieve three goals: (1) obtain information about habitat quality of fishing grounds and fishing effort to aid in the design of the research component of the program; (2) increase fisher awareness about marine conservation issues to build stakeholder resource management capacity; and (3) develop an understanding of what fishers believe to be key marine conservation concerns and appropriate strategies for resolving them. Our participatory approach was unusual in that it was also designed to allow assessment of the information collected on fishing grounds in order to evaluate its accuracy and consistency. We did this by comparing two interview methods and by comparing fishers' perceptions of fishing ground habitat quality with ecological measures from underwater transects (Samoilys *et. al.* 2001) conducted on a subset of the fishing grounds. This analysis evaluated the degree of correspondence between fishers' perceptions and ecological measures of habitat quality.

Methods

The study consisted of two components: (i) an initial scoping survey; (ii) community meetings which involved a) sessions in which the results of the scoping survey were fed back to the fishers and the survey was repeated, and (b) marine resource management discussions to collect information on fishers' knowledge, opinions and actions in relation to their fishery resources. The scoping survey was done by one community organiser (CO), who was then replaced for the community meetings by a second CO (JE). Community organizers are trained social workers that focus on community level social issues as opposed to family or individual level issues. They are an integral part of many community-based resource management programmes in the Philippines (Third World Center 1990). The presence of a Filipino CO, who was fluent in the national language and supported by a local assistant fluent in the local language, was pivotal to the research methods.

1. Scoping survey

The scoping survey was conducted from March to May, 1999, and was designed to: (i) determine the number of fishers involved in the seahorse lantern fishery on Danajon Bank and their distribution among villages, (ii) identify the number of fishing grounds exploited in the seahorse lantern fishery, (iii) quantify fishing effort per fisher and per ground, and (iv) assess habitat quality on the fishing grounds. This information was subsequently used to identify 28 coralline fishing grounds for the ecological research project (Samoilys *et. al.* 2001).

The CO visited 19 seahorse fishing communities in the municipalities of Getafe, Talibon, Bien Unido, Carlos P. Garcia, Ubay, and Tubigon in northern Bohol, Central Philippines (Table 1, Fig 1). In each fishing community, the CO first contacted village leaders to explain the project and ask permission to work in the community. Lantern fishers in the community were then identified, frequently by village leaders, and interviews requested. All fishers asked to participate agreed to do the interview, a total of 199 fishers, 9.1 ± 7.7 (s.d.) fisher per village (Table 1, overleaf).

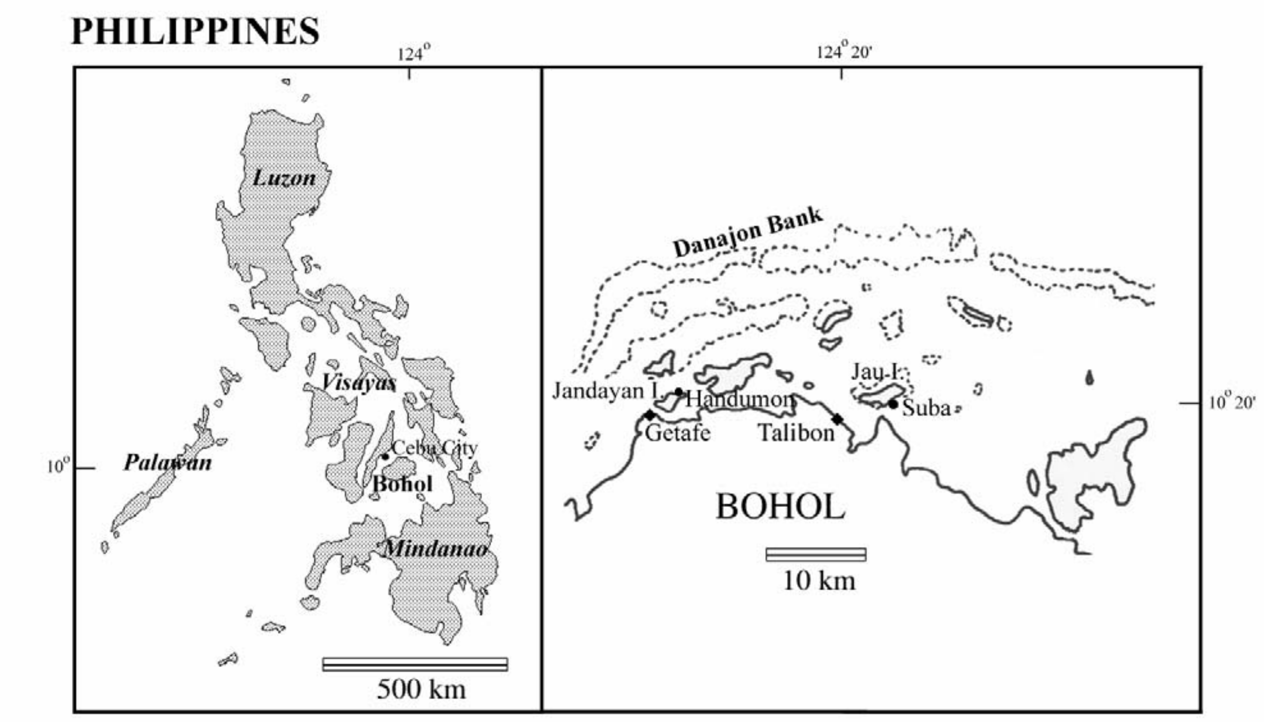


Fig. 1. Map of the Philippines showing the study area of Danajon Bank in northern Bohol, central Visayas.

Table 1. List of villages participating in the scoping and community meetings. Communities in bold participated in both components; others only in the scoping study. CPG = Carlos P. Garcia municipality.

Village	Municipality	Gears	#fishers interviewed	#lantern fishers	#fishing grounds/ village	#lantern fishing grounds/ village
Alumar	Getafe	lantern and hookah	8	6	11	11
Banacon	Getafe	lantern and hookah	6	5	7	7
Bansaan	Talibon	lantern only	8	8	19	19
Batasan	Tubigon	lantern and hookah	20	9	16	6
Calituban	Talibon	lantern and hookah	4	3	3	3
Cataban	Talibon	lantern only	15	15	7	7
Guindacpan	Talibon	lantern only	13	13	9	9
Handay-Norte	Getafe	lantern only	5	5	22	22
Handumon	Getafe	lantern only	33	33	46	46
Jagoliao	Getafe	lantern only	14	14	13	13
Nasingin	Getafe	lantern and hookah	9	3	21	18
Nocnocan	Talibon	hookah only	5	0	2	0
Paraiso	CPG	lantern only	11	11	7	7
Pinamgo	Bien Unido	lantern only	4	4	4	4
Sagasa	Bien Unido	lantern only	3	3	2	2
Sagisi	CPG	lantern only	4	4	5	5
Sinandingan	Ubay	lantern only	20	20	22	22
Suba	Talibon	lantern only	11	11	2	2
Lipata	CPG	lantern only	6	6	6	6
Total			199	173	11.79	11.00

Each interview consisted of a brief questionnaire administered verbally to fishers. Limited information on the fisher (name, number of children) and gear (lantern *vs*. hookah, and paddled *vs*. motored boat) was collected. Fishers were then asked to list all of the fishing grounds they visit. For each of these fishing grounds, they told us the number of hours spent fishing per trip, the number of trips per week, weeks per month, and months per year that they fished the ground. This information allowed the calculation of perceived annual total fishing effort (hours per year) for each fisher for each fishing ground. To indicate the total fishing pressure over time and current levels, fishers also indicated the year they began fishing each ground and the last year that they went there, if they no longer fished it. With respect to the habitat quality of these largely coralline fishing grounds, fishers were asked to: indicate whether the site was "good" (*ma'ayo*) or "bad" (*guba*), identify the major habitat types, and rank all of the sites they fished from best (=1) to worst (= number of sites identified). For each site, we then calculated the following fishing ground indices:

1. % good = the % of fishers that identified each fishing ground as "good";
2. % coral = the % of fishers that identified live coral as the dominant habitat component of a particular fishing ground;
3. fishers' relative rank (FRR) = the average of the rank each fisher gives the fishing ground. Each rank is relative to the total number of fishing grounds ranked by a fisher (e.g. 4^{th} of 10 sites gives a relative rank of 0.4).

All three indices range from 0 to 1, where 1 indicates a good site (e.g. all fishers think it is good, or all fishers identify live coral as the dominant habitat component or it ranks at the top of their lists), and 0 indicates a poor site (e.g. no fishers think it is good or no fishers identify live coral as the dominant habitat component or it ranks at the bottom of their lists).

2a. Community-based meetings: feedback sessions

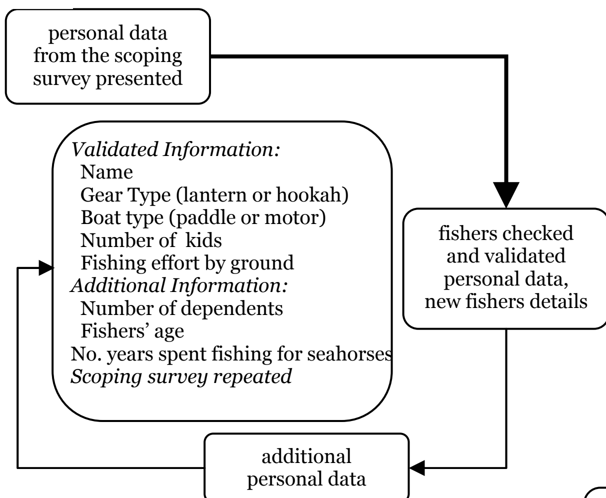
Community-based meetings were held from June to September 2000, except for one village (Alumar) which was visited in February 2001. Meetings were held with fishers in 10 target villages for the feedback sessions (Table 1) and 9 villages for the marine resource management discussions. These villages included those with the greatest number of lantern fishers (average of 12.6 fisher/village). The community meetings involved focus group discussions using highly visual but low cost methods developed by one of the authors (JE) based on the Reflect method of community interviews. Such methods were necessary given the low level of literacy among fishers and the need to engage their interest for 1-2 day periods. The approach also allowed open-ended questions, a key characteristic for areas in which the researchers had little existing information. The community-based meetings also encouraged fishers to express and formulate their ideas on marine conservation and fisheries management, and engaged fishers in the research process. The gathering of data used graphical symbols, such as cut-outs of seahorses and crabs of various sizes to indicate abundance. Fishers posted these symbols on large gridded sheets with columns for each fisher (Fig. 2). Throughout the meetings, fishers shared or validated information either individually using fishers' worksheets or through group activities using graphic symbols and large gridded sheets. In the group interactions, individual responses could still be tracked as graphic cards were uniquely numbered for each fisher.

The goals of the feedback sessions were to: (i) share and validate the data collected in the scoping survey; and (ii) repeat the scoping survey, gather additional data, and add fishers who were unable to participate in the scoping survey. The structure of the feedback sessions in each village is given in Fig. 3a. To repeat the questions in the scoping survey, a mixture of individual questionnaires and focus group discussions were used. The latter were used to solicit information on the lantern fishing grounds, in terms of habitat type (first identified in the scoping survey) and quality (Fig. 3b).

2b. Community-based meetings: marine resource management discussions

The goals of the marine resource management discussions were to collect the fishers' views on: (i) the relative importance of various marine resources; (ii) the status of marine resources in the past, present and future; and (iii) the causes of resource degradation and their relative importance. In this component of the meetings, fishers were asked to rank the six marine resources identified in the scoping survey in terms of their general economic importance to the fishers, both as a source of cash and food. These resources were grouped by fishers under widely differing taxonomic divisions, including order, family and genus: (i) crabs and other crustacea, (ii) fish, (iii) sea cucumbers, (iv) seahorses, (v) seaweed, and (vi) shells.

3a



[1] Fishing effort calculated as # hours per trip x # trips per month x # months fisher per year

3b

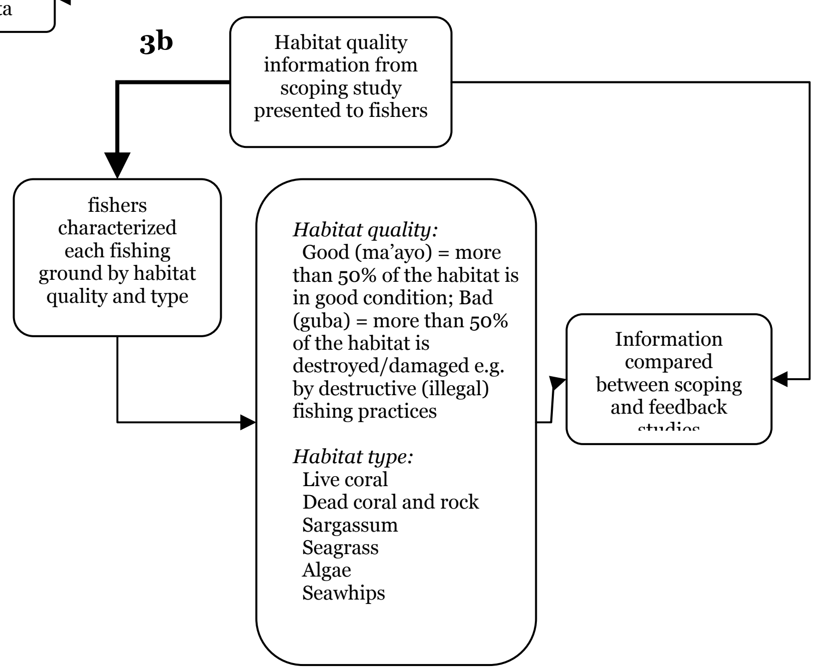


Fig. 2. Structure of a) feedback sessions to validate personal and fishing effort data and repeat scoping survey for catch and effort data, b) focus group discussions on fishing ground habitat type and quality.

Fishers were also asked to provide information for the past (1990), present (2000) and future (2010), on three main topics: the status of their livelihood as fishers, the seahorse fishery, and the fishing grounds. Fishers were asked to assign their answers into categories. Fishing grounds were described as Good (>50% of habitat is in good condition), Mixed (~ 50% of habitat is in good condition), or Bad (> 50% of habitat has been damaged or destroyed). Seahorse populations were described as many, average, or few. Fishers' livelihood was described as Good (income from fishing is sufficient to support the family - includes food, education and recreation), Bad (income from fishing is barely enough to support basic necessities such as food), Very Bad (income is not sufficient to support the basic necessities). Collective discussions were then held to ask fishers for possible reasons for the trends and possible solutions, and to rank both reasons and solutions. The marine resource discussions also consisted of several sessions covering a range of topics such as destructive fishing, particularly blast fishing, and how it affects their fishing grounds. Management options such as protected areas or sanctuaries were also discussed.

In most villages, the CO acted as facilitator for the entire group. However, for villages with more than 12 participants, fishers were subdivided into 2-3 groups with 5-6 members each and groups were assigned different topics. A local facilitator was used for each sub-group, with the CO overseeing all groups. At the end, each sub-group reported and discussed their results with the whole group of fishers.

Data Analysis

The feedback sessions provided an opportunity to evaluate the accuracy and consistency of answers provided by fishers in the scoping survey. The two surveys differed both in terms of the fishers participating and the number of fishing grounds they considered. We analysed similarities between the two surveys for: (i) all fishers and fishing grounds in the scoping survey (173 fishers and 67 fishing grounds, see fishing effort below) *vs*. 117 fishers and 25 fishing grounds in the feedback survey, and (ii) using only those fishers and fishing grounds common to both surveys. Seventy-one fishers and 25 fishing grounds were common to both the scoping and feedback surveys.

The fishers' ranking of fishing grounds by habitat quality was compared to ecological survey data from underwater transects (Samoilys *et. al.* 2001) conducted on a subset of these fishing grounds.

RESULTS

The ability to attract fishers was essential to the success of the community meetings. 117 fishers, 68% of all lantern fishers in 10 villages, participated in the feedback sessions. 114 lantern fishers in 9 villages participated in the marine resource management discussions. Feedback sessions were done in the morning with the resource management discussions in the afternoon, with 97 % attendance throughout the day's meeting. This high participation rate was attributed to the popular highly visual and graphic methods used by the CO.

Profile of Danajon Bank lantern fishers

Of the 199 fishers interviewed from 19 villages across the Danajon Bank region, 87% were exclusively lantern fishers (Table 1). In most villages, lantern gear was used exclusively, though hookah gear was also used. On average there were 9 lantern fishers per village, accessing 11 lantern fishing grounds per village (Table 1). Fishing grounds were common to several villages. Sixty percent of the lantern fishers in the scoping survey and 53% of fishers participating in the feedback sessions still used non-motorised paddle boats. The average number of children per fisher from the scoping survey was 4.1±2.4 (s.d.), and the average number of dependents from the feedback sessions was 5.2±3.0 (sd). On average, the number of children per fisher was 80.5%±35.4 (sd, n=70) of the total number of dependents. This relatively low number of children for the region probably reflects the relatively young age of the fishers: 33.6±10.8 (sd) years.

Fishers participating in the community meetings ranged from those who started fishing seahorses in 1961 to those who started in 2000. Nineteen of the fishers had stopped fishing seahorses between 1990 and 1999, the rest were still actively fishing.

Fishers gave names for 147 fishing grounds. However, reference to a map of the area indicated that these names represented 92 distinct fishing grounds, of which 73% were dominantly used by lantern fishers (>95% of the total effort per ground from lantern fishers), 16% were used by both lantern and hookah fishers, and 11% were exclusively used by hookah fishers. Nine fishing grounds were exploited in 1961, increasing to 67 in 1999 with the most rapid expansion occurring in the early 1970's (Fig. 4).

Only two grounds had been entirely abandoned in 1999. On average, fishing grounds had been exploited for 14.5 years ± 5.7 (s.d.) (range 3-39).

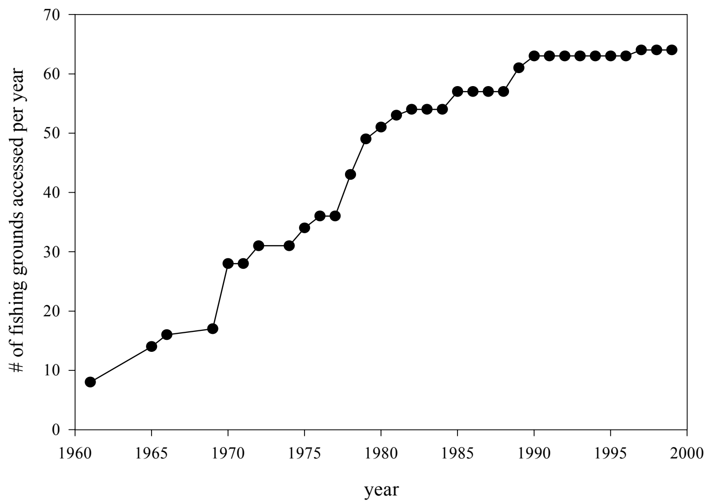


Fig. 4. The number of grounds fished per year on Danajon Bank, Bohol

Fishing Effort

Reported annual fishing effort per fisher and per fishing ground differed markedly between the scoping and feedback studies (Table 2). Considering the 67 grounds on which lantern fishing comprised at least 95% of total annual effort, fishers in the scoping survey reported they were spending around 30% of their nights fishing (111 fishing trips per year, Table 2). On average, each fishing ground was fished almost one trip per night for every night of the year (Table 2). In contrast, fishers in the feedback survey reported that they were spending up to 50% of their nights fishing on the 25 lantern fishing grounds considered (Table 2). Furthermore, these grounds were fished on average 2.5 trips per night for every night of the year.

Considering the subset of data for fishers and fishing grounds common to both studies, fishers in the feedback sessions reported total annual effort 2.6 times greater than that reported by the same fishers for the same grounds in the scoping study (45,665 $hrs \cdot yr^{-1}$ vs. 17,513 $hrs \cdot yr^{-1}$, respectively). Annual effort per fisher within the overlapping group was significantly greater in the feedback group than in the scoping group (paired t-test, df=70, $p<0.0005$). Reported effort per fishing ground was also significantly greater in the feedback group than in the scoping group (paired t-test, df=21, p=0.027). Despite the absolute difference between the two groups, error estimates were relatively consistent, both by fisher (Fig 5a) and by ground (Fig 5b). Note that there was no correspondence between the estimates from fishers in Alumar and Bansaan villages, and these two outliers were therefore excluded from the analyses.

Fishing ground habitat quality

Habitat quality on the lantern fishing grounds was generally considered to be good by fishers in both the surveys. 78% of fishers (± 28% s.d., range 0-100%, n=67 sites) said the fishing grounds were in good condition in the scoping survey, and 75% of fishers (± 35% s.d., range 0-100%, n=25 sites) said the fishing grounds were in good condition in the feedback sessions. If the group of fishers and grounds common to both studies are considered, 77.3%±6.7% and 81.4±7.4% of the fishing grounds were described as "good" by fishers in the scoping and feedback groups, respectively. No significant differences could be detected and indeed, when considering the responses of each fisher for each fishing ground (n=128), 76% of the answers were consistent between the two studies.

Table 2. Annual lantern fishing effort on Danajon Bank as reported by fishers from the scoping and feedback surveys. Figures in parentheses are standard deviations. Fishing trip duration was not asked in the scoping survey: the value is an approximation. n refers to the number of fishers interviewed.

	Fishing trip duration	**Total fishing effort**		**Fishing effort per fisher**		**Fishing effort per ground**	
	Hours	**Trips**	**Hours**	**Trips**	**Hours**	**Trips**	**Hours**
Scoping survey (n=173)	~4	19,141	76,562	111 (82)	444	334 (539)	1,334
Feedback sessions (n=117)	3.5 (1.8)	21,653	75,114	192 (148)	671 (519)	894 (1,254)	3,129

The Fishers Relative Ranking allowed sites to be ranked from high (FRR near 0) to low quality (FRR near 1). Although fishers' assessments varied both qualitatively and as a function of the number of fishing grounds fished, there was sufficient consistency to allow fishing grounds to be distinguished (Fig. 6).

The assessment of habitat type was more problematic. In the scoping survey, on average, 45% of fishers (± 31% s.d., range 0-100%, n=67 sites) said that the fishing grounds were dominated by live coral, as opposed to 26% of fishers (± 31% s.d., range 0-100%, n=25 sites) in the feedback survey. Using the same group of fishers and fishing grounds common to both studies, 49.2±6.5% of fishers described fishing grounds as dominated by live coral in the scoping study, whereas only 22.1±6.8% of fishers described the same fishing grounds as dominated by live coral in the feedback sessions. This difference was significant (paired t-test, n=25, p=0.007). When considering the responses of each fisher for each fishing ground (n=128), only 20.9% of responses were consistent between the two studies.

Fishers' assessments of habitat quality generally did not correlate with any formal measurements of habitat composition (e.g. % live coral, % *Sargassum*, % dead coral etc.) as measured by a biologist (Samoilys *et. al.* 2001) using the line intercept method (English *et. al.* 1994). The only significant relationship was that between the % of fishers indicating that a fishing ground was "good" and % rubble cover (Fig. 7). The fishers' assessment of habitat quality was significantly negatively correlated with % rubble cover for both surveys.

Resource management discussions

Food fish were ranked as the most economically important resource (mean rank = 1.61 (±0.11s.e.) followed by sea cucumbers (2.81±0.11), seahorses (3.04±0.16), crabs (3.60±0.11), seaweed (4.28±0.13) and shells (5.24±0.10). Notably, one seahorse genus (*Hippocampus*), ranked third among orders and families of other organisms. The fishers' assessment of seahorse populations, fishing ground habitat quality and their livelihood indicates that these were largely healthy in the past (10 years ago), but conditions are felt to have deteriorated to the present with a poor outlook for the future (Fig. 8).

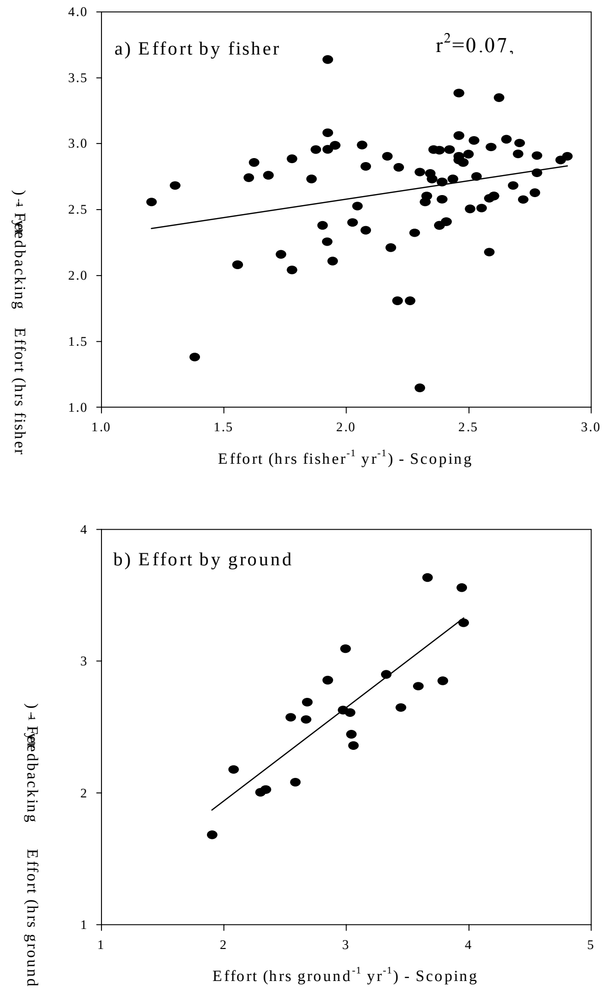


Figure 5. Correlations of effort by a) fisher and b) fishing ground in the group of overlapping fishers (n= 71) and grounds (n=25) for the Scoping (S) and Feedback (F) studies.

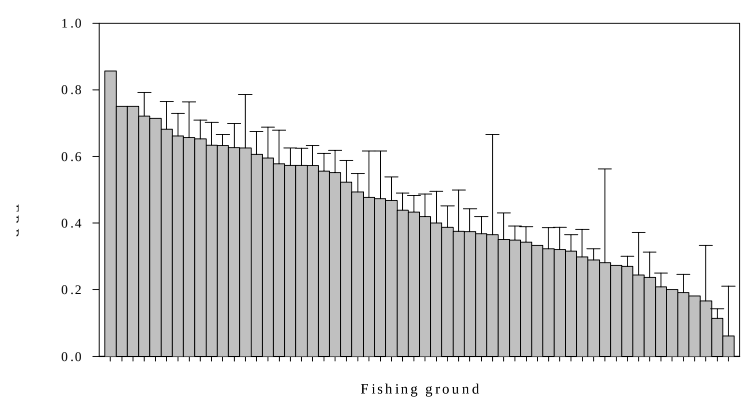


Figure. 6. Mean fisher's relative ranking (FRR) of habitat quality by fishing ground; error bars indicate standard errors.

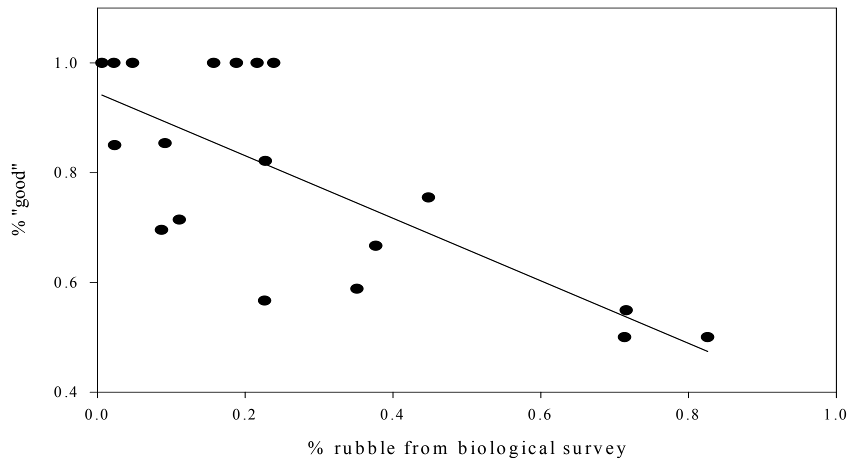


Fig. 7. Correlation between % of fishers indicating a site is "good" and % rubble cover measured on ecological surveys (points shown are from scoping survey)

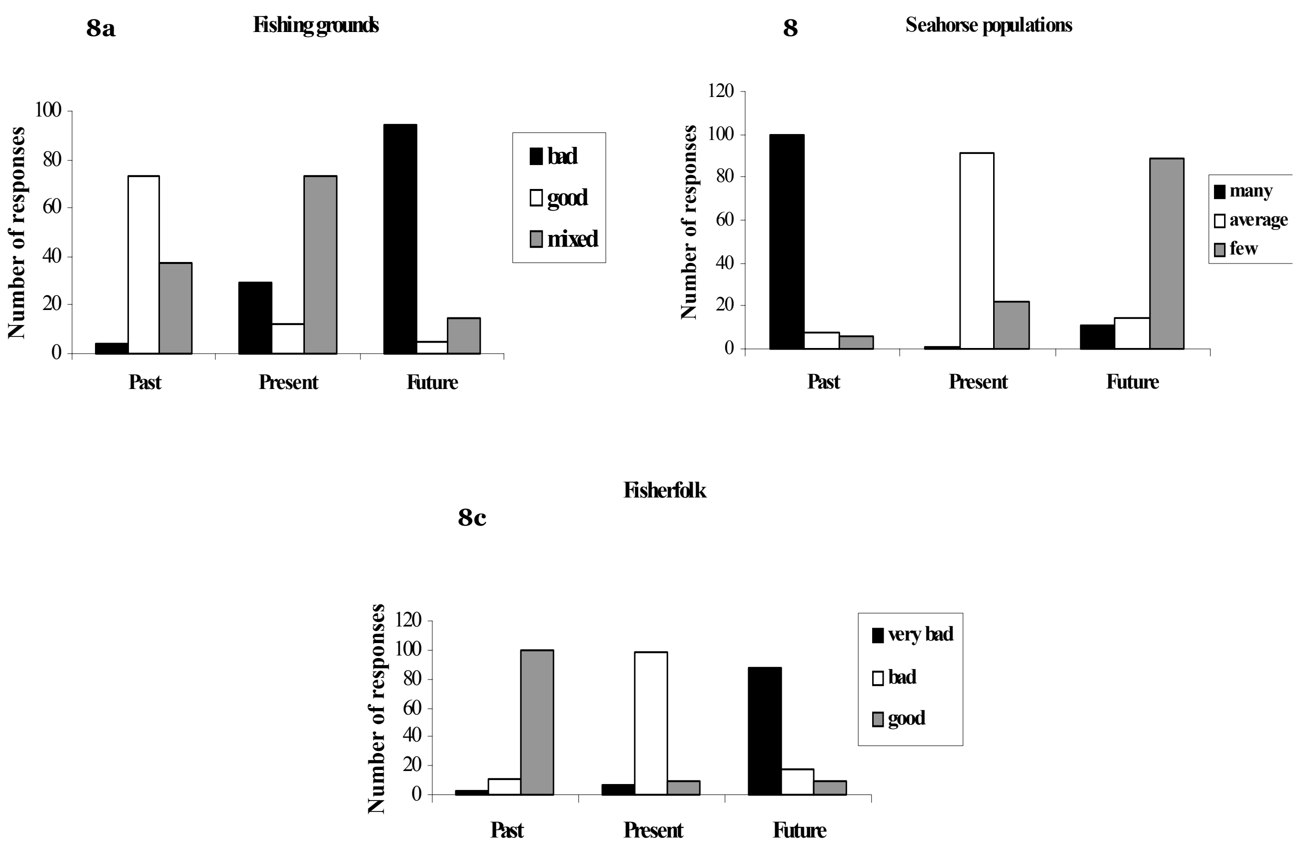


Fig. 8: Trends in status of a) fishing ground condition , b) seahorse populations and c) fishers' livelihood assessed by fishers from Past (1990), Present (2000) to Future (2010).

Reasons for the negative trends in fishing grounds, seahorse populations, and fishers' quality of life were proposed and ranked, and suggestions for improvements were given (Tables 3-5). Fishers in all villages listed destructive (generally illegal) fishing as the most important reason for the poor condition of the fishing grounds. Dynamite ("blast" fishing), cyanide and *tubli*, a local plant poison, were the major illegal gears used (Table 3).

Commercial fishing, primarily trawling and Danish seining (*liba liba*), was cited as the second most important reason for the degradation of fishing grounds. Both trawling and Danish seining are illegal within municipal waters. Fishers frequently used the terms commercial fishing and destructive fishing synonymously. Beach seining (*baling*), though legal in some municipal waters, was also cited as a destructive fishing method. Fishers stated strongly that the fishing grounds were likely to deteriorate further due primarily to continuing illegal and destructive fishing, and also increasing numbers of fishers and a lack of concern regarding protection of the seas from fishers and government (Table 3). Fishers in some villages stated that illegal fishing would continue because there was either no will on the part of government to enforce fishery laws, and/or that government officials were conniving with illegal fishers. Fishers in all villages listed the stopping of destructive and illegal fishing as the highest-ranking solution to the deterioration of their fishing grounds (Table 3). They suggested this should be done through strict and proper enforcement of fishery laws by local government units (village and municipal level), through involvement of non-government organisations (NGOs) in fishery law enforcement, and through appointing more fish wardens.

Reasons for perceived declines in seahorse populations were more variable (Table 4). Fishers perceived the taking of pregnant seahorses and habitat destruction as primary reasons for the decline. Increased effort was also listed and was ascribed to an increase in the number of fishers, partly due to fishers switching from other fishery resources (e.g. fin fish) that had declined. Fishers felt declines in seahorses are likely to continue due to insufficient numbers of adult seahorses, deteriorating habitat quality, and a lack of juveniles (Table 4). To halt declines in seahorse populations, fishers most frequently suggested stopping destructive fishing and protecting pregnant seahorses (Table 4).

Table 3: Results of marine resource discussions on the destruction of fishing grounds. The number of villages that ranked each reason or solution from most important (rank = 1) to least important (rank = 5) is indicated. Destructive fishing included both methods destructive to the habitat and illegal fishing such as trawling and seining in municipal waters. Total villages = total number of villages providing each reason/solution.

	Rank					Total Villages
	1	2	3	4	5	
Reasons for the destruction of fishing grounds						
Destructive (illegal) fishing	9					9
Commercial fishing		8				8
Typhoons			3			3
Coral collecting				1		1
Increasing # of fishers				1		1
Increasing # of outside fishers					1	1
Reasons destruction will continue in the future						
Continuing destructive fishing	7		1			8
Increasing # of fishers	1	5	2			8
Lack of concern in protecting the sea (fishers and/or government)	1	2				3
Increasing effort per fisher		1	1	1		3
Improved fishing methods				1		1
Solutions to arrest the destruction of fishing grounds						
Stop destructive and commercial fishing	9					9
Establish more MPAs		4	2			6
Stop buying destructively bought fish		1	1			2
Educate and inform fishers		1	1			2
Maintain own MPA		1				1
Alternative livelihoods for fishers			1			1
Stop outside fishers		1				1
Organize fishers			1			1

Table 4: Results of marine resource discussions on declines in seahorse populations. The number of villages that ranked each reason or solution from most important (rank = 1) to least important (rank = 7) is indicated. Total villages = total number of villages providing each reason/solution. MPA = marine protected area or sanctuary implemented and managed at the village level.

	Rank							Total Villages
	1	2	3	4	5	6	7	
Reasons for declines in seahorse populations								
Taking pregnant seahorses	3	3	1					7
Habitat destruction	3	2	1	1				7
Catching juveniles		2	2					4
Destructive fishing		1	2					3
Increased fishing effort	3		2	1				6
Weather		1	1	1	1			4
Indiscriminant catching				1				1
Catch during spawning season						1		1
Pollution							1	1
Reasons declines will continue in the future								
Few adults for reproduction	3	1						4
Continuing habitat destruction	3	1	1					5
Lack of good habitat (destroyed)	2	3	1					6
Few juveniles		2						2
Increasing effort	1	1	2					4
Catching pregnant seahorses		2						2
Solutions to arrest declines in seahorse populations								
Stop destructive fishing	4							4
Stop catching of pregnant seahorses	4	2						6
Caging of pregnant seahorses		2		1				3
Stop fishing juveniles	1	2	1					4
Establish sanctuaries		1	1					2
Moratorium on seahorse fishing		1	2					3
Regulation of trade and catch			2	1				3
MPA management			1					1
Protect habitat		1						1
Seasonal closures		1						1
Fishers to cooperate with LGU, NGO		1						1

Reasons for the poor condition of fishers' livelihood and why their situation would be very bad in the future were varied, and there was less consistency across villages (Table 5). Less income was cited as the main reason for the poor situation of fishers today, that is, less income derived from fishing which results in less disposable income for recreation. Secondarily, fishers cited an increase in the costs of living and fishing as significant factors. They also listed a lack of alternative livelihoods to fishing. The reasons for the continuing decline in quality of life were rooted in the status of the fishing grounds, with destructive fishing cited as the main reason, followed by less catch and more fishing effort. Alternative livelihoods were perceived as the most important tool to improve the fishers' situation with the need to stop destructive fishing as the second most important solution (Table 5).

Table 5: Results of marine resource discussions on the status of fishers' livelihoods. The number of villages that ranked each reason or solution from most important (rank = 1) to least important (rank = 6) is indicated. Total villages = total number of villages providing each reason/solution. MPA = marine protected area or sanctuary implemented and managed at the village level.

	Rank						Total Villages
	1	2	3	4	5	6	
Reasons for deterioration of fishers' livelihoods							
Less income	5	1			1		7
Increased price of commodities		2	3				5
Increased operating costs	1	1	1				3
No alternative livelihoods		1	1				2
Difficulty meeting basic food needs	1	1	1	3			6
Inability to improve gear technology			3		1		4
Difficulty funding kids' schooling		1		1			2
Bad weather	1	1					2
Travel further to fishing grounds				1			1
Reasons livelihood deterioration will continue							
Destructive fishing	6						6
Less catch	1	3	1	1			6
Increased # of fishers	1	1	2	1			5
Increased operating costs	1		1		1		3
Bad weather							0
Travel further to fish		1					1
No alternative livelihoods			1				1
Destroyed fishing grounds		1					1
Commercial fishing							0
Solutions to arrest the deterioration of fishers' livelihoods							
Alternative livelihood	5	3					8
Stop destructive fishing	3	1					4
Alternative income		2	1				3
Fishers' cooperative		2					2
Improve technology			3				3

Discussion

The participatory approaches of the focus group discussions generated a lot of interest among the lantern fishers of Danajon Bank. The highly visual, graphical methods of conveying data were very effective in engaging the fishers and soliciting responses. The method is particularly well suited to fishers who are semi – literate. For example, only 11% complete elementary school in Handumon village (Buhat *et. al.* in prep.). High participation rates indicated this element of the program was successful.

One issue in the focus group discussion approach is the validity of the responses obtained from the group. Bias towards answers provided by dominating fishers which other fishers copy is likely. In the present study we were able to examine this by comparing reported fishing effort data obtained from the conventional questionnaire–based approach (the scoping survey) with the focus group discussions of the feedback survey. Although there were differences in the absolute values obtained, trends in fishing effort among fishing grounds were significantly correlated between the two surveys. Similarly, there were no significant differences in the description of the overall quality of the fishing grounds between the two methods.

Most of the fishing communities of Danajon Bank that we visited had not been involved in our conservation program and therefore this study served to integrate the CO into the communities and to engage the fishers in our research and management initiatives.

One objective of the study was to generate discussions on resource management, and though at times dominated by key members in the fisher communities, group discussions served as opportunities for sharing ideas particularly between the CO and the communities. This step of educating, informing and agitating fishers (called "conscientization", in Filipino CO terminology) is vital in the community organising process (Third World Studies Center 1990). It is also fundamental to stakeholder involvement in conservation and management initiatives (Ruddle 1994; Walters *et. al.* 1998; Alcala 1999; Cooke *et. al.* 2000; White and Vogt 2000).

A much higher estimate of fishing effort was obtained from the feedback survey compared with the scoping survey. This may reflect bias from the group discussions or the difference in sample size. There were 67 fishing grounds included in the scoping survey and only 25 in the feedback survey. However, with a change in CO during the feedback survey, we found that not all fishers had responded to the questions of fishing effort during the scoping survey, and that estimates per village were in fact based on only around 2 fishers. Therefore it is likely that the feedback survey, which collected effort estimates from each fisher in each village (mean = 9 fishers per village), provides a more accurate estimate of fishing effort. An average of 2.5 fishing trips per night per lantern fishing ground throughout the year was recorded, which is high considering the fishing grounds were less than $1km^2$ in size (Samoilys *et. al.* 2001) and fishing trips lasted for 3.5 hours.

Estimates of fishing effort from interviews with fishers are renowned for their inaccuracy in terms of absolute value (Rawlinson 1993, Die 1997). However they provide useful relative estimates, and can be used to plot trends over time. This is well demonstrated in the present study. Highly consistent relative estimates of fishing effort per fishing ground were obtained between the two surveys. Effort per fisher was less consistent, therefore presumably less reliable, but still significantly correlated between the two surveys.

We suggest that long term blast fishing and other destructive fishing methods in this region means that fishers' perceptions of a healthy fishing ground have changed and now differ markedly from ours. Fishers described their fishing grounds to be in good condition in the scoping and feedback surveys. In contrast, independent transect surveys revealed average % live coral cover of 15% and % rubble/dead coral cover (an indication of blast fishing damage) to be 37% for the same fishing grounds (Samoilys *et. al.* 2001), suggesting the fishing grounds are in poor condition. This discrepancy indicates fishers and ecologists are using different criteria to assess fishing ground habitat quality. There is a difference in threshold, or a shift in baseline (Pauly 1995 and 1996), for perception of a healthy habitat, with the fishers' threshold being substantially lower. Fishers may use the extent of rubble cover as an indication of habitat quality since the relationship between fishers' perceptions of good habitat was significantly negatively correlated with % rubble cover from independent surveys. A fishing ground was not considered to be in bad condition by fishers until rubble cover exceeded 50%, a value that would be considered very high by ecologists (Gomez *et. al.* 1994; Chou 2000).

Our results highlighted potential difficulties in composing suitable questions when interviewing fishers. Fishers may interpret questions quite differently from how they were intended by the interviewer, and results can be easily misinterpreted. This is a common problem when conducting interviews and focus group discussions with subsistence fishers (Baird, this vol). In our study the definition of habitat "quality" was poorly defined, and was open to many interpretations. This may explain why the fishers described their fishing grounds to be in poor condition when asked during the marine resource status discussions. Such questions need to be defined very specifically, so that fishers' knowledge can be accurately interpreted.

The marine resource discussions revealed that 20 year trends (1990-2010) in the status of the fishing grounds, seahorse populations and the fishers' livelihood as lantern fishers were all negative. In many cases there was strong consensus across villages for the reasons and for the solutions to these trends. For example, illegal fishing (primarily blast fishing) was cited as the primary cause of the poor state of the fishing grounds, with its corollary of stopping illegal fishing as the primary solution. In other cases there was less consensus amongst fishers. For example, fishers assessed their livelihood as being bad for a number of different reasons, though most of these did relate to an increasing need for cash which their livelihood could not provide. In all cases it was clear that fishers recognized their problems and had informed ideas on how to alleviate them, though perceived themselves to be largely powerless to effect change. It was overwhelmingly clear that stopping illegal fishing, especially blast fishing, and finding alternative livelihoods for the fishers were key solutions to the problems in the Danajon Bank lantern fishery. These results provide us with useful backing when directing our conservation efforts, though neither result is surprising. The prevalence and problem of blast fishing in the Philippines is well recognised (Alcala and Gomez 1987, Yap and Gomez 1988, Bryant *et. al.* 1998, Chou 2000). Furthermore, the lantern fishers of Danajon Bank are marginalized, comprising a relatively small proportion (nine fishers per village) of the total village population, with the lowest average income in the region, living well below the national poverty level (Buhat *et. al.* in prep.). Considering the fact that they fish for up to 50% of their nights in arduous conditions, using paddle canoes and spending on average 3.5 hours in the water per night with no protection, it is not surprising that they would gladly welcome a supplemented livelihood.

The fishers' views are guiding us in our fishery management planning with various stakeholders (Martin-Smith *et. al.* In prep.), The fishers demonstrated a good understanding that gravid seahorses are important for population sustainability, citing the taking of pregnant seahorses as the primary cause of population depletion, and that the ensuing lack of adults and juveniles will contribute to further decline. It was not clear whether they knew that the pregnant seahorses were males (Vincent 1994), however the option of protecting pregnant seahorses through fishery regulations is clearly understood (Martin-Smith *et. al.* in prep.). Fishers also linked population decline directly to habitat destruction. Fishers from the village of Handumon, where Project Seahorse has been active since 1995 (Vincent and Pajaro 1997), provided the same range of reasons and solutions to their problems as other villages. One village, Guindacpan, consistently provided more answers and appeared more informed. The reasons for some of the differences between villages require further study.

Fishers' knowledge can guide conservation initiatives. We are acting on their knowledge and formalising it. The lantern fishers demonstrated that they are aware of conservation and management issues, are concerned about their marine resources and their livelihoods, recognise the negative trends, and know the reasons for their demise. However, they feel powerless to do anything about it, and see the government as being responsible but ineffective. These results have been instrumental in our initiatives to introduce supplementary livelihoods, and to facilitate the formation of a fishers' alliance across Danajon Bank to provide seahorse fishers with their own institution with which they can effect change.

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QUESTIONS

Ian Baird: I have a comment regarding the apparent inconsistencies in the fishers' answers regarding the conditions of seahorse habitat. There can be explanations for these inconsistencies. For example, since you mentioned that there has been dynamite fishing for a long time, the habitat may have been in even worse condition than it is now, and people perceive it relative to the way it was before. They could also be comparing the habitat to adjacent places that are in even worse condition. It may not be as much of an inconsistency as it looks like initially. What you should do is go back to the fishers and tell them what you told us, and ask why there may be such inconsistencies.

Melita Samoilys: That's the next step in the project, to take our results back to the fishers and show them what we got and to ask fishers about the conditions of the fishing ground. They could be relating it to how it is doing compared to seahorses and not the habitat itself. We have to be careful.

Willard Sparrow: How do you deal with cultural understandings?

Melita Samoilys: We were fortunate in that Joel Erediano, who is in the project, is Filipino so he speaks the language. There's difficulty in translating it back to English, and it is hard for someone like myself to interpret the results.

FOCUSING AND TESTING FISHER KNOW-HOW TO SOLVE CONSERVATION PROBLEMS: A COMMON SENSE APPROACH

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ABSTRACT

Worldwide, the incidental capture or bycatch of marine organisms, especially mammals, turtles and seabirds, can pose serious threats to specific animal populations causing public outcry and regulatory attention. When such issues arise, especially in US fisheries, they can threaten fisheries and necessitate immediate solutions. Unfortunately, no standard mechanisms exist within stewardship and regulatory authorities to go beyond problem identification to crafting solutions. We have worked to devise solutions to seabird mortality in two fisheries: the Puget Sound drift gillnet fishery for sockeye salmon and the longline fisheries in Alaska for sablefish and Pacific cod. Although these fisheries are very different, the cooperative research model we have developed is the same and is proving successful in both. At the most basic level, this model includes communication and cooperation with all stakeholders, strict scientific protocols and development of effective and practical regulations. Although this model was developed with specific reference to seabird bycatch reductions, it is readily applicable to a wide range of conservation issues. There are three key elements: 1) Working with industry leaders through relevant industry associations to identify possible new technologies and/or operational practices that are practical and likely to solve the problem; 2) Testing the proposed solutions in a collaborative study on active fishing vessels using strict scientific protocols, and developing incentives for individual participants to: a) host scientists, who collect the necessary data, and b) adhere to a specific scientific protocol within their standard operation is key; 3) Crafting new regulations based on the results of the research program in cooperation with the industry, resource management agencies and conservation organizations. Our model results in proof at two levels. At the practical level, fisher's ideas are tested in the context of an active fishery. At the scientific level, peer review and publication certify results for the regulatory, academic, and conservation communities.

INTRODUCTION

Worldwide, the incidental capture or bycatch of marine organisms in fisheries has posed serious threats to specific animal populations as well as to specific fisheries. In particular, bycatch of mammals, turtles and seabirds has proven problematic because of the sensitivity of these species to even slight increases in adult mortality, and public opinion that these charismatic animals must be protected. When such conservation issues arise, especially in US fisheries, they necessitate immediate solutions to satisfy requirements of existing environmental law, the demands of the environmental community, and concerns of the public. Unfortunately, no standard mechanisms exist within stewardship and regulatory authorities to go beyond problem identification to the crafting of solutions.

Since 1994, we have developed cooperative research programs to devise solutions to seabird mortality of in two fisheries: the Puget Sound drift gillnet fishery for sockeye salmon (*Onchorynchus nerka)* and the Alaskan longline fisheries for sablefish (*Anoplopoma fimbria*) and Pacific cod (*Gadus macrocephalus*). The gillnet work was completed in 1996 (Melvin *et al*. 1999) and the longline work was completed in 2001 (Melvin *et al.* 2001). Although these fisheries are very different, the same cooperative research model proved successful in both. This essay outlines a cooperative research model that includes industry and agency input, cooperation at all levels, strict scientific protocols and clear direction towards effective and practical regulations.

DEFINING THE MODEL

From the outset, it was realized that successful solutions must satisfy three basic criteria:

- reduce bycatch without reducing target catch or increasing the bycatch of other species;
- be acceptable and practicable for fishers; and,
- be scientifically acceptable to managers, conservation organizations and the public.

Although the cooperative research model was developed specifically to reduce seabird bycatch, it is readily applicable to a wide range of conservation issues. There are three key elements:

1. Working with industry leaders through relevant industry associations to identify new technologies and/or operational practices that are practicable and likely to solve the problem. Cooperation with

managers and agency scientists, academic scientists, and representatives of the conservation community is also essential.
2. Testing the proposed solutions in a collaborative study using strict scientific protocols under actual fishing conditions. Developing incentives for individual participants to:
    a) host scientists to collect necessary data;
    b) adhere to a specific scientific protocol within their standard operations.
3. Crafting new regulations based on the results of the research program in cooperation with the industry, resource management agencies and conservation organizations.

This model results in proof at two levels. Because practitioners within the industry have a primary role in developing potential solutions, and are involved in the actual research activity, they develop trust in the scientific process and are satisfied that technologies or methods tested are practical and actually work. Managers, scientists, and conservation groups are satisfied because mitigation techniques are rigorously tested, and results are scientifically defensible through peer review and ultimate publication in the scientific literature.

For this model to be effective, both industry and managers must be highly motivated, funding must be available, and a qualified and willing third party must be available to lead the effort. Unfortunately, these conditions rarely exist without a motivating crisis. Crises are important for at least two reasons:

1) Industry is not likely to respond to conservation issues unless the livelihood of its practitioners is threatened. Similarly, management agencies rarely respond to loss of non-commercial species unless they are threatened by litigation or requirements of environmental law, e.g. the Endangered Species Act (ESA), the Marine Mammal Protection Act, the Migratory Bird Treaty Act or Court injunction.
2) Funding for applied conservation research is not likely to be forthcoming unless there is a crisis. In the case histories below, the threat of litigation played a primary role in motivating funding for the research activities.

Finally, scientifically credible and independent third parties are important, because they do not come with an underlying political agenda, and are therefore in a better position to establish trust. Applying this model through agency scientists can be difficult because they represent institutions that are both regulatory and scientific. The agencies routinely find themselves in conflict with industry. Scientists associated with conservation organizations or environmental groups are often seen by industry as biased against harvesters of natural resources.

Case Study #1: Gillnets and Seabirds

Observer programs established that mortalities of marbled murrelets, listed as threatened under ESA in 1992, were in fact extremely rare in Puget Sound gillnet fisheries, but also established that these fisheries can entangle large numbers of other diving seabirds such as common murres (*Uria aalge*) and rhinoceros auklets (*Cerorhinca monocerata*). The fishery was faced with partial and full closure if research was not initiated to develop techniques that reduce the incidental mortality of diving seabirds. The Washington Department of Fish and Wildlife (WDFW) was threatened with litigation from a group representing sport fishers. Neither a research plan nor funding to carry out research was in place. After a Sea Grant pilot project in 1994, research was scaled up in 1995 and 1996 with funding from the Saltonstall Kennedy Program of National Marine Fisheries Service (NMFS S/K) the US Fish and Wildlife Service (USFWS), and the Washington Sea Grant Program (WSGP). Ultimately gear modifications (nets with visual barriers in the upper net), the elimination of dawn fishing, and ecosystem approaches were proposed for new regulations based on the research. Regulations were adopted with industry support, marking the first time solutions for seabird bycatch in gillnets were proven and implemented.

In this cooperative study, the Puget Sound Gillnetters' Association (PSGA) and (WDFW) played key roles. PSGA was the lead entity for the industry, promoting cooperation within the association, identifying individual cooperators, and establishing a forum to identify possible solutions. WDFW established the capability to use the proceeds from a test fishery to pay for vessel charters and fish outside scheduled openings, which in turn provided the incentive for individual fishers to participate in research. WDFW also played a lead role in organizing meetings of fishers, scientists and the conservation community.

Case Study #2: Alaska Longline Fisheries

Alaska longline fisheries for groundfish and halibut (*Hippoglossus stenolepis*) together yield about $300 million in ex-vessel revenue from approximately 2,200 vessels. These fisheries have been estimated to catch between 10,000 and 20,000 seabirds per year including exceedingly rare catches of the internationally endangered short-tailed albatross (*Diomedea albatrus*). Under the Biological Opinion of the USFWS under the Endangered Species Act (ESA), bycatch exceeding four short-tail albatross every two years in the groundfish fishery and two short-tailed albatross every two years in the halibut fishery could close or curtail these otherwise healthy fisheries. The motivation to develop effective mitigation techniques was clear to industry, and research to develop bycatch deterrent strategies was required but not funded. Funding was obtained from USFWS, NMFS S/K Program and WSGP to conduct research over two seasons in the Gulf of Alaska sablefish and halibut fisheries and the Bering Sea Pacific cod fishery.

An *ad hoc* industry committee was established through the Fishing Vessels Owners Association and the North Pacific Longline Association with participation by NMFS and USFWS representatives. Deterrent techniques specific to each fishery were identified for testing through a series of meetings of the *ad hoc* group. In the case of sablefish, cooperating fishers received free NMFS-required observer coverage. In the case of Pacific cod, an exempted fishing permit from the North Pacific Fisheries Management Council allowed two vessels to fish under the research protocols for 25 days each prior to the open access season. The collaboration process concluded with meetings of the *ad hoc* industry group to share results of the research program and develop recommendations for new regulations to replace those borrowed from fisheries in the Southern Oceans. The goal was to develop new, practical regulations specific to Alaska fisheries with the support of industry, the resource management agencies and the conservation community. Those recommendations were included in the final technical report and were the basis for final regulations adopted by the North Pacific Fisheries Management Council in December 2001.

CONCLUSION

Cooperative research as described here has limitations. Field research is costly and entities willing to fund solutions are few. Organizing a collaborative process with a field program takes a great deal of effort and trust, and perhaps, some luck. Critical to both the programs described was a Principal Investigator (Melvin) associated with a neutral agency (Washington Sea Grant Program) dedicated almost full-time to the project. Most academics and agency scientists have neither the freedom nor the mandate to dedicate themselves to problem solving activities. Collaborations with academics within the School of Aquatic and Fishery Sciences at the University of Washington and with managers from state and federal agencies were also key components. Finally, we had the good fortune to work with fishing industry associations and fishers with vision and dedication, who understood the threat and the challenge to their industry. This model may not always appropriate, but when the circumstances and the people are right, it is a win-win formula. It is simply common sense.

RELATED LITERATURE

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QUESTIONS

Charlie Beliss: You're one of the first people I've seen looking at both fish management and bird management and bringing the two together.

Edward Melvin: That's probably true. It's so new that no one else has done it. I don't know if it is necessarily a good or a bad thing. It did come up because of the sequence of events. When I looked around to see who had done this kind of work I did not find much.

METHODOLOGY FOR INTEGRATION OF FISHERS' ECOLOGICAL KNOWLEDGE IN FISHERIES BIOLOGY AND MANAGEMENT USING KNOWLEDGE REPRESENTATION [ARTIFICIAL INTELLIGENCE]

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ABSTRACT

The fisheries crisis of the last decades and the overexploitation of a great number of stocks (FAO 1995) have been due mainly to the inadequacy of scientific knowledge, uncertainties in assessments and/or failures of the management systems. These problems are critical when the management of coastal ecosystems and artisanal fisheries is involved. These systems possess great complexity due to the high number of human factors that influence their functioning and the fishing activity. Small-scale coastal fisheries have a much greater social significance than offshore industrial fisheries, despite the larger economical importance of the latter (only in macro-economic terms).

The artisanal coastal fisheries in Galicia (NW Spain) are in a general state of overexploitation derived from the mismatch between management (derived implicitly from models designed for industrial finfisheries) and the biological and socioeconomic context. Freire & García-Allut (2000) proposed a new management policy (based on the establishment of territorial users' rights, the involvement of fishers in the assessment and management process in collaboration with the government agencies, and the use of protected areas and minimum landing sizes as key regulations) to solve the above problems. As well as a new management system, research should pay special attention to the design and use of inexpensive and rapid methodologies to get relevant scientific data, and introduce local or traditional ecological knowledge of the fishers to the assessment and management process.

In this paper, we analyze the values and characteristics of fishers' ecological knowledge (FEK). Using the artisanal coastal fisheries of Galicia as a case study, we present the objectives of the integration of FEK in fisheries biology and management and propose a methodology for that goal. The use of Artificial Intelligence (AI) as a tool for the analysis and integration of FEK is discussed, and the role of *Knowledge Representation,* a branch of AI, is described to show the epistemological and technological adequacy of the chosen languages and tools in a non-computer science forum.

INTRODUCTION

World fisheries are in crisis. According to the FAO (1995), 69% of the world's marine stocks are either fully to heavily exploited, overexploited or depleted, and are therefore in need of urgent conservation and management measures. The causes of the collapse of exploited marine populations have been the subject of wide debate, pitting those who believe that excessive fishing effort leads to over-exploitation, against those arguing that fluctuations in population dynamics are attributable to natural environmental changes. Myers and other researchers in (1996 and 1997) studied the collapse of the cod fishery in Newfoundland and concluded that the overexploitation hypothesis is backed by scientific evidence which is much stronger than other related to environmental changes. The collapse of stocks constitutes the final stage of overexploitation generated by an excessive fishing effort. This process may be attributed either to a lack of appropriate scientific information or, on occasion, where there *was* suitable assessment, to faulty management systems or failure to enforce the compliance of several fisheries.

In the case of artisanal fisheries in Galicia (NW Spain) there are also a number of indicators that reveal overfishing (Freire 1999; Freire 1000a): 1) the virtual depletion and collapse of several stocks (for example lobster, spiny lobster, sea bream) whose catches are irrelevant today but were important historically in the area, 2) the time series of catches that, despite problematic interpretation, show that there has been a decline in many cases from the 1940s-60s to the present time, e.g. crustaceans, and 3) specific assessments, such as on the spider crab in the Ría de Arousa (Freire 1000b) reveal exploitation rates greater than 90% per fishing session. As well as showing indicators of overfishing, the following differential characteristics of the artisanal sector complicate the design of successful management systems:

1. From a biological standpoint, the species harvested by the artisanal coastal fleet of Galicia, and particularly the great majority of invertebrate species, present a number of characteristics which render useless the classical analytical models of finfish population dynamics used in the management of industrial fisheries. These species, sedentary benthic or mobile benthic/ demersal, have a strong and persistent spatial structure and are characterized by the following: 1) complex life cycles (planktonic dispersing larval stages and sedentary or low mobile benthic or demersal postlarval stages), 2) a spatial distribution characterized by the existence of aggregations which are evident on different scales, 3) a population structure that could be defined as meroplanktonic meta-populations in which the postlarval stages make up a chain of local populations along the coast with low migration and dispersal levels, interconnected by a planktonic larval stage, and 4) the aggregated stock-recruitment relationship is not applicable to a segment of a metapopulation.
2. In an industrial fishery, the relationships between the economic benefits obtained by the fishery and its biological and social complexity is high, which would make it possible to fund and develop intensive lines of research. In terms of the artisanal coastal fisheries of Galicia, the economic yield of each of the species harvested does not appear to be able to support specific lines of research which could complete our incomplete scientific knowledge.

Faced with these scenarios, some argue that finding ways to incorporate fishers' participation would improve our capacity to manage fisheries sustainable. Neis (1999) presents a methodology for collecting and integrating fishers' ecological knowledge into resource management, but the formal representation of this knowledge is not addressed. We believe that formal representation using AI (specifically *Knowledge Representation*) techniques could not only assist in the acquisition and refinement of this knowledge, but could also facilitate comparison with other knowledge systems (scientific knowledge), the observation of possible changes in these over time, and the impact of both knowledge systems on management initiatives. The aim of this paper is to a) show that *Description Logics* and *Terminological Systems* are good candidates for this task, b) describe the methodology designed to carry out this task, c) develop a case study implementing this and d) document the evaluation by biologists.

Also, following this line of work, it is worth mentioning a *fuzzy logic* expert system whose knowledge base incorporates fishers' knowledge in the form of heuristic rules (Mackinson and Nottestad 1998). Consequently our approach complements the work in (Neis 1999) and (Mackinson 1998) both in content and methodological aspects.

The remainder of the paper is organized as follows. The next section defines the concept of Fishers' Ecological Knowledge (FEK) which is rooted in ethnoscience and cultural ecology traditions. Section 3 argues that given the characteristics of FEK and what we want to do with it, *Description Logics* (DLs) are a good choice to represent FEK. In section 4 we describe our methodology. A visual terminological language which has been designed to facilitate knowledge input is described in section 5. The paper ends with some conclusions.

FISHERS' ECOLOGICAL KNOWLEDGE

FEK is a specialized branch of TEK (Traditional Ecological Knowledge). The concept of TEK appeared in the mid-1980s, and social scientists have argued that it represents at least a critical supplement to scientific understanding. Mailhot (1993) gave an explanatory definition of TEK:

> *"the sum of the data and ideas acquired by a human group on its environment as a result of the group's use and occupation of a region over many generations"*.

FEK (Neis 1999) typically includes not only categories of fishes, but also information on behavior, ecology, meteorology and oceanography, and references to time and space that can complement scientific knowledge. Moreover, FEK is an updated understanding that includes the latest changes occurring in the local marine environment. However, those who plan management policies are usually politicians who work unilaterally in collaboration with technicians from the administrations, and disregard entirely the knowledge of the fishers within their field of experience. Some examples that occurred in Galicia in recent years may serve as an illustration. Artisanal fishers used the traditional fish trap (cylindrical and closed) to fish velvet swimming crab and octopus. In order to regulate these resources, the administration required fishers to employ a more selective type of trap (square and open) designed by its technicians to fish exclusively octopus. The fishers bought these new traps and soon discovered that they were inefficient. They required more work and produced less. The response of fishers was to replace the new traps with the traditional ones behind the back of the administration. This process went on for several years before the administration recognized its error which had resulted in an economical setback for the artisanal fisheries. The government, in opposition to an important sector of fishers, also opened the fishing season for velvet swimming crab at a critical time of its reproduction, thus putting the stock in danger. This latter situation example continued for several years.

Therefore, our main objective is to acquire new knowledge that can be applied to the sciences involved in designing management models for artisanal fisheries in Galicia. The generic scope of knowledge that we will need to achieve the above goals will be centred, in turn, on acquiring knowledge and information on coastal ecosystems, population dynamics, descriptions of habitats and bottom types, interactions and relationships between species, behavior and feeding habits, reproductive zones and seasons, climate (atmospheric and oceanic) influences on the species, stock assessment of fishes, crustaceans and molluscs, reconstruction of the history of marine ecosystems in relatively short periods, etc. After filtering, systemizing and formalizing fishers' ecological knowledge, it can contribute to broaden our understanding of many of these topics.

METHODOLOGICAL CHOICE: DESCRIPTION LOGICS

It has been recognized by Neis (1999) that the main hurdle associated with combining science and FEK is methodological: finding ways to combine these two knowledge systems. In (Neis 1999) and other works, methodologies and research techniques to acquire traditional knowledge are described. These include: analysis of discourse, selection of information, semi-guided open interviews, surveys on specific points of knowledge, analysis of the distribution maps of the resources and habitats drawn up by the fishers (Ames, this volume), and other documents of a functional nature that they may have, such as notebooks and graph interpretations (depth sounder, radar), etc. This work is being done almost exclusively by anthropologists and this knowledge circulates mostly through channels of dissemination of maritime anthropology. If this knowledge could be represented in a formal manner, it could be refined, reused, shared with others or integrated with biological knowledge in a principled way. Therefore *Knowledge Representation* (KR) plays an important role in improving the knowledge of biologists, technicians, anthropologists and fishers, with the ultimate goal of designing better fisheries policies.

Two main properties of FEK are that it is a very large body of knowledge and it is subject to continuous changes. Up to now, anthropologists have seen the work of formalizing FEK as part of their research area. This situation motivated us to seek a methodology where the anthropologist is not only an end-user of the resulting knowledge-based system, but he/she is involved in the knowledge engineering process from the beginning. Anthropologists can certainly break down the domain into its characteristic elements, even possibly express them in a computer language. However these tasks must be accomplished in the framework of a formal model, since the lack of a formal semantic foundation could lead to several problems such as inconsistencies or circular definitions. Therefore, to be successful the *Knowledge Representation Language* (KRL) must be carefully selected. Epistemological adequacy must derive from the nature of FEK. Note that one of the major components of FEK is the categorization used by fishers to classify components of the environment and the organization of these categories into a system of representation. From a technological perspective we need a language that is both expressive and easy to learn. Implementations of DLs seem to be the right choice.

From a logical and formal view, DLs integrate research done in semantic networks, frame systems and other object-oriented representations, and constitute the formal successor of the family of KL-ONE languages (Brachman 1985). During the last fifteen years the main issue of research in Description Logics has been the identification of the sources of intractability. The results of this research allow us to depart from a very basic language and to increase expressiveness while ensuring computational tractability.

The primary aim of DLs is to express knowledge about *concepts* and *hierarchies of concepts*. DLs have declarative tarskian semantics and can be identified as sublanguages of *First Order Logic* (FOL). A *concept expression* is a general description of a class of objects in the target domain. Concept expressions are formed using various *constructors*, some of them expressing relations with other concepts (roles). Relations expressed by means of roles, can be qualified in several ways (type restrictions, value restrictions, number restrictions, etc.). Just by analyzing concept expressions, a taxonomy of concepts following generality-specificity criteria can be built. The efficient implementation of reasoning services is based on this hierarchical structure.

The basic blocks of the descriptive languages are atomic concepts and roles. Atomic concepts can be considered as unary predicates, and atomic roles can be considered as binary predicates. Atomic concepts and roles are combined to build complex concepts and roles. Semantics allows the interpretation of concepts as subsets of objects (here called individuals) of the domain and the interpretation of roles as binary relations between objects of the domain. Therefore the extension of a concept is a set of individuals, and the extension of a role is a binary relation between individuals. Also following the semantics of language constructors, the equivalent in FOL of any concept or role expression can be obtained.

Satisfiability and subsumption are the basic inferences in DLs. A concept is satisfiable if it can have a on-empty extension. A concept C is subsumed by a concept D if the extension of C is always a subset of the extension of D. Other inference tasks of great utility such as equivalence or classification can be reduced to satisfiability and subsumption. Reasoning about individuals is also provided with these logics. Since the seminal works in the field (Levesque 19 and 1987), reasoning in DLs and the tradeoff between expressiveness and tractability have been deeply studied, leading to important results - see Donini (1997) for a survey.

Terminological languages (also called concept languages) are implementations of DLs. *Classic* (Patel-Schneider 1991) and *Fact* (Horrocks 1998) are examples of well-known terminological languages. These languages allow us to define concepts and roles, to organize them by means of taxonomies, to define individuals and to make inferences on these elements and structures. Practical applications of description logics (terminological systems) using these and other terminological languages exist in a wide variety of domains: data and knowledge management systems (Borgida 1993 and 1995), global information systems (Levy 1995), clinical information systems (Rector 1997), software engineering (Devanbu 1991), etc.

In our project, we have chosen to use *Classic* for several reasons. The language is expressive enough to be useful and limited enough to assure tractable reasoning. The language is simple and small enough to be really usable because it can be learned by non-experts in computer science. Even a methodology for using *Classic* has been published (Brachman 1991). This knowledge engineering methodology has been elaborated, emphasizing the modeling choices that arise in the process of describing a domain and the key difficulties encountered by new users. The language has additional features that increase usability such as a limited forward-chaining rule system and the possibility of concept definitions written as test functions in a procedural programming language. However, these additional features are designed following the principle that user code cannot subvert the knowledge representation system, that is, these additional features have to be kept opaque and should not destroy the correspondence between the reasoning subsystem and the formal semantics - Lisp, C and C++ implementations of *Classic* exist, and an API (Application Programmer's Interface) is available. The distribution is now being handled by Bell Labs and licenses for research and commercial use can be obtained (ATT 1999).

Putting it into practice

This section shows our methodology from the following points of view: 1) interdisciplinarity, 2) description of the case study, 3) formulation of the case study and 4) evaluation of the results by a biologist.

Interdisciplinarity

The framework in which this research has been carried out is characterized by the convergence of anthropological and marine biological objectives for obtaining new knowledge about Galician coastal ecosystems. The final objective is to improve and increase biological knowledge of the coastal ecosystems and to apply it in the management of Galician artisanal fisheries. In summary, this process has been carried out in the following way:

- The original question (posed by the biologist) is related to the search for information (data) and knowledge about species of fishery interest;
- In the population-dynamics framework, a catalogue of themes to elicit is established in the fishers' communities under study;
- Using social science methodologies, a large corpus of knowledge relating to this field is obtained;
- The knowledge is systematized and methodologies of closed interviews, discussion groups, etc., are applied;

- Since the knowledge obtained from fishers is much extended, one specific topic, the microhabitats, was selected to be formalized.

Description of the case study.

When speaking about coastal ecosystems, fishers frequently mention elements and descriptive characteristics of the marine benthic habitats associated with the presence of different species. Also, in their descriptions, fishers include variables such as depth, tides, time, season, climatology, etc. This knowledge, once it has been systematized, allows the construction of a typology of bottom classes and their relationships with the species. Since both the knowledge and the information about this topic is extensive, we selected it as the topic of study.

Specifically, the relationship among different types of rocky bottoms (microhabitats) and a selection of species (involving crustaceans, molluscs and fishes) is described. Other species, such as seaweeds or echinoderms, were excluded to make the results easier to understand.

For rocky bottoms, fishers differentiate spatial and morphological categories according to the types of rocks and the species using the different microhabitats. The rocks are characterized using morphological factors such as form, size, rugosity, height, etc (BOLO, LAXA, PETON, PEDRA BRAVA, CHAN, LAXA, CABEZO, etc.). These categories are related to their location and extension over the bottom, constituting characteristic microhabitats: VEIRADAS, BOLEIRAS, OIADOS, RODAS, etc. Fishers use these microhabitats as the conceptual background to their daily fishing operations decision-making.

Definition of some of the concepts used by fishers:
"Bolos": smooth and round rocks.
"Boleiras": a zone of boulders of variable size extended randomly over a smooth rocky substrate.
“Laxa”: flat rock .
"Laxeado": area of flat rocks covering surfaces of up to 6000 m^2.
"Pedra brava": rock with strong rugosities.
"Chans": rocky bottoms without relief.
"Cabezo": a rock with a high relief but always underwater.
"Veiradas": transition between sandy and rocky bottoms.
"Oidados": areas with mixed rocky and sandy bottoms. Usually small areas, between 50 and 100s of m^2.
"Roda": small area of rocks inside a large sandy bottom.

Formalization of the case study

We must recall that our goal is not only to represent FEK; but also that the anthropologist become involved in this task. We distinguish three phases.

1. The anthropologist is trained in the basic concepts of terminological languages.
2. The domain must be broken down into its elements in accordance with the representation basics.
3. The result of the second phase must be transformed in *Classic* expressions.

Firstly, the anthropologist must acquire the basic concepts of descriptive languages: individuals, concepts, roles and taxonomies. This can be done in an informal but fair way without resorting to formal model-theoretic notions. DLs are particularly well suited to this process because their basic elements can be explained just using elementary set-theoretic and algebra concepts.

When developing a Knowledge Base (KB) in a terminological language, the second phase is a knowledge engineering process where the key is finding the way to break the domain into individuals, concepts and roles. In the case of *Classic* a methodology especially devised for beginners is available (Brachman 1991). Though this method may oversimplify some aspects of the knowledge representation process, it is ideal for our purpose of introducing the anthropologist to using Classic. The method consists of twelve basic steps exemplified with the *wine and meal* example: 1) enumerate object types, 2) distinguish concepts from roles, 3) develop concept taxonomy, 4) isolate individuals and for each individual try to determine all of the concepts that describe it, 5) determine properties and parts, 6) determine number restrictions, 7) determine value restrictions, 8) detail unrepresented value restrictions, 9) determine inter-role relationships, 10) distinguish essential and incidental properties, 11) distinguish primitive and defined concepts, 12) determine disjoint primitive concepts.

Background:

- The example analyzed here has not been the subject of specific scientific studies, at least in our area.
- There is a previous general knowledge of the habitat use of the species, basically using wide habitat categories defined by the type of substrate (sand / rock), which is not useful for management objectives.

```
(createRole shape true)
(createRole rugosity true)
(createRole fastening true)
(createTole size true)
(createrole surface-closeness true)
(createRole height true)
(createRole fishes)
(createRole bordering true)
 (createRole rocktype)
(createRole sand true)

(createConcept ROCK (and  (all rugosity (oneOf Smooth Rough))
                          (all shape (oneOf Rounded Flat))
                          (all fastening (oneOf Fastened Loose))
                          (all size (oneOf Small Medium Big))
                          (all surface-closeness (oneOf Near Far))
                          (all height (oneOf High Low))))

 (createIndividual Bolo (and ROCK (fills rugosity Smooth)
                          (fills shape Rounded)
                          (fills fastening Loose)
                          (fills size Small)))

(createIndividual Laxa (and ROCK (fills rugosity Smooth)
                          (fills shape Flat)))

 (createIndividual Peton (and ROCK (fills fastening Fastened)
                          (fills height High)))

 (createConcept FISH (oneOf Wrasse-female Wrasse-male Turbot
                          (Sea-bream Velvet-swimming-crab Octopus Conger-eel Bib))

(createConcept ENVIRONMENT (and (all bordering (oneOf Yes No))
                          (all rocktype ROCK)
                          (all sand (oneOf Yes No))
                          (all fishes FISH)))

 (createConcept OIADOS (and ENVIRONMENT (fills bordering No)
                          (fills rocktype Bolo)
                          (fills sand Yes)))

 (createConcept VEIRADAS (and ENVIRONMENT (fills bordering Yes)
                          (fills sand Yes)))

(createConcept RODAS (and ENVIRONMENT (fills bordering No)
                           (fills rocktype Peton)
                          (fills sand Yes)))

(createConcept BOLEIRAS (and ENVIRONMENT (fills bordering No)
                          (fills rocktype Bolo)
                          (fills sand No)))

(createRule one VEIRADAS (and   (fills fishes Wrasse-female)
                          (fills fishes Wrasse-male)
                          (fills fishes Turbot)
                          (fills fishes Sea-bream)
                          (fills fishes Velvet-swimming-crab)
                          (fills fishes Octopus)))

(createRule two OIADOS (and (fills fishes Conger-eel)
                          (fills fishes Wrasse-male)
                          (fills fishes Turbot)
                          (fills fishes Sea-bream)
                          (fills fishes Velvet-swimming-crab)
                          (fills fishes Wrasse-female)))

(createRule three RODAS (and   (fills fishes Bib) ))
            (createRule four BOLEIRAS (and  (fills fishes Conger-eel)
                          (fills fishes Octopus)
```

Figure 1. Terminological Knowledge Base written in Classic

Practice with this method is done through the use of real examples extracted from FEK. For instance, the anthropologist has useful knowledge about rocks (*laxa, bolo, petón*), clusters of rocks (*veiradas, oiados, boleiras, rodas*) and species associated with these *environments* or microhabitats. Following the method, this domain is decomposed into elements of the terminological language. The result of the second phase is an informal representation that in the third phase must be transformed into a *Classic* KB. To serve as an example, Fig. 1 shows the *Classic* KB with fishers' knowledge about microhabitats of some species of interest.

The following lines explain the meaning of the KB. The first ten terminological axioms define the set of roles of the KB using the function *createRole*. *Roles* are the entities that represent the properties of individuals. They map individuals to other individuals. The roles of an individual can be filled by individuals (the role fillers) or have their potential fillers restricted by concepts, or both. Each role definition includes the name of the new role and the boolean specifies whether the role is an attribute. An attribute is a role that has at most one filler. For instance, size is an *attribute* because we use this role to model a property for rocks and a rock is supposed to have a specific size. On the contrary, 'fishes' is not an attribute because this role models the relationship between an environment and the fishes within it. Clearly, within an environment different species can occur. The first six role axioms correspond to properties for rocks and the last four role axioms define environmental features. After creating the roles, we define the concept ROCK by means of the function *createConcept*. In this terminological axiom the symbol ROCK is the name of the concept being defined and the description is the concept definition. The 'and' concept constructor creates the conjunction of a number of descriptions. The 'all' restriction specifies that all the fillers of a particular role must be individuals described by a particular description, and 'one-Of' is a concept constructor which forms a concept enumerating its individuals. Therefore, the axiom defining ROCK includes a domain constraint for each one of the properties of a rock. In this case, the domain is constrained by specifying the set of individuals that can be fillers for each role. For instance, the 'rugosity' of a rock has to be either smooth or rough or the shape has to be either rounded or flat. Individuals are specific instances of concepts that are used to represent the real-world objects of the domain. Individuals are created by means of the function 'createIndividual'. In the function call, the first symbol is the name of the individual being created, and the description is the definition of the individual. The 'fills' concept constructor specifies that a particular role is filled by the individuals specified. Once a rock is defined, the individuals Bolo, Laxa and Peton are created. As an example, Laxa is an individual belonging to the concept ROCK whose rugosity is smooth and whose shape is flat. The definition of the concept FISH simply specifies the set of its individuals. The concept ENVIRONMENT models *environments* as sets of individuals whose rocktype property is constrained to be a ROCK (all rocktype ROCK) and where several types of fishes can occur (all fishes FISH).
Environments can have sand [all sand (oneOf Yes No)] and can border other elements [(all bordering (oneOf Yes No)]. The concepts VEIRADAS, OIADOS, RODAS and BOLEIRAS are subconcepts of ENVIRONMENT with specific fillers for the involved roles. Specific instances (individuals) of these concepts representing specific locations of these environments could be added to this knowledge base. The final lines of the KB define several *rules* via the function 'createRule'. A *rule* consists of an *antecedent*, which must be a *concept*, and a *consequent*, which is a *concept description*. As soon as an individual is known to belong to the antecedent concept, the rule is fired, and the individual is deduced to belong to the consequent description. The individual does not need to be described by the consequent in order to be classified under the antecedent. Once the rule is fired, the individual is further classified based on the new information provided by the rule. These rules allow us to infer automatically the set of species occurring in a given environment. For instance, from the third rule, each individual belonging to the concept RODAS has the species Bib (*Trysopterus luscus)* as one of its fillers for the role fishes. This way, when defining an environment we do not have to specify the set of fishes that occur, but the system infers them automatically. The use of rules permits to distinguish between definitional and incidental properties. The set of fishes living in a given environment is not a definitional aspect for the environment but the definitional aspects of an environment, i.e. shape, rocks, etc., are the elements that really determine the set of fishes which can live within those conditions.

Since we have to provide the biologist with the results obtained in an understandable and efficient format, we have drawn graphical representations e.g. Fig. 2. In these graphical representations we use the notation of Gaines (1991). It is important to point out that, for the sake of clarity, we allow duplication of graphical nodes that are associated with a single knowledge representation element. Note also that the graphical syntax of Gaines (1991) allows only defined concepts as consequents in rules, but *Classic* allows any concept description in the consequent part of a rule and not just a defined concept. These unnamed concepts are simply represented in Fig. 2 as ovals without labels. We have recognized a multiple purpose of this graphical representation: 1) it reinforces the knowledge engineering methodology, 2) it has been used to explain FEK to biologists and technicians and 3) it has motivated us to implement a visual terminological language which facilitates the task of writing *Classic* KBs thus giving more weight to the role of the anthropologist in the knowledge engineering process and providing a tool to overcome the difficulties presented in the third phase.

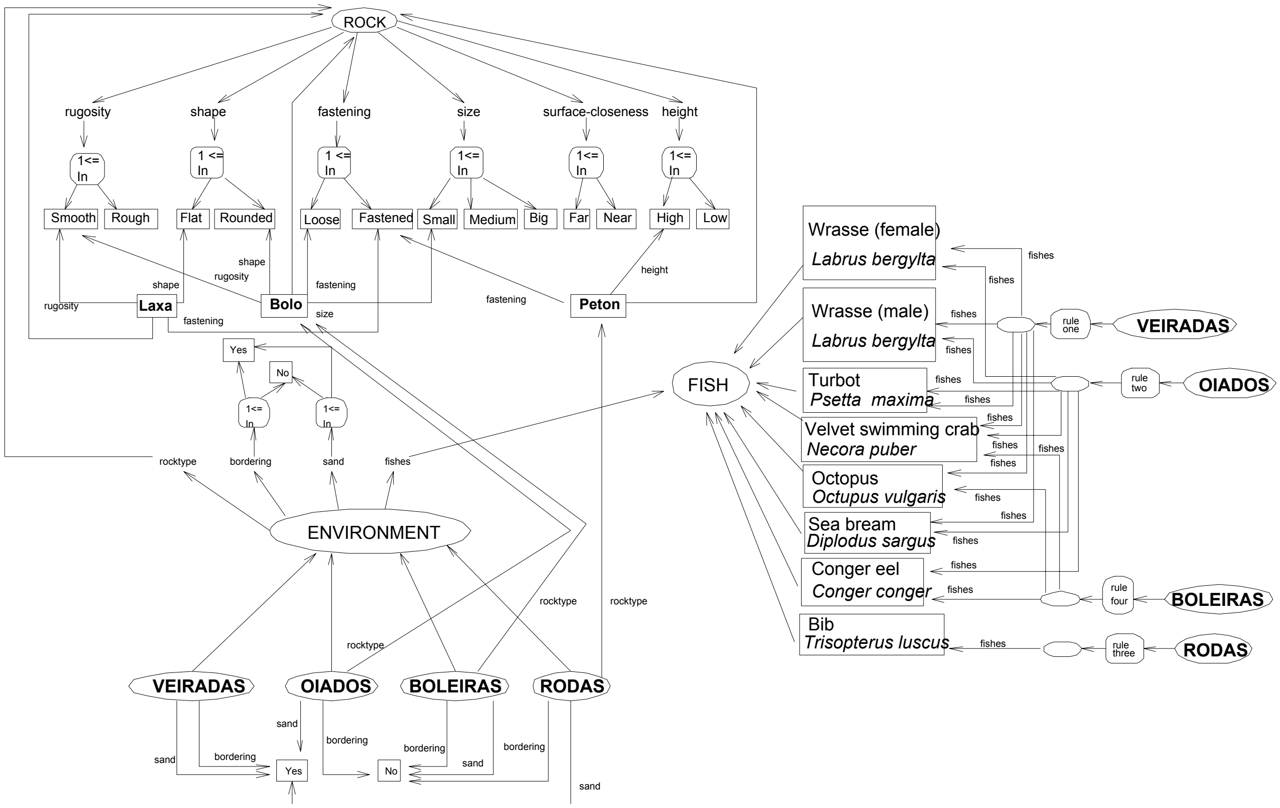

Figure 2. Graphical representation of the terminological knowledge base

EVALUATION OF THE RESULTS OBTAINED OF THE ANALYSIS OF THE FEK

Representation of the knowledge

Biologists are used to working with information in a tabular format where all variables of interest are explicit; this fact limits the usefulness of the raw verbal FEK. The representation of the knowledge base obtained *translates* the original FEK to a format operative for biological analysis. The diagram obtained clearly reflects these components and relationships and allows the biologists to use this semi-quantitative information in their hypotheses and models.

Biological knowledge obtained

The results obtained constitute new information about the problem analyzed. In brief:

- the basic components of the habitat (different kinds of rocks, defined by their morphology and size) are identified,
- the microhabitats are the result of the spatial configuration in the small-scale of these components,
- each species shows a different pattern of use of the microhabitats here identified.

The level of detail attained is very high in comparison with typical biological sampling or experimental studies, indicating the importance of some habitat features usually overlooked in scientific studies.

Potential uses of the results obtained

Two basic applications are identified in the biological and fisheries management contexts:

- **Fisheries management**. In coastal ecosystems exploited by artisanal fleets, management models are changing from direct effort regulations to systems based on regulation of the use of space. In this context, knowledge of the species-habitat relationships is fundamental to assess the value of different areas and to optimize their human uses. The results of the FEK analyses combined with maps of the distribution of the habitat components would allow rapid assessment of the value of different areas and the proposal of management strategies based in different uses of areas.

Visual terminological language

To facilitate the use and understanding of these methodologies to other potential users (fishery technicians, biologists, fishers, etc) we decided to use help tools for this task. For this reason we transformed these languages into visual languages to improve the usability. In this section we describe a visual terminological language for *Classic* and give a sketch of the implementation.

The visual language

For the sake of being concise, the visual syntax is illustrated with figures 3, 4 and 5.

Visual descriptions.
Fig. 3 shows the visual descriptions that can be built with concept constructors, and the corresponding *Classic* expressions. *Classic* has no role constructors, therefore the only role expressions are formed with atomic roles. For this reason there are no additional visual role descriptions.

Visual axioms and rules.
Concept descriptions and atomic roles and attributes are used in the axioms that define concepts, individuals and roles, and in the rules definition. The visual axioms and rules, and the corresponding Classic expressions are shown in Fig. 4.

Temporal definitions. The visual language provides temporal definitions for concepts, individuals and rules. These elements allow us to differentiate between what is being defined (temporal axioms and rules) and what is actually defined (real axioms and rules). Fig. 5 shows a temporal definition for the case of a defined concept.

Implementation

Visual descriptions, axioms, rules and temporal definitions are represented as Directed Acyclic Graphs (DAGs). Operations over these visual elements are implemented as operations over graphs. Fig. 6 shows the main window of the interface for this visual language. In the normal operation and using the buttons on the left, the user can define roles and attributes, build visual descriptions, attach them to concepts and individuals to create temporal definitions and eventually transform these temporal definitions into axioms and rules. The result is a visual knowledge base, i.e. a collection of visual axioms and rules subject to certain rules that facilitate the visual representation. For instance, note how in Fig. 6 the representation of the visual axioms for the definition of Bolo and ROCK avoid the duplication of the ROCK node, but for reasons of clarity in the visual representations, duplication of nodes corresponding to the same role rugosity is allowed. Also note that roles do not carry descriptions with them due to the absence of role constructors, this facilitates the graphical duplication of role nodes.

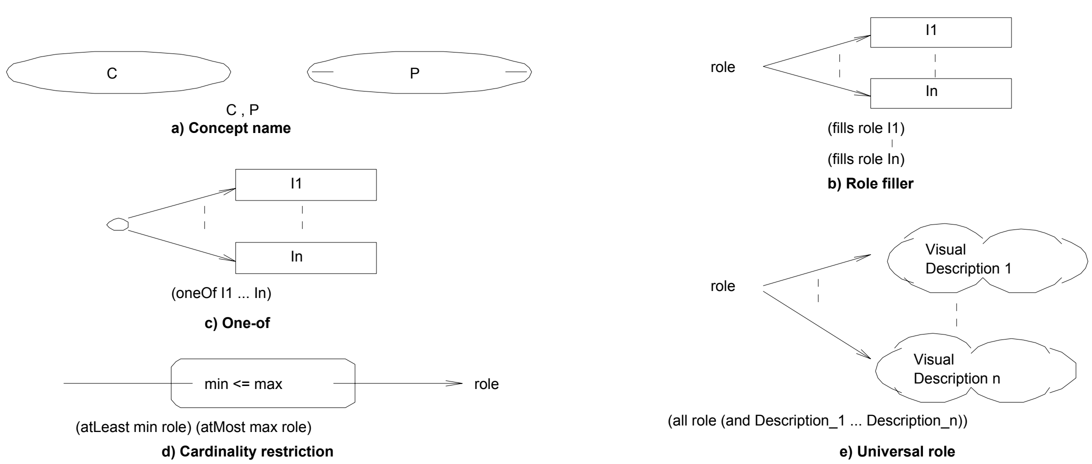

Figure 3. Visual descriptions

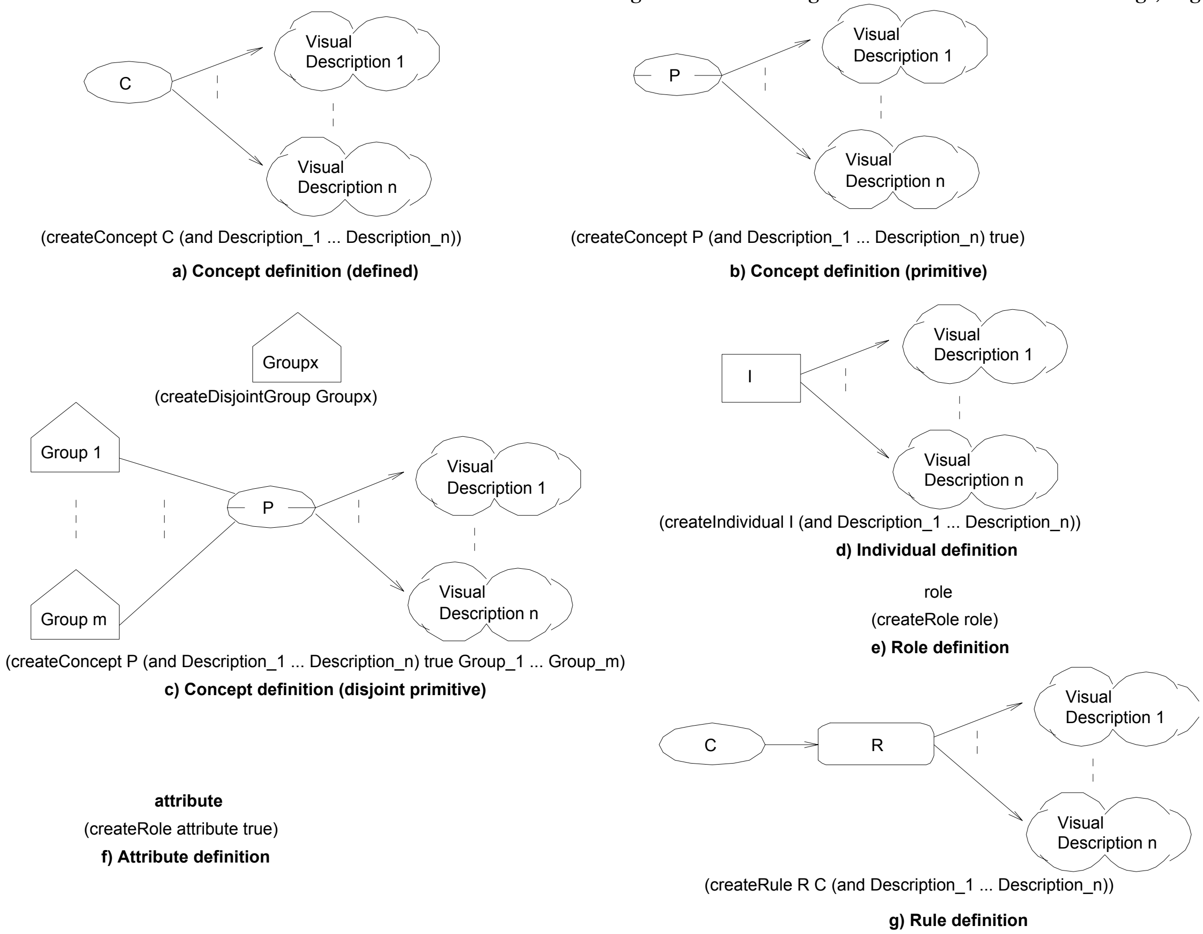

Figure 4. Visual axioms and rules

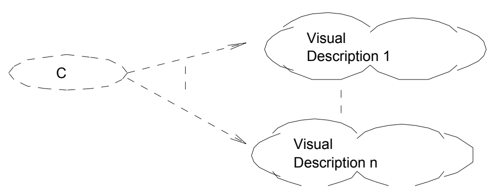

Figure 5. Temporal definition of a defined concept

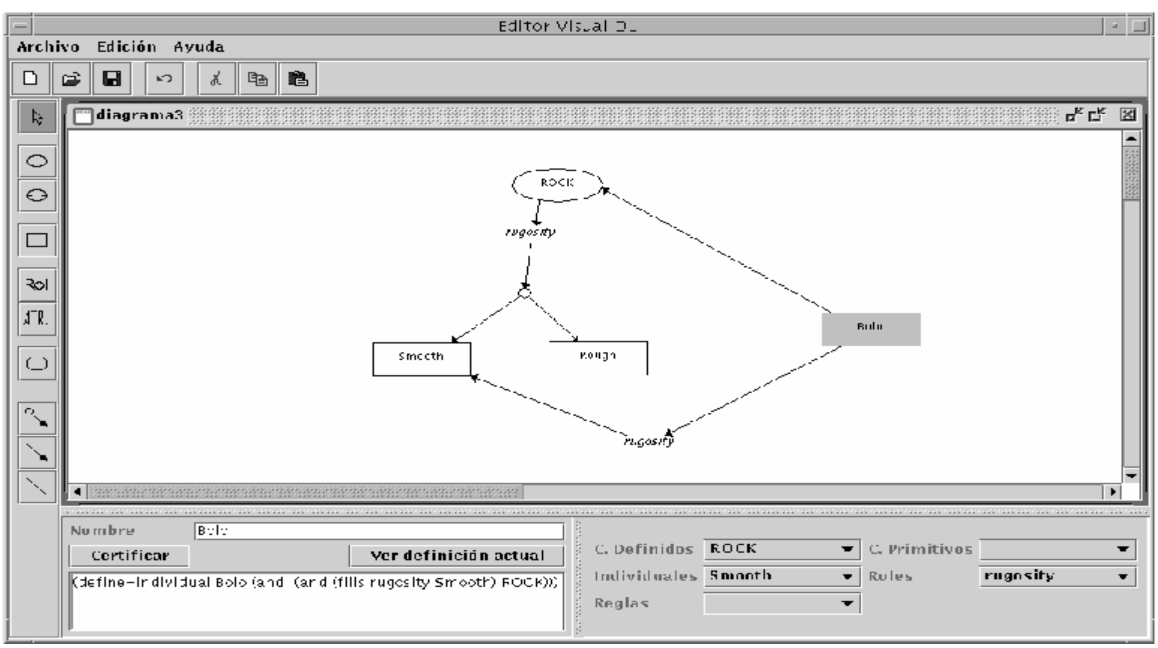

Figure 6. Interface for the visual language

CONCLUSIONS

We have presented a methodology to incorporate Fishers' Ecological Knowledge in the research of artisanal fisheries based on a knowledge representation formalisation and a knowledge engineering technique reinforced with the appropriate tools. An evaluation of this work in terms of usability, productivity and knowledge content is still to be done and in this task anthropologists, biologists and fishers themselves must be involved. But preliminary results are encouraged and we think that this approach can be considered in other domains where Traditional Ecological Knowledge can be incorporated into the management of natural resources.

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Integrating Fishers' Knowledge with Survey Data to Understand the Structure, Ecology and use of a Seascape off Southeastern Australia

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Abstract

Australia involves fishers at all stages of the fishery assessment and management process. A key factor in the success of this approach is using fishers' information to supplement and interpret standard fisheries data. From 1994, we collected fishers' information on fishing grounds and habitats as part of a 5-year study of a continental shelf fishery. We met regularly with experienced fishers during port visits, commercial fishing operations at sea and in formal (management) meetings. This pattern of liaison enabled us to build relationships and a level of trust that facilitated a two-way sharing of knowledge. We integrated the ecological knowledge of fishers with scientific survey data to map and understand the seascape (seabed landscape) in a way that would not have been possible from scientific data alone. Fishers provided detailed information on the fishery, navigation, fishing effort distribution, individual species, fish behaviour, productivity, seabed biology, geology, and oceanography. A key result was an interpreted seascape map incorporating geomorphological features and biological facies at a variety of spatial scales of resolution from 10s to 100s of km. Supported by industry, we are now extending the mapping project to the entire shelf and slope of the South East Fishery region. Fishers believe that the project provides them with the opportunity to contribute to developing spatial management under Australia's 'Oceans Policy', and guarantees their involvement in a developing program of 'regional marine planning'. However, they also fear that their information will be used against them - especially for closing off valuable fishery areas. We discuss the importance of fishers' knowledge to interpreting scientific data, and the need for an ongoing dialogue between the fishing industry, scientists and managers. Only this ongoing dialogue will ensure that fishers' knowledge is used appropriately and, equally importantly, that fishers' concerns are addressed in developing management options for this area.

Introduction

Management of the world's oceans has typically been driven by single issues – for example, how many fish to catch, where to discard waste, where to mine, dredge, or drill for oil, and more recently which areas to protect (Allison *et al.* 1998; McNeill 1994). At its simplest, single-issue management can be achieved with specific and limited information and by ignoring many of the potential interactions with other issues or aspects of the marine environment. However, coincident with our increasing awareness of the ecosystem services provided by the marine environment (Norse 1993), is an increasing recognition of the limitations of single-issue management (Sainsbury *et al.* 1997), especially as our use of the oceans continues to increase.

It is no longer sufficient to manage a fishery solely on the basis of the number of fish removed; instead, where and how fishing occurs, and with what impacts, have become equally important questions. To answer these questions requires first that we define the management units we are dealing with (Langton *et al.* 1995). In particular, and as has been the case on land for centuries, spatial attributes of the marine environment have become increasingly important for effective management. This requires that we understand the ecological patterns at regional and local scales, and integrate over these scales to provide a 'seascape' perspective (Garcia-Charton and Perez-Ruzafa 1999).

Australia is developing integrated management of its marine resources through *Australia's Oceans Policy*, launched in December 1998. Principal drivers for the policy are: ecosystem-based management; integrated oceans planning and management for multiple use; promoting ecologically sustainable marine-based industries; and managing for uncertainty (Commonwealth of Australia 1998). It is recognized that real success of the plan will depend on all Australians gaining an appreciation and understanding of both the complexity of the ocean environment, and the interaction of humans within that environment (Sakell 2001).

The marine environment off southeast Australia is the test case for 'regional marine planning' in Australia as it forms the first of 13 'large marine domains' (LMDs) that will eventually be covered by management plans. While there are some spatial data relevant to fishery management available for this area, in general they are either of low resolution (e.g. the start and end positions of commercial fishing operations from fishery logbook records), or lack ecological interpretation (e.g. bathymetric and geological maps from geoscience sampling). Until recently, little was known about the spatial organization of habitats (substrata, biota and adjacent water column) or the ways in which the seabed is used as fishing grounds. Seabed habitat in the South East Fishery (SEF) was mapped for the first time as part of a five-year study to interpret the ecological processes contributing to the productivity of the shelf fishery ecosystem – 'the ecosystem project' (Bax and Williams 1999). The SEF is a complex, multi-species, multi-sector fishery (Tilzey and Rowling 2001) that operates in a large fraction of the South East LMD adjacent to mainland Australia. The mapped area was ~24,000 sq km of the continental shelf (~25-200 m depths) adjacent to the coastline between Wilsons Promontory in eastern Victoria and Green Cape in southern NSW – the south-eastern point of the Australian continental margin where east and south coasts meet (Bax and Williams 2001: Fig. 1). In that study, survey data provided the means to determine the structure of the seabed and its association with biological communities and environmental factors at particular scales in space and time (Bax and Williams 2001; Williams and Bax 2001). The addition of fishers' ecological knowledge aided the interpretation of those associations, as well as enabling an understanding of the ways in which the seabed is used by the commercial fishing fleet. As it turned out, fishers' information was so useful that we developed a second study – 'the mapping project' – using fishers' information on habitat types and distribution (interpreted through scientific knowledge and ground-truthing) as the primary data source to develop fine-scale maps of the southeast Australian seascape.

In this paper, we first describe how fishers' knowledge contributed to the ecosystem project and explain why this provided a better understanding than a study based on scientific survey data alone. Second, we provide an overview of our methodology for collecting and integrating fishers' knowledge in the follow-up mapping project. Finally, we draw attention to the benefits of combining fishers' ecological knowledge with scientific survey data to provide a seascape perspective of the marine environment, and stress that this combination requires an ongoing dialogue between the fishing industry, scientists and managers. The direct benefit of combining our knowledge in this way is an improved understanding of the seascape. An indirect benefit is that it empowers fishers with the opportunity to be actively involved in developing management options for the marine environment that they are most familiar with.

The South East Fishery

The continental shelf and slope off south-eastern Australia is the area of greatest fishing effort within the South East Fishery (SEF) – Australia's largest scalefish fishery, and the most important source of scalefish for domestic markets. Trawling started in the early 1900s, and by 1999 the SEF fleet was made up of 89 operating otter-board trawlers (draggers) and 20 Danish seiners (the 'trawl sector') (Tilzey and Rowling 2001), as well as a smaller number of demersal longliners, dropliners, mesh-netters and trappers (the 'non-trawl sector'). More than 100 species form the commercial catch of the fishery, but 18 species or closely-related species-groups managed by a system of catch-quotas make up the bulk (> 80%). Annual total allowable catches of individual species range from a few hundred to a few thousand tonnes generating a total value for the fishery of about A$70 million.

Overview of the 'ecosystem' and 'mapping' projects

The ecosystem project was designed to consider the ways in which management intervention, beyond the established single-species fisheries management, could have a direct effect on the long-term productivity of this fishery ecosystem (Bax *et al*. 1999). Production was taken to mean both the production of fish and the factors that determine their availability to the fishery, while our concept of "ecosystem management" was tied strongly to the notion of needing to manage peoples' interactions with ecosystem components (Bax *et al*. 1999). Engagement with the fishing industry was desirable to understand how fishers viewed the ecosystem, how they interacted with it, and how to best target our limited survey time. Accordingly, we initiated a two-pronged industry liaison program when the project started. Depending on individual skills and experience, members of the project team became involved in formal fishery management and assessment meetings, and/ or spent time in the two big ports in our study area (Eden and Lakes Entrance) and did trips to sea on fishing boats (several trips in the first year, then only 1-2 per year). A particularly useful feature of our sampling program was using industry vessels for specialized fishing. Collectively, these interactions enabled us to establish contact with a range of industry personnel from the working skippers to the association executives. This gained us the support (and data) of individual operators and, in addition, the endorsement of the executive to further develop the project.

We maintained fairly regular contact with a core group of operators and were able to build up a level of trust and dialogue with this core group as the project developed. Our findings were reported back to individuals and the peak industry associations on an ad-hoc basis during the course of the project. So, in summary, our approach to industry involvement evolved naturally during the ecosystem project – importantly, it lacked systematic planning or protocols, and there were no obvious benefits for industry.

The contacts with industry members and associations that we developed during the ecosystem project proved crucial in garnishing support for the second project – the mapping project – that makes extensive use of industry information and has explicit benefits (and risks) for industry. In this partnership project, we are extending the seascape mapping to the entire continental shelf and upper slope (to ~ 1000 m depth) of the SEF region. In contrast to the ecosystem project, the mapping project has a planned methodology for collection, review and release of industry data. However, our approach is necessarily adaptive as the scale and detail of outputs are realized, and as industry responds to a rapidly evolving environmentally-focused fishery management regime. Key elements of the methodology are discussed in the final part of this paper.

Value of fishers' knowledge for navigating and mapping

When we started the ecosystem project our means of navigating around the fishery seabed was limited to what could be gleaned from third-party, coarse-scale bathymetry data and navigation charts – primarily point-source depth soundings, the approximate positions of key depth contours including the continental shelf edge at ~ 200 m, and the positions of some near-surface rocky banks identified as shipping hazards (Table 1). This information, in combination with some prior survey data and some rapid exploration by echosounding during survey, enabled us to fix a set of transects and sampling sites, stratified by depth and latitude (Bax and Williams 2001: Fig. 1). These were used for broad-scale coverage of the area during 4 seasonal trawl surveys – by definition on sediment substrata. But to meet the core aim of the project, which was to understand the importance of habitat to fisheries productivity, we needed to both survey a range of characteristic rocky reef habitats in the study area and understand the spatial context of habitats, e.g. patch sizes, boundary types and distributions.

This is where we really started to benefit from our dialogue with fishers – they told us where to look. At an early stage we were able to build a focused study of habitats into the field surveys to intensively sample at a relatively small number of sites (Bax and Williams 2001: Fig. 1). This enabled us to understand the ecological roles of particular features, and their often small spatial scales (100s of meters to a few kilometers), for example the use of prominent reef edges by commercially important semi-pelagic, feature-associated species. Fishers' knowledge (Table 1) enabled us to progressively build a spatial framework on which to interpret the range of information we were collecting during our surveys. For example, by providing information on the boundaries of rocky reefs we were able to produce thematic maps of underlying geology (Bax and Williams 2001: Fig. 3). Over the course of the project we collected sufficient spatial information from fishers to put together what we called our 'fishers map' (Bax and Williams 2001: Fig. 4). In many ways it is a coarse-scale map of habitats, although its units – fishing grounds – are actually a hybrid mix of geomorphological features, such as sediment plains and rocky banks, and biological facies or biotope types – patches of substratum dominated by one particular community or animal. In summary, fishers contributed unique mapping knowledge, such as ground types, boundaries and names, which enabled us to understand the make-up of the seascape at a variety of spatial scales – from small-scale features through to a regional overview.

Value of fishers' information for understanding species' ecology and their environment

Two fundamental differences between observations made by fishers during commercial fishing and by scientists during survey are related to the timing and frequency of sampling - the temporal and spatial resolution (Table 1). While time spent at sea by skippers varies considerably, some average over 200 days per year and sustain this for many years, building on the experience of their parents or other older skippers. In addition to learning where to fish, their mode of operation often includes searching and watching to enable precise target-fishing of fish "marks" seen on echosounders. For example, the first shot of the day is often delayed until the 'feed layer' (or acoustic scattering layer) descends to the bottom – around first light

Table 1 Sources and types of information used to describe the continental shelf seascape in the south-eastern South East Fishery during the 'ecosystem project'

	Project surveys	Fisher's knowledge
Navigation over seabed	Navigational charts, depth contours	Accumulated maps in charts and plotters; names for features
Fishery	Fish species and size composition (quantified seasonal catches– trawl, trap, mesh-net)	Fish species and size composition (unquantified daily catches– trawl, mesh-net)
Fish behaviour (use of grounds)	Seasonal, diel (at times of surveys)	Time scales from days to decades
Fishing effort distribution	Logbooks (aggregated start position data)	Detailed tracks and marks of individual vessels
Productivity	Detailed energy flows at set points in time	Dependability of fishing grounds over decades
Seabed biology	Fish and invertebrate communities (quantified, but few samples from nets, sleds, and photography); detailed species information	Dominant fish and invertebrate types (unquantified, but numerous net catches); local species-mixes or 'taxonomies'
Seabed geology	Rock type and geological history (dredge rocks); sediment classification (grab samples); depth contours (echo soundings from survey track lines)	'Ground-type' classification (gear damage/ wear, by-catch of rocks, mud etc.); depth contours (echo soundings accumulated over years of exploration)
Oceanography	Regional surface currents (SSTs; sea surface height) and local vertical structure (CTDs); bottom currents (sediment modification in photographs)	Local surface and bottom current direction and speed (gear/ vessel behaviour)

(Prince *et al.* 1998). In contrast, our survey samples (a combination of randomly directed and targeted) were fixed on the calendar, but essentially random in time as they took no account of the annual variability in seasonal progression (Bax *et al.* 2001) or of fine-scale patterns of fish movement. Sampling was only regulated (standardized) to either day or night, but not by season, or by considering a site-season interaction. Relative to the high number and frequency of commercial sampling, surveys represent very brief snapshots in time and space. In the year when we sampled most intensively (2 surveys in 1996) we completed less than 100 trawl tows on the continental shelf (< 250 m depth) while the trawl fleet completed over 10,000 – a two orders of magnitude difference in intensity spread widely across the fishery.

What differences in knowledge of species ecology and the fishery ecosystem resulted from these differences in sampling? One of many species examples is illustrated by the morwong (or sea bream), a mainstay quota species on the domestic market. Our survey sampling – including targeted sampling based on prior information from fishers – showed that morwong were associated with limestone reef and sediment substrata, and had high abundance on reef edges. It is primarily a benthic feeder, and presumably moves away from the shelter of reefs to forage on sediments plains. It had a generally higher abundance in the southern part of the study area (consistent with its broad temperate distribution) and was most abundant (in our seasonal trawl samples from sediment plains) in spring and autumn. Catch rates were higher during the day than at night in diel gillnet samples. Local trawl fishers report that movements of morwong are linked to season, depth, habitat type and time of day in a more complex way. Thus, in autumn, they catch this species in the south of the area, but catches are taken progressively shallower and northwards over a period of weeks, during which time it is caught only at night (i.e. it is not available to trawl during the day). Through winter and spring, with a peak in September, morwong move onto the elongate banks of limestone reef to the north where they are caught in what are called the "gutters" between reefs, but now *only during the day*.

Our scientific data show that this is not a spawning movement, and while oceanographic data indicate a general correlation between the horizontal movement of fish and opposing seasonal flows of warm and cool currents, the processes that drive the depth-related, substratum-associated and vertical patterns (the latter inferred from variable availability to trawl) remain unexplained. Irrespective, the distinct patterns known to fishers would be very unlikely to be detected by a typical scientific survey or by analysis of logbook data, and this is just one of the many examples for individual species. Information at this fine spatial and temporal resolution, unless provided by fishers, is not available to survey design, for the interpretation of CPUE or other fishery statistics, nor to assist an understanding of individual species' ecology such as habitat utilization.

Although fishers tend not to talk about their knowledge of the fishery "ecosystem", it is the environment in which they conduct the business of catching fish. For example, successful fishers have considerable insights into structures and processes that affect production – the availability of particular species or species-groups, of the right size, and in commercial quantities. In our region, fishers know that production is concentrated at the shelf break and on the upper slope (~150-700 m) particularly around canyon heads. Successful fishing depends on knowing when and where the right combinations of depth, bottom types, currents and good feed marks occur together. There are hot-spots, but they are dynamic over periods of days, weeks or years – for example, with hydrodynamic climate being influenced by daily tide, episodes of upwelling, wind-driven currents, and the moon, as well as 'long-term' seasonal events. Fishers may not be aware of the movement of the eddies of the East Australian Current onto the shelf, but their observations of how fish catchability changes with 'clean' or 'dirty' water matches the movement of these eddies. The extent to which hot-spots can be detected or predicted is closely linked to the degree of success in fishing over time.

We were able to explain some of the patterns known to fishers by identifying food webs and sources of primary production from analysis of diets, stable isotopes and pigment breakdown products in survey data (Bax and Williams 1999; Bax *et al.* 2001). Oceanic production (food) is highly important whereas terrestrial or nearshore inputs are relatively trivial. Commercial shelf fishes– including many traditionally viewed as demersal or 'bottom dwelling'– prey heavily on the animals that form 'feed layers' in the oceanic water column (pelagic prey) as well as those in local sediments (benthic prey) (Bulman *et al*, 2001). As a consequence, the seabed at the shelf-break is productive because it is bathed with upwelled slope waters containing high levels of nutrients, particulate organic matter, oceanic pelagic prey, and particular elements of oceanic micronekton at their near-shore limit of distribution (e.g. lanternfishes) (Bax and Williams 1999). Fishing is especially productive in the first few hours of daylight, the time at which this feed layer intersects with the bottom. Thus, because fishers and scientists tend to observe the fishery ecosystem at different spatial and temporal scales, their observations are often complementary. Fishers' knowledge may permit scientific observing to be better targeted, and more insightful, while survey data can provide the detail that leads to a more rigorous interpretation of fishers' knowledge.

Role of fishers' information in understanding seascape use

The ways in which the seascape of this area is being used and impacted by fishing is the subject of developing interest by fishery mangers, environmental and conservation agencies, the general public, and by industry itself. Management of the seabed is being considered more actively, but whereas spatial management (or zoning) is universally accepted on land, it has only recently been considered as an option, or even necessary, in the ocean (Bohnsack 1996). Spatial management on the land has benefited from numerous datasets available from visual observation of the landscape – in person, from the air, or via satellite. Similar information is not available for the seascape because it cannot be observed directly (except at the shallowest depths). Increasingly, scientific surveys can be used to provide detailed 'pictures' of the seabed with single beam acoustics (Kloser *et al.*, 2001a) or multibeam acoustics (Kloser *et al.* 2001b), but even the most modern techniques are very time consuming and therefore expensive, especially at shallower depths where the acoustic sampling footprint is comparatively small. Only large-scale undersea features such as upwellings of colder water driven by topographic features or sea level rises over submarine ridges can be observed from satellite. What is needed for spatial management, at anything less than the coarsest scale (bioregion and depth), is an information source of sufficient resolution to detect seabed features at the scale where management is possible (less than 1 km for fisheries where satellite transponders are fitted to vessels). Fishers operate below this level of resolution, and we suggest that their information has the potential to provide information on the seabed at a scale suitable for spatial management.

In the SEF, the distribution of trawl tows has been used as an index of disturbance (Larcombe *et al.* 2001). However, interpretation of the resulting maps is limited because fishing is highly targeted at specific seabed features that occur at scales less than the typical 3-hour trawl tow. Even unaggregated trawl start (or end) positions are poor representations of tows that are, on average, three hours in duration and therefore up to ~10 nautical miles in length. Analysis based on shot mid-points provides a closer spatial approximation of effort by considering both end-points, but suffers from the introduction of unknown errors because trawl tows do not follow straight lines. They most often follow physical boundaries and may involve several directional changes, for example to navigate through 'broken-ground'; the ~12-nautical mile 'Snake Track' through the Howe-Gabo Reef complex is one aptly-named example. We conclude that logbook data (start and end positions) enable interpretation of effort distribution at the scale of fishing grounds (10s-100s of sq km), but provide limited insights into impacts of seabed use because most significant habitat features occur at a finer spatial scale (10s-1000s of sq m) (Bax and Williams 2001).

In the SEF, the vulnerability of seabed types to fishing impacts is highly variable. Fishers have shown us that when areas of low-relief limestone slabs are fished, benthic fauna and some of the actual substratum can be removed. On the other hand, high-relief and heavily cemented limestones will never be trawlable and these are regarded as 'natural refuges' by trawl fishers. However, these same 'natural refuges' are often the prime fishing grounds of the non-trawl sector that fishes with static gears such as gillnets, traps, and hook and line. This is a potential source of conflict between industry sectors when spatial management is introduced to the fishery. Habitat features at the scale at which the industry sectors operate will need to be considered if equitable management arrangements are to be introduced, although actual management regulations may operate at a coarser scale. The only feasible way to map the seascape at a resolution similar to that at which fishers operate, is to use the information collected by the fishers themselves. However, this information is sometimes highly confidential, being the commercial advantage that one fisher may have over another. In the following section we describe how we set about accessing this confidential information.

INTEGRATION OF FISHERS' KNOWLEDGE IN THE MAPPING PROJECT

"Integrating fishing industry knowledge of fishing grounds with scientific data on habitats for informed spatial management and ESD evaluation in the SEF" – the official title of the mapping project – has the explicit aim of incorporating fishers' knowledge of the seascape into strategic management planning. We have broad support from industry because the project is viewed as a mechanism to have industry information considered in decision-making processes for the fishery, and that *informed* decisions will result. However, support is not unanimous and this is due, in large part, to many fishers remaining skeptical that their information will not be used appropriately. Moreover, fishers are not a single cohesive group, and have different views of the system they fish, and short- or long-term approaches to sustainability – based, at least in part, on their level of tenure in the fishery. Some fishers are unwilling to share their commercially confidential information with us. Many fear that their information will be used against them, especially for closing off valuable fishery areas – they are well aware of the link between areas of high fishery productivity and areas of high biodiversity. Our approach to gathering, storing and releasing industry information needed to address these concerns to the extent possible; we needed to maximize our support from industry, whilst retaining the option to release aggregated industry knowledge to a broad audience in the form of map products.

We argued the benefits of the project aims to individuals and the peak bodies for several years (including through several failed proposals) before we gained support and funding. Our key argument was that the project would provide a tool to help industry respond to the raft of upcoming environmental legislation soon to affect the fishery. Legislation includes spatial management of all marine industries under Australia's Oceans Policy – a developing program of Regional Marine Planning that includes a National Representative System of Marine Protected Areas – as well as fishery specific "strategic environment impact assessments" that aim to support ecological sustainability. With their information systematically collected and rigorously evaluated, fishers would be positioned to critically evaluate proposed spatial management plans, such as the placement of MPAs, and require management agencies to have clearly defined and measurable aims for their proposed management options.

Interestingly, the peak industry bodies supported the project, at least in part, because they saw it as a mechanism for industry to be actively engaged in the process of management planning, rather than just reacting to it. Our hope is that the project, by broadening industry understanding of the seascape they rely on, will encourage proactive thinking and actions from industry to enhance the sustainability of their fishery. In addition, the project provides industry with a tool for improving its public image. Presently, there is discontent and concern about what fishers see as poorly-informed and often misleading media and scientific reporting on interactions between fishing and the environment. This project will provide industry with some hard facts that they can use to demonstrate their real level of impact on the seascape – the trawl sector is particularly keen to be able to demonstrate that large areas of the fishery are untrawlable or untrawled.

The project is structured in a very transparent way to give fishers a high degree of control over the form in which information is released and the timing of various outputs. We have agreed that habitat maps of the area will be released following review by individual contributors and the relevant associations, and that these maps will include summary detail from commercially confidential information. Higher resolution maps of specific areas of interest, showing precisely the trawled and untrawled areas may also be released but these will require the approval of individual fishers.

The key processes and infrastructure of the project include:

- Project staff that are known and trusted by fishers - including consultants who have history and regular contact with the trawl and non-trawl sectors
- Data collection in ports and at sea
- Registration and strictly controlled storage of industry's information
- Rapid data acquisition and map-making by using raw track and mark data from fishing vessel trackplotters in conjuction with a GIS
- Collection of habitat attribute data (including terrain and bottom types, species mix and fishing patterns) using a questionnaire that was developed with industry help
- Verification and validation procedures to ensure data are scientifically rigorous
- Data management (spatial and attribute) and map production facilitated by a custom-designed spatial database
- A step-wise release of map products with clear arrangements for industry review and approval of maps prior to release
- A statement of arrangements and responsibilities of CSIRO and industry set out in a memorandum of understanding
- Field sampling from industry vessels - including photography with a high-tech camera system designed and built as part of the project
- Value adding with scientific survey data (geology/ oceanography/ video)
- Continued involvement of industry through the associations, and
- Involvement of a Steering Committee with cross-sector industry representation

Our approach is adaptive to a degree for two main reasons. First, it is difficult to determine what level of spatial scale and detail is acceptable for map outputs until data are collected and mapped. We have an explicit step-wise protocol for making, reviewing and releasing maps – but this has the flexibility to release maps at various resolutions depending on the specific needs and concerns of ourselves and industry. Secondly, the implementation of the new legislation for this fishery is evolving rapidly: the transition from conceptual to operational objectives may make demands on information that we have not anticipated. For that reason we have developed a comprehensive questionnaire, requiring the repeated involvement of active fishers. The resulting data will be available as new management approaches develop, thus allowing industry to have an input in their development, and managers to access information in a form that best addresses their specific management objectives.

CONCLUSIONS

Management for conservation, multiple-use or fishery goals will benefit from collaboration with the fishing industry because fishers know the seascape considerably better than other stakeholders, and they have a broad understanding of the processes that influence fishery productivity. As concisely stated by Neis (1995), "fishers deal regularly with a landscape that no one has seen". In addition, fishers potentially provide the means for cost-effective acquisition of mapping data over large areas, and they have an important stake in ensuring that any spatial management of the seabed is based on reliable information interpreted appropriately. Acquiring reliable data requires a structured, verifiable collection process, and methods to resolve conflicting information.

However, collaboration with industry is not limited to acquiring their data, but requires an ongoing dialogue if the data are to be interpreted judiciously, and industry is to understand the value of any proposed management measures (Neis 1995). Developing maps of the seabed is one thing, but interpreting them to provide the basis for improved management of the fishery that accounts for the diversity and specialisation of fisher's daily activities is another. This is where the ongoing dialogue between the fishing industry and scientists really begins.

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Sustainability Vectors as Guides in Fisheries Management: with examples from net fisheries in the Philippines and Australia

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Abstract

Catch data provided by fishers, when transformed into 'sustainability vector' format, provide a broad picture of the status of fishery resources. These sustainability vectors were developed to evaluate the status of net fisheries at three fishing areas in central Visayas, Philippines and three fishing areas in north Queensland, Australia. Magnitude and direction were the two properties of a vector used. The annual catch was used as the magnitude. The length of each vector was expressed as mean annual catch per family in kg/yr. The direction of a vector was represented by the catch trend. This parameter was measured on a five-point Likert scale, from rapidly increasing to rapidly declining. The catch trends for the net fisheries were only increasing in lower Burdekin, Australia and Apo Island, Philippines. It is speculated that the fishers of Apo Island reported a high annual catch possibly due to a genuine increase in yield as a result of the established fish sanctuary. The increasing catch trend in the lower Burdekin may be due to relatively underexploited fishery resources and/or lesser competition with other fisher groups.

Sustainability vectors may be used as a handy guide for busy fisheries managers and administrators. In their present format, sustainability vectors provide the following information at the taxonomic family level: annual catch, catch trend, proportion relative to the total catch, and fishing gear used. The concept may be improved by incorporating other parameters, such as actual fishing effort, economic value of particular species and natural variations in fish population.

Introduction

One of the crucial problems in fisheries management in the tropics is the difficulty in evaluating whether or not a certain form of management is effective. For example, can it be stated that fisheries management in state X or village Y is successful? Such a question cannot be easily answered with a straightforward 'yes' or 'no'. In fact, the answer will vary if the question is posed to a fisheries manager, a practising fisher, or to an environmental lobbyist. All of these stakeholders have different perspectives of success. The evaluation of fisheries management is controversial, because it is enmeshed in the political process and affected by the subjectivity of the evaluators.

A major constraint in evaluation is the lack of valid or reliable indicators to measure either success or failure of a given fisheries management system (Smith 1996; Staples 1996b; Sainsbury *et al.* 1999). There have been attempts to construct more reliable sets of management indicators. The 1996 World Fisheries Congress (Hancock *et al.* 1996), the 1999 Australia-FAO Technical Consultation on Sustainability Indicators in Marine Capture Fisheries (FAO 1999), and the 1999 Workshop on Performance Indicators for the Great Barrier Reef (Dinesen 1999) were among the key attempts to identify indicators for a comprehensive evaluation of fisheries management programs. Unfortunately, these efforts have led to the proliferation of jargon associated with the term indicator. These included fisheries 'sustainability' indicators (Garcia 1996); 'reference points' for fisheries management (Caddy and Mahon 1995); 'barometer' of sustainability (IUCN 1997); and 'performance' indicators in the context of recreational fisheries (Kirkegaard and Gartside 1998). The significance of using reliable indicators for evaluating fisheries resource management systems is paramount as "the choice of indicator or focus will be critical to the social construction of the problem, maintaining diversity and resilience of ecosystems for sustainable fisheries" (Hammer 1995 p 147).

The critical state of fisheries management in the tropics cannot be understated (FAO 1994; ADB 1995) with overfishing an overriding issue (Pauly and Chua 1988). Wilkinson (1994) describes the worsening situation of the fisheries and other coastal resources in tropical Asia. Fisheries are crucial to the economies of both Australia (a developed country) and the Philippines (a developing country); however, there are contrasting details. There are about 10,000 commercial fishing vessels in Australia (Zann

1995), and 200 different types of fish and 60 species of crustaceans are harvested (Kailola *et al.* 1993). The "value of commercial fisheries production is estimated at A$1.8 billion per annum" (Commonwealth of Australia 1998, p 9) and the average seafood consumption is 12 kg/capita/year (Zann 1995). Fishing is comparatively economically more important in the Philippines because it is often the employer of last resort. The 1994 marine fisheries landings were 1.67 million tons (62% of total fisheries production from all sources) valued at US$1.65 billion, and the 172,000 tons exported were valued at US$578 million (BFAR 1995). Fish consumption is high at 28.5 kg/capita/year (Barut *et al.* 1997), more than twice the Australian average.

The governments of both countries are actively seeking the participation of fishers in management. This type of partnership between the government and the fishers is often called fisheries co-management and/or cooperative management (McGoodwin 1992; Pinkerton 1993; Pomeroy 1993; Sen and Nielsen 1996). It is argued that one advantage of a co-management system is that it effectively utilizes indigenous and non-expert knowledge (McCay 1993). Many governments in the tropics are now moving towards some form of co-management in the administration of their marine fisheries. Part of the institutional strengthening is the formation of Fisheries and Aquatic Management Councils (FARMCs) in the Philippines and the Management Advisory Committees (MACs) in Australia. A thrust of co-management is involving the fishers themselves, who may become partners for collecting and analysing data for the monitoring of fish stocks (World Bank 1993).

The information derived from fishers through social surveys, however, has been contentious in at least two aspects. The first is in terms of reliability. To what extent the information supplied by fishers can be relied upon has been the subject of intense debate between scientists. Many 'hard-nosed' fishery biologists would not accept the data from fishers because of statistical imprecision, or due to lack of a proper sampling design in data collection. On the other hand, many social scientists argue that the knowledge of fishers could be readily used for practical management. For example, Johannes (1981, 1998a) argues that the knowledge of fishers is even encyclopaedic in some areas; Starr and Fox (1996) report that commercial fishers' log book data on fish distribution and abundance are comparable to results from a research survey; Berkes (1994) contends that the local knowledge of fishers is useable because it has been accumulated from observation over many generations. The second aspect of the debate is how to present the information fishers provide in a way that could be useful to both researchers and policy makers. 'Sustainability' has become a byword in marine fisheries. Fishers are encouraged to become involved in achieving it. Yet there is a conspicuous lack of indicators that enable 'sustainability' to be assessed in practical fisheries management. Sustainability - which has over 100 definitions since popularised by the Brundtland Commission in 1987 - is a contentious issue because it is difficult to define in practical terms, and the expansion of the concept beyond fishing income and conservation of fish stocks is fairly recent. These indicators should be able to determine whether the fisheries are better or worse compared with some earlier point in time Pitcher (2001) argues that in depleted systems, 'sustainability' is the wrong goal – all we are doing compared to past abundance levels, is 'sustaining the present misery'. A measure of successful management is the fact that the natural resource (in this case fisheries) has not been squandered (Bromley 1992).

The objective of this paper is to compare the sustainability of net fisheries at selected study sites in the Philippines and Australia. The bases of evaluation are the reported annual catch and catch trends of fishers, through a social survey. These data sets are transformed into sustainability vectors. This study evaluates the comparability of data supplied by fishers, with the existing ecological and fishery literature, as well as view of experts. Any data collection scheme involving fisher groups should be designed in such a manner as to allow appropriate checks for verification.

METHODS

Sampling design

This study adopted a purposive (non-probability) sampling in the selection of fisher respondents. The social survey was limited to only three fisher groups in each country (see Fig.1). Hence, a total of six fisher groups was purposively selected. A census or 100% enumeration was attempted in each of the six fisher groups. Three criteria were used for selection of the fisher groups. First, the fishers were operating in marine areas under some form of marine protected area (MPA) status such as marine parks, marine reserves, fisheries habitat reserves, or fish sanctuaries. Secondly, the fishers were willing to participate by completing the questionnaire form themselves, or through a guided interview. Thirdly, secondary information on fish catch was available to which the responses of the fishers could be compared.

In an experimental sense, the six study sites were nested: three within each country. The design, in the context of social research, was a 'retrospective panel design' (de Vaus 1993). As such, the fishers were asked about their beliefs or perceptions about the status of fisheries management across two time periods: past and present.

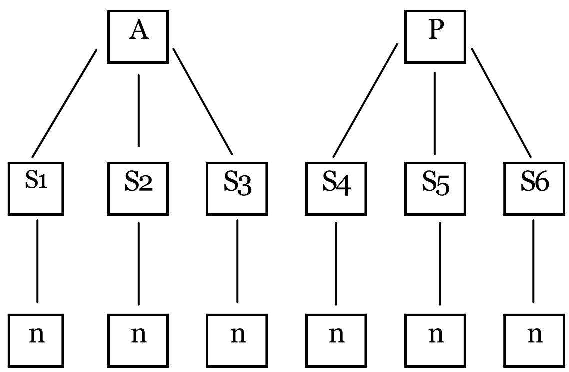

Fig. 1. Sampling design of the social survey respondents. (A = Australia; P = Philippines; S = study sites; n = number of respondents)

Respondents and study sites

A total of 351 occupational fishers participated in the social survey: 241 from the Philippines and 110 from Australia (Table 1). The number of active fishers, i.e., those currently fishing at the time of the study in 1997/98, served as the base figure for the population (N). The percent of samples was calculated by simply dividing the population size (N) by the sample size (n), and then multiplying by 100./.;

The three study sites selected in Australia were all part of north Queensland's Great Barrier Reef Marine Park (GBRMP) within the Great Barrier Reef region (Fig. 2). The GBRMP's inshore areas in the central section are adjacent to the Townsville/Whitsunday Marine Park, a Queensland state marine park. In effect, the study sites in Australia are mixtures of multiple use marine parks and fish sanctuaries because north Queensland's coast is under various forms of MPA status. These sites were selected based on their geographical proximity to the location of the Queensland Commercial Fishermen's Organisation (QCFO), a formal organization where all licensed commercial fishermen (those who earn a living through fishing) are required to become members. These sites are also called 'management areas,' adopting the term used for the Townsville/Whitsunday Marine Park (QNPWS 1987). It was assumed that most QCFO fishers operated near their place of residence. Site 1 (Hinchinbrook Management Area) included the adjacent Family and Palm Islands, as well as the inshore areas of Rockingham and Halifax bays. The QCFO Branch 6 is based in Lucinda. Site 2 was the Magnetic Island Management Area including Pallarenda and Cleveland bay. The QCFO Branch 7 is based in Townsville. Site 3 was Bowling Green Bay Management Area including the adjacent Cape Upstart. The QCFO Branch 8 is based in lower Burdekin.

The three study sites in the Philippines were all situated in the Central Visayan region (Fig. 3). Site 4 was Apo Island, a 74-ha volcanic island situated in the Mindanao Sea off the southeastern coast of Negros Island. A 1.5-km^2 reef area surrounds it. Apo Island was established as a marine reserve in 1986. Site 5 was Pamilacan Island, a coralline island with about 200 hectares of land area. It is about 10 km south of the town of Baclayon in the southern main island of Bohol. Its 1.80 km^2 fringing reef area is mostly flat and gradually sloping. Pamilacan Island was established as a marine reserve area in 1985. The first two sites were considered as inshore 'small' islands. Site Area 6 was Capinahan, a coastal village in the city of Bais in the eastern coast of the main island of Negros. The coastal region has a mixture of coral reefs, seagrass beds, mangroves, and soft-bottom communities. It was established as a marine protected area and fish sanctuary in 1992. The three Philippine sites are comparable to the Queensland sites in terms of proximity of small islands to the mainland coast, and are similar in some marine habitats such as mangroves and sea grass beds. However, Queensland and Filipino fishers differ significantly in socio-economic conditions, such as population pressure and the relative economic prosperity.

Data collection techniques

A questionnaire was used to collect the social survey data. The study was conducted between May 1997 and June 1998. The substantive content of the Filipino and Australian questionnaires was identical. The Australian questionnaire was written in English but the Filipino questionnaire was translated into Cebuano, the dialect of the central Philippines. This paper focuses on the responses of Australian and Filipino fishers regarding volume of catch and catch trend in net fisheries.

Close to two-thirds of the questionnaires were completed through guided interview while the rest were completed by the fishers themselves.

Table 1. Summary of fisher groups for social survey.

Country	Fishing area	No. Active Fishers (N)	Sample size (n)	Sample as % of all fishers (n/N)
Australia	Site 1: Hinchinbrook Management Area	49	31	63%
	Site 2: Magnetic Island Management Area	120	68	57%
	Site 3: Bowling Green Bay Management Area	16	11	69%
	Australian Sub-total=	***185***	***110***	***59%***
Philippines	Site 4: Apo Island Marine Reserve	90	73	81%
	Site 5: Pamilacan Marine Reserve Area	140	80	57%
	Site 6: Capinahan Fish Sanctuary	130	88	68%
	Philippine Sub-total=	***360***	***241***	***67%***

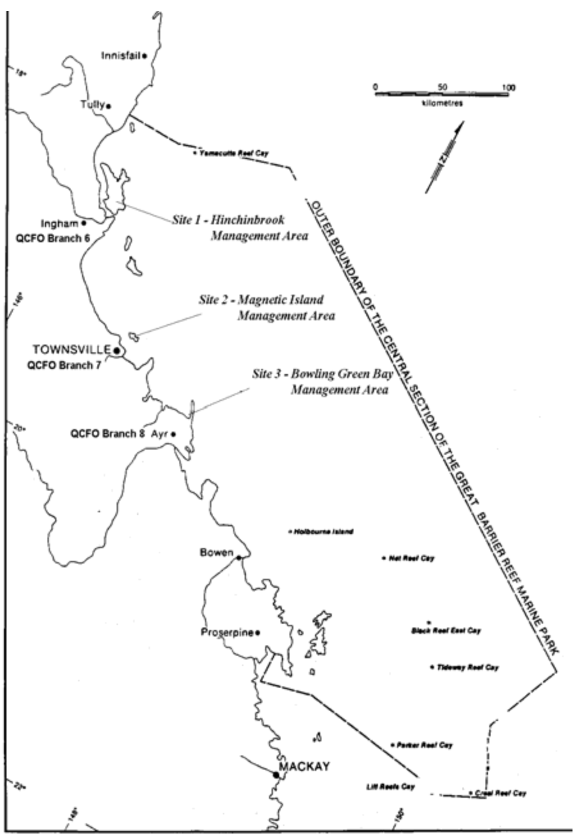

Fig. 2. Location of three study sites in the Great Barrier Region of North Queensland, Australia.

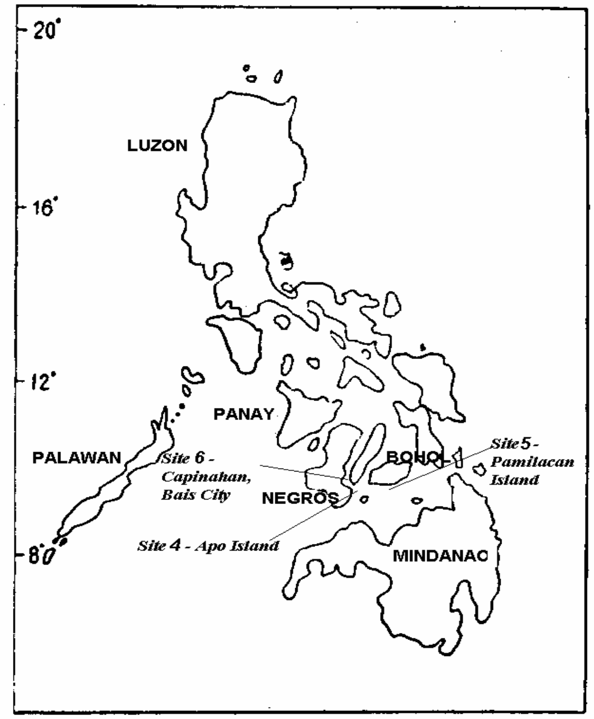

Fig. 3. Location of three study sites in central Visayan region, Philippines.

Data analysis

A series of data analyses was undertaken to compare the sustainability of net fisheries in the six study sites in terms of annual catch[1] and catch trends (measured on the five-point Likert Scale from rapidly increasing to rapidly declining). To compare the net catch per year per fisher differ between countries and between study sites, the data were organized in three ways. First, the types of fish caught using nets were classified in an upward taxonomic hierarchy, species, genus, and family. Second, the reported annual catch of each fisher by species was tabulated. Third, an ANOVA was performed to determine if the differences between countries and between sites were significant. The design was a Nested Two-factor ANOVA, with one factor nested inside the other with replicates. Hence, the six sites were nested, three sites within each country. The country was treated as a fixed factor while the site was treated as a random factor. The dependent variable was the annual catch (kg/yr) of fishers using nets.

To determine if there is a pattern in catch trend for net fisheries between the six study sites, the data were analyzed in three ways. First, the annual catch and catch trends for net were summarised at the species level. Second, this information was aggregated at the taxonomic level of a family. For example, narrow-barred Spanish mackerel (*Scomberomorus commerson*), school mackerel (*Scomberomorus queenslandicus*), and grey mackerel (*Scomberomorus munroi*) are three different species but they all belong to the family Scombridae. Third, the combined annual catch and catch trend data sets were presented in terms of sustainability 'vectors'.

A vector is an entity that has two properties: magnitude and direction. In this case, the annual catch was used as the magnitude. The length of each vector was expressed as the mean or average annual catch per family. This was measured on an interval scale, expressed as kg/yr. The information was aggregated at the family level to simplify the presentation. Some families are represented by a single species, such as barramundi (*Lates calcarifer*) for the family Centropomidae, while Lutjanidae is comprised of various species of snappers. As an example of the vector's magnitude (or length of the line), the net fishers at Hinchinbrook region (Site 1) reported a total annual catch of 31,559 kg for family Scombridae (mackerel). There was a total of 15 responses or entries for all species belonging to this family. Hence, the mean annual catch for Scombridae was 2,104 kg/yr, obtained by dividing 31,559 kg by 15 responses. The length of the vector was then represented by the mean value of 2,104 kg.

The direction of the vector was represented by the catch trend. Similar to annual catch, a catch trend was aggregated at the family level. Each species has distinct values for annual catch and catch trend. The original five categories of a catch trend in ordinal scale were given values as follows: 1 = rapidly declining; 2 = slowly declining; 3 = no change; 4 = slowly increasing; and 5 = rapidly increasing. This is graphically represented in Fig. 4. The zero value is the point of origin. A vector exactly along this zero point means the catch trend is constant or no change, i.e., a value of 3. Anything above this horizontal zero line means the catch trend is increasing, while all vectors below indicate a declining catch trend. This model assumes that the difference in fisher's perception about a catch trend between the ordinal categories is the same. Hence, the angles corresponded to the five ordinal scales as follows: 5 = 0 degree; 4 = 45 degrees; 3 = 90 degrees; 2 = 135 degrees; and 1 = 180 degrees. Therefore, the difference in angle from no change (= 3) to slowly increasing (= 4) is 45 degrees. Consequently, the difference in angle from no change (= 3) to slowly declining (= 2) is also equal to 45 degrees.

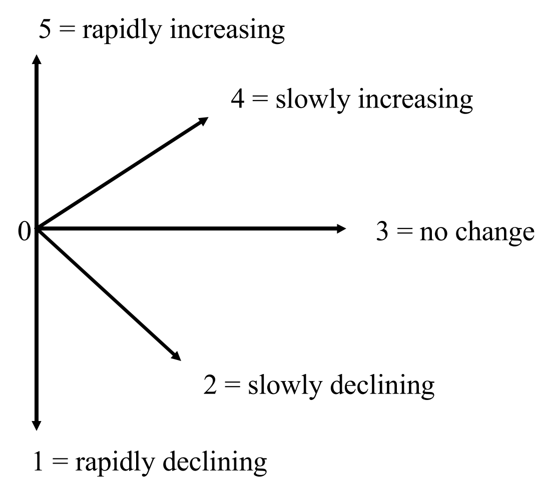

Fig. 4. Graphical representation of catch trend.

[1] Only the value for annual catch in terms of kg/yr was supplied by the fishers in the questionnaire. The Philippine fishers estimated this value for each species they caught by recalling their typical daily catch, and then multiplied by their total number of days fishing in a year. Queensland fishers, used the annual summary in their fishing log books. The kg/yr as a parameter says something about the value of the fish with respect to the fisher's annual income. It is acknowledged, however, that it is not a good measure of fish abundance without detailed information, such as number of hours and length of net, as indicators of actual fishing effort. As a social research project, this study simply aimed to look at general patterns of sustainability of the fisheries through reported annual catch and catch trends of fishers.

Fig. 5 presents a schematic of combined annual catch and catch trends for five families of fish. The length of the vector represents the mean annual catch, while the direction of the vector (from 0 to 180 degrees) signifies the catch trend. In this framework, the highest mean annual catch is for family Priacanthidae but its catch trend is constant or no change (= 3). The direction of the vector for Priacanthidae indicates either the catch trends for all species belonging to this family are all no change (= 3), or a combination of catch trends from 1 (rapidly declining) through 5 (rapidly increasing) but the average or mean value is equal to three. The lowest mean annual catch is for the family Scaridae; however, its catch trend is rapidly increasing (= 5). Although the family Pomacentridae has the worst catch trend (= 1), its mean annual catch or yield is still higher when compared with the families Scaridae and Siganidae. Going back to the Hinchinbrook example, the catch trend for the family Scombridae had a mean value of 2.79. Since this value is below 3 (no change), the overall catch trend for this family was declining. It implies that most fishers in this region perceived that their catches using net were declining for mackerel. Therefore, the direction of the vector for Scombridae (given its mean trend value of 2.79) is below Priacanthidae, which has a trend value of 3.

RESULTS

A summary of net fisheries between the six study sites is given in Table 2. Table 3 shows the reported catch of gill netters. There are more varieties of fish caught in the Philippines at all taxonomic levels across all sites. Overall, the mean annual catch in Australia was higher compared with the Philippines. An ANOVA was performed to determine if the differences between countries and between sites were significant. The ANOVA results show that the annual catch between gill netters differed significantly between sites. However, the difference between Australia and the Philippines was not significant. There was no difference between the two countries because the Apo Island fishers, one of the three Philippine sites, reported a similar annual catch to the three Australian fisher groups (Table 4). This was confirmed by post-hoc analysis, showing that the Philippine fisher groups from Capinahan and Pamilacan Island reported similar annual catches, which were significantly different from the Apo Island fishers and the three Australian fisher groups.

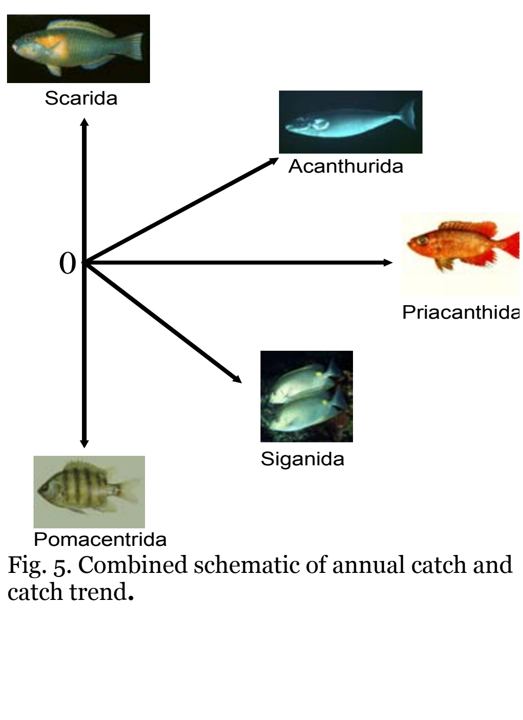

Fig. 5. Combined schematic of annual catch and catch trend.

Table 2: Comparative annual catch of gill netters at six study sites

Country	Site number and site name	Total annual catch (kg/yr)	Number of fishers	Mean annual catch/fisher (kg/yr)
Australia	1 - Hinchinbrook	93481	17	5499
	2 - Townsville	165770	13	12752
	3 - lower Burdekin	90563	9	10063
Philippines	4 - Apo Island	201682	29	6955
	5 - Pamilacan Island	44047	24	1835
	6 - Capinahan	66649	49	1360

Table 3: Count by taxonomic grouping of fish caught by net at six study sites

Country	Site number and site name	Family	Genus	Species
Australia	1 - Hinchinbrook	10	13	17
	2 - Townsville	9	11	15
	3 - lower Burdekin	12	14	16
Philippines	4 - Apo Island	14	21	28
	5 - Pamilacan Island	20	27	45
	6 - Capinahan	23	31	38

Table 4: ANOVA of annual catch (kg/yr) of net fishers between countries and sites.

Source of variation	Sum of squares	df	Mean square	F	Sig.
Country	10.598	1	10.598	4.032	.112
Site (Country)	13.214	4	3.303	13.003	.000
Error	34.298	135	.254		

Comparison of net catch trend

Sets of sustainability vectors[2] were constructed to determine if there was a pattern in catch trend for net fisheries between the six study sites" The vectors for the three Australian sites are given in Figs. 5 through 7. The results of catch trend for net fisheries in the three Queensland sites are contrasting. All families in Hinchinbrook and Townsville were declining, while most families in lower Burdekin were increasing. The vectors for the three Philippine sites are presented in Figs. 8 to 10. The results are mixed: the Apo Island fishers reported an increasing catch trend, while the fishers from the two other sites reported a declining catch trend.

Note: % of catch based on total of 93,481 kg.

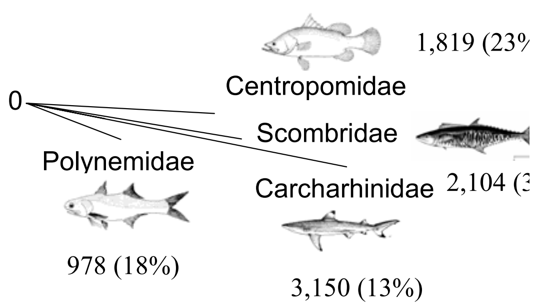

Figure 5. Sustainability vectors of major families caugh net fishers from Hinchinbrook, Australia.

Note: % of catch based on total of 165,770 kg.

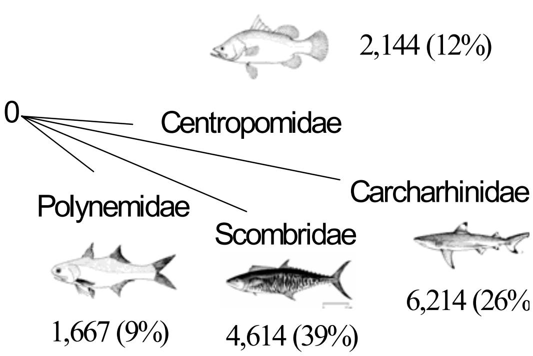

Figure 6. Sustainability vectors of major families cau net fishers from Townsville, Australia.

Note: % of catch based on total of 90,563 kg.

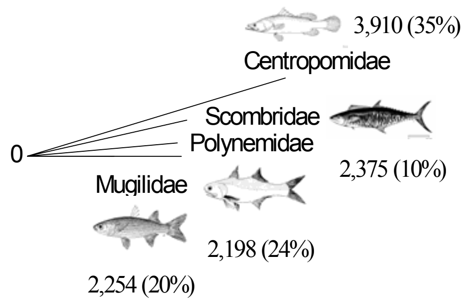

Figure 7. Sustainability vectors of major families caught by net fishers from lower Burdekin, Australia.

Note: % of catch based on total of 201,682 kg.

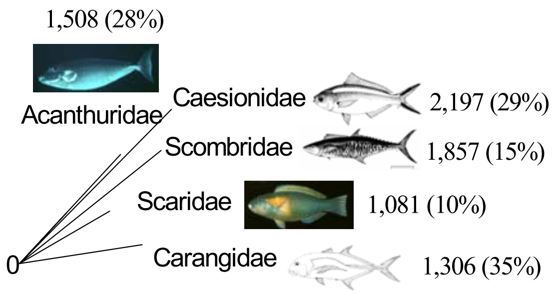

Figure 8: Sustainability vectors of major families caught by net fishers from Apo Island, Philippines.

Note: % of catch based on total of 44,047 kg.

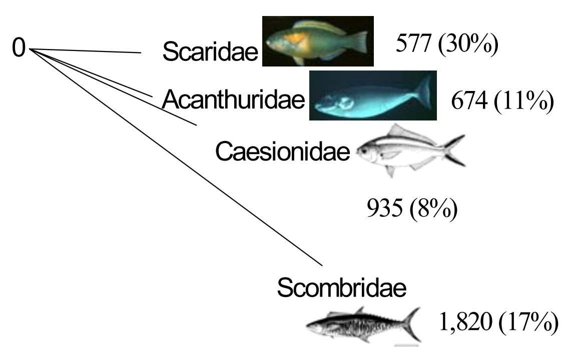

Figure 9. Sustainability vectors of major families caught by net fishers from Pamilacan Island, Philippines.

Note: % of catch based on total of 66,649 kg.

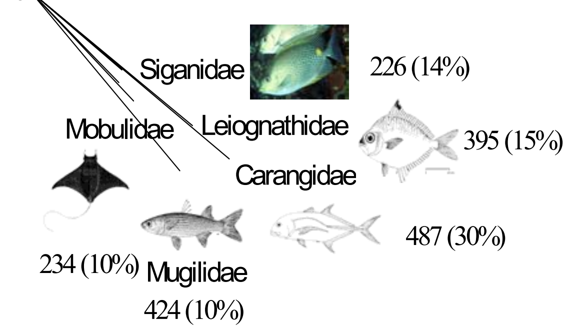

Figure 10. Sustainability vectors of major families caught by net fishers from Capinahan, Philippines.

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[2] The elements of the sustainability 'vectors' are recapitulated. The length of the vector is equivalent to the mean annual catch per family. As such, the magnitude of a vector is measured in kg/yr. The direction of a vector along horizontal zero line means the catch trend for that family of fish is constant or no change. If the direction is above the horizontal zero line, it indicates an increasing catch trend; if it is below the horizontal zero line, the interpretation is a declining catch trend. The percentage in bracket refers to the proportion of catch for that family in relation to the total catch for a particular fishing gear. The figure would not add up to 100% because only the major families are represented. There are 6 vectors in all to compare the catch trends: six for net fisheries (Figs. 5 through 10).

Discussion

Comparison of annual catch using net

It is difficult to interpret, from the angle of coastal marine habitat, why there were more species of fish caught using nets in the Philippines than in Australia (Table 3). The gill netters operated in different marine habitats, hence, it is difficult to make a conjecture about species diversity between the two countries. The three Australian fisher groups operated in estuarine environments. In the Philippines, however, the fishers of Apo and Pamilacan Islands were netting in coral reef areas, while the fishers of Capinahan operated in mixed estuarine and coral reef environments. Netting is permitted in the Philippine reefs but not in Australian reefs. Therefore, the most logical reason for the difference is that there are few commercially exploited species for net fisheries in Australia. The major species that comprise the bulk of net catch are barramundi (Centropomidae), black tip shark (Carcharhinidae), sea and flat-tail mullets (Mugilidae), blue and king threadfins (Polynemidae), and grey and school mackerels (Scombridae). Other species caught in the net, which cannot be sold in the market, are thrown back to the sea as discards or trash fish. There may be more species 'caught', compared with those species of fish 'caught and kept' for commercial trading (M. Bishop pers comm).

In the Philippines, there is no discrimination in gear catch (FSP-PMO 1991). Everything caught in the net, which includes the juveniles and non-target species, is utilised. The catch that cannot be eaten is transformed into other economic uses such as animal feed. Although all the six fisher groups used nets, a between country and between site comparison is difficult due to the difference in target species, and the difference in habitats where the fishers operated.

The unexpected ANOVA results (Table 4) indicated that the annual catch (kg/yr) of gill netters differed significantly between sites but not between countries. Although different species of fish were involved, the mean annual catch for the three Australian sites was anticipated to be higher in comparison with the three Philippine sites. Hence, the predicted difference between the two countries would be significant. The expected higher annual catch in the three Queensland sites is due to the following reasons: there were fewer commercial fishers; they used motorised boats and sophisticated equipment such as fish finders; the estuarine marine habitats where they operated, such as mangrove and sea grass beds, were generally intact; the quality of marine waters overall was high; and the target species were not classified as over exploited. The post-hoc analysis revealed that the reported annual catch was not statistically significant between the two countries because of data sets provided by the Apo Island fishers. The mean annual catch (see Table 2) for an Apo Island netter was 6,955 kg/yr, even higher than their counterpart in Hinchinbrook who reported an average annual catch of 5,499 kg/yr. If the Apo Island netters had reported a mean annual catch comparable with the two other Filipino fisher groups (1,835 kg/yr in Pamilacan Island and 1,360 kg/yr in Capinahan), there would have been a significant difference between the two countries.

Several reasons may be suggested to explain why the fishers at Apo Island reported higher annual catch compared with the fishers at Pamilacan Island and Capinahan. First, there might have been a genuine increase in fish yield in their fishing grounds. In 1985, a fish sanctuary (no fishing zone) was established as a component of the Apo Island Marine Reserve. Before 1985, the reefs surrounding the island were subjected to destructive fishing practices, such as the use of dynamite and cyanide. With the establishment of the Marine Reserve, however, such destructive fishing techniques were totally stopped. The members of the local community were also able to keep the sanctuary free from fishing activities. There are empirical studies that support the increase in diversity and density of the species within the sanctuary (Alcala and Russ 1990; Russ and Alcala 1996a, 1996b, 1999). The adult fish populations from the sanctuary could have easily migrated (spillover effect) into the fishing zones. Given such increases in abundance of the target species, it is logical for the fishers to report an increase in their yield.

Secondly, the reef of Apo Island may have higher natural productivity compared with the two other reefs. Russ (1991) notes that the yields of fishes from actively growing coral reef vary from as low as 5.0 kg/yr/km^2 in Port Moresby, Papua New Guinea to as high as 36.9 kg/yr/km^2 in Sumilon Island, the Philippines. There are more genera of corals and fishes in Apo Island compared with Pamilacan Island (White and Savina 1987; White 1988b). Salm (1984) argues that the ecological boundaries for coral reef reserves should be properly delineated so that their contribution to the conservation of fisheries and other coastal resources can be properly evaluated. Thirdly, the fishers might have reported the upper range of their catch, ie, the days when they had good catch. Since their catch per day was multiplied by the total number of days they fished in a year, their annual catch (kg/yr) could easily be overestimated. Bellwood (1988) reported that the sustainable yield of reef fishes in Apo Island was around 24,860 kg/yr/km^2. Since the extent of the reef is only about 1.5 km^2, the theoretical catch could only be around 37,290 kg/yr. If we calculate the yield using the productivity figure of 36.9 kg/yr/km^2 in Sumilon Island (Alcala 1981), the yield would be higher at about 55,350 kg/yr. The gill netters, however, recounted a total yield of 287,354 kg/yr using net. This figure is an overestimation when compared with the two other estimates from the literature. The fishers of Apo Island may have also overestimated their catch by recalling only the days when they had a good harvest. There could have been double or triple counting of catch. Most fishers undertake netting or line fishing in groups, ranging from 2-5 people in a boat. Hence, fisher Y could have also reported the catch reported by fisher X from the same boat.

Comparison of net catch trend

The results (Figs. 5 through 10) for the catch trends of major families of fish using net were mixed. Some results were supported by the literature while others were in contrast to logic. In theory, because the six fisher groups were fishing in areas with various forms of MPAs, it is anticipated that the catch trend for the major families would be at least stable. This assumption holds true for the lower Burdekin (Fig. 7), one of the three Queensland sites. The reported catch trend was stable for Mugilidae, and increasing for Centropomidae, Polynemidae, and Scombridae. The reported catch trends for major families for the Townsville (Fig.6) and Hinchinbrook (Fig. 5) regions, however, were all declining. The catch trend for some families in these two other sites were consistent with the findings of Ludescher (1997) about the decline of some fishery resources in north Queensland. Some of the species in decline are sharks (Carcharhinidae), blue salmon (Polynemidae), and grey mackerel (Scombridae). It is possible that the regional differences for catch trends between the three sites might be attributed to the smaller number of active fishers in the lower Burdekin (16 fishers) compared with 49 fishers in Hinchinbrook and 120 fishers in Townsville. There are also more recreational anglers in the Hinchinbrook and Townsville districts who compete with professional fishers for potential catch. Some ecological factors may also favour recruitment and growth in the lower Burdekin area.

It is difficult to evaluate the contribution of the GBRMP and State Marine Parks to the sustainability of fishery resources in the three Australian sites (Robertson 1997, p 397). These MPAs have 'green zones' (no fishing areas) scattered all over the coast of Queensland. In addition to these marine parks, there are several riverine and estuarine Declared Fish Habitat Areas (Mayer and Beumer 1993; Zeller and Beumer 1996). Except for the project on the 'Effects of Line Fishing on the Great Barrier Reef' (Mapstone *et al.* 1997), however, there is no other literature that provides a quantitative estimate on how these MPAs contribute to improved fisheries management by providing habitats to juveniles. Due to the wide geographical coverage of the three study sites, it is also difficult to assess if there are spillover effect or migrations of adult populations from the 'green zones' to the multiple use fishing zones. Tanzer *et al.* (1997 p 306) added that "whether this should be interpreted as the result of management interventions that have been in place or as a function of the large area of the Great Barrier Reef fisheries and the relatively low effort per unit area to date is a matter of conjecture and opinion."

In the Philippines, only the fishers of Apo Island (Fig. 8) reported increasing catch trends for major families. As described earlier, this perceived increasing catch trend might be attributed to a genuine increase in yield due to the establishment of the fish sanctuary. In the cases of Pamilacan Island (Fig. 9) and Capinahan (Fig. 10), catch trends have declined for the major species. It appears that while the MPAs may have eliminated destructive practices, such as dynamite and cyanide fishing, and have contributed to the conservation of the coastal habitats, the fishing effort outside the reserves remains uncontrolled. In Pamilacan Island, there are more young people entering the fisheries than adults moving out (C. Valeroso pers comm). Hence, whatever contribution the reserve provides in terms of spillover effects to the fishing zone is negated by the continuous increase in fishing effort. The fish sanctuary in Capinahan had only been established for five years at the time of the study. Hence, the sanctuary may not as yet have had an impact on the fisheries in terms of larval dispersal or migration of adult population.

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

This study provides an avenue along which to reassess sustainability of fishery resources in terms of annual catch and catch trends. In a comparative sense, Queensland has one of the best catch statistics datasets for commercial fisheries throughout the world. Yet Williams and Russ (1994) in their review of the catch information about commercial line fisheries in the GBR region acknowledged the difficulty in comparing databases collected through varying methodologies by different researchers. The problem of objective evaluation is further accentuated by data gaps at certain time periods. The database for commercial fishing (known as CFISH) officially started in 1998 when commercial fishers were required to enter a summary of their fishing activity by location, effort, and landed weight by species in their logbooks (Trainor 1991). Under this database system, Queensland waters were partitioned into bands of 30 nautical miles width. However, the annual catch information provided by fisher respondents in this study could not be readily compared with the CFISH database. Although the CFISH database provides information by species, gear, time, and geography, it does not organize the information in terms of fishing area. For example, the datasets on annual catch and catch trends were aggregated based on the geographic location of the QCFO branch. The net fishers from Hinchinbrook (QCFO Branch 6) reported a total net catch of 93,481 kg/yr. These netters, however, fished up to Tully in the north and down to Cape Upstart in the south. What is reflected in the CFISH data base are reported catches for the Hinchinbrook region by species, gear, and year, but not the identity of the fisher groups who reported the information. Some of these catch records, then, may have been reported by the Townsville fishers (QCFO Branch 7) or lower Burdekin fishers (QCFO Branch 8). This study illustrates the difficulty of assessing the sustainability of the fishery resources when variables such as time, location of fishing grounds, gear, species caught, and geographic mobility of the fishers groups are incorporated in the analysis.

Validation of the catch statistics provided by the Filipino fishers is even more difficult. Unlike Queensland, the Philippines has not yet established computerized records of CPUE in fisheries. Hence, the reported annual catch and catch trends could only be compared in two ways. The first is by comparison based on certain standards, e.g., established range of fish yield ($kg/yr/km^2$) from actively growing coral reefs. For instance, the reported annual catches of fishers from Apo and Pamilacan Islands were higher compared with the productivity of 36.9 $kg/yr/km^2$ in Sumilon Island (Alcala 1981), a similar small island in the region. The variation is difficult to quantify, however, because the fishers combined their catch in the reef with the non-reef catch such as small pelagics. The secondly is to seek the opinion of experts in the field to validate the data sets of fishers. The annual catch provided by net and line fishers in three Queensland sites were reasonable (M. Bishop pers comm). The situation is more complicated in the Philippines, particularly Capinahan (Site 6), because the fishers operated in a variety of marine habitats. Although their reported annual catch and catch trends were reasonable (G. Russ pers comm), it is difficult to correlate their yield with the productivity of the marine habitats where they operated. It is stressed that the data provided by fishers in terms of annual catch and catch trends were based on their perceptions. While this information is useful in providing a ‘broad picture’ of the sustainability of the fishery resources, it must be correlated with other relevant variables such as number of days fishing, length of net, natural variation in fish population and conditions of fish habitats.

This study recognizes the difficulty in understanding the sustainability of marine fisheries solely in terms of annual catch and catch trends. This information is difficult to collect, even for trained biologists. Such data should be collected systematically over a long period of time, in order to discern significant patterns of use. Research of this nature also requires robust sampling designs, to be able to establish generalizations or make unequivocal statements about cause-effect relationships. In this social study, the datasets obtained for annual catch and catch trend were derived solely from the perceptions of the fisher groups. Many of the results were supported by the literature or were theoretically plausible. On the other hand, the annual catch information supplied by the Apo Island fishers in particular was biologically improbable. Although there are studies which indicate that the perceptions of the fishers were either close to established knowledge (Johannes 1981), or consistent with information collected by the scientists, such as catch estimates for trawling (Starr and Fox 1996), this does not necessarily apply to this study, due to the mixed results. What may be concluded is that the data provided by fishers in terms of annual catch and catch trends were excellent ‘starting points’ for providing a general pattern of the sustainability of the fishery resources. This information will only become more useful, however, when correlated with other variables related to fishing effort. Sustainability should also be contextualized in terms of comparative differences between the two countries, such as the density of fishers and the types of gear used.

The catch statistics supplied by fishers, when transformed into formats similar to sustainability vectors, may be used as a guide for fisheries managers and administrators. In its present format, a sustainability vector provides the following information at the taxonomic level of family: annual catch, catch trend, proportion relative to the total catch, and fishing gear used. It does not yet include other variables related to the actual fishing effort, such as number of days fishing, length of net, and number of boats. In addition to the incorporation of such variables, several recommendations are proposed to improve the present format of the vector. The first is to disaggregate each vector from the taxonomic level of family down to the level of genus or species. This will increase the level of detail. The length of the vector may also be expressed as total catch instead of mean catch. The second is to add the cost factor in terms of economic value of that particular species. For example, although the volume of coral trout caught is lower than mackerel, coral trout are more economically valuable because they command a higher price both in the domestic and export markets. Thirdly, appropriate spatial and temporal dimensions may be incorporated. For instance, the yearly fish yield of a given area of fish habitat, say 20 km^2 of coral reefs, may be assessed given the number of fishers harvesting the resource. Fourthly, a colour code should be provided that reflects the harvesting level of each species. Similar to a traffic light, a species coloured red is overfished and the effort has to be reduced; a species coloured yellow is approaching full biological exploitation and the effort has to be maintained at that level; a species coloured green is at a sustainable level or possibly still underexploited, effort may therefore be maintained or possibly even increased. The vector information is also relatively easy to collect from the fishers. This research area is suited to mathematicians and modellers. Reinterpreting the concept of sustainability in terms of 'vectors' is a simple way of presenting complex information about annual catch and catch trends. This is also a cost-effective method because the information can be easily derived from the fishers.

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Questions

Tony Pitcher: I can't help commenting that we have an ecosystem model of coral reefs to see the impact of MPAs. Under certain conditions, they can yield 200,000 tonnes. We thought it was just a mistake, but Michael just corroborated it!

Ian Baird: You talk about validating the information from fishers with science, but the other side of it is that a lot of scientific information needs to be validated by fishers. We need to go both ways on this. People can falsify information in science as well, and they can have incorrect methods. You also talk about the villagers fooling you, but the problem may lie in the way you collect data or other factors relating to how you asked for the information. Maybe you confused them with the questions, and they didn't deliberately set out to lie to you. Maybe it's your methodology. In Laos, we found that we were getting inaccurate information but it seemed that the problem was more with the people who were asking the questions.

Michael Pido: To answer your first point, yes, that's true. While scientists should evaluate the information given by fishers, the fishers can also evaluate the information given by scientists. It goes both ways. Regarding the second question, I think that the fishers get tired of being asked questions all the time. In Apo Island I think that the establishment of MPAs led to an increase of researchers and the fishers felt I am just one of the many researchers, so they gave me what they thought I wanted to hear. The fishers think that they can't say that the yield is going down, so they say that it's going up.

Ian Baird: I'm not denying that's not a possible reason, but it might not be the only one. Maybe it says a bit about your methodology if the villagers lie to you; maybe they didn't trust you.

Michael Pido: I know some of the villagers personally and I used some people from the University but they gave me inflated figures. The other study areas gave reasonable estimates, so they act as good comparisons. However, I don't rule out that possibility.

FISHER AND FISHERY SCIENTIST: NO LONGER FOE, BUT NOT YET FRIEND

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ABSTRACT
It has often been assumed that, in natural resource issues, particularly ethical issues related to fisheries, fisheries scientists, fishers, and the general public differ in their opinions. Typically, these assumed differences are neither investigated nor quantified. This paper describes an approach to examine these assumed differences and demonstrates their implications in fisheries management. The method combines the Rapfish assessment of fisheries sustainability with the paired comparison method, in ranking fisheries sustainability using the nine ethical Rapfish attributes as criteria. A paired comparison questionnaire of these attributes was given to scientists, fishers and the general public. The resulting importance weighting of these attributes was applied to the normalised raw Rapfish scores for selected Canadian fisheries. We found no significant difference between respondent groups in the importance ranking of these attributes, thus no effect on the sustainability ranking of the examined fisheries when all attributes were considered. However, when sustainability was measured using only the three most important attributes, the rankings provided by fishers differed slightly from those by scientists and the general public.

INTRODUCTION
Never in the history of fishery management has there been a time more favourable to user-participation, community involvement and co-management than the past decade. Recent publications indicate the growing interest in user and community involvement. Jentoft and McCay (1995) listed eleven countries in Europe and North America as examples of various levels of user participation in fisheries management. Sen and Nielsen (1996) complemented this study by reviewing 22 case studies on fisheries co-management, with an expansion to developing countries in Africa, Asia, the Caribbean and the Pacific. Both studies observed similar difficulties in involving user groups in the management process, ranging from the choice of appropriate mechanism to encourage and enable participation, to the ability of user groups to participate fully, and the willingness of government officials to share their management authority.

The level of user participation and community involvement in resource management ranges from the minimum exchange of information between government and users, as in the 'instructive' type of co-management to the 'informative' type where government has delegated authority to the user groups and community (Sen and Nielsen 1996; see also Arnstein 1969 for a general discussion on citizen participation). In Canada, fisheries co-management initiatives tend to occur at the 'consultative' level, where government bodies consult with users, but retain the final decision-making power; some have shifted into the 'co-operative' type of participation, where government and users co-operate in the decision-making process, as in the case of some Atlantic fisheries (Jentoft and McCay 1995).

Frequent issues in the design of institutional co-management arrangements include the heterogeneity of user groups (Felt 1990), community representation (Jentoft *et al.* 1998), community support (Noble, 2000), and the genuine devolution of power (Sandersen and Koester 2000). Underlying these issues is the common belief that users, scientists and managers, and the general public typically hold different positions in resource management. Users are thought to be concerned only with their own personal welfare (thus, the 'Tragedy of the Commons'). Scientists and managers are assigned the role of managing the resources for the society as a whole, despite the fact that scientists are often accused of being unable to provide fishery managers with the information needed to make decisions. Community and user group involvement is commonly touted as a means to resolve these perceived conflicts. Such involvement may take the form of consultation processes, public meetings and workshops, and formation of resource management committees, comprised of representatives from various user groups, community groups, scientists and managers or policy makers.

In this paper, we propose an alternative viewpoint. Rather than assuming the existence of fundamental differences of opinions between scientists, users, and community members, we explored potential commonalities which may serve as a starting point in the design of fisheries policy. Our approach is based on the work of Chuenpagdee *et al.* (2000), who reported that scientists, managers, resource users and communities did not differ significantly in their opinion about the importance of the resources and the impacts of different activities on the resources.

To test our thesis, we chose to explore perceptions of a potentially controversial topic, the ethical issues associated with fisheries. These include, *inter alia*, traditional access to fisheries, influences on fishers' values, unreported catches, as well as the inclusion of fishers in management decisions. Using a selection of fisheries from Canada's east and west coasts as case studies, we began with a Rapfish assessment of fisheries sustainability by researchers, fishers, and fishery scientists and managers, based on the nine ethical attributes described by Pitcher and Power (2000). Next, we used the paired comparison method to present these nine ethical attributes to scientists (including natural and social scientists, and researchers from other related disciplines), fishers, and the general public to determine the aggregate, ranked preferences of each group. The rankings of the importance of these attributes according to each of the three respondent groups were then tested for correlation before applying the resulting weighting to the ethical attributes for the selected fisheries. The detailed methodology and the results of the study are described below.

Appraisal of fisheries sustainability using 'Rapfish'

Rapfish is a relatively new technique for the rapid appraisal of fisheries. Initially designed to evaluate the health of fisheries on ecological, economic, social, and technological grounds (see Pitcher *et al.* 1998 for early development; see also Pitcher and Preikshot 2001 for subsequent applications), it has subsequently been extended to include ethical considerations (see Pitcher and Power 2000). Further developments have included criteria to evaluate fisheries with regard to the UN FAO Code of Conduct for Responsible Fisheries (Pitcher 1999).

In Rapfish, fisheries are evaluated in terms of sustainability or health as defined within each of five discrete 'fields' or disciplines: ecological, economic, ethical, social, and technological. Each filed is characterised by between nine and twelve criteria or 'attributes'. A simple scoring scheme is applied to each fishery for each attribute, representing the range of possible responses to each attribute. (See Table 1 in Appendix for the ethical attributes and the scoring scheme associated with those attributes.) A multidimensional scaling routine is then conducted for the single field for all fisheries in the evaluation.

The technique allows flexibility in the definition of 'fishery', hence, the evaluated fisheries may be aggregated or subdivided as needed (Pitcher and Preikshot 2001). For instance, fisheries may be defined on a scale ranging from a single boat through a whole fleet in a given region, or subdivided by, for instance, species, or gear type. A given fishery may also be tracked through time. Two 'constructed' or hypothetical fisheries are also included in the assessment: one comprised of the best possible scores for all attributes within the field, defining the fishery with highest or 'Good' level of sustainability; and the other with the worst possible scores, resulting in the fishery with lowest or 'Bad' level of sustainability. These two constructed fisheries constrain the results of the analysis and allow for arrangement of the actual assessed fisheries along a scale of sustainability from high to low. The results, therefore, demonstrate the overall sustainability of the assessed fishery within the field of evaluation, and may be expressed in a variety of ways including a percentage scale, wherein the constructed low sustainable fishery scores 0% and the constructed high sustainable fishery scores 100%, with the actual fisheries ranging along the percentage scale.

It must be noted that Rapfish is not a method for stock assessment (Pitcher and Preikshot 2001). Rather, it is a useful tool for evaluating the overall health of a fishery based upon a number of defined criteria. As fisheries may also be evaluated over time, trends in a specific fishery over time may be identified and assessed. Furthermore, fisheries can be compared against one another using the defined criteria, regardless of time period, scale, or geographic range.

Weighting of ethical attributes using paired-comparison method

Rapfish attributes have previously been applied with equal weighting. It has become apparent, however, that in the real world, the factors represented by each attribute may not contribute equally to the sustainability of a fishery. The approach taken in this paper is to use the paired comparison method to obtain an appropriate weighting for each attribute based on the aggregated preferences of respondents. The case study is limited to the nine ethical attributes first identified by Pitcher and Power (2000).

The paired-comparison method is normally used to elicit preferences and subjective judgements, such as in taste-testing or colour comparison (David 1988). The method involves the presentation of objects in pairs to a sample of respondents. Respondents are asked to simply choose, within each pair, the one object that they prefer or consider to be more important. This method is particularly useful when the number of objects to be judged is large or when the objects are complex or too similar, such that a direct ranking of preference is no longer a simple task. Moreover, because the resulting preference scale is interval, not ordinal, the distance between objects A and B is meaningful in comparison to that between objects B and C. Finally, it is possible to detect the intransitive responses that can occur due to the complexity of the objects for comparison, the high similarity between objects, and/or the lack of competence of respondents (David 1988). One common form of intransitivity is the circular triad, which refers to a situation where, in a paired comparison of three objects, x, y, and z, the results are such that x is preferred to y and y is preferred to z, but z is preferred to x. This information is particularly valuable when dealing with complicated issues such as ethical considerations in the management of fisheries.

The basic model employs all possible paired comparisons of n objects by k judges, with the total number of possible pairs for each judge equal to $n(n-1)/2$. In this study, the nine ethical attributes described in Table 1 were used to create a total of 36 pairs for comparison. Box 1 shows an example of one pair.

Box 1: An example of a paired comparison of ethical attributes

In your opinion, which one of these two factors should receive **GREATER** consideration by policy makers in designing fisheries policy? (Please choose only **A** or **B**, even if you feel they are equally important)

A	B
The distance to and the reliance on the fishery	The existence of alternative sources of livelihood

Earlier uses of paired comparisons in environmental management include the effort by Opaluch *et al.* (1993) to rank potential sites for noxious facilities, described in terms of acreages of various land uses, groundwater quality, wildlife habitat, and cost per household, and the Peterson and Brown (1998) study of the reliability and transitivity of paired comparison judgements involving a mix of public and private goods. The first study found that the choices made between alternative sites using the paired comparison approach were more natural than the responses to questions of willingness to pay to preserve specific attributes of such sites. The latter supported the use of the paired comparison method to yield highly reliable and transitive judgements, even with 155 pairs.

More recently, Chuenpagdee *et al.* (2001 a, b) conducted an empirical study of the importance of coastal resources in Thailand, with an emphasis on testing the differences between the judgements from experts, fishers and other interested groups in the coastal communities. They found that the paired comparison method provided consistent judgements from various groups of respondents. The study reported in this paper was modelled after their research.

Using stratified quota sampling, the study was structured such that the respondents included three groups, i.e. scientists, fishers, and general public. The questionnaire booklet contained pairs of ethical attributes randomised in their order and left-right position such that each booklet was unique. The questionnaire was distributed, either by mail or by personal delivery, to the pre-identified scientists, based on their recognized expertise in the topic area. The survey of the fishermen and the general pubic was conducted at fishing piers, fish markets, and at fishermen association meetings in British Columbia. A total of 22 scientists, 17 fishers and 19 other people responded to the survey. Note that the 'scientists' group included natural and social scientists as well as researchers in related fields.

The analysis of the paired comparison results followed the variance stable rank sum method of Dunn-Rankin (1983), which allowed the aggregation of individual preference scores and the normalization to a scale of 0 to 100 using a proportional procedure. In this study, an ethical attribute with 0 score reflects no importance, such that the attribute was never chosen as being more important than other attributes. On the other hand, the score of 100 indicates the highest importance of a particular attribute, as it was selected as being more important in every pair combination. We used the normalised, aggregated scores of all individuals in each respondent group to present the comparison of the resulting scale values, as in Figure 1 (in Appendix 1).

Further, we provided a ranking of these attributes based on their scale values, and used rank correlation analysis to test for significant difference (Table 2, in Appendix 1). The results suggest that fishers considered inclusion of fishers in the management to be the most important factor in the design of fisheries policy. In comparison, the scientists and general public did not rank this attribute as being as important as the impacts of fishing and the human influences on fisheries ecosystems. While all groups agreed that the existence of alternative sources of livelihood was the least important consideration, they differed slightly in their opinion about the importance of the existence of traditional or historical fishing access, the level of utilisation of fish (or discarding), and the existence of social and political structures influencing fishers' value (Figure 1, Appendix 1). Despite these differences, the ranking of the nine attributes provided by each group of respondents was not significantly different from the other two groups at $p = 0.05$ (Table 2, Appendix 1). It was thus possible to aggregate further the preference scores across all three groups of respondents and represent them as a single set of aggregated scale values. This aggregated scale was used in subsequent stages of the study.

Reassessment of fisheries sustainability

To demonstrate how the application of different weightings to the Rapfish ethical attributes can complement the assessment of fisheries sustainability, we applied the scale values obtained from the paired comparison survey to the raw, normalised Rapfish scores of thirteen fisheries conducted on Canada's Atlantic and Pacific coasts. The procedure followed three steps. For each fishery, we first normalised the original raw Rapfish scores of each attribute to a scale of 0 to 100. Next, we multiplied each Rapfish scale value with the attribute scale value. Finally, we calculated the weighted average using equation (1), after Jongman *et al.* (1993):

$$WA = (Y_1U_1 + Y_2U_2 + \ldots + Y_mU_m) / (U1 + U2 + \ldots + Um) \qquad (1)$$

where Y is the Rapfish score and U is the attribute score.

We compared the original Rapfish scores with the weighted scores based on all respondents to demonstrate the varying importance of these attributes in the decision about fisheries policy (Table 3, Appendix 1). We found that the rankings of fisheries were not significantly different (with a rank correlation coefficient of 0.9761). A traditional west coast Aboriginal fishery, the herring spawn-on-kelp fishery, was considered to be most sustainable in both cases, while the British Columbia lingcod fishery was considered least sustainable. Except for the herring spawn-on-kelp fishery, the east coast fisheries were considered more sustainable than the west coast fisheries based on both scoring methods.

Further analysis was performed to test the impact of the ethical attributes on the sustainability ranking of the fisheries. Instead of using all nine attributes to weight the Rapfish scores, we first used only the three most important attributes according to all respondents, specifically, fishing impacts on the ecosystem, inclusion of fishers in management, and human impacts on fish habitats. In the next round of analysis, we used the top six attributes. These two sets of weighted scores were ranked and tested for correlation with the Rapfish scores weighted using all nine attributes, as shown in Table 4 (Appendix 1). While the rankings based on the three sets of scores were not significantly different, we observed that the correlation coefficient was lowest between the ranking of fisheries sustainability based on the top three ethical attributes compared with that based on all nine attributes. It should also be noted that, although the rankings were not significantly different, the scores and their range varied. When using only the top three attributes in the weighting average, west coast halibut and salmon fisheries were ranked higher than east coast lobster, cod, and mackerel fisheries. The opposite was found when the ranking used all attributes. The least sustainable fishery based on the top three attributes was the British Columbia trawl fishery, not the lingcod fishery as with all attributes. Adding three more attributes to the weighting gave the ranking a higher correlation coefficient to the overall attribute weighting. As with using only the top three attributes, we found that the ranking of mackerel, halibut and salmon varied slightly from that with the all attributes. Further, we observed that when using the top three attributes as criteria for sustainability, only herring spawn-on-kelp and snow crab fisheries scored higher than the 50% mid-point. As we added three more attributes, capelin scored higher than 50%, and when considering all attributes, the east coast herring fisheries also exceeded the mid-point. The other nine fisheries remained at the lower end of the sustainability scale in all considerations. Finally, the correlation between the rankings of fisheries sustainability obtained from the original Rapfish score and those based on top three attributes was lower than other pairs at 0.7874.

Implications for fisheries management

An awareness that fishers, communities, and scientists do not differ significantly in their opinions regarding the ethical issues that ought to be considered in assessing fisheries sustainability can be quite helpful in both the design of fisheries policy and in co-management efforts. Priorities in management can be set using the general agreement between these groups and subsequent discussions can focus on issues where the groups may be at odds. As illustrated above, ethical considerations, such as the ecosystem impacts of fishing, inclusion of fishers in management, and the human impacts on fish habitat, provide clear distinction between fisheries in terms of sustainability when used as primary criteria to assess sustainability of fisheries. As well, the ranking of fisheries in terms of their sustainability shifts slightly when applying weighted attributes. This shift will more likely be significant if stakeholders differ in their opinion about the importance of attributes used in assessing fisheries sustainability. In such case, careful considerations must be taken when formulating fisheries policies.

The paired comparison survey conducted in the case study included a small sample size. Clearly, a more comprehensive survey should be conducted to assure proper representation of each stakeholder group. Once this is done, these inputs can assist policy makers in the design of fisheries policies that are in accord with the judgements of stakeholder groups. For example, the results suggest that fishers should be involved in designing policies that address fishing impacts on ecosystems, and human impacts on fish habitats. At the same time, it implies that the management of fisheries that are scored low on the sustainability scale should be evaluated and revised for improvement.

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QUESTIONS

Christina Soto: I didn’t follow how you score the fisheries. How did you do it?

Melanie Power: In the original raw data, which goes back 4 years now, each attribute has a range of scores that go from 0-1 to 0-5 in some cases. For example, for the distance to fishery and reliance on fishery attribute, the scores reflect whether the fishery has been around for hundreds of years or whether they’re very modern.

Christina Soto: The socio-political attributes are so hard to score. How did you do it?

Melanie Power: Yes, that’s problematic. Because it was used in the original raw data, it has to stay in this study. It’s part of my thesis, but I think I will excise it.

Ian Baird: It was an interesting presentation and I don't want to detract from it, but I have one small note. We talked about terminology a few times today, and I want to advise you to be careful about using the term "expert". That's implying that fishers know less than the others, which is not necessarily true. Maybe you can use "scientists" versus "fishers"?

Melanie Power: I agree, and I am chastened. I was using the shorthand; we usually use the phrase "formal expert", which refers to people who are trained in an institution. I hesitate to use the term "scientist", because I'm not one myself. It is hard to find a good phrase.

Saudiel Ramirez-Sanchez: What did you do when you had cases of complete triads?

Melanie Power: We were looking for inconsistencies. I didn't take the survey myself, but when I was looking through the book, I thought, "How could I choose between some of these choices?" When there are indecisions, you get some sense of where the grey areas are and how closely the choices are preferred.

Saudiel Ramirez-Sanchez: What is your explanation of the inconsistencies? What are the implications? Is it the method or is it the way people think?

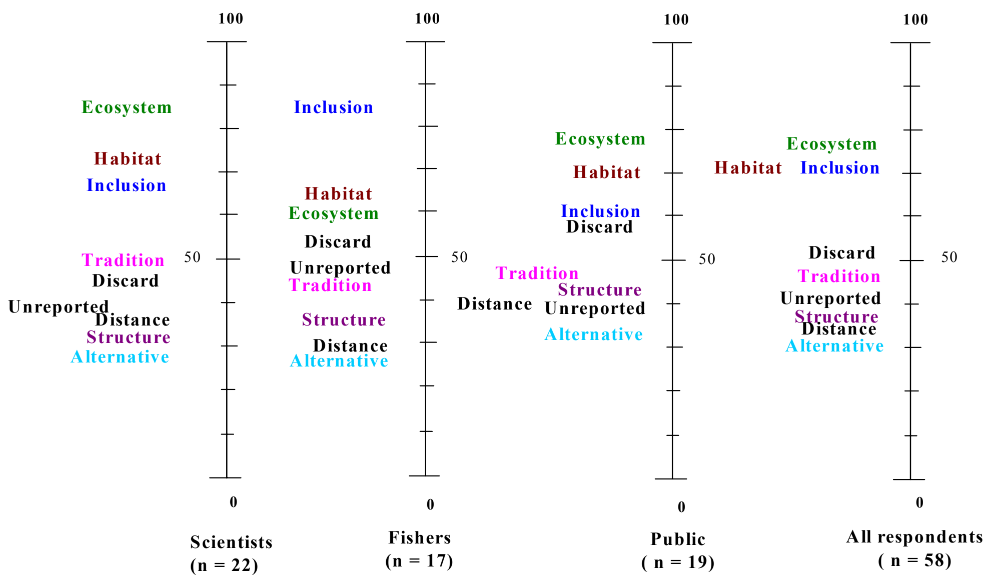
Melanie Power: It's the way people think. In my spreadsheet, I made a note of which ones were inconsistent, because I was expecting it. Out of 59 respondents, only 10 were consistent.

Appendix 1

Table 1 Rapfish Ethical attributes and scoring scheme.

Attribute*	Scoring Scheme	Best Possible Score	Worst Possible Score
The distance to and the reliance on the fishery.	0 to 3	3	0
The existence of alternative sources of livelihood.	0 to 2	2	0
The existence of traditional or historical fishing access.	0 to 2	2	0
The inclusion of fishers in the management of their fishery.	0 to 4	0	4
The existence of social/political structures influencing fishers' values.	0 to 4	4	0
The human influences on fish habitats.	0 to 4	4	0
The fishing impacts on the fisheries ecosystem.	0 to 4	4	0
The existence of fishing practices beyond regulations.	0 to 2	0	2
The level of utilisation of fish which are caught in a fishery.	0 to 2	0	2

* These attributes were first described and applied by Pitcher and Power (2000), and re-worded for simplicity and neutrality in the present study.



Notes:

Ecosystem	The fishing impacts on fisheries ecosystem
Habitat	The human influences on fish habitats
Inclusion	The inclusion of fishers in fishery management
Discard	The level of utilisation of fish which are caught in a fishery
Tradition	The existence of traditional or historical fishing access
Unreported	The existence of fishing practices beyond regulations
Distance	The distance to and the reliance on the fishery
Structure	The existence of social / political structures influencing fishers' values
Alternative	The existence of alternative sources of livelihood

Figure 1. Scale value reflecting the importance of nine ethical attributes as judged by scientists, fishers and the general public

Table 2 Scale value and ranking of the ethical attributes by scientists, fishers and the general public.

	Scientists		Fishers		Public	
Attributes	Score	Rank	Score	Rank	Score	Rank
Ecosystem	84.7	1	60.3	3	77.6	1
Habitat	73.9	2	65.4	2	69.1	2
Inclusion	66.5	3	83.8	1	60.5	3
Traditional	50.0	4	46.3	6	43.4	5
Discard	42.6	5	54.4	4	57.2	4
Unreported	35.8	6	48.5	5	40.1	7
Distance	35.2	7	29.4	8	38.2	8
Structure	33.0	8	35.3	7	42.8	6
Alternatives	28.4	9	26.5	9	33.6	9

Correlation table

	Scientists	Fishers	Public
Scientists	1		
Fishers	0.8667	1	
Public	0.9333	0.8833	1

Table 3 Rankings of fisheries sustainability based on direct Rapfish scores and on weighted averages obtained from paired comparison (E and W indicate east coast and west coast fisheries, respectively)

	Rapfish Average score		Weighted PC All groups (n = 58)	
	score	rank	score	rank
Herring Spawn-on-kelp (W)	66.7	1	72.3	1
Herring (E)	61.3	2	57.1	4
Snow crab (E)	60.2	3	58.3	2
Capelin (E)	60.2	3	59.4	3
Lobster (E)	51.6	5	47.5	6
Shrimp (E)	49.5	6	48.2	5
Northern cod (E)	49.3	7	46.0	7
Mackerel (E)	46.8	8	40.1	8
Halibut (W)	41.2	9	39.1	9
Groundfish trawl (W)	33.8	10	29.6	11
Salmon (W)	32.6	11	33.2	10
Herring (W)	30.1	12	29.2	12
Ling cod (W)	28.7	13	27.5	13

Table 4 Weighted scores and ranking of fisheries, based on three, six and all nine attributes

	Wt.Ave All Att.		Wt.Ave. Top 3		Wt. Ave. Top 6	
	score	rank	score	rank	score	rank
Herring Spawn-on-kelp (W)	72.3	1	100.0	1	70.7	1
Snow crab (E)	59.4	2	57.5	2	57.8	3
Capelin (E)	58.3	3	41.9	4	58.5	2
Herring (E)	57.1	4	47.8	3	49.1	4
Shrimp (E)	48.2	5	37.8	5	46.6	5
Lobster (E)	47.5	6	31.4	9	42.0	6
Northern cod (E)	46.0	7	31.5	8	40.5	7
Mackerel (E)	40.1	8	16.4	12	31.4	10
Halibut (W)	39.1	9	37.2	6	36.0	8
Salmon (W)	33.2	10	36.4	7	32.0	9
Groundfish trawl (W)	29.6	11	12.2	13	27.6	11
Herring (W)	29.2	12	29.1	10	27.5	12
Ling cod (W)	27.5	13	20.9	11	26.1	13

Rank Correlation Table (2)

	Wt. All	Wt. 3	Wt. 6
Wt. All	1		
Wt. 3	0.8407	1	
Wt. 6	0.9780	0.8901	1

HARVESTING AN INLAND SEA: FOLK HISTORY, TEK, AND THE CLAIMS OF LAKE MICHIGAN'S COMMERCIAL FISHERY

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ABSTRACT

In 1998, the Great Lakes Center for Maritime Studies began a two-year documentation project on the contested history of Lake Michigan's fisheries management and policy. After World War Two, the debate over Lake Michigan's fisheries became more acute as four stakeholder groups made highly vocal and strident claims to the fisheries resources of this ecologically sensitive freshwater basin. State governments sought to re-claim managerial control they had informally relinquished to the federal government. Sport fishers sought to create what they saw as a more economically and ecologically sustainable fishery. Native Americans began to re-claim treaty fishing rights in an act of cultural and economic revitalization. Commercial fishers simply sought to survive. Of all the groups documented, Lake Michigan's commercial fishers made traditional ecological knowledge a principal theme of their oral and folk histories. Specifically, they used the theme of TEK in their oral histories to explain, justify, and claim Lake Michigan's commercial fishery as their economic and cultural patrimony.

This paper will examine how these oral histories and their expression of traditional ecological knowledge illuminate the longstanding politics and culture of fisheries claims on Lake Michigan; in short, it will consider oral history not just as past accounts, but as continuously circulating narratives in an on-going historical debate. This was never more evident then during the re-negotiation of a Federal Consent Order in 2000 to settle historical claims among these groups. These oral histories profoundly delineate this fragmented legacy and clarify how divergent politics, cultures, and ethics of fisheries claims developed on Lake Michigan in the modern age. Not surprisingly, these oral histories corroborate the late 19th/early 20th century genesis of these debates, and verbally continue the endurance and revision of claims in the present. By interpreting the verbal expressions of the history and traditional ecological knowledge of Lake Michigan's commercial fisheries, this paper will reveal paradoxical considerations that will continue to inform the evaluation of fisheries history and the formulation of future fisheries policy and stakeholder relations.

INTRODUCTION

This essay uses Lake Michigan as a case study to explore the relevance of folk history and traditional ecological knowledge (TEK) in commercial fisher oral tradition. Specifically, this study considers a number of factors that have made TEK a prevalent theme in the oral histories of Lake Michigan's commercial fishers. This trend has been particularly noticeable over the past twenty years as Lake Michigan's commercial fishers have used TEK to justify the retention or expansion of their allocation of fisheries resources.[1] By invoking TEK in current policy debates, commercial fishers are, in Paul Thompson's words, "living the fishing," and are historically accounting and validating the acquired knowledge, rules, and working contexts that are their most traditional management framework.[2] Thus, the folk history of Lake Michigan's commercial fishers—their own accounts and interpretation of the events of their lives—are narratives whose meaning is rooted in each fisher's individual and collective experience of the basin's fisheries ecology. When these ecological insights and relationships take the form of oral history, they underline that "folk" or "vernacular" fisheries management is deeply entrenched in the regular work routines, social affairs, and political deliberations of fishing communities. Viewed from this perspective, oral history's role in contextualizing a commercial fishery's folk history reveals social and cultural dimensions of TEK that inform innumerable management or policy decisions on a daily basis. Unfortunately, most environmental policy historians have not evaluated these vernacular management schemes that are ecologically forged through work and orally expressed in an occupational culture that displays a high degree of historical consciousness. Nor have researchers adequately availed themselves of commercial fishing technology and material culture to elicit TEK when interpreting occupationally-specific resource use values and their ultimate relationship to "official," government-mandated policy (Figure 1). [3]

The historical narratives of this study of Lake Michigan's commercial fishers were shaped and collected during an era of changing occupation, when claims to fisheries resources were consistently challenged. Keeping in mind that an expansive definition of TEK is its relationship to the social and cultural parameters of the commercial fishery's folk history, such insight was, and continues to be, the inhabitant's principal means of expressing and contextualizing its position in this half-century debate. Quite simply, TEK's standing in the oral historical tradition of Lake Michigan's commercial fishing community serves as a policy response that legitimates the group's claims to fisheries resources. While historical and cultural research in fishing communities shows TEK's longstanding function as an adaptive vernacular management system, its rhetorical use in confrontational fishing policy debate is less frequently recognized. This situation exists on Lake Michigan, where, over the past half century, commercial fishers have been severely restricted by state regulation and the ecological problems wrought by the non-indigenous species. Having worked in a socio-political and ecological context that has not been favorable to their economic interests, they have been less inclined to argue over abstract policy issues and instead narrate life histories that focus on TEK as a bulwark of their regulatory prerogatives and occupational survival. The thematic organization of TEK in these historical narratives reveals that Lake Michigan's commercial fishers consider the harvesting process to be not only a tangible factor in determining economic return, but, as an ecological index, a means of historically evaluating fish stocks, adaptive technologies, changes to the fisheries landscape, environmental conditions, and the quandaries of occupational endurance.

Figure 1-Ray Wakild of South Haven, Michigan used photographs of fish tugs to describe historical and ecological dimensions of Lake Michigan's commercial fisheries. (Photograph by Chiarappa)

At the close of the twentieth century, Lake Michigan's principal fish-using constituencies felt a heightened sense of historical identity. The dawn of a new millennium was coinciding with the end of a fifty-year time period in which Lake Michigan's fisheries had undergone significant change. Amidst this context, fish-using groups were taking serious retrospective views of the extreme political and ecological developments that had re-shaped the lake's fisheries. It was the conclusion of an era that had severely tested Lake Michigan's fisheries management and policy. Specifically, it was a time frame punctuated by the biological invasion of sea lamprey (*Petromyzon marinus*), alewife (*Alosa pseudoharengus*), and zebra mussel (*Dreissena polymorpha*), the decision of state government to prioritize sport fishing over commercial fishing, and the re-assertion of treaty-rights fishing by Native Americans. For years, these issues engendered intense debate around the shores of Lake Michigan; both the documentary record and oral testimony reveal the strident positions that commercial fishers, sport fishers, Native American fishers and government took regarding the allocation of fish or the manipulation of Lake Michigan's fisheries ecology.[4]

These events define the broad context of the contested relations that have existed between Lake Michigan's principal fish-using groups since the mid-twentieth century. The afflictions of this management and policy-making legacy were exacerbated by the inadequate consideration of historical and cultural factors that shaped each group's view on the use of fisheries resources. Many standard documentary sources did not go far in explaining the more in-depth historical basis for each constituency's emphatic claim to both use the resource and participate in the governance of its allocation. When information did exist or new sources were identified, their effective consideration was plagued by the polemical tone of Lake Michigan's fisheries debates. Extreme posturing by each constituency often meant that valuable management perspectives from each stakeholder group—historical and cultural views of fisheries resource use—were ignored, derided, or mishandled in deliberations that made Lake Michigan the most "political" of all the Great Lakes. In an effort to evaluate these oversights, faculty and students from Western Michigan University's Department of History conducted a two-year documentation project to better understand the history and culture that informed each group's fisheries management perspective.

Rather than just examine the traditional policy-making process, the project re-cast the issue with a more holistic perspective in mind and asked what historical factors shape the resource-use values that are the basis for each group's claim to the resource. This examination of a more expansive notion of fisheries management and policy required the use of written documents, fishing technology, and the cultural landscape as source material. But the traditions and decisions that guide the use or allocation of fisheries resources are also engulfed in daily deliberations, casual talk, and highly vocal debates—a social and cultural process that plays out on the streets, in homes, on the docks, in fishing boats, at community meetings, in government offices and legislatures, and in adjudicative bodies throughout the world. Within this oral culture circulates an extensive array of historical perspectives that either go undocumented or are not carefully interpreted in the process of fisheries policy debate. These circumstances made the collection and interpretation of oral history a focal point of this documentation project. As expected, these narratives conveyed the divided opinion of a fifty-year fisheries debate. However, of greater significance, these narratives showed the differences in how each group historically perceived and expressed what can variously be called their resource-use values or their policies or their management methods. While the content of these oral histories show that each group's resource-use priorities are shaped through a multi-faceted occupational and environmental experience, the longtime debates over the use of Lake Michigan's fish were consistently waged through a simplified dialogue of selected economic and allocation issues. Within this framework, each group's oral history was scarcely recognized or evaluated as expressing elements of an informal, occupationally-derived environmental position—traditional ecological knowledge—an ethnographic oversight in the policy-making process that failed to account for the diverse ways in which fish-using groups justify their claim to the resource.

Aware of these problems, this documentation effort got underway in 1999, just as a 1985 Federal Consent Order settling Native American fishing rights disputes in Michigan's Great Lakes waters was being re-negotiated. Once again, the clamorous voices of Lake Michigan's fishing constituencies were raised on all sides. Interviewees were asked to chronicle their lifetime involvement in Lake Michigan's fisheries and their group's fish management priorities and resource-use values. From these interviews, each group's custodial view of Lake Michigan's fish emerged as their own unique historical perspective—folk histories that justified their claim to the resource. Much of this material qualified as traditional ecological knowledge—an understanding of fish behavior and fishing grounds (Figures 2 and 3), the development of technology and shoreside facilities to pursue these species, and the evolution of local management systems.

Figure 2-This map shows the locations of pound net fisheries on Lake Michigan in 1885. While not all of these grounds are utilized today, they do shape the historical foundations of traditional ecological knowledge (TEK) among Lake Michigan's contemporary commercial fishers. (U.S. Commission of Fish and Fisheries-1887 Report)

Of all these major stakeholder groups, Lake Michigan's commercial fishers most consistently invoked TEK as the basis of their occupational history and as justification for the resource-use values and vernacular governance they presented and claimed in policy debates. In short, the wide-ranging ecological perspectives and ecological responses that Lake Michigan's commercial fishers describe in their oral histories are their management positions; in practical terms, these historical and contemporary experiences are their contribution to the formulation of fisheries policy. Since Lake Michigan's commercial fishers contribute their multi-generational use patterns and observations through a traditional occupational prism, this project seeks to assist fisheries policy-making and fisheries management in documenting and interpreting the ethnographic shroud that covers these compelling ecological insights on the challenges of harvesting and processing fish. As vernacular or occupationally-derived policy statements, these oral histories begin to delineate the ethnographic logic that guides the integrated use of TEK and traditional occupational management in Lake Michigan's commercial fishery. For those outside of the commercial fishing community, TEK's thematic emphasis in oral history can be seen as a narrative pattern that functions rhetorically to present the occupation's environmental ethic and occupationally-based policy perspectives.

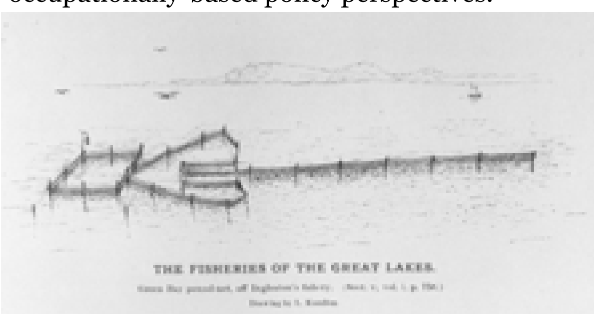

Figure 3-The typical configuration of a Lake Michigan pound net in the late19/early 20th century. (U.S. Commission of Fish and Fisheries-1887 Report)

Identifying the thematic patterns of these orally expressed occupational and ecological histories is the first step in applying them to more holistic management plans. The everyday utility of these oral histories emerges in thematic patterns that convey knowledge and use of fisheries resources as an ecological map. The content of this ecological map is historically shaped, but these antecedents provide a longstanding context that informs contemporary fisheries practice and its adaptation.

Life Histories in Fishing Locales: TEK, Geographic Sentiment, and Resource Claims

One's claim to use the knowledge that defines this ecological map arises in oral history that links family, ethnic, and community tradition with the work organization of each particular fishery and the sense of place that connects its participants to a fishing area. In short, these oral testimonies specify the human factors that function as compass points in each fisher's environmental experience. Daniel "Pete" LeClair of Two Rivers, Wisconsin describes the ecological basis of this relationship through the transitions he and his family have made from the pound net fishery to the gill net fishery to trawling and trap net fishing:

> *Our main fishing area is north of the harbor—about ten miles. If we went further, then we would get up near the nuclear plants and that's all big rocks. This is where my dad fished—in the Kidville area—that's all nice sand there. But you get closer to the nuclear plant and its all big rocks and you cannot fish there with pound nets, trap nets or gill nets or nothing—it's just unfishable...I know this little area here. Half of these grids are rocks and shipwrecks, so we can maybe only fish in half of it. We have fished straight out of here—five miles southeast of Two Rivers and ten miles north. So we're talking about a 15 mile area that is 4 to 5 miles wide.*[5]

He adds:

> *I have been in it since I was old enough to walk. Some of our pound nets were in 80 feet of water, but most of them were for lake herring (Coregonus artedi) and lake whitefish (Coregonus clupeaformis)in 40 feet of water. Around 1946-47, the lamprey got so thick and they killed all the lake trout (Salvelinus namaycush). That was the end of our pound net operation and then we had to go to gill net fishing for chubs (Coregonus hoyi-johanne-kiyi-nigripinnis-reighardi-zenithicus) and so forth...When the lamprey arrived, it was an awful mess. The dead lake trout were 2 feet thick on the bottom of the lake and when you would fish gill nets the lake trout would just rot and lay on the bottom. You could not pull your nets out of the dead, decaying lake trout on the bottom...So they (the state) encouraged us to start trawling for chubs, alewife, and smelt (Osmerus mordax)...there were too many...it takes a long, long time to get these captains experienced on the operation of the net, the equipment, where to fish, and so forth. Once you lose these guys, there is no way you're coming back...under the present management system they are not going to stay...it will*

never come back…they do not have the knowledge like the older people in developing this type of fishery.[6]

William Carlson of Leland, Michigan has worked the fishing grounds around Michigan's Leelanau Peninsula his entire life, making transitions from gill nets to trap nets to purse seines. He invokes community-based knowledge of this habitat in chronicling his participation in fishery policy debate and occupational endurance over the past thirty years:

> *The native species that commercial fishermen pursued in the Great Lakes were lake trout and whitefish and lake sturgeon (Acipenser fulvescens) and chubs and yellow perch (Perca flavescens) and menominees (Menominee whitefish-Coregonus quadrilateralis), though lake trout and whitefish were the most valuable and that's what they concentrated on…A lot of the knowledge that we have was passed down. Species that are indigenous to this area of the Great Lakes, they're doing things for a reason—reasons we may not know—but they do not change very often. Exotic species, species that may have been introduced, those are the things the we've had to learn about—the salmon, for instance, what their habits are and why they react to things. But the information that's been passed down to us, traditional spawning grounds, traditional feeding areas, the ways fish move, that's information that somebody learned the hard way and we've learned the easy way…*
>
> *We're still doing a lot of research and learning things but when it comes right down to it, we're still going back to those traditional fishing grounds that have been passed on from generation to generation.*[7]

He continues:

> *But historically, we still have the advantage that my father and my grandfather and my great-grandfather passed onto us that gives us a lot of shortcuts. We know where the fish should be at certain times of the year. They were not as sophisticated in understanding water temperature. I do not think they knew why fish came up shoal. I do not think they knew why fish went deep or why they came off the bottom. We have a better feel for that. I do not even remember my father saying much about water temperature being a factor. He said he knew when the fish came up—if the pollen is on the water the whitefish will be shoal. Now whether he associated that with white—the pollen—with the whitefish coming shoal, I have no idea, but that's how he gauged when to move his nets into shoal water. If there was a lot of east wind, he would tell me: " well, we're going to have better fishing in shallow water." But the reason was that the wind blows the surface water away from this shore and brings colder water up from the bottom and the fish are temperature oriented. Whitefish like water that is in the 40's and low 50's. Lake trout like it a little bit warmer. Salmon like 55 degrees. We learned that because of advances made in technology. But most of it was observation—trial and error—putting those things together.*[8]

The U.S. Fish Commission's earliest economic surveys of Lake Michigan's fisheries account for these combined ethnic, family, and regional affiliations, a work structure that led to the development of frequently referenced "fishing centers" or "fish towns" and their recognized fishing grounds. From these locations, members of Lake Michigan's fishing communities developed TEK's geographic vocabulary and spatial sense of species behavior. For all its strengths and weaknesses, the ecological basis of this management tradition is long and vestiges survive among Lake Michigan's small commercial fishery.[9] While these forms of vernacular governance and vernacular ecological interpretation are easily romanticized, oral history reveals the manner in which these human geographic affiliations and occupational folk histories use TEK to socially and culturally validate the commercial fishing community's claims to the resource.

The Technological Interface: TEK's Relationship to Tradition and Change in Harvesting Methods

Commenting on the roots of inherited knowledge of Lake Michigan's fisheries ecology, commercial fishers describe the knowledge of lake bottom that was required to successfully use the pound net, gill nets, and set lines by prior generations. Mastery of this technology established the fisher's ecological relationship to the resource, knowledge that could easily be disrupted by biological invasions, overfishing, planting of non-indigenous species or lack of skill in using harvesting technology. Commercial fishers' oral histories reveal that their technological proficiency not only determined economic success, but also determined the fisher's ability to evaluate the overall ecology of the fishery. Lake Michigan commercial fishers who made the transition between pound nets, gill nets, trap nets (Figures 4 and 5), and trawling, attest to this system of ecological learning.

Figure 4-The *Joy*, which works out of Leland, Michigan, is typical of the trap net boats that are used on Lake Michigan today. It long, open stern area allows for the safe and manageable retrieval of the trap net's pot section—the end of the net and the main entrapment device on this type of harvesting technology. The trap net is essentially a submerged version of a pound net. (Photograph by Chiarappa)

Figure 5-The Weborg family of Gills Rock, Wisconsin has fished Lake Michigan's waters for the past century. Having started as gill net fishers, they have translated their knowledge into a successful trap net fishery for lake whitefish (Coregonus clupeaformis). In this photograph, two members retrieve the pot of the trap net. (Photograph by Chiarappa)

For each generation that has fished Lake Michigan over the past half century, each harvesting technology and its environmental context has established relative ecological relationships, ethnoscience, and evaluative functions. Alan Priest of Leland, Michigan describes how his mentors instilled, and his owned working experience affirmed, TEK's synergistic dependence on technology and fishing environments:

> *Ross and Fred Lang taught me how to work. You cannot show up for work and jump on the boat and go out and catch chubs. It does not work that way. Right here in the shed is 90 percent of your fishing—working on nets. If you do not keep up your nets…your not going to produce anything. I'm not saying go out and rape the lake or take every fish that you can catch, no…they taught me how to work and be responsible. Well, you have to learn the banks. Certain spots produce better in the summer than they do in the fall. Over the years, you just learn which spots produce better at certain times of the year and at what depth of the water. You keep a logbook. I write the weather conditions. While we are lifting nets, I always have the sounder on so I can see where we are catching most of our fish. So, when you set back, you put most of your nets in that depth. But you do not concentrate on that depth. Say the fish are in 57 to 60 fathoms. Well, you might start out in 63 and go up to 49 and then go down to 57, 58, 59, 60 and set seven or eight boxes in that depth. You always have two or three that are up above or deeper because the chubs move up and down the bank.*[10]

Although a generation older than Alan Priest, "Pete" LeClair of Two Rivers, Wisconsin describes a similar situation when he converted his gill net tugs to trawlers to harvest chub, alewife, and smelt. LeClair described a significant adaptive process in learning how to achieve the proper spread with the otter trawl and in the need to install a hauling ramp on the fish tug to avoid being swamped by the weight of the full cod end. But LeClair's emphasizes, particularly in policy debate, the demands of acquiring new ecological knowledge to find and successfully harvest each species:

> *We started trawling here in the Two Rivers area in1962. We started with the old small Susie Q and I'll tell you, we did not have much money to buy a trawl net (Figure 6). At the time, trawl nets were*

$1500—I believe. We went out the first day and we lost her—our trawl net. Got a shipwreck and lost the whole works. Went out the next day, lost another one. I said this is not going to work so we had to go to our next plan. So then we got a hold of an old car ferry captain. He had been on the lake a long time and he had a map of all the lakes showing shipwrecks, explaining the lake bottoms, where the rocks were, where the reefs were, and where the clay balls were. We worked with him for several weeks and mapped out an area that had a good sand bottom where we had half of a chance of fishing. Fortunately, now with loran and shipwrecks charted, you know where you can go and where you cannot go. So, all this was part of the development of the fishery. We went from charts to sounders to color TV sounders to fish finders. The only way you do all this is through experience. You cannot take a guy off the street, throw him in the boat, and say your going fishing. We tried fishing up in Lake Superior a couple of times, but if you're not familiar with the grounds it is difficult. We took our trawlers up there and we tried to catch smelt on Lake Superior. But we were not familiar with the bottoms and we tore our nets and lost some nets. There are clay balls up there and we got clay balls in our nets and they destroyed the whole operation. It just did not work. You have to grow up in an area of the lakes and you have to know your lake bottom.[11]

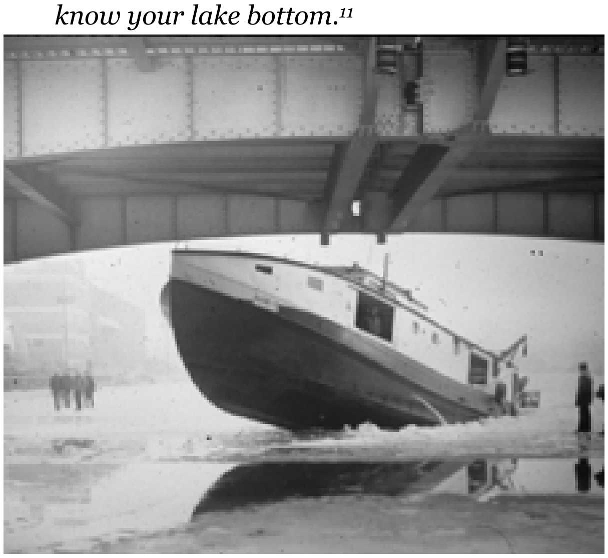

Figure 6-Daniel "Pete" LeClair's fish tug *Susie Q.* breaking ice at Two Rivers, Wisconsin. This boat was originally designed for gill net fishing and LeClair converted it to trawling—no small task considering the boat's low freeboard. The boat technologically adapted to the ecological factors of trawling for alewife, smelt, and chub. (Photograph courtesy of Daniel "Pete" LeClair)

Filling the inshore waters, these fishing grounds, harvesting technologies, and shoreside facilities (fish houses, shanties, reel yards, processing buildings), create an ecological synthesis that was tuned to the instinctive movements of various Great Lakes fish—most notably whitefish, lake herring, and lake trout—and the undulating seasonal rhythms and temperature of the freshwater sea's surface water. Both Pete LeClair and William Carlson note that their families earlier use of pound nets set the precedent for these localized management schemes, and their proximity to their shoreside facilities and created ecological relationships and knowledge that initially established each family's customary notion of its territorial or home fishing grounds. It was not just architecture and technology's economic function that engendered this sentiment, but the manner in which the integrated use of buildings, boats, and netting fostered each family's intimate understanding of their local fish habitat (Figure 7).

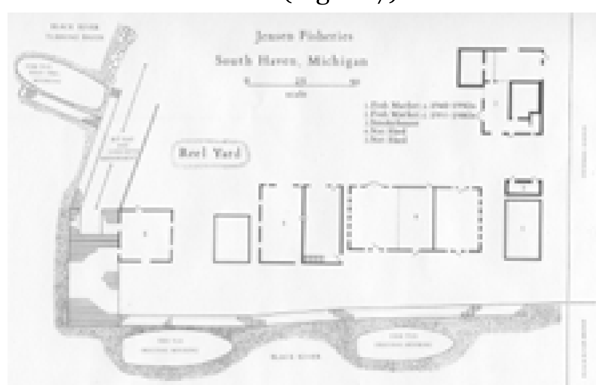

Figure 7-This site plan of the Jensen fishery in South Haven, Michigan is representative of the region's "fishing centers" or "fish towns." Such sites and their architecture provide territorial bearings and technological infrastructure that figures prominently in the formulation of TEK. (Drawing by Chiarappa)

Great Lakes commercial fishing struggled through the 1940s and 1950s. While this was partly attributable to the over-fishing of certain stocks, it was more shockingly revealed in the effects of non-Native species. In particular, the predacious, non-Native sea lamprey practically extinguished the lake trout population of the Great Lakes basin. These factors, combined with the events of World War II, instigated a series of logical, yet varied, adjustments in the interface between TEK and technology. In this regard, the technological and ecological versatility of the earlier fish tug design, which was used exclusively for gill netting, found new expression in the larger, steel-hulled fish tugs (Figure 8) and trap net boats of the mid-twentieth century (used for gill netting, trap netting, and trawling). For reasons relating to its basic occupational function and geographic affiliation, these larger, more durable boats assumed distinct cultural value within the commercial fishing community—a sense of technological empowerment and new TEK that enabled them to face new problems that were confronting the industry.[12]

Figure 8-This advertisement shows how the design and use of Great Lakes fish tugs, and, by extension, TEK, was being influenced by wider technological developments. (Atlantic Fisherman)

Daniel "Pete" LeClair, Jack Cross of Charlevoix, and Charles Jensen of South Haven noted that new fish tug and trap boat designs, navigation equipment, and bottom reading technology responded to ecological and policy changes, but, in turn, fostered the creation of new TEK.[13] William Carlson describes the process as follows:

> *We've used other techniques in catching fish that helped us learn quite a bit. In the 1970s, we adapted the purse seine to the Great Lakes to catch whitefish. We built a boat, outfitted it, got equipment made for the particular areas we intended to fish in and the areas that we were limited to, had gear made to fit those conditions, and then we used the purse seine on the Great Lakes. It worked very, very well and we learned a lot about fishing doing that. We learned a lot about whitefish—what they did, what were their general movements, how they congregated or schooled and the strata of water that they would be located in. Because it was a new technique on the Great Lakes—we were pioneering it—we had to do a tremendous amount of research, a lot of trial and error. It's no longer used here, but that's because we cannot fish in the waters where we used it. They're Indian waters and they have exclusive rights to those areas. The purse seine had its limitations in that it had to be fished in good weather, and so we looked for bays and areas where we could get protected waters to fish it in, and those areas we can no longer fish in. So there's a lot of learning in a situation like that, but in the traditional gear like trap nets and pound nets, we're doing that on a historical level. We're learning a little bit, especially with trap nets, because we're fishing areas that were never fished with pound nets.*[14]

Through these changes, informants describe fishing vessels, harvesting technology, and processing buildings as maintaining the vital balance between old and new TEK as the commercial fishing community's negotiating position became increasingly marginalized making TEK a much needed hedge as the industry pursued new target species and adjusted to sport fishing policy and Native American treaty rights fishing. Technology and TEK are fused in the oral record as an archive of the commercial fishing community's effort to adapt its claims to fisheries resources amidst Lake Michigan's uncertain ecological and policy changes.

OF ICE AND MEN: TEK, TECHNOLOGICAL AFFINITY, AND THE GREAT LAKES FISH TUG

Over the course of the twentieth century, the Great Lakes fish tug occupied a central position in the region's commercial fishing ecology. These stout, durable boats—distinguished by their totally enclosed working areas—mediated their user's relationship with the Great Lakes. As Great Lakes fishermen pursued various target species in frequently rough and ice-ridden waters, the fish tug framed an experience that was at once technologically empowering and environmentally humbling. These conditions prompted not only the technological necessity of the fish tug, but also the technological affinity that defined its ecological role and occupational status. As Lake Michigan's commercial fishing activity became more fragile due to diminishing stocks of target species and the biological invasion of non-indigenous species, the fish tug's role as an archive of collective memory and TEK became more acute. Why did this boat's ecological profile—as harvesting technology and visual icon--function so prominently as a memory device in personal histories, local historical events, descriptions of the environment, and accounts of work patterns (Figures 9, 10, 11-The evolution of twentieth century Great Lakes fish tug design. To mitigate weather conditions, facilitate the efficient retrieval of gill nets, and provide fish processing space, the fish tug went from being principally an open deck vessel to being fully enclosed).

Figure 9-The fish tug *Herbert* of St. Joseph, Michigan, c. 1910-1920. (Courtesy of Kathryn Chappel)

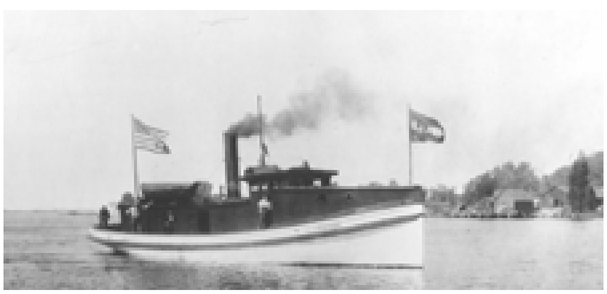

Figure 10-the fish tug *H.J. Dornbos* of Grand Haven, Michigan, c. 1930-1935. (Courtesy of Fern and Robert Ver Duin)

Figure 11-The fish tug *Butch LaFond* of South Haven, Michigan, c. 1940 (Courtesy of Michigan Maritime Museum)

Oral history, along with written and visual documentary sources, establishes the context and wider expression of a technological affinity or "technologically sublime" relationship between fish tug users, the vessels, and the fisheries ecology within which they are used.[15] Initially, the fish tug empowered the ecological perspective of Lake Michigan fishers by allowing them to travel greater distances and harvest greater volume of their two principal target species—lake trout, whitefish, and lake herring. Having been restricted by the limited range of the Mackinaw boat, the steam and diesel-powered fish tug made Lake Michigan fishers less bound to a single port of operation and could explore a wider range of off-shore fishing grounds. After World War II, when lake trout and whitefish declined in number, the fish tug enabled fishers to investigate new fishing grounds for previously underutilized stocks of perch, chub, and walleye. Both wood and steel fish tugs allowed Lake Michigan's fishers to be more mobile and able to understand the more diverse complexion of the basin's fisheries ecology. Oral history consistently sheds insight into how the fish tug continued to foster each fisher's local ecological consciousness and gradually facilitated a more holistic view of the spatial diversification that characterized the lake's fisheries ecology. In this role, fish tugs not only allowed fishermen to act on the ecological contingencies of the fishing enterprise, but also acted as a visible marker of the fisher's extra-territorial affiliations.[16]

When the Mollhagen family of St. Joseph, Michigan built the steam-powered fish tug *Herbert* in 1908—before the rise of the enclosed-deck fish tug—they did not hesitate to adorn their business stationery with a drawing of the boat and the by-line: "Great Lakes steel fish tug." The sentiment behind this label is most revealing and substantiates the fish tug's longtime technological tenure and the manner in which it engendered ecologically-specific relationships on Lake Michigan and the other Great Lakes. Oral testimony correlates the production of steel tugs in local Great Lakes boatyards with the vernacular re-definition and re-appraisal of Lake Michigan fisheries ecology.

The ecological contingencies of this learning process are emphasized in narratives that describe the region's cold water, highly capricious wave-action, and, most of all, arduous ice conditions. Alan Priest describes a typical situation:

> *In the wintertime we try to fish close to home. There's a place called the Northeast Channel bank and the channel bank which is right off the northeast corner of North Manitou Island. They're about an hour and ten minutes out. And that's because of the weather. It blows just about every day starting the end of October until the ice is out or spring. It's very rare, but we fished the last three winters all winter. It's very seldom that we get to do that. The harbor freezes up with ice every once in a while. Then we take the boat up and turn it around at the falls and get her pointed down the river and just give her the berries. We can go through lots of ice. What you do is you hit the ice with the bow and you feel it. Then you give her the throttle and the tug goes up and breaks the ice. Always make sure you have a clear spot behind the boat so you do not get stuck. You can turn around, but it will take time. But right here in the harbor, we can get through anything that will build up. It's just the drift. I call it snowballs. You will start with a snowflake and then it will freeze and roll. You can get some that are as big as these fish sheds. Then they pack in here. You get a southwest wind and it just packs in here. You have to be careful if you're out on the lake and you get ice drifting around—you have to get home.17*

Chuck Jensen of South Haven, Michigan cited similar circumstances regarding his lifetime experiences with fish tugs on Lake Michigan. He, along with other commercial fishers, acquired knowledge about various aspects of Lake Michigan's fisheries ecology through using a fish tug. But in extreme weather conditions, he hastened to note that the vessel's technological benefits hinged on the fisher's understanding of pre-existing ice conditions in port locations and his ability to read wind conditions that created large ice floes that Great Lakes fishers refer to as "ice windrows."[18] In both cases, Jensen and Priest evaluate the earlier ecological lessons that had been wrought from fish tug use. Steel tugs were never to be a reality for many of Lake Michigan's fishers, but they did reinforce a pervasive mindset within Lake Michigan's commercial fishing community that is evident in Priest's hyperbole: "I have more faith in these old fish tugs than I do a freighter or a sailboat or any kind of boat…I'm married to my fish tug, just like my wife."[19]

CONCLUSION: TEK, OCCUPATIONAL STRUGGLE AND THE CODED CLAIMS OF LAKE MICHIGAN'S COMMERCIAL FISHERS

When Lake Michigan's commercial fishers narrate their participation in the management debates of the later twentieth century, their perspective is colored by their efforts to occupationally survive. This stance certainly elicits commentary on policy that has either facilitated or hindered their pursuit of fish. But for commercial fishers, fisheries management is a far more entrenched claim whose historical effect is only minimally gauged by the printed word of the policy making process. Not surprisingly, when asked to provide oral testimony on their view of the historic relationship between fisheries management and their economic livelihood, most of Lake Michigan's commercial fishers chose to do so through description of their fishing grounds, harvesting technologies, shoreside communities, and family affiliations.

In the oral histories of Lake Michigan's commercial fishers—in the themes emphasized, in the points made, in the resonating reflections—herein lies the critical nuance of TEK's capacity to measure a fishing community's past and present prospects. Oral history allows its narrators to explore the broader implications of TEK and offer it as counterpoint to "official" regulations, scientific reports, and evaluations of harvesting technology. In developing new co-management schemes, fisheries managers can use these narratives for their sheer content or they can ethnographically observe their use in various contexts within the commercial fishing community. In either case, our view of Lake Michigan fisheries management and policy will be revised and will embrace far greater criteria; in short, by mapping human sentiment, oral history reminds us that fisheries management and policy is the exercise and expression of values, needs, and ecological relationships. Much material can embody these intentions, but oral history clarifies how they are complexly synthesized as TEK.

Lake Michigan commercial fishers use oral history to invoke TEK's authority as a form of vernacular governance and enlist it in on-going historical claims over the right to use Lake Michigan's fish. As in many debates, there have been points of striking division and surprising agreement since Lake Michigan's commercial fishers first began asserting their competing claims among the basin's stakeholder groups. Pete LeClair's testimony is emblematic of the sympathies and conflicts that consume the expression of TEK:

> *The fishery is so up and down it's almost impossible to manage it by sitting at your desk in Madison (Wisconsin)—saying we have to put quotas on them and we have to do this when they do not even know what's out in that lake or what the biomass really is. Fish and Wildlife go around once a year with their small net and their boat. It is just a waste of time because if you go one week earlier or one week later from when they go, or if you go in a different depth of water, the whole project would be turned right around. You can get a ton of smelt and you go out the next day you cannot find one and you're in the same depth of water and same area. So, the current, the water temperature—it all changes and you cannot do this by going around the lake 2 weeks out of the year and say this is what is out in the lake. That's false. It's very, very, very disturbing when you try to manage a lake off this kind of a data. You just cannot do it and we would like to be part of a research program where we could go and make test drags with our nets. We know the nets -- we know what the nets can catch because we proved it. We would like to be a good research team with the DNR* [Department of Natural Resources]—*take the DNR people out there and monitor our catches, study the classes, study the gross factors, study the sex ratios and really know what's going on out on that lake. If you have more forage fish, you have to plant more predator fish. If the forage fish is down you plant less predator fish. If you do this, you can maintain a perch fishery, maintain a sports fishery and maintain a commercial fishery that produces food for human consumption. This is what this is about.*[20]

But competing claims to natural resources are scarcely unique in broad historical perspective, and historians and anthropologists are just starting to take note of how the threshold or liminal nature of the maritime environment shapes these dynamics. During the late nineteenth century, the seeds of a complex array of claims or authority over Lake Michigan's fisheries began to take place. The major fishing constituencies on Lake Michigan began this self-referential (at times, polemical) claiming exercise by describing their administrative prerogative or natural heritage or economic livelihood or cultural birthright. For Lake Michigan's commercial fishers, oral testimony unifies these strands of TEK and places them at the center of the group's folk historical consciousness. The folk historical dimensions of TEK verbally corroborate the past and verbally continue the endurance and revision of fishing claims in the present. The utility of these perspectives in wider planning arrangements rests with oral and public history's ability to "share authority" with those groups who will continue to bear the burden of fisheries management and policy in the future.[21] In this way, the inextricable relationship between TEK and folk historical identity reveals paradoxical considerations that will inform the evaluations of fisheries history and the formulation of future fisheries policy and stakeholder relations.

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[1] For more on collection, interpretation, and application of traditional ecological knowledge see: Barbara Neis, Lawrence F. Felt, Richard L. Haedrich and David C. Schneider, "An Interdisciplinary Method for Collecting and Integrating Fishers' Ecological Knowledge into ResourceManagement," in Fishing Places, Fishing People: Traditions and Issues in Canadian Small-ScaleFisheries, eds. Dianne Newell and Rosemary E. Ommer (Toronto: University of Toronto Press, 1999), 217-238; Barbara Neis and Lawrence Felt, eds. Finding Our Sea Legs: Linking Fishery People and Their Knowledge with Science and Management (St. Johns, Newfoundland: Institute of Social and Economic Research, 2000).

[2] Paul Thompson, with Tony Wailey and Trevor Lummis, Living the Fishing (London: Routledge and Kegan Paul, 1983).

[3] A number of works present the intersection of folk history and oral history in fishing communities. See: Timothy C. Lloyd and Patrick B. Mullen, Lake Erie Fishermen: Work, Tradition, and Identity (Urbana: University of Illinois Press, 1990); Janet C. Gilmore, The World of the Oregon Fishboat: A Study in Maritime Folklife (Ann Arbor, MI: UMI Research Press, 1986); James Acheson,*The Lobster Gangs of Maine* (Hanover, NH: University Press of New England, 1988) For more on methodological and interpretive considerations surrounding oral history and folk history see: Rosemary E. Ommer, "Rosie's Cove: Settlement Morphology, History, Economy, and Culture in a Newfoundland Outport," in Fishing Places, Fishing People: Traditions and Issues in Canadian Small-Scale Fisheries (Toronto: University of Toronto Press, 1999), 17-31; Jean L. Manore and John J. Van West, "'The Water and the Life': Family , Work, and Trade in the Commercial Poundnet Fisheries of Grand Bend, Ontario, 1890-1955," in Fishing Places, Fishing People, 55-79; Henry Glassie, "The Practice and Purpose of History,"Journal of American History 81 (December 1994): 961-968; Passing the Time in Ballymenone: Culture and History of an Ulster Community (Philadelphia:University of Pennsylvania Press, 1982); Sam Schrager, "What is Social in Oral History,"International Journal of Oral History 4: 76-98; Charles L. Briggs, Learning How to Ask: A Sociolinguistic Appraisal of the Role of the Interview in Social Science Research (Cambridge:Cambridge University Press, 1986); Edward D. Ives, George Magoon and the Down East Game War (Urbana:University of Illinois Press, 1988); Robert Perks and Alistair Thomson, eds. The Oral History Reader

(London: Routledge, 1998); Stephen Caunce, Oral History and the Local Historian (London: Longman, 1994).

[4] The broad historical patterns of commercial fishing on the Great Lakes are presented in Margaret Beattie Bogue, Fishing the Great Lakes: An Environmental History, 1783-1933 (Madison: The University of Wisconsin Press, 2000) and A. B. McCullough, The Commercial Fishery of the Canadian Great Lakes (Ottawa, Canada: National Historic Parks and Sites/Canadian Parks Service/Environment Canada, 1989). The contested issues surrounding Great Lakes commercial fishing since the middle of the twentieth century are well-documented in: Robert Doherty, *Disputed Waters*: Native Americans and the Great Lakes Fishery (Lexington: The University Press of Kentucky, 1990); ; Tom Kuchenberg, Reflections in a Tarnished Mirror: The Use and Abuse of the Great Lakes (Sturgeon Bay, WI: Golden Glow Publishing, 1978).

[5] Daniel "Pete" LeClair, interview by author, tape recording, Two Rivers, WI, 11 December 1997.

[6] Daniel "Pete" LeClair interview.

[7] Lester William "Bill" Carlson, interview by author, tape recording, Leland, MI, 26 and 27 May 1999.

[8] Lester William "Bill" Carlson interview.

[9] Hugh M. Smith and Merwin-Marie Snell, "Review of the Fisheries of the Great Lakes in 1885," U.S. Commission of Fish and Fisheries, *Report of the Commissioner for 1887* (Washington, D.C.:GPO, 1891), 1-333.

[10] Alan Priest, interview by author, tape recording, Leland, MI, 29 May 1999.

[11] Daniel "Pete" LeClair interview.

[12] "Great Lakes Fish Tug Has Dual Engine Drive," *Atlantic Fisherman* (hereafter *AF*) 26 (October 1945), 27; "42 Ft. Steel Fishing Tug Has New Features," *AF* 26 (November 1945), 40; "Gill Netter 'Sir Knight' Added to Michigan Fleet," *AF* 26 (January 1946). The later twentieth century context, values, and temperament that shaped the Great Lakes fish tug are reflected in feature articles and photographs in *Atlantic Fisherman*. See *AF* 27 (May 1946), 33; *AF* 27 (June 1946), 31; *AF* 27 (December 1946), 25; *AF* 28 (March 1947), 24; *AF* 28 (August 1947), 26; *AF* 29 (April 1948), 20; *AF* 29 (July 1948), 25. See also: Frank E. Firth, " Fishing Gear and Fishing Methods, " in *Marine Products of Commerce* by Donald K. Tressler and James McW. Lemon (New York: Reinhold Publishing Corporation, 1951), 263-264; Shari L. Dann, *The Life of the Lakes: A Guide to the Great Lakes Fishery* (East Lansing, MI: Michigan Sea Grant Extension/Michigan State University, 1993), 30; "Fisheries of the Great Lakes Waters: Over Half of Nation's Fresh-Water Yield Comes from Eight Lakes States, Led by Michigan," in *AF* 31 (December 1950), 14, 35; *AF* 26 (September 1945), 34; *AF* 28 (April 1947), 26; *AF* 28 (June 1947), 18. See Robert C. Grunst, "Farsighted Designs: The Fish Tug *Johanna* and Trends in the Upper Great Lakes Fishery," *Inland Seas: Quarterly Journal of the Great Lakes Historical Society* 53 (Summer 1997), 97-108, for one of the few contextual studies of the Great Lakes fish tug.

[13] Daniel "Pete" LeClair, interview; Charles Jensen, interview; Jack Cross, interview, tape recording, Charlevoix, MI, 27 May 1999

[14] Lester William "Bill" Carlson interview.

[15] David Nye, *American Technological Sublime* (Cambridge, MA: MIT Press, 1994).

[16] Smith and Snell, "Fisheries of the Great Lakes," 185; HowardWeborg, interview by author, tape recording, Gills Rock, WI, 1 June 1999; Kenneth Peterson, interview by author, tape recording, Fairport, MI, 4 June 1999. Commercial fishing trade journals—*The Fishing Gazette, The Fisherman: The News Journal of the Great Lakes Fisheries, and Atlantic Fisherman*—contain frequent references to the geographical movement of Great Lakes fishermen during their occupational calendar year.

[17] Alan Priest, interview.

[18] Charles Jensen, interview.

[19] Alan Priest, interview.

[20] Daniel "Pete" LeClair, interview.

[21] Michael Frisch, A Shared Authority: Essays on the Craft and Meaning of Oral and Public History (Albany, NY: State University of New York Press, 1990).

CAN HISTORICAL NAMES & FISHERS' KNOWLEDGE HELP TO RECONSTRUCT LAKES?

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ABSTRACT
Reconstructing the historical distribution of local Brown trout populations is of great importance. Information of what has actually been lost and its causes is necessary for rebuilding natural lake ecosystems and recreational fisheries, as well as monitoring future changes. Older fishermen and local fishing right owners in 63 privately governed fishery management organizations (FMOs) in Northern Sweden were interviewed, focusing on current species distribution, stocking, introductions and extinctions in 1509 lakes. Names were collected for each lake from modern and historical maps. Historical archives concerning fish species distribution and stocking were also compiled. Brown trout lake candidates were surveyed with multimesh-sized gillnets or other methods. Observations of bottom substrate confirmed or ruled out existence of proper habitat conditions for spawning. Chemical, physical and biological anthropogenic impacts were assessed by archival data and limnological surveys over 20 years. Information gathered from a number of sources and methods allowed for comprehensive validation of lake name evidence and interviews. All data were temporally as well as geographically referenced and stored in a GIS-linked database. One third of all lakes with historical or present Brown trout populations had *Rö,* or other dialectal terms commonly used for brown trout, included in their names. By targeting *Rö*-lakes, there was a minimum of a 90% chance of finding an historically or currently present brown trout population, compared with 11% when lakes were randomly chosen. Lake names were shown to be strongly associated with details regarding the fish fauna as well as the habitat. This study is, to my knowledge, the first published attempt to employ lake-name evidence in investigating fish species distribution. The entire data supports the idea of long-term stable brown trout lake distribution under pre-industrial natural conditions. However, since the 1920's, 27% of *Rö*-lake populations were found to have suffered permanent extinction (extinction rate >3 % per decade) mainly associated with fish introductions. Historical names, fishers' knowledge and documentary evidence combined with limnological data proved powerful in revealing the past natural distribution, as well as initiating restoration of brown trout lakes in Northern Sweden.

INTRODUCTION
Most marine and freshwater ecosystems around the world are being degraded and fish species pushed towards extinction (Moyle & Leidy 1992; Maitland 1995; Pitcher 2001). European inland waters are subjected to chemical, physical and biological anthropogenic disturbances leading to extinction of local fish populations (Lelek 1987; Maitland & Lyle 1991; Bulger & Lien 1993; Crivelli & Maitland 1995). From this perspective, knowledge on the most basal questions like, which populations have survived? or, which populations have been lost? are fundamental to practical conservation and management. For example, anthropogenic impact is eradicating or reducing brown trout (*Salmo trutta* L.) populations all over the species range according to Laikre *et al.* (1999). They conclude that the valuable biological resources that local brown trout populations represent are being lost at an alarming rate. Consequently, reconstructing the historical distribution of local Brown trout populations is of great importance. Information of what has actually been lost is necessary for rebuilding natural lake ecosystems and recreational fisheries, as well as monitoring future changes. However, no scientific investigations appear to have addressed the problem of reconstructing either the historical distribution of local Brown trout populations in any country in Europe, what has actually been lost to date, or the extinction rate. Laikre *et al.* (1999) strongly recommended that such studies of local brown trout populations be carried out both on a national and international level. Thus, empirical studies that include the historical dimension are needed to provide insight into conservation and management on a wider landscape scale.

Spatial dimension
If the objective is to cover large areas and achieve a wider landscape scale study on fish species presence or absence, it can mean surveying thousands of lakes. Conventional scientific methods with multimesh-sized gillnets (Appelberg 2000) by skilled personnel can be too time consuming, labour intense and costly if every lake were to be sampled. Making use of fishers' knowledge gathered through interviews can enable larger scale studies with less effort producing valuable data if properly validated (Hesthagen *et al.* 1993).

Historical dimension

In the absence of paleontological methods, the sources of information on historical distribution of species are limited to interviews and rare, fragmented archival records, where they exist. With first hand interviews it might be possible in some cases, to extend our perspective 80 or so years back in time, and with some rare archival data, perhaps even longer. A few studies have also suggested that many hundreds of years old place-names from maps can be useful historical sources of information on different species occurrence and habitat. Place-name evidence for the former distribution of beaver, wolf, crane and pine-marten is put forward in three studies in Britain. (Aybes & Yalden 1995; Boisseau and Yalden 1998; Webster 2001). Examples of place names in maps as historical sources on the past occurrence of halibut, sturgeon and whale is mentioned in Wallace (1998). The feasibility of using place names as indicators of original landscapes is tested and verified in a recent study (Sousa & Garcia-Murillo 2001). Lake names with species terms could prove to be valuable historical records of fishers' knowledge. If so, it might be one of few pre-industrial sources on fish species information for many lakes. The present study aims to show that historical lake names from maps can be useful indicators of past and present fish distribution if properly validated. To my knowledge, this is the first published scientific attempt to employ lake names in investigating fish species distribution.

The main objective of this study is to demonstrate how fishers' knowledge from interviews and historical fishers' knowledge from maps and archives together with limnological surveys can be used to elucidate the past and present distribution of fish species. This is exemplified by discerning brown trout lakes among 1509 lakes in northern Sweden. The following hypothesis is tested: "historical brown trout term" lakes with/without brown trout populations are represented at the same frequency as other lakes with/without this species. Making use of fishers' knowledge, it is intended that results from this study will serve as a template for ecosystem reconstruction as well as help management with policies and action to avoid present populations going extinct.

Material and Methods

Study area

The present study focussed on one geographic region to enable high sensitivity in detecting local dialectal phenomena, in contrast to choosing a more scattered random sample with the same effort e.g. a national survey. The study area with its center situated near 63°32´N 18°12´E extended over roughly one third of northern Västernorrland and parts of Västerbotten in the northern boreal region of Sweden (Fig 1). This investigation included 1,509 lakes and was delimited within the lake watersheds covering over 700,000 hectares. This area consists of 20 entire adjoining watersheds, each of which drains into the Baltic Sea, plus 40 partial drainage basins. The lake district is a result of deglaciation from 7,600 B.C. and new lakes are continuously being formed by the isostatic uplift of the coastline at a rate of around 8mm/year (Anon. 2001). Lakes have an elevation range of 0.1 to 515m above sea level. They are mostly oligotrophic, located in hilly productive forest land or bogs although some eutrophic lakes are found in cultivated areas. The region is sparsely populated with 8 inhabitants per km^2, most of which are concentrated in a few population centres. A majority of lakes belong to 63 privately governed Fishery Management Organisations (FMOs). FMOs consist of associations of private and company landowners that sell licenses to the public and manage the waters, as well as provide information about the fisheries (Fig 2).

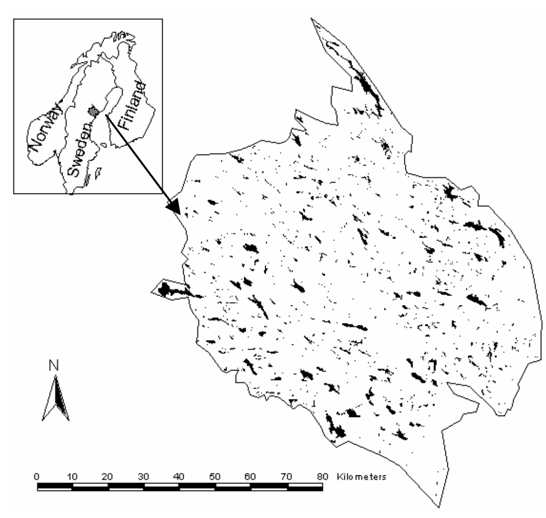

Fig 1. 1509 lakes within the study area.

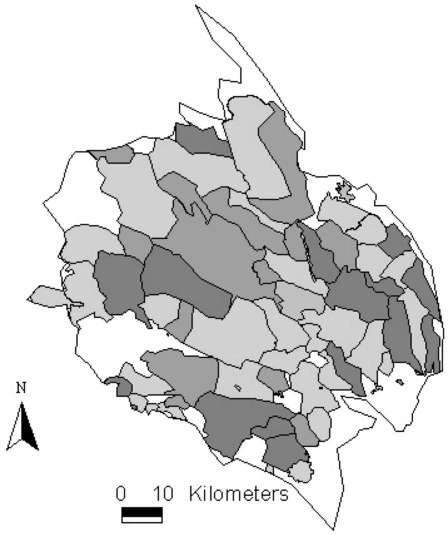

Fig 2. Coverage of 63 fishery management organizations (FMO:s) within the study area

Methods

Face to face in-depth interviews with older fishermen and 250 local fishing right owners in FMOs were held between 1985-2001, focusing on current species distribution, stocking, introductions and extinctions in all lakes. In addition, similar data was collected from local fishermen in remaining non-organized areas. Interviews generally commenced in a structured manner with specific questions concerning key issues e.g. brown trout distribution, spawning areas and stocking. This was gradually followed by in-depth interviews that gave an understanding of the informant's area of knowledge. Furthermore it provided additional contacts with other people knowledgeable on specific waters, fish species or historic events concerning the fisheries. In return, information on management and conservation was given which contributed to a comprehensive exchange of information concerning the waters of interest. Formal meetings were held indoors, often with the aid of maps for proper orientation and to avoid any mix up of lakes. Moreover, in most FMOs, additional field meetings were combined with observations of essential features of their waters. Relationships were built with most interviewees leading to several additional contacts over the years. Data were sought from at least two concordant primary sources when evaluating fish species presence-absence records from interviews. Discrete presence-absence data less prone to impacts of ordinary natural sweeping cyclic environmental change was collected in an effort to make data comparable with different methods and sources as well as avoiding subjective personal opinion. I also investigated archived audio recordings and written linguistic records of fishers born in the nineteenth century from the region of interest, dealing with fish species in local dialects. Scientific papers, encyclopaedias and archives with dialectology, onomastics and folklore research in Scandinavian languages were explored, focusing on lake names and historical brown trout names.

Historical documents concerning fish species distribution and stocking between 1872-2000 were collected from 3 major forest companies, county and municipality administrations, FMOs, the National Board of Fisheries and other sources. Approximately nine months were spent in archival research work, collecting hard-to-access fisheries related information concerning these waters of interest. Stocking data were evaluated in concert with other investigations to discriminate between native and introduced self-sustaining populations as well as non-reproducing populations. The majority of Brown trout lake candidates were inventory sampled with multi-mesh-sized gillnets according to Appelberg (2000) or with a somewhat modified stratification. A few were surveyed with other methods e.g. trapping, rod or single-pass electrofishing with a (LUGAB Inc.) backpack unit in the inlets and outlets. A population was considered extinct when sampling efforts of 0.5-2 multi mesh-sized gillnets per hectare/night plus electrofishing[1] in potential spawning areas did not generate any fish. Moreover, classification of each lake was tested for consistency with limnological survey data and interviews. Lake tributaries and outlets were classified as sufficient for brown trout spawning and early growth depending on the stream size, calculated from hydrological data and field studies. Visual qualitative observations of bottom substrate confirmed or ruled out the existence of proper habitat conditions for spawning of salmonids, determining the capability of lakes to hold self sustainable populations of brown trout. In the current study, waters were considered to lack spawning substrate suitable for brown trout if the bottom material totally consisted of sand or organic fine material (≤ 1 mm). Spawning substrate was confirmed if particle sizes in the range gravel, pebble or cobble (Bain and Stevenson 1999) could be found in patches of a minimum length depending on particle size. (See Witzel and MacCrimmon 1983 and Crisp 1996 for formulae on critical minimum sizes of spawning

[1] In pike-invaded lakes, extinction classification did not consistently include electrofishing.

substrate.) Natural fish migration barriers up and downstream from brown trout lakes were identified, thus determining the possibility of access to spawning-grounds as well as the progeny's ability to get back to the lake. A number of hydraulic, hydrologic and ecological factors were taken into consideration when classifying absolute barriers (Stuart 1962; Jones *et al.* 1974; Reiser & Peacock 1985; Powers & Orsborn 1985). Chemical, physical and biological anthropogenic impacts were assessed using archival data spanning 1925 to 2000, and limnological surveys spanning 1985 to 2001. Names were collected for each lake from 1:50,000 topographic maps (The Swedish National Land Survey 1961-1967). Additional names from county, parish, ordnance or village maps (The Swedish National Land Survey 1672-1908) were collected as well. The production date of each map provided a minimum age of every lake name. All data were temporally as well as geographically referenced and stored in a GIS-linked database. With modern tools like GIS systems and database software it was possible to store and access large amounts of information and achieve a wider grasp of both space and time. Having access to a number of sources and methods on species presence and absence, such as fishers' knowledge, archival data, historical names from maps and limnological surveys, allowed for validation of data concerning each lake. The hypothesis that "historic brown trout term" lakes with/without this species are represented in the same frequency as the number of brown trout populations if any lake is randomly chosen, was tested and rejected with Pearson Chi-square ($p<0.001$).

Feedback to FMOs on the preliminary results generated in this study was given in an effort to make use of the knowledge gained, to help management and in some cases initiate lake restoration.

Quality control of presence-absence

Face to face in-depth interviews, that gave an understanding of the informant's area of knowledge and allowed for collection of data that matched their expertise, were utilized to generate more reliable data. In *Rö*-named lakes, presence/absence data from interviews were validated with the combined data from test-fishing results, stocking records and other archival data as well as habitat surveys. In this respect, interviews succeeded in targeting all lakes with past and present self-sustaining brown trout populations, but within these lakes, two extinct populations were classified as still present. Archival data corresponded to these interview results except for two cases where non-brown trout lakes had been stocked with this species and a brown trout lake that was noted as a single species perch lake. Further validations were made to verify the informants' ability to target non-brown trout lakes. An additional 60 lakes pointed out through interviews as non-brown trout waters were confirmed brown trout free, by multi-mesh sized gillnet surveys. One possible brown trout-term lake was not classified as present or extinct in this study because of insufficiencies in data collected and so was excluded from all the results and evaluations.

RESULTS

Fishers' knowledge gathered from interviews and historical documents discerned several hundred brown trout lake candidates from the 1,509 lakes in the study area. Some lakes were sifted out when surveys found no suitable brown trout habitat e.g. lack of spawning substrate. Stocking data together with other investigations revealed a number of introduced, self-sustaining populations as well as non-reproducing populations totally dependant on hatcheries. These translocated brown trout populations were also excluded from further evaluation. Finally, multimesh-sized gillnets and other methods could verify that 161 lakes, i.e. the majority of remaining brown trout lake candidates, represented past or present self–sustaining local brown trout populations. Hence, if a lake was randomly chosen in this area, there was an 11% chance of targeting a brown trout lake (Fig 3). In addition to the *Rö*-named lakes treated herein, the entire set of lakes will be reported on by Spens (*in prep*) or elsewhere.

Interviews with an elderly fisherman revealed an old oral traditional term for Brown trout - *Rö,* which is not a recognized term for this species in modern language but a common prefix of lake names in modern and historical maps. Furthermore, several records relating to the name form *Röa* in local dialect were found in archives. The following excerpts are from part of the interviews made in Norrland around 40 years ago, freely translated: "Röding i.e. brown trout we call it rödingen" (Dahlstedt 1956). "*Röa* is a large kind of brown trout with red meat, not arctic charr" (Dahlstedt 1961). The term had also been dealt with in onomastic papers that referred to this geographic area e.g. "*Rö*-lake is characterized by its richness in *röa*, i.e. Brown trout" (Edlund 1975). However the linkage of the term *Rö* to brown trout was not known among fishers in the study area.

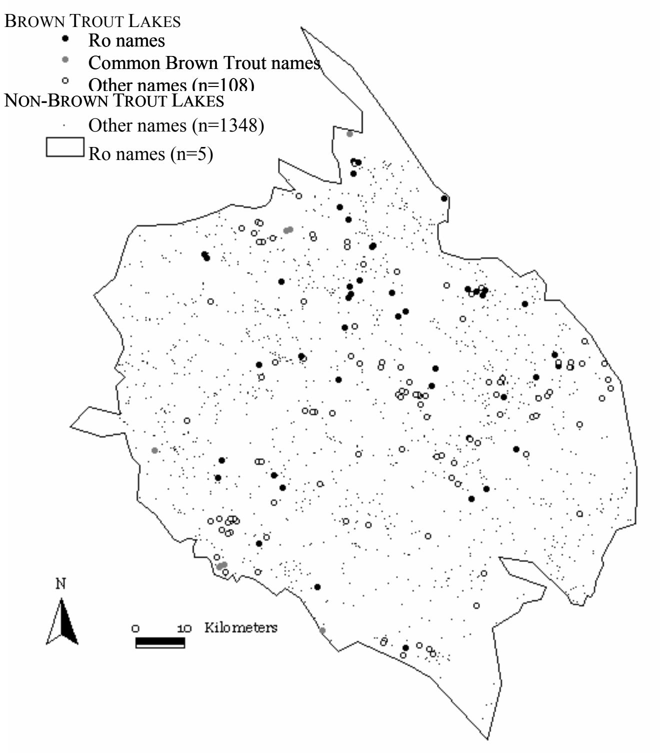

Fig 3 Brown trout and non-brown trout lakes in the study area.

Of all lakes with historically or currently present Brown trout populations, 28% had *Rö* as part of its name. An additional 5% of brown trout lakes in the outskirts of the study area had one of two other dialectal terms commonly used for brown trout (Fig 3). Hence, one third of all brown trout lakes in the study area had been named after brown trout. By targeting *Rö*-lakes, there was a minimum 90% chance of finding an historically or currently present brown trout population. The hypothesis that *Rö*- lakes with/without this species are represented in the same frequency as the number of brown trout populations if any lake is randomly chosen was rejected with Pearson Chi-square test ($\chi^2 = 341.5$; $p<0.001$). Accordingly, *Rö*-lakes were associated with historically and currently present self-sustaining brown trout populations. The *Rö*-name indicated that good natural habitat conditions for this species could be found in these lakes (Table 1):

1) 94% had outlet or inlet streams of sufficient size for brown trout spawning and early growth,
2) 94% had outlet or inlet streams with proper spawning substrate,
3) 94% lacked natural barriers to potential spawning areas,
4) 96% lacked an indigenous severe brown trout predator e.g. northern pike (*Esox lucius*).
5) 100% were isolated by natural barriers from several fish species downstream

Temporal perspective of methods

All types of lake names were found to be "evolutionarily" conservative and most were virtually unchanged through the centuries. A few *Rö*-lakes nevertheless, had been renamed with terms unrelated to brown trout. Many older fishermen used an elderly form of pronunciation not found in modern maps, thus providing evidence of names being passed on in a conservative oral tradition. Detailed maps over 100 years old were scarce as well as fragmented in the heart of the study region and generally drawn at too coarse a scale to illustrate the small lakes in this current study. Even so, 43 *Rö*-names were found dating back 100-330 years, many to pre-industrial times (Table 1 & Fig 4). However it was also assumed that the remaining 7 smaller *Rö*-lakes found on maps produced in the 1960s were initially named more than a hundred years ago. This was since the historical *Rö*-term almost vanished as a species word during the previous century. Moreover, the smaller size of these lakes explained why there was less chance of being marked on the coarse-scale and simple maps produced in this area more than 100 years ago. Archival sources referring to brown trout presence in lakes were found to date back 129 years. First-hand interviews had a maximum scope of 80 years back in time with a median of 61 years.

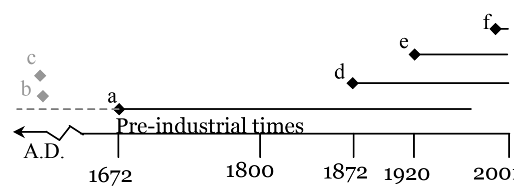

Fig 4. Temporal perspective of methods to reconstruct brown trout distribution in lakes within the study area in northern Sweden.
[a] Lakes names [b] Paleontology: Lack of fish fossil evidence makes reconstruction impossible for individual lakes. [c] Models are not yet developed for reconstruction of fish fauna. [d] Archival data
[e] First hand Interviews [f] Field Surveys

Anthropogenically induced permanent extinctions (1920's -1990's)

Interviews identified 10 of the *Rö*-lakes with brown trout as having lost their populations during the last 80 years (Fig 5). Archival data could verify that the majority of these were historic brown trout lakes. Two independent test-fishing results confirmed that the lakes no longer harboured this species. Two additional recently extinct populations were discovered by

Table 1. *Rö*- Named Lakes and Methods Elucidating Past and Present Brown Trout Populations.

[a] *=Modern maps list a different name. [b] P.ex.b. = Possibly extinct before decade or no population ever existed. [c] Yes = sufficient spawning stream size and substrate existed as well as no natural absolute migration barriers to spawning streams in lake outlet or inlets. [d] [R]=reproductive area called *Rö*-. [e] [N]=Written historical documentation does not mention brown trout [f] Fishers' earliest recollection of brown trout population (decade), [NE] = interviewees never observed Brown trout in lake during the time-span from listed decade until present. [2nd] =Interviews consist of several concordant second-hand sources [g] Self–sustainable local brown trout population sampled year (A.D.), [NO] = no brown trout observed when test-fishing, classified as extinct if evidence of past population exists.

Lake names[a]	Lat° Long° (WGS 84)	Self-sustaining Brown trout population[b]	Spawning substrate access[c]	Earliest records (A.D.)			Test-fishing[g]
				Rö-names[d]	Archive[e]	Interviews[f]	
Hattsjö-Röjdtjärnen	63°37´02´´N 18°59´15´´E	Present	Yes	1852	1961	1930	2001
Hemling.-Rödtjärnen	63°37´20´´N18°29´55´´E	Extinct 1930's	Yes	1766		1930[2nd]	1995[NO]
Inner-Rötjärnen	63°25´05´´N 18°40´13´´E	Never existed	No	1799		1940 [NE]	
Inre Rödingträsksjön	63°59´33´´N 18°12´14´´E	Present	Yes	1792		1980	1999
Lill-Rödtjärnen	63°42´55´´N 18°21´38´´E	Present	Yes	1837		1930	2000
Lill-Rödtjärnen	63°45´30´´N 18°38´29´´E	Present	Yes	1837		1920	1998
Lill-Rödtjärnen	63°14´46´´N 17°59´18´´E	Never existed	No	1824		1950[NE]	
Lill-Rödvattenssjön	63°50´15´´N 17°36´04´´E	Present	Yes	1758 [R]	1958	1930	2001
Lill-Rödvattnet	63°46´13´´N 18°10´10´´E	Present	Yes	1865	1955	1940	2000
Lill-Rötjern*	63°45´12´´N 18°40´23´´E	Present	Yes	1864		1920	2000
Lill-Rötjärnen	63°45´31´´N 18°41´50´´E	Present	Yes	1961		1920	2001
Norra Rötjärn*	63°54´40´´N 18°08´33´´E	Present	Yes	1837		1930	1998
Rödingtjärnen	63°55´14´´N 18°33´51´´E	Present	Yes	1856		1940	2001
Rödtjärnarna	63°50´21´´N 18°15´56´´E	Present	Yes	1961		1930	2000
Rödtjärnarna	63°50´34´´N 18°16´12´´E	Present	Yes	1961		1930	2000
Rödtjärnen	63°38´30´´N17°48´12´´E	Extinct 1930's	Yes	1968		1920	2000 [NO]
Rödtjärnen	63°39´16´´N 17°58´22´´E	Extinct 1920's	Yes	1961		1920[2nd]	2000 [NO]
Rödtjärnen	63°36´35´´N 18°06´54´´E	Present	Yes	1707	1930	1970	2001
Rödtjärnen	63°42´01´´N 18°08´39´´E	Present	Yes	1830		1950	1995
Rödtjärnen	63°35´33´´N 18°28´48´´E	Extinct 1990's	Yes	1766	1940	1930	2000 [NO]
Rödtjärnen	63°29´52´´N 18°37´15´´E	Present	Yes	1961		1950	1990
Rödtjärnen	63°26´27´´N 18°08´59´´E	Present	Yes	1961		1940	1999
Rödtjärnen	63°26´43´´N 17°51´09´´E	Present	Yes	1680	1958	1940	1990
Rödtjärnen	63°45´00´´N17°31´36´´E	Never existed	No	1820		1940[NE]	
Rödtjärnen	63°07´54´´N18°20´21´´E	Extinct 1950's	Yes	1762		1940[2nd]	2001 [NO]
Rödtjärnen	63°25´24´´N 17°53´08´´E	Present	Yes	1776		1920	1999
Rödtjärnen	63°45´25´´N 18°20´19´´E	Present	Yes	1837		1930	2000
Rödtjärnen	63°19´34´´N 17°46´58´´E	Extinct 1970's	Yes	1755	1961	1960	2000 [NO]
Rödtjärnen	63°58´16´´N 18°12´09´´E	Present	Yes	1886		1930	2001
Rödvattensjön	63°47´05´´N 17°54´22´´E	Extinct 1980's	Yes	1752	1967	1930	2000 [NO]
Rödvattnet	63°28´23´´N 17°38´47´´E	Extinct 1990's	Yes	1856	1943	1990	2000 [NO]
Röftierna*	63°28´30´´N 18°48´06´´E	Present	Yes	1711		1970	1998
Röjdtjärnen	63°35´58´´N 18°53´37´´E	Present	Yes	1774		1998	2000
Röjtjärnen	63°43´36´´N 18°51´50´´E	Present	Yes	1790		1990	1998
Rörsjötjärnen	63°45´07´´N 18°09´45´´E	Reintroduced	Yes	1825	1959	1940	2000
Rötenburstjerna*	63°23´24´´N 18°37´07´´E	Extinct 1950's	Yes	1676	1953	1940[2nd]	2001 [NO]
Rötjern*	63°44´50´´N 18°41´57´´E	Present	Yes	1864		1920	2000
Rötjärnen	63°26´39´´N 17°37´53´´E	Extinct 1950's	Yes	1804	1951	1950[2nd]	2001 [NO]
Rötjärnen	63°34´03´´N 18°45´53´´E	Present	Yes	1705		1940	1999
Rötjärnen	63°53´24´´N 18°10´42´´E	Present	Yes	1837		1930	2000
Rötjärnen	63°21´13´´N 19°04´57´´E	P.ex.b. 1930's	Yes	1902	1958[N]	1930[NE]	2000 [NO]
Stor-Rödtjärnen	63°43´22´´N 18°23´32´´E	Present	Yes	1844		1930	2001
Stor-Rödtjärnen	63°14´44´´N 18°00´22´´E	Present	Yes	1672	1958	1930[2nd]	2001
Stor-Rödvattenssjön	63°49´49´´N 17°36´42´´E	Present	Yes	1758 [R]	1937	1930	2000
Stor-Rödvattnet	63°46´54´´N 18°12´45´´E	Present	Yes	1865	1955	1940	2000
Stor-Röjdtjärnen	63°38´19´´N 18°58´28´´E	Extinct 1960's	Yes	1901	1940	1960	2000 [NO]
Stor-Rötjärnen	63°45´21´´N 18°42´40´´E	Present	Yes	1837	1960[N]	1920	1997
Västergiss.-Rötjärnen	63°33´35´´N 18°47´25´´E	P.ex.b. 1920's	Yes	1901		1920[NE]	1996 [NO]
Ytter-Rötjärnen	63°24´25´´N 18°40´53´´E	Present	Yes	1799		1940	1998
Yttre Rödingträsksjön	63°59´22´´N 18°13´36´´E	Present	Yes	1792		1980	1999

way of test fishing, making the total 12 (27% lost in eight decades). The average anthropogenic extinction rate during this time was estimated to exceed 3% per decade. Insight into possible explanations for eradications was gained by limnological surveys and archival data. All *Rö*-lakes, where brown trout populations were classified as extinct, had experienced major anthropogenic impact, in many cases decisive for the survival of populations (Table 2). Such anthropogenic impacts were not observed in any other *Rö*-lake with brown trout present (except for brook charr at a few spawning areas), strengthening the interview and archival data that affected lakes once possessed self-sustaining populations. The lakes (n=12) pointed out as having lost populations were more stricken by anthropogenic impact (n=33) than lakes where populations still existed: Fisher's exact test (total impact $p<0.001$), (brook charr in spawning areas $p<0.05$). Feedback to local fishing right owners on preliminary results generated in this study led to action by FMOs to restore *Rö*-lakes with self-sustaining populations.

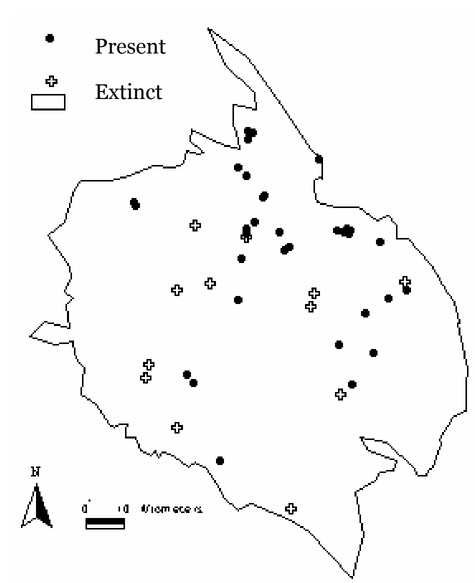

Figure 5. Rö-named lakes with brown trout populations

Table 2. Factors Associated With the Extinction of Brown Trout Populations in *Rö*-Named Lakes. [a] Number of lakes (n=12) affected by specific impact. [b] One lake was classified in two categories. [c] Permanently acidified pH=4,7 to 4,9. [d] Once impossible now recolonized by brown trout

Anthropogenic Impact		Brown trout habitat	L[a]
Bio	Brook charr	Spawn. area overtake	5 [b]
	Pike transloc.	Strong predation	3
Chem	Acidification	Impossible[c]	2
	Rotenone	Impossible[d]	1
Phys	Barrier	Impossible	2 [b]

Maximum natural or anthropogenic permanent extinctions (1672 – 1920)

A total of 45 out of 50 *Rö*-named lakes were confirmed to still have harboured self sustainable brown trout populations in the 20th century (Tables 1 & 3). Interviews with a maximum historical scope of 30-80 years back in time, asserted that five of the Rö-lakes never carried self-sustaining brown trout populations during this time. Habitat surveys in the same five lakes determined that reproducing brown trout populations could never have existed in three of these lakes. The remaining two lakes were found to have historically suitable habitat conditions for holding brown trout, although a man-made barrier prevented reproduction in one of these lakes. Test fishing confirmed interviews, that these lakes did not hold brown trout. Since all but these 2 out of 47 lakes with natural potential conditions for brown trout were confirmed brown trout waters, 2/47 was found to be the maximum potential fraction of lakes suffering permanent extinction before the scope of interviews and historical documents could detect this. If *Rö*-lakes represented a non-biased sample of all brown trout lakes in the study area, (there are no indications to the contrary), then between none and seven brown trout lakes out of 161-168 in the whole study area would have suffered permanent extinction prior to 1920. It was concluded that the pre-industrial distribution of brown trout was 11% of all lakes in the study area, and remained so until the 1930s.

Table 3. Estimating the maximum (E_{MAX}) of permanent extinctions occurring 1672-1920, from lake names (before the scope of possible detection by interviews and historical documents). [a]=Brown trout confirmed 1920-2001

Self-sustaining Brown trout populations		No. lakes
Present[a]		33
Extinct[a]		12
Possibly extinct or never existed (P)		2
Max. number of Rö- brown trout lakes (M)		47
Never existed (impossible habitat)		3
Total number of Rö-lakes		50
Non-Rö brown trout lakes [a]		116
Total number of brown trout lakes [a]		161
E_{MAX} (1672-1920) (P/M)	(4.3%)	2/47
E_{MAX} (1672-1920) Number of pop.		7
Max. Brown trout lakes (1672-1920)		168

Possible misinterpretations of the Rö-term

Three *Rö*-term lakes were excluded from the current study when the earliest name forms in older maps clarified that these names were originally derived from *Ry*, meaning something other than brown trout. One explanation of the *Rö*-term in lake names, red water colour, was refuted at field visits since none of the waters were more reddish in colour compared to other lakes in general. Another possible mix-up of the *Rö*-term meaning was suggested to be arctic charr (Salvelinus alpinus L.), called röding in Swedish. The *Rö*-name was however not an indicator of suitable arctic charr habitat. The majority of *Rö*-lakes did not contain spawning grounds for arctic charr and could never have harboured self-sustaining charr populations. This species was only found in 3 out of 50 *Rö*-lakes and were too few in all lakes to gain any statistical evidence on an association with the name. Since repeated stocking of charr had been done in all three lakes, it could not be ruled out that these populations were non-native to these lakes. Nothing in the entire data set indicated that arctic charr could have had an historically wider distribution in *Rö*-lakes. Arctic char was an uncommon species in the whole study area and was only considered possibly indigenous to one additional lake out of 1509 lakes.

DISCUSSION

Historical names

The results allow some general conclusions to be drawn. For instance, lake names are just arbitrary, but reveal details regarding the fish fauna as well as the habitat. These historical records of fishers' knowledge in the form of lake names in maps can communicate valuable information on environmental history that can, in turn, have an impact on management and conservation. Danko (1998) recommends collecting ecological data from the regions studied to increase the reliability of fish-terms used as evidence of past occurrence. The present study uses a number of sources and methods allowing for comprehensive validation of lake name evidence. When lake names are verified to be positively (or negatively) associated with certain species, the spatial and temporal data linked to the name can then be used in a variety of ways. This study verifies that *Rö*-named lakes are associated with past or present self-sustaining brown trout populations. Thus, lakes with species-associated names can help identify habitats suitable for deeper investigations or restoration. Could landscape scale inventories of certain fish species benefit from selecting lakes from names in maps instead of performing a random survey? A fictional inventory in the present study area with knowledge of local dialect and the *Rö*-term deciphered would provide wide spatial coverage with less effort. A simple overview of local maps targets 1/3 of all brown trout populations among 1,509 lakes. To pick out the same amount of brown trout lakes by random sampling with multi-mesh sized gillnets (Appelberg 2000), would take approximately 5 years' full time fishing for two persons during the ice-free season. The gillnet inventory would, however, have missed all extinct populations and also be lacking the temporal perspective that lake-names provide.

Another useful feature of lake names is that historical anthropogenic impacts or past natural perturbations may be discovered and further investigated where lake names do not correspond to the species currently living in the lakes. The remaining two *Rö*-lakes (4.3%) that cannot be confirmed by interviews or archival data as brown trout waters in spite of historically suitable habitat might have harboured populations now lost both in nature and in local collective knowledge. In that case, the populations went extinct long before the scope of possible detection by interviews or archival data. However, it is predicted that one of these lakes will be colonized in the near future from a downstream population, once a man-made migration barrier discovered in this study is removed. Other essential ecological information such as details regarding habitats and fish communities is also associated with these lake names. Inlet or outlet streams of a specific minimum size with spawning gravel suitable for brown trout are found in 94% of *Rö*-lakes. Picking out *Rö*-lakes, we also find that 96% of the original fish communities are not exposed to large predators like pike, and that 100% of the lakes are isolated by natural barriers stopping the upward migration of several fish species downstream. *Rö*-lakes can thus be considered as refuges protected from severe predators.

Pike is represented in most lakes elsewhere in the study area and studies indicate that predation by pike limits brown trout distribution in slow flowing streams (Näslund *et al.* 1998) and in lakes (Went, A. E. J. 1957; Toner, E. D. 1959). Consequently, with the *Rö*-names, fishers from hundreds of years back in time are communicating to us and saying: - *This lake is characterized by its richness in brown trout. There are good habitat conditions for this species here.* The past distribution of fish populations in a given area can be estimated from the wide temporal and spatial data generated from historical lake names associated with fish species, providing that associations are properly validated. This is demonstrated in the present paper by utilizing occurrences of lake-names fixed in time from historical maps. Most *Rö*-names are found to date back more than 160 years, revealing a pre-industrial perspective of brown trout distribution. All types of lake names in maps are found to be "evolutionarily" conservative and most meanings or core structures are virtually unchanged through the centuries. This is further supported in this study by findings that *Rö*-lake names are being passed on in a conservative oral tradition, even though the historical species name *Röa* has disappeared from the common language. For this reason, it is proposed here that there is little chance the core structure will change once a lake has been named. Edlund (1997) suggests that prehistoric fishermen and trappers developed a fixed onomastic system for lakes and rivers and gives examples together with C_{14}-dating of settlements and other data implying a genesis of a fisheries related name-complex in the heart of the study area 1,900 years ago. It is possible that *Rö*-lakes were named during this prehistoric period. Since all but 2 out of 47 *Rö*-lakes with possible brown trout populations are accounted for in interviews and archival data, it is highly unlikely that extensive permanent extinctions of brown trout took place prior to the 1920s. This is supported by limnological surveys of lakes in the area. The past distribution of brown trout was consequently 11 % of all lakes in the study area, and remained so until the 1930s when extinctions started to become evident.

Interviews

The use of fishers' knowledge obtained from interviews can also provide wide temporal and spatial insights into the past and present distribution of fish populations. This is demonstrated in the present paper by utilizing fishers' knowledge gathered from in-depth interviews and validated by a number of methods. Interviews result in a temporally and geographically more extensive picture of the fish fauna distribution than could ever be achieved through conventional scientific methods, with the same effort. To identify the brown trout lakes found in this survey among 1,509 lakes would take two persons a minimum of 15 years of full time fishing with multi-mesh sized gillnets (Appelberg 2000) during the ice-free season. The gillnet inventory would however miss all extinct populations and also be lacking the temporal perspective of up to 80 years at times, provided by interviews in the current study. The interviews reveal most of the distribution of brown trout in the study area within a temporal scope of 20 years, up to a maximum of 80 years in some cases. No populations "new" to the informants were discovered by test-fishing among the *Rö*-lakes. However, interviews are slightly over optimistic concerning the existence of self-sustaining populations.

Masking of abundance by stocking activities was discussed in Hesthagen *et al.* (1993) who reported that interviews concerning the status of fish-populations in Norwegian acid lakes were too optimistic. They also suggested that bias might result from a time-lag before anthropogenically-induced population damage becomes evident to fishermen. This might be the case for one *Rö*-lake where unawareness of a recent extinction was evident. Another *Rö*-lake was stocked annually, masking extinction of the original population.

Apart from these two examples, fishers' knowledge obtained from in-depth interviews regarding the *Rö*-lakes was totally reliable, matching the test-fishing results and consistent with habitat surveys. Discussing the future of fisheries science Mackinson and Nøttestad (1998) emphasize that it is imperative for scientists to use diverse data sources to their maximum potential, and advocate the increasing use of local fishers' knowledge. Face to face interviews are claimed to be most effective. This view is supported by the findings in this study. The accumulated interviews reveal that the lion's share of brown trout population extirpations has happened during the last eight decades. Archival data can validate that most of these extinct populations once existed, while their current absence is confirmed by a combination of test-fishing methods. More than a quarter of the populations are lost. Explanations for what is causing this wave of extinctions are needed if these lakes are to be restored. Limnological surveys demonstrate that all extinctions are associated with severe anthropogenic impact. Extinctions of brown trout populations caused by acidification of Scandinavian lakes during the 20th century are reported in several papers (Bergquist 1991, Bulger 1993, Lien 1996) as well as in this study. Local extinction of fish species caused by anthropogenic biological impacts is also reported (Nilsson 1985, Crivelli 1995, Lassuy 1995, Townsend 1996). Similarly, historical records and present data in this study demonstrate that a minimum of 95.7% of all brown trout populations survived until the 20th century when the successful colonization of introduced fish species in the lakes resulted in the extinction of the original trout populations. Many of these brown trout populations are now long gone and forgotten, but the names of the lakes remain and, being deciphered, help to remind us of all that is lost. The entire data set supports the idea of long-term stable brown trout lake distribution under pre-industrial natural conditions. In part owing to the *Rö*-names, people are now motivated to restore *Rö*-lakes with self-sustaining local populations of brown trout. Before this study, the available methods to collect historical data on fish species distribution in northern lakes were limited to interviews and archival data. Integrating the use of historical names and historical fishers' knowledge into fisheries science will facilitate investigations to move from brief snapshots of local scale to the wider landscape context and historical dimension. In conclusion, historical names, fishers' knowledge and documentary evidence combined with limnological surveys have proven useful in revealing the past natural distribution, as well as initiating restoration of brown trout lakes in Northern Sweden.

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Questions

Bryan Pierce: Do the private fisheries and managers use local stocks for the replanting program or do they access fish stocks from elsewhere?

Johan Spens: They used local populations

Saudiel Ramirez-Sanchez: In the previous presentation, there was an emphasis on fisheries that have caused reduction in the abundances of fishes. In this presentation you have shown how other anthropogenic factors can influence fish abundance. If Ecopath and Ecosim assume that the most important factor affecting fish abundance is fishing without considering other factors, like logging, you put the entire blame on where it is not. There could be other factors that should be considered when reconstructing ecosystems.

Johan Spens: It is a complex problem and there are a lot of factors. We have multivariate VPA with hundreds of factors. It is safe to say that a lake environment differs a lot from marine environments- for example; lakes do not sustain many fisheries.

Nigel Haggan: In a recently published paper, Carl Walters said that habitat destruction accounts for 20% of salmon population depletion while overfishing accounts for about 80%. Fisheries are designed to kill fish and hence are a big factor in depletion.

Tony Pitcher: It is possible in Ecosim to partition the effect of fisheries from other environmental factors. I agree with Nigel - there have been a number of studies that show that most of the degradation is by fishing while other environmental factors are important but not as much, at least in the marine environment. The situation seems to be different in inland waters, such as these lakes in Sweden, where it seems that the introduction of an exotic species – the pike - has had a significant effect.

EXPLORING CULTURAL CONSTRUCTS: THE CASE OF SEA MULLET MANAGEMENT IN MORETON BAY, SOUTH EAST QUEENSLAND, AUSTRALIA

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ABSTRACT
Incorporating indigenous knowledge into fisheries management is becoming increasingly important in the derivation of alternative management solutions. It also satisfies the political demands of indigenous communities to exercise their rights and responsibilities to traditional resources and their management. Using a methodology that considers perceptions or constructs of the environment to be dependent on the social and cultural structures in which they operate, we compare indigenous and government management of sea mullet in Moreton Bay, Australia. Our investigation focuses specifically on the landscape and seascape constructs of the Queensland Fisheries Service (QFS) and the traditional Aboriginal community of Moreton Bay – the people of Quandamooka. Results from the case study indicate that while both management parties aspire to achieve ecologically sustainable development, a divergence between the constructs of the QFS and the Quandamooka community for sea mullet management is evident. Current QFS approaches reflect 'scientific truth' and economically-dominated strategies whilst the Quandamooka community approach represents constructivist and holistic ecosystems-based strategies. The research highlights the need for more collaborative and inclusive fisheries management approaches that move beyond viewing the Quandamooka community as just another stakeholder. We argue that the QFS needs to recognize the relationship between the Quandamooka community and the Bay in order to value indigenous knowledge of the Bay and its resources. Furthermore, it is critical for the QFS to move beyond economic and species-specific dominated strategies towards ecosystem and adaptive management strategies to include indigenous knowledge and to achieve ecologically sustainable development.

[1and2] We would like to acknowledge and thank members of the Quandamooka community, especially Dale Ruska for their input.

INTRODUCTION
Although government resource management agencies regularly dismiss indigenous knowledge for being anecdotal, untrustworthy and inferior (King 1997; Sillitoe 1998; Simpson 1999; Wolfley 1998), they recognize that alternative management practices are needed to achieve ecologically sustainable resource management. Indigenous knowledge is increasingly being sought to guide these alternatives (Salas *et al.* 1998). The inclusion of indigenous knowledge in its totality, as defined by Berkes (1999) for example, also serves to satisfy the political demands of indigenous communities to exercise their rights and responsibilities to resources and their management. However, one major obstacle to the inclusion of indigenous knowledge in mainstream environmental management is the failure of managers to understand and / or appreciate the different constructs that underpin their own as well as other management strategies (Pomeroy 1994). Gaining an appreciation of these underlying constructs would help to avoid the piecemeal inclusion of indigenous knowledge that has plagued more recent attempts to include traditional owners' views. In this article we provide a preliminary comparison of indigenous and government approaches to the management of the sea mullet spawning migration in Moreton Bay, southeast Queensland, Australia. The objective is to examine different knowledge constructs to see if they present barriers to the joint sharing and application of knowledge and management practices.

Case Study Background
Moreton Bay is situated in southeast Queensland, Australia (Figure 1) and covers an area of approximately 1490 km² (Dennison and Abal 1999). While numerous studies have defined the Bay differently depending on what aspects they have studied (QFMA 1996a) and from which cultural perspective they have come, Moreton Bay is commonly defined as stretching for 160 km from the northern tip of Bribie Island in the north to the southern tip of south Stradbroke Island in the south (Dennison and Abal 1999). The Bay encompasses 360 islands of varying sizes including three of the biggest islands in the Bay – Moreton, North Stradbroke and South Stradbroke Islands (Neil 1998).

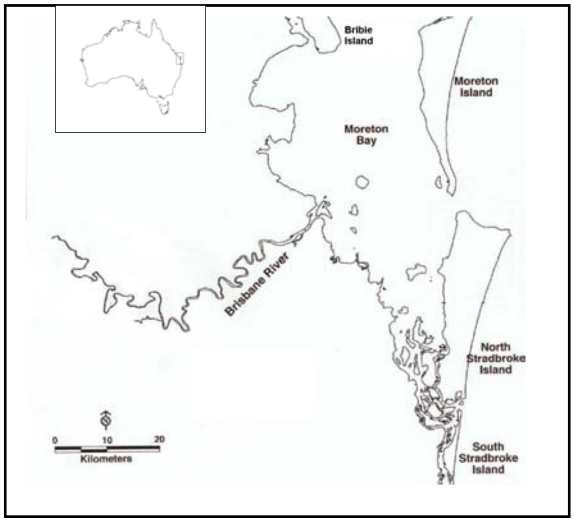

Figure 1. Map of Moreton Bay

Moreton Bay was chosen as the case study site for several reasons. Firstly, the Bay is of environmental significance as evidenced by the establishment of the Moreton Bay Marine Park in 1993 and its extension in 1997 to encompass nearly all tidal land and waters to three nautical miles off the east coast of the barrier islands (Dennison and Abal 1999). The park is also listed under Ramsar as a significant migratory bird habitat. It is an important fish breeding ground with recent scientific research having identified around four hundred different fish species within the Bay (Davie and Hooper 1998), and it is home to a significant population of dugongs and bottle-nose dolphins (EPA 1999). Secondly, Moreton Bay is of economic significance to the fishing, ports and tourism industries, amongst others which are dependent on the Bay (McDonald and Brown 1992; Perkins 1996).

While the environmental and economic importance of the Bay is well known and cited by many mainstream environmental managers and scientists, the cultural importance of the Bay is often neglected or relegated to a short introductory passage in historical descriptions (see, for example, BRMG 1997; Haysom 1999; Neil 1998). However Moreton Bay and its fisheries were and continue to be, sources of cultural importance to the Aboriginal communities who reside within and around the Bay. The key to Aboriginal cultural survival is the continuation of traditional cultural management practices that allow indigenous knowledge to evolve and adapt.

The Quandamooka Aboriginal community is a prominent indigenous community in the Bay. Many members still reside on North Stradbroke Island, the traditional country of two of the clans that make up the Quandamooka people. This community retains their traditional knowledge of the natural resources of the Bay and its islands, and desires to practice this knowledge as a component of mainstream land and sea management.

As well as the indigenous population, Moreton Bay provides the eastern extent of the urban expansion of Brisbane, the largest city and capital of Queensland. At present the Moreton Bay region contains more than two million people and is expanding at around 2.9% per annum (Skinner *et al.* 1998). With a projected increase of 430,000 to 650,000 people between 1996 and 2006 along the coastline of the Moreton region (Skinner *et al.* 1998), increased pressure is being placed on Moreton Bay to cater for this growth in human activity. Urbanization, agricultural production, industrial development, floodplain modification, and sand and water extraction among other factors have led to the degradation of habitats, increased sedimentation and decreased fishing productivity in the Bay (BRMG 1997; Dennison and Abal 1999; Williams 1992).

Approximately 400 licensed fishing vessels operate in and around Moreton Bay, and in addition an estimated 300,000 commercial and recreational fishers spend 1.5 million fishing days per year in the Bay (Williams 1992). This amount of fishing activity combined with development pressures, has led to concerns for the viability of fisheries, including the sea mullet fishery that is important to commercial, recreational and indigenous fishers.

Sea mullet is alternatively known as 'bully' or *Mugil cephalus* in the Western scientific sense (QFMA 1996b) or as *andacall* (Crowthers *et al.* 1997) or *nandacall* (Ross and Quandamooka Land Council 1996b) by the people of Quandamooka. It is a migratory fish species found throughout tropical and subtropical seas, including Australian estuaries, coastal waters and some rivers (Virgona *et al.* 1998). In Moreton Bay, during the autumn and winter months of April to August, mature reproductive mullet aggregate in estuaries and travel northwards to spawn at sea. The spent adults move back southwards, re-entering the estuarine and river systems to resume feeding, as do the fry (mullet larvae), which are carried southwards by the prevailing currents where they enter the estuarine systems to feed and grow (DPI 2000; QFMA 1996b).

Moreton Bay is "the most important estuarine fishery for sea mullet in Queensland" (Kailola *et al.* 1993: 332). The Quandamooka people regard sea mullet as a source of food as well as a source of cultural, economic and spiritual sustenance. In the 'traditional' sense, sea mullet was caught for nutritional, medicinal and trade purposes, and applying sea mullet management practices sustained the cultural well being of the community (Ross and Quandamooka Land Council 1996b).

Sea mullet is also an important commercial fishery. Mullet comprise the largest component of the inshore net fishery along the Queensland coast and the fishery is worth an estimated $AUD8-10 million per year (Shane Hansford, QFS Senior Policy Officer, pers. comm. 2000). According to commercial fishery records, approximately 2000 tonnes of sea mullet are caught in Queensland each year (Virgona *et al.* 1998), with about half being derived from Moreton Bay fishing grounds (Virgona *et al.* 1998).

Most commercial operators target mature mullet for their roe (egg sacs) given the high export price they receive in overseas markets relative to domestic market prices for sea mullet meat (Halliday 1992). Consequently, comparatively few sea mullet are caught with seine nets along ocean beaches during the summer months or with gill and tunnel nets in rivers and estuaries throughout the year (Kailola *et al.* 1993). The vast majority of sea mullet (around 70-80%) in Queensland are taken during their winter spawning migration (Virgona *et al.* 1998). However, recent commercial catch statistics have indicated a decline in the total annual catch of mullet (Virgona *et al.* 1998) and this coincides with a decline in the total number of days commercial fishers spend fishing. The Queensland Fisheries Service (QFS - formerly the Queensland Fisheries Management Authority or QFMA) has suggested the following reasons for the decline in mullet catches:

a) a change in behavior of commercial fishers, with a tendency to fish for fewer mullet;
b) reduction in the abundance of mullet; and
c) reduction in the size of fish taken (QFMA 1996b:51)

Williams (1992) expressed concern over targeting spawning fish given their vulnerability to capture while aggregated in schools. The Quandamooka community has also expressed its concern over the declining sea mullet harvest and current harvesting practices. For example, community members have expressed concern over the high level of exploitation that has led to the sale of whole mullet for crab bait (Sinnamon 1997).

This wide-ranging concern from several quarters indicates that there is a significant problem and that the future of a healthy sea mullet fishery in the Bay is predicated on good management. We now review the management programs that the original (aboriginal) and present-day (government) management authorities have devised for sea mullet management. But first we feel it is important to examine the methodological framework within which we conducted this study.

METHODOLOGY

An alternative research approach to the prevalent scientific realist and positivist approach generally adopted by government agencies that employ scientists as their management bureaucrats has been used. Positivist paradigms assume that the environment exists outside of human perception, a view that forms the basis for the majority of scientific research. Cultural anthropologists and sociologists have criticized this approach, because it dismisses the recursive influence of humans on the environment (Berkes 1999; Linzey 1995; Pálsson 1998). A social constructivist approach caters for the human construction of the environment and while several authors such as Agrawal (1995), Bradley (1998) and Murdock and Clark (1994) have argued that the concentration on culture can artificially inflate cultural differences between management parties, culture forms an important filter that results in different perceptions of the environment (McCarthy 1996).

A constructivist research approach has far reaching implications for how the environment can be viewed and how resource management problems may be solved (Linzey 1995). Alongside multiple perspectives there exists an array of different management solutions to solve environmental problems (Linzey 1995; Taylor 1990). It allows for different cultural conceptions of the environment to be viewed on an equal basis as "no one culture has a worldview or interpretation of the world which can be seen as more 'correct' than that of another because they are both interpretations of the subjective and therefore unknowable universe" (Rose 1995: 167). Moreover, the constructivist approach allows for a comparison between the religious based indigenous knowledge and the scientific based Western knowledge. For,

> *"if science and religion are compared as legitimating belief systems, they can be compared on the basis of their similarities as accepted systems of knowledge, where each system legitimates certain social practices in the name of truth, reason and reality"* (Wright 1992: 43-44).

This type of research lends itself to an interpretivist qualitative approach, which requires a clear statement of the researcher/s' intent and purpose. This is especially important given the contentious nature of research regarding indigenous views and knowledge. This kind of research has predominantly been carried out by white, male, middle class academics (Wall 1995). Wall (1995) alleges that these attributes form a privileged point of view that determines the reader's way of seeing and provides voice to certain minority perceptions while silencing others. The power differential created by this approach has been the subject of extensive criticism. Simpson (1999: 6) for example, argues that the "widely accepted academic concept of TEK is fundamentally Western, not Aboriginal".

Consequently, a crisis stemming from the representation of 'others' has developed, particularly relating to who should represent whom (Linzey 1995). This is an argument that has fostered growing demands for indigenous people to become researchers of themselves (Linzey 1995; Nakata 2001; Simpson 1999; Tripcony 1997). There is no denying that there are definite advantages in indigenous people restoring and reclaiming their own knowledge and controlling its portrayal in academic literature (Nakata 2001). According to Nakata (2001:41) "nowhere is there an authoritative indigenous reference point from which to develop our ideas and ways of thinking, beyond the narrative of citing our experience". However this should not imply that cross-cultural research has no merit. Rather, beneficial outcomes may be achieved when indigenous research is undertaken with the overriding objective to increase knowledge and understanding of the interests and concerns of indigenous people.

There are, however, several strategies that non-indigenous researchers can adopt to counteract the crisis in the representation of the 'other'. Researchers can confine themselves to their *perception* of 'others' rather than the *representation* of 'others' (Berkes 1999; Jackson 1991; Linzey 1995; Wall 1995). This can be achieved by recording indigenous knowledge and views and clearly distinguishing them from the researcher's interpretation. Including indigenous people in the research process can also help to counteract the colonial domination of indigenous research (Berkes 1999).

For this current study, the primary intent and purpose was the achievement of a Master of Science degree for Barker. For Ross, the intent and purpose was an understanding of indigenous knowledge constructs to assist in the interpretation of archaeological data. We are both female academics, trained in a Western scientific paradigm. For both of us, indigenous knowledge constructs are foreign, and for a while they challenged our own worldviews. However, the length of time during which we have both been involved with this community has allowed us to view indigenous knowledge with less prejudice than we originally brought to our investigation.

The principal researcher (Barker) did not have a close association with the Aboriginal community of Quandamooka at the time the study was undertaken, having only worked in this area for two years. She had therefore not developed the necessary level of trust needed to perform cross-cultural collaborative research (Posey 1995). Consequently, we opted to rely predominantly on existing documents that had been written by members of the Quandamooka community either themselves or in conjunction with Ross[2], and published or otherwise made available in a public forum. In addition, we included specific interviews with nominated members of the Quandamooka community at particular stages of the research process. However, for the purposes of this publication, we use documented sources of information only, to avoid the direct appropriation of the intellectual property rights of members of the Quandamooka community.

Collection of information about government management strategies was based, similarly, on published articles and reports and on communications with specialist staff of the QFS fisheries management agency.

THE MANAGERS

The people of Quandamooka comprise the Koenpil, Nunukul and Nughi people whose traditional estate includes the land and waters of the Bay extending into the Pacific Ocean (Ross and Quandamooka Land Council 1996a). The definition of Quandamooka includes both the land and marine environment in and around the

[2] Ross has over eight years of research collaboration with the Aboriginal people of Quandamooka.

Bay and is also the name of the customary law and the Aboriginal community of the Bay. Their knowledge of sea mullet management forms one element of our comparative analysis.

The Queensland Fisheries Service (QFS) was established in 2000 as the primary government agency responsible for fisheries management in Queensland. It has the current carriage of fisheries management in Moreton Bay, and the knowledge of sea mullet management held by their scientists forms the other element of this comparison.

We present the results of the sea mullet case study by outlining the roles and responsibilities adopted by each management party. These are based upon the legal framework from which they derive their management responsibilities, how they define Moreton Bay, and how the QFS approaches the incorporation of Quandamooka knowledge in management. We outline each of these factors below.

Aboriginal and Government Roles and Responsibilities in Sea Mullet Management

The legislative framework

As in other colonized countries, upon European settlement the Australian government charged itself with responsibilities for the management of sea resources. Up until the Australian Federal Court judgment that recognized Native Title rights to sea country around Croker Island in the Northern Territory, the Australian government had not officially recognized that Native Title rights extended over 'sea country' and had treated sea resources accordingly, as unowned and unmanaged common property resources (Rigsby 1998). According to Gordon's (1954) economic theory of fisheries as extended to wildlife management in general by Hardin's (1968) seminal paper 'The Tragedy of the Commons', resources which are not privately owned will be exploited and degraded if people are left up to their own devices. This rationale extended the basis for governmental management (Freeman 1999) as stated in several Queensland government reports such as *Fisheries: Managing for the Future Report* (DPI 1993) - the precursor to the *Queensland Fisheries Act 1994*) and *Review of the Queensland Fisheries Act Interim Report* published in November 1999.

At the federal governmental level, the Australian Fisheries Management Authority (AFMA) is charged with management of Australia's 200 nautical mile fishing zone as declared by the *UN Convention on the Law of the Sea 1994*. While the *Coastal Waters State Powers Act 1980* charges the State governments with fisheries responsibility over a 'territorial sea' that extends for three nautical miles from the land (Robinson and Mercer 2000), "from 1988 onwards, the common practice has been to manage individual fisheries in different ways" (Robinson and Mercer 2000: 358).

Several fisheries, including sea mullet, have been assigned to state government level management, with the *Queensland Fisheries Act 1994* providing the over-arching legislative framework for fisheries management in Queensland. Section 14 of this Act lists as its objectives:

1) To ensure fisheries resources are used in an ecologically sustainable way;
2) To achieve the optimum community, economic and other benefits obtainable from fisheries resources; and
3) To ensure access to fisheries is fair.

The Act does recognize "a limited right for Aboriginal and Torres Strait Islander peoples to take fisheries resources in accordance with tradition and custom" (Sutherland 1996: 4). Section 16 of the Act provides that:

1) An Aborigine may take, use or keep fisheries resources, or use fish habitats, under Aboriginal tradition…;
2) However, subsection (1) is subject to a provision of a regulation or management plan that expressly applies to acts done under Aboriginal tradition;
3) A regulation or management plan mentioned in subsection (2) may be developed only after cooperating with Aborigines… considered by the fisheries agencies to be appropriate, to reach agreement or reasonably attempt to reach agreement, about the proposed regulation or plan.

According to 'mainstream' legal provisions, then, Aboriginal people do have rights to the resources of Moreton Bay, but these rights are subordinate to the responsibilities that the government has assigned to itself. But there is another legal system for Moreton Bay.

The Aboriginal people of Quandamooka are the traditional custodians of Moreton Bay:

> *"My people are the traditional custodians of Quandamooka which is now called Moreton Bay … [and]… we continue to protect Quandamooka as our obligation is*

> *sacrosanct"* (Alan Perry, former Quandamooka Land Council Chairman, in Sinnamon 1997:4).

This sense of responsibility is derived from customary law, which provides the central and unifying framework of living for the people of Quandamooka. It governs all aspects of the traditional way of life and the lives of other beings. Customary law confers a host of rights and associated responsibilities to the people of Quandamooka, including communal ownership rights. Ownership rights of the traditional estate do not, however, imply that the people of Quandamooka consider themselves above or apart from the environment:

> *"Like my ancestors before me, I will always come back to this place to share the feeling of the land with all living things. I belong here where the spirit of the Earth Mother is strong in the land and me"* (Noonuccal and Noonuccal 1998).

Rights to country and its resources are conferred by customary law:

> *We have a system of laws and we have a system of tribal councils which administered those laws. We also have Aboriginal people who were born and are still being born with a human blood right, the same as Aboriginal people all over the country who have inherited the blood right … For me, I speak on behalf of myself and my own family on the Koenpil side solely, for my great great grandfather, who was the Mookan, was the one who inherited the right of the Mooka, of the Quandamooka. He was the man or the Mookan of many Mookans before him who was born with that blood inherent right to oversee the law of the land. Not just the law of the land, but the law of society, and also how land was used and how it was exploited* (Ruska 1997: 44).

The community of Quandamooka wants to regain their management position over their traditional estate in order to "assure the ecological, economic and spiritual security for future generations" (Alan Perry in Sinnamon 1997:4) and for the "maintenance of lifestyle, spiritual attachment, culture and sustainable economic development" (Quandamooka community members quoted in Sinnamon 1997: 11).

From the above it becomes clear that both the present-day and the original managers of the Moreton Bay fishery consider that they have a legal right to be custodians of fishery resources within the Bay.

The definition of Moreton Bay

The QFS defines Moreton Bay as the *waters* in the Bay (QFMA 1996a). The land and freshwater elements, such as islands, mainland rivers and swamps, are not included in this definition. This view contrasts with that of the Aboriginal community of Quandamooka. Their ownership rights extend across a much wider traditional territory. Alan Perry, a former Quandamooka Land Council chairman, defines the traditional estate as follows:

> *"Our traditional estate takes in Moorgulpin known as Moreton Island, Minjerribah also known as North Stradbroke Island and the smaller islands. The western boundary extends along the coast from the Brisbane River, south to the Southport [on the mainland at the southern tip of South Stradbroke Island] region. The eastern boundary extends out into the Pacific Ocean"* (quoted in Sinnamon 1997:4).

Their holistic concept of the Bay is enhanced by their construction of the environment as a living sentient being. To repeat in part Alan Perry's statement, theirs is a sacrosanct obligation, with the well-being of the Bay directly connected to the well-being of the Quandamooka community itself. Thus, this ethical and spiritual sense of responsibility differs from the views of QFS managers who have a statutory obligation to fulfill a particular management role.

Therefore customary ownership rights and management responsibilities extend over the land, sea and waters (both fresh and marine) that make up Quandamooka (Ross and Quandamooka Land Council 2001) not just the Bay waters. This provides the first of the many differences in approach to fisheries management by the QFS and the Quandamooka community. This difference in the scope of the management geography of the fishery underpins many of the other differences between the two management agencies.

QFS approaches to sea mullet management

Under the Queensland Fisheries Act 1994, the principal avenue through which the QFS manages sea mullet and other Queensland fisheries, is the establishment of management plans, regulations and declarations. The Act provides the statutory guidelines for structuring the management plans. The QFS has prepared and is in the process of preparing, a number of species-specific harvesting methods and area-specific management plans which will ultimately combine to provide management guidelines for all fisheries resources within Queensland. Special taskforces known as Management Advisory Committees (MACs) and Zonal Advisory Committees (ZACs) have been created to provide management advice specific to these plans. Committee members in these cases are typically nominated by the QFS.

At present there are two management plans that directly affect sea mullet management in and around Moreton Bay. The Subtropical Inshore Finfish Fishery Management Plan incorporates sea mullet management advice, while the Moreton Bay Fishery Management Plan provides management advice for all fisheries within the area.

Figure 2 shows the general process by which these management plans were produced, their current stage of development, how they interrelate to one another, and the representatives of organizations that have been included on the respective advisory boards.

Figure 2 indicates that in most cases, a single member of each identified stakeholder group was invited onto the respective MAC and ZAC boards. The only indigenous representative to be included came from the national Aboriginal and

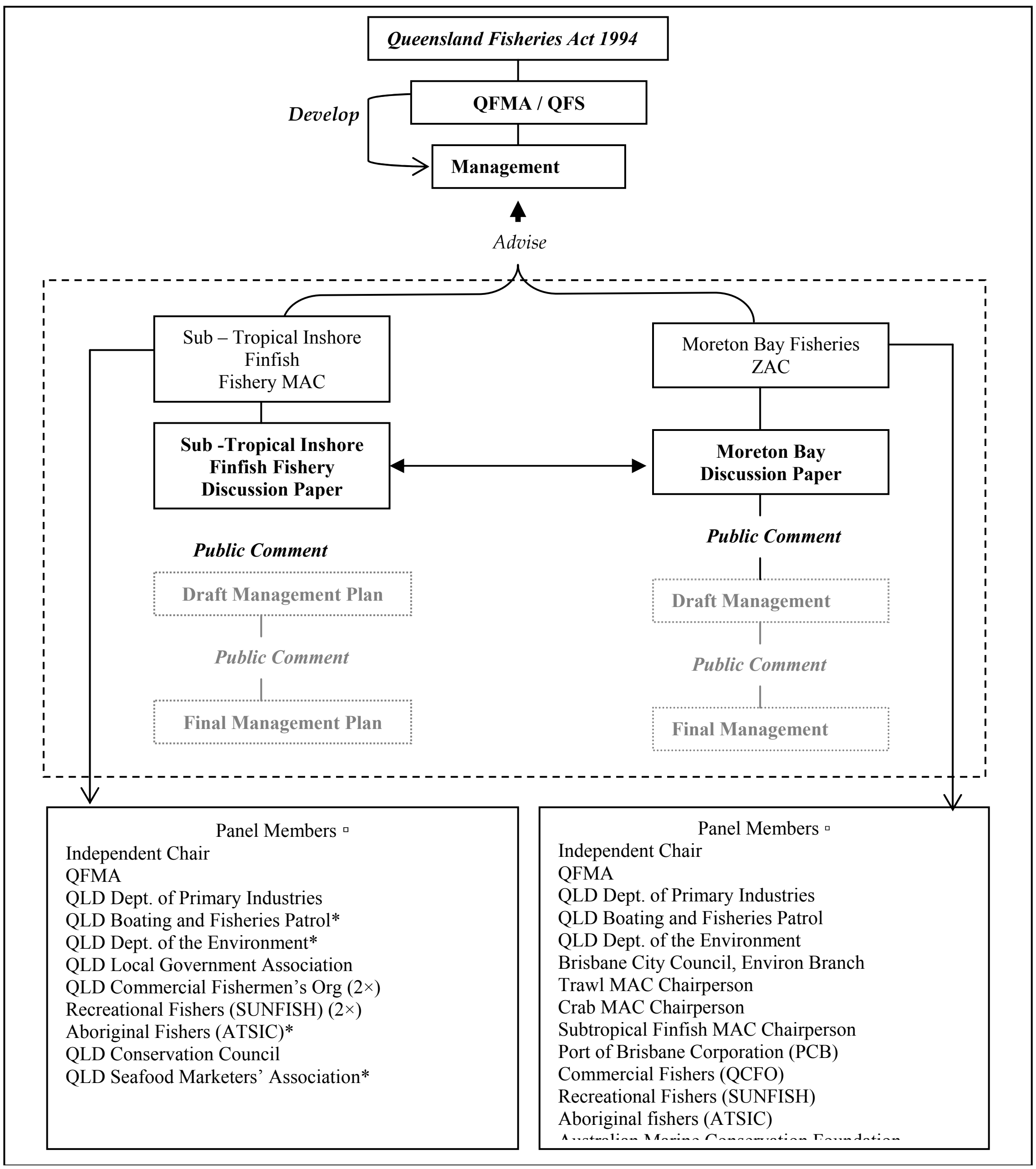

Figure 1 Management plans relevant to sea mullet management in Moreton Bay, their current stage of development and panel members involved on the advisory panels.

Torres Strait Islander Commission (ATSIC). This meant that the Quandamooka community itself may not have been represented. In the Subtropical Inshore Finfish Fishery discussion paper, the QFS rationalized that traditional or customary indigenous fishing did not require special provisions because:

> *"Indigenous people fishing for recreational or commercial purposes are subject to all prescribed fisheries legislation. No general fisheries permits, allowing for the taking, buying, processing or selling of … [fish] have been issued to indigenous people"* (QFMA 1996b: 16).

The QFS aims to cater for Aboriginal subsistence fishing by providing access to the fisheries, and by exempting Aborigines from fishing regulations, thereby recognizing the existence of an Aboriginal fishery to some extent (Smyth 1999). However, the individual based licensing system that the QFS operates presents various barriers to the implementation of Quandamooka management practices as outlined in Table 1.

It is important that appropriate management practices are devised to respond to the different fishing intensities, strategies and motivations of fishers. Commercial and Quandamooka community fishers use different fishing technologies that result in differing fishing intensities. The majority of Quandamooka fishing occurs at the time of the mullet spawning migration. As mullet enter Moreton Bay, fishers rely heavily on dolphins to drive the fish and hand-held tow row nets to catch the mullet (Ross and Quandamooka Land Council 1996b). Numbers of fish taken are comparatively low. Contemporary commercial fishers, on the other hand, utilize various technologies such as boats and echo-locating devices to exploit the spawning migration both out at sea and within the Bay. Commercial fishers therefore have access to almost all mullet schools that migrate past the coast and into the Bay (See also Kalikoski and Vasconcellos, this vol).

Pending the development of management plans, sea mullet are currently managed by a system of input controls on commercial operators and recreational fishers in accordance with the *Queensland Fisheries Regulation 1995*. This regulation specifies the operational level of rights for commercial and recreational fishers. Separate management practices and regulations have been devised for the commercial sea mullet ocean beach net fishery. A system of 8 zones has been created along the Queensland coast in order to reduce potential conflict between commercial fishers (QFMA 1996b). Each zone is assigned a limited number of commercial fishing operators. Commercial fishers gain access rights to a zone by purchasing a license. The license authorizes harvesting or withdrawal rights from that particular zone and licensees are able to harvest any fish (apart from barramundi) within these zones (Schedule 13, part 1.3).

Table 1. Effects of current QFS management strategies on the Quandamooka community involvement in management

Status	• Treated as a political or interest group rather than as traditional custodians of the Bay; • Other interest groups with greater political lobbying power and representation overwhelm the Aboriginal 'voice'.
Level of involvement	• Determined by the QFS. The *Fisheries Act 1994 (Qld)* charges the QFS with deciding the level of appropriate consultation needed with Aborigines to reach or attempt to reach an agreement about a proposed plan.
Interpretation of 'traditional' fishing	• QFS regulations specify that Quandamooka community fishing is for subsistence purposes only, whilst ethnographic evidence demonstrates that 'traditional' fishing also formed the basis of a lucrative trading base with neighbouring and visiting Aboriginal community members (Ross and Quandamooka Land Council 1996b); • Contributed to the exclusion of Aboriginal involvement in the Sub-Tropical Inshore Finfish Fishery MAC. • Neglects past and future Aboriginal interests in the commercial finfishery.

The licenses are seasonally based and there are three zones in the Moreton Bay region (but outside the Bay itself) that coincide with the traditional estate of the Quandamooka people. Although the *Queensland Fisheries Regulation 1995* does recognize that indigenous fishers can fish according to Aboriginal traditions, in practice this right is subordinate to the rights of license holders, who have priority in resource extraction.

The QFS zoning management strategy for the ocean beach fishery was created in response to a large proportion of commercial fishing occurring out at sea. Thus, the zoning strategy assisted in alleviating conflict between commercial fishers. However, current QFS management controls perpetuate the view of fisheries as an unlimited resource, a notion inherent in capitalist thought. This is demonstrated by the QFS granting commercial licensees within the Bay unlimited access to sea mullet during the spawning season with no specific output controls either within or outside the Bay. Indeed, the boat, net and fish size restrictions are minimalist management strategies that are unlikely to deter the over-exploitation of these schools given the economic incentive to do so.

Regulations applicable to the commercial ocean beach fishery, the estuarine commercial fishery and the indigenous fishery are given in Table 2. The table reveals that current sea mullet management is based on input controls that focus on "the size and numbers of species, rather than on the fish species and the habitat of the species" (Ross and Pickering, in press:9) rather than on output controls and the principles of ecologically sustainable development.

Table 2: Regulations for Sea Mullet Fisheries

Winter Ocean Beach Fishery	
Seasonal	System of zones (K1-K8)
Input controls	Net restrictions: • only seine nets allowed • A seine net may be no longer than 500m
	Boat restrictions: • A primary commercial fishing boat must not be longer than 14m • A tender commercial fishing boat must not be more than 800m form the primary vessel (Schedule 13, Part 2.9 FRA 1995)
	Minimum legal size length: 30 cm
Estuarine Commercial Fishery	
Input controls	Minimum legal size length: 30 cm
Fish Habitat Areas	Commercial fishing closures including Fish Habitat Areas such as Swan Bay at the southern end of North Stradbroke Island
	Fish Habitat Areas A and Fish Habitat Areas B
Indigenous fishing	
	S16 – can fish according to Aboriginal traditions

In summary, the government management of sea mullet is formulated within bureaucratic systems such as MACs and ZACs, with each stakeholder group being represented. Management regulations focus almost entirely on input controls, such as licenses and restricting the number of fishers per management zone. But there is a pre-existing local system of mullet management for Moreton Bay that is based on long-term ecologically sustainable management. Despite the impact of colonization and the consequent dispossession of Aboriginal people, the people of Quandamooka have maintained their occupation of traditional country and their knowledge of resource management.

Quandamooka approaches to sea mullet management

According to Quandamooka tradition, in pre-colonial times, mullet elders guided the spawning migration of sea mullet northwards, up the east coast of North Stradbroke Island and into the Bay through the passages between the tip of North Stradbroke Island and Moreton Island, and at Cape Moreton on Moreton Island

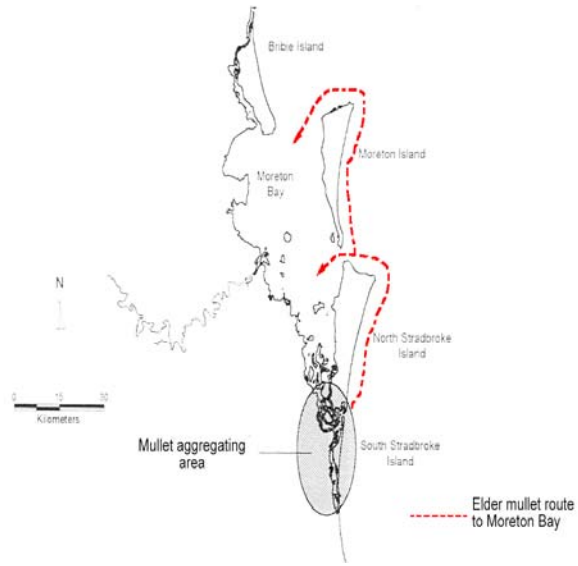

Figure 3. Traditional sea mullet route into Moreton Bay (Ross and Quandamooka Land Council 1996b:2)

(Ross and Quandamooka Land Council 1996b; – see Figure 3).

By allowing the mullet to follow this route into the Bay, rather than continuing on to the open sea, the fish could be easily herded toward the shore with the help of dolphins (Hall 1984; Ross and Quandamooka Land Council 1996b). It remains common practice amongst Quandamooka fishers to avoid catching the elder mullet until the elders have led the younger fish on the correct migration path into the Bay and thereby passed on the knowledge of the migration route (Ross and Quandamooka Land Council 1996b).

The Quandamooka people use a number of signs to indicate when the spawning migration has begun and where the fish are on their route. These signs are mostly land based indicators, although the most important signal came from the dolphins. In pre-contact times, Quandamooka elders would call the dolphins by hitting their spears on the surf, thereby requesting their assistance in summoning fish towards the foreshore (Ross and Quandamooka Land Council 1996b). Dolphins would guide the fish into the net, however, tradition stipulated that the best fish were to be given to the dolphins in order to ensure they would grant approval for future catches (Hall 1984).

Sea mullet was and continues to be an important subsistence resource for the people of Quandamooka. In the past it was also used for trade purposes. According to Quandamooka tradition, access to sea mullet harvesting in Moreton Bay was confined to the people of Quandamooka unless neighboring Aboriginal communities requested and received permission to fish in that country:

> *"... when our systems of land tenure were fully applied, visiting people coming over to this country here from say Yugarra country, which is up around Ipswich, could not just come to Stradbroke Island, set up their own camp, go out and help themselves to the resources, take whatever they wanted by way of fish and shellfish and stay here as long as they wanted. They had to first obtain the permission of the traditional land law people of this country. If that permission was granted, then they were able to come here and share and enjoy the value of the environment and everything that it provided"* (Ruska 1997:44).

This approach to sea mullet management is more holistic than that used by the QFS. The Quandamooka people do not restrict their management of this resource entirely to the sea. The land resources play a part in signaling the harvesting sequence. Furthermore, the Quandamooka approach is one that incorporates both input controls over the resource (there are rules for when and where fish can be taken and by whom) and output controls (based on the numbers of fish and which fish can be taken at what stage during the migration path). This differs from the QFS management approach.

SEA MULLET MANAGEMENT: A COMPARISON

General management differences are bound to permeate species-specific management practices. Apart from variation in terminology, a clear difference exists in how the QFS and the Quandamooka community relate to sea mullet both directly (code of behaviour) and indirectly (moral obligation). For example, Quandamooka Aboriginal people view themselves as part of the environment and therefore show a high level of respect for nature. This relationship governs their resource management practices, which stipulate an equal coexistence between humans and nature. This discourages a 'formula' style approach to resource control. Rather, for the Quandamooka people, sea mullet harvesting is dictated by the signals of other resources both on the land and in the sea. In contrast, the QFS view sea mullet (and most other fisheries) as an economic resource. This is a perspective that warrants human control and exploitation. Clearly, these two viewpoints are in direct conflict with one another.

Other areas of divergence include access and withdrawal rights. The QFS is governed by legislation and relevant management authorities such as the MAC / ZAC committees which stipulate that access to Moreton Bay can be obtained following the purchase of a license to fishing zones in the area. Withdrawal of fishing rights is obtained by designating restricted fishing zones. In contrast, Aboriginal elders of the Quandamooka community represent the decision makers and they govern the collective rights of the community to fish sea mullet. With regards to access or withdrawal of fishing rights, the Quandamooka people hold the viewpoint that their community members can fish in their own country in accordance with customary law. They believe they should control whether or not people from outside the community can access the Bay and its resources.

The specific differences discussed infiltrate the respective resource management practices. Thus, while the QFS are enforcing restrictions in terms of input controls such as fishing boats or vessels, nets and fish sizes as well as declaring protected areas, their output control is non-existent. In contrast the Quandamooka people's resource management practices stem from a shared belief system, which respects and appreciates nature, thereby encouraging people to take only as much as is needed in an effort to ensure the sustainability of the environment and all its species. The Quandamooka community uses its knowledge of the sea mullet social structure, as well as environmental indicators and the interrelationship between sea mullet and predators (dolphins) to guide their harvesting practices. In this way Quandamooka resource management is active - the people are active participants in setting and administering the law as well as in the actual implementation of the law. For the QFS, on the other hand, management is passive - it is imposed by the government and the bureaucracy on those who actually do the fishing. The QFS is therefore divorced from the actual practice of sea mullet harvesting.

DISCUSSION

The aim of this research is to examine different knowledge constructs to see if they present barriers to the joint sharing and application of knowledge and management practices. There are several broad conceptual differences between the two fisheries management parties, including differences in power and authority, management responsibilities, definition of the Bay and management goals. These represent important barriers to participatory management in their own right and each will be discussed in more detail below.

Authority and power

Both the QFS and Quandamooka community view themselves as legal custodians of the Bay's fishery resources. This should provide a common platform from which to pursue knowledge sharing and joint management arrangements. However, the QFS does not recognize the Quandamooka community as co-managers of the Bay. Although the QFS does acknowledge the people of Quandamooka as traditional custodians, this recognition is more of symbolic attachment than of responsibilities and requirements assigned to joint managers. The Quandamooka community is viewed, at best, as a stakeholder in the design of sea mullet management strategies. A contributing factor is that the rationale for government management is based on Hardin's 'Tragedy of the Commons' model. As Ruddle (1994: 64) explains, deeply embedded within this model, and within modern Western constructs of sea space and sea resources, is the "erroneous notion that the misuse of fisheries resources stems from the institution of common property, which was and unfortunately often still is, mistakenly assumed to be synonymous with open access". Thus, the concept of the Bay as common property to all contrasts strongly with the Quandamooka view that the Bay belongs to them.

Layt (1999) has also identified the limited role for indigenous owners in the Queensland Fisheries Management Authority (the pre-merged QFS). She criticized the QFMA for their reaction to Smyth's (1999) report '*Towards an Aboriginal and Torres Strait Islander fisheries strategy for Queensland'*. The report was produced in response to the recommendations of the Commonwealth Coastal Zone Inquiry to implement structures to foster the mutual exchange of coastal aquatic resources and thereby satisfy legal requirements under s14(3) of the *Fisheries Act 1994 (Qld)* to promote the involvement of indigenous people in the management and planning of fisheries resources (Smyth 1999). The report entailed recommendations derived from four regional workshops, comprising various parties including the Quandamooka Land Council and other Aboriginal communities and organizations (Smyth 1999). In essence, Layt argues that this document represented an ideal opportunity to incorporate customary law into natural resource law, but the opportunity was ignored.

Layt (1999) reported that QFMA only considered the recommendations in the report relating to the legislative process in accordance with Native Title notification procedures. In so doing, Layt argued, the QFS effectively separated Aboriginal political claims for involvement in fisheries management from Native Title property claims. This conceptual divide between political and property claims is alien to indigenous concepts of marine tenure (Layt 1999) and represents a major barrier to knowledge sharing and joint management arrangements in the Bay.

Management responsibilities

In terms of management responsibility, QFS management is confined to Queensland fisheries resources and under Australian statutory law, sea and land ownership are treated very differently. This can be seen in the narrow definition afforded to the Bay by the QFS compared to the holistic and ecosystems definition of the Quandamooka community. Underlying the QFS compartmentalized approach is the belief that the world is rational, that it can be easily divided and understood (Linzey 1995). This tends not to be the indigenous view.

The fluid Quandamooka definition of the Bay represents another challenge. The Quandamooka management responsibilities beyond the eastern boundaries of the Bay are not delineated. This contrasts with the well-delineated approach between the State and Commonwealth government arrangements for the management of the Australian coastline and represents a challenge in determining how far the interests of the Quandamooka community extend outwards from the eastern boundaries of the barrier islands.

The above definitional differences of the Bay pose several barriers to cooperation between the management parties, for they refer to different aspects of what constitutes the Bay and identify different management responsibilities over the

Bay. A number of communication problems result from the different constructs of Moreton Bay, and these are highlighted by Quandamooka members, stating that their concerns are often interpreted as being unrelated to fisheries:

> *"Management authorities often discover that issues identified by indigenous fishers for management of the resource often involve topics not immediately seen to be directly associated to the fishery by more conventional minds"* (Sinnamon 1997: 12).

This conflict can be seen in the dispute over the boundaries that are used to manage sea mullet harvests in the Bay. Measures that are based on the Bay as delineated by the western shores of Moreton, North and South Stradbroke Islands (the QFS definition) discount those fishing impacts that occur along the eastern shores of the islands and beyond (the Quandamooka definition). These impacts are mainly on the 'elders' of the sea mullet migration. Once these fish are taken, the Quandamooka argue, the younger fish will not know the way into the Bay (Ross and Quandamooka Land Council 1996b) and this then has an influence on the fishery within the Bay itself. This has prompted Quandamooka community members to argue that the QFS definition of the Bay does not serve the interests of sea mullet (Sinnamon 1997). The QFS responds that fishing zones on the eastern, oceanic side of the islands have imposed limitations on the impacts of commercial fishing outside the Bay, but declining numbers of mullet entering the Bay (Sinnamon 1997) suggest otherwise.

Essentially, the QFS is limited in its capacity to manage the Bay's fisheries if its responsibilities are confined to fisheries alone and not the wider environment. As Ross and Quandamooka Land Council (2001:10) note:

> *"There are fourteen separate pieces of legislation, administered by four different State government departments and nine local government authorities, which relate to the management of the Bay (QFMA 1996: 16-20). Each department and authority has a different responsibility toward the management of the resources of the Bay. Consequently, demarcation and compartmentalization of responsibilities under legislation and government structure makes an holistic approach to the management of the waters and resources of the Bay politically impossible, however desirable it may be".*

Management goals

The degree of overlap between the management goals of both parties can also help to determine the success of co-management arrangements. In essence, the closer they are, the greater the chance for collaboration. For Moreton Bay, both management parties aspire to achieve sustainability, providing a common platform from which to pursue cooperative management arrangements.

The QFS definition of sustainability emphasizes the *development* aspect of ecologically sustainable development (ESD). Brunk and Dunham (2000) argue that the prioritization of economics and development often leads to the depreciation of other values. The Quandamooka definition of sustainability emphasizes human benefits of ecosystems management, as the maintenance of spiritual and cultural aspects of the community are emphasized. However given the inseparability between the community and their environment, the environmental well-being of the Bay is considered to be reciprocally linked to the well-being of the Quandamooka people. Economic values are also considered an important factor for self-determination and self-sufficiency purposes, but they do not dominate, and therefore conflict strongly with the QFS approach to fisheries management.

The QFS establishes individual rights for fishers through legislative and regulatory means and various management advisory committees (such as MACs and ZACs). Quandamooka elders make decisions on behalf of the whole community through customary law. This difference of State and local responsibilities represents various challenges to cooperative management. For example, advisory committees represent a useful strategy for including stakeholder groups in the fisheries management process. However, because the Quandamooka community is considered by the QFS as a single stakeholder, rather than a group of people with a variety of rights and responsibilities to resource management in the Bay generally, they therefore have only a single Aboriginal representative on the QFS Management Advisory Committee (and that person may not even come from the Moreton Bay area). This means government managers can more easily take the path of least resistance and listen to the strongest lobbying presence, which tends to be the four representatives of the fishing industry (see figure 2). Such outcomes are unlikely to result in the best solution for all.

The disregard of the Quandamooka community management structure is partly a reflection of the differences in marine tenure and definitions of the Bay. But more importantly, the use of power and authority to privilege the QFS management structures over those of the Quandamooka community is reminiscent of Enlightenment thinking (Wallace *et al.* 1996).

Bodies of knowledge and paradigms

The sea mullet case study has identified several elements of the QFS and the Quandamooka community's management approaches to this fishery. Both management parties have property rights systems in place to manage fishing of the sea mullet spawning migration that passes through and around Moreton Bay. Further, both management parties specify operational rights for their respective fishers, yet substantial differences exist in terms of how these are orchestrated. We argue that the underlying basis for this difference is in the environmental constructions that inform the management practices of both agencies.

The QFS commonly refers to and manages sea mullet according to such terms as 'resources', 'stocks' and 'numbers'. This nomenclature is synonymous with business terms, what Newell and Ommer (1999) refer to as equating fisheries with disposable items. This exposes the view that humans are apart from and above the environment, and highlights the close connection between QFS management and the capitalist mode of thinking, again a reflection of Enlightenment or positivist thinking.

Quandamooka fishers and their community, on the other hand, although also placing economic value on the sea mullet spawning migration (as they traded these items), see economic value as just one element embedded within other, multiple values. These values essentially equate to the Quandamooka community's view of these fisheries as being within the environment and seeing themselves as part of that environment. This is embodied in such management strategies as fishing according to the sea mullet social structure and treating sea mullet with respect once caught. The Quandamooka community thereby respects sea mullet as living parts of the environment. This poses a challenge to joint management arrangements given the differing values and paradigms within which the management parties operate.

Several interesting elements are revealed by the above comparisons. Firstly, the concentration on fishing effort and the absence of output controls in the QFS management approach emphasizes human exploitation of these species. Embedded in this management approach is the view that humans can control the environment, a basis of human supremacy over the environment. On the other hand, Quandamooka management strategies include wider environmental considerations and reciprocity principles such as returning the best mullet to the dolphins in order to ensure a good catch next season. These are indicative that influences beyond the control of the Quandamooka community are considered integral to proper resource management and that the Quandamooka people view themselves as part of the wider natural and social environment.

Thus, while knowledge is available to manage the fish species on an ecological basis, it seems that the QFS does not consider this knowledge as a valid basis for 'scientific' decision-making. This could be due to a number of reasons, including:

- The inability of the QFS to use *qualitative* knowledge and measures;
- The supremacy of Western science and quantifiable measures; and / or
- the need for certainty and simplicity and the need to perpetuate current regulations and rules for administrative ease (Wilson, this vol).

Conclusion

The management practices employed by the QFS and the Quandamooka community are intrinsically political in nature. The QFS practices favor commercial interests while the Quandamooka community's approach favors community interests.

The application of a social constructivist methodology allowed a comparative study of some of the constructs inherent in the Quandamooka community and QFS approaches to sea mullet management to be undertaken. In light of Berkes' (1999) analytical model, the case study revealed that different cultural constructs resonate throughout the two different management approaches. Clearly, the construction or perception of the environment has far reaching implications for how values are assigned, what and how knowledge is constructed and what management strategies are devised.

The results indicate that Western constructs dominate fisheries management in Moreton Bay. Despite a change in Western environmental values over recent decades, key principles, implicitly and explicitly embodied in current QFS management approaches, remain embedded in the Western constructs of the Enlightenment period. Recurring themes in the QFS management approach are the concepts of human supremacy over the sea and its resources, State authority and power, individualism, and economic dominance - all assumptions founded in a positivist theoretical framework. Quandamooka community management practices, knowledge and concerns are treated as those of a stakeholder. Moreover, current commercial management and harvesting methods undermine the application of Quandamooka management practices, thereby marginalizing the development of their knowledge and culture. The marginalization of resource management responsibilities can in turn lead to a loss of management practices and knowledge not just for the Quandamooka community but also for humanity as a whole. Such loss signifies the loss of another way of knowing and another way of interacting with the environment (Linzey 1995).

Principles inherent in the Quandamooka community's approach to sea mullet management reflect a constructive, holistic and spiritualistic indigenous framework for resource management. Instead of separating the economic well-being of the resources from ecological considerations, and devising separate management strategies for each, resource productivity is seen as being dependent on the ecological and human well-being, where the environment is managed as a whole.

Clearly, current QFS management practices fall short of the sustainability goal, however it may be defined. Following Brunk and Dunham (2000), distributive justice is not catered for as current QFS practices fail to provide fair access to fisheries, the Quandamooka community is excluded from meaningful engagement in management decision-making and Quandamooka management practices are dismissed. Current QFS management practices also deny ecological justice. Apart from the delimitation of Fisheries Habitat Areas, the inclusion of ecological aspects in the QFS approach to sea mullet management remains negligible. The continued targeting of mature sea mullet can only lead to an eventual collapse of the fishery.

We are not implying that Western management strategies and science should be discarded, for science can provide valuable insights into environmental management. Scientific knowledge is paramount in larger scale ecological studies that take into account the cumulative impacts of fishing for sea mullet that migrate between the New South Wales and Queensland borders. Indeed, indigenous knowledge does not represent a panacea for environmental management either, given the many uses of and influences on the Bay and the local scale focus for indigenous knowledge. Instead multiple perspectives, knowledge bases and management strategies are needed for Moreton Bay fisheries management, as voiced by Penny Tripcony (1997:9), a member of the Quandamooka Land Council:

> *"We believe that by marrying the two systems of knowledge (that is Aboriginal scientific knowledge, technology and attitudes to the environment; and Western science and technology), the collective wisdom of both cultures will ensure a more holistic approach to life. Science, technology and the environment ideally would no longer be discrete separate units, but as ongoing interactions within the total ecosystem".*

However, Penny Tripcony's vision for genuine collaboration in management will not be achieved until there has been a fundamental shift in dominant perceptions and values.

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QUESTIONS

Ross Wilson: How did you use dolphins to harvest mullets?

Tanuja Barker: It exploits the relationship between the fish and the dolphins during the seasonal migrations. The dolphins would guide the schools of fish into the bay where the nets were set – fishers would just scoop them up.

Ian Baird: The same thing happens in southern Thailand.

Tanuja Barker: Yes, and I believe it is the same in South America.

WHO'S LISTENING? ISLANDER KNOWLEDGE IN FISHERIES MANAGEMENT IN TORRES STRAIT, NORTHERN AUSTRALIA

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ABSTRACT

This paper addresses the fisheries management-related knowledge of indigenous Islanders in Torres Strait, northern Australia. Islander knowledge will be situated both culturally and historically, before turning to the contemporary context of fisheries management and development. Islander fishermen have recently established dialogue with scientific fisheries managers; I argue that the success of this dialogue depends on recognition of various political and legal strategies deployed by Islanders to control the allocation and management of fisheries resources within their traditional marine territories.

INTRODUCTION

To ask whether or not an indigenous society practices resource management risks simplistic response. It is always more revealing to ask *which* resources are conserved or managed, under what circumstances. The Torres Strait presents an interesting context in which to examine this question. Located between Papua New Guinea and the Cape York Peninsula of northern Queensland, this reef-strewn passage is home to a group of Melanesian Islanders who have an intimate and long-standing connection to the small islands, extensive reefs and tropical waters of their traditional territory.

For the period prior to colonization by Europeans, there is little direct evidence for the resource use and management strategies of Islanders. There is a suggestion, however, in the 1898 research of the Cambridge Anthropological Expedition to Torres Strait, that Islander culture involved collective awareness of ecological constraints, and of the possibility of human action directed toward sustainability. Stern taboos regulated human population size, for example (Haddon 1908: 107-9). The cultural ideal was two children per nuclear family, and it was contrary to tribal law to have more than three. Infanticide, or adopting-out of a fourth child to a family with fewer children, was the rule. Although Haddon has nothing to say on the motivation for this taboo, the limiting factor for human population size was surely not seafood supplies; it was almost certainly fresh water, in short supply on most Torres Strait islands.

Certain other renewable resources were in short supply, according to Islander oral history. There was no surplus of garden lands, and indeed the relatively barren sand cays of the central Strait depended on trade for vegetable produce from the more fertile Eastern volcanic islands. In the Eastern islands, seabird manure was used to boost garden production according to local informants today, but local cays and islets did not accumulate guano at a sufficient rate to meet the need. Hence, Eastern Islanders journeyed considerable distances to the outer limits of their sea territories, either northward to Bramble Cay near the Fly River estuary of Papua New Guinea, or southward to Raine Island, well down the Great Barrier Reef, where large cays are found that support large seabird concentrations.

Sand cays, as sanctuaries for nesting turtles and seabirds, are sacred places for Eastern Islanders. Mythology surrounding the creation of Bramble Cay, in the marine estate of Erub (Darnley Island), emphasizes the possibility of marine resource depletion, and human responsibility to protect resources (Scott, under review). Legendary ancestors used their magic to create the cay because nesting seabirds and turtles had been victims of human overexploitation nearer the home island. In response, ground was taken by clan leaders from the home island to create the Cay far enough away to afford these important resources some protection, but close enough to be of use, with the comings and goings of visitors to the Cay overseen by clan elders.

From the 1860s to the 1960s, Islanders were involved as seamen and divers with a range of industrial fisheries – bêche-de-mer, pearl shell and trochus shell (Beckett 1987; Ganter 1994). This experience provided a lesson in the exhaustibility of resources that would not have been depleted under pre-contact conditions. Islanders witnessed first-hand the depletion of wild pearl shell and trochus shell to the point that a crew might dive all day for what a man might formerly have easily gathered in half an hour. The patterns of commercial exploitation, and of management policy to the extent it existed, were, however, out of the hands of Islanders. Islanders were maritime workers for the most part, not owners of vessels. Even the small number of Islander-skippered commercial vessels was strictly under the thumb of the colonial Protector until the 1970s.

The 1970s saw further crises: the giant clam, which under aboriginal conditions were an exhaustible resource and seen as such; and sardines, which under aboriginal conditions were effectively inexhaustible. Giant clams have the potential to be easily overexploited. Their meat is highly savored and involves limited harvesting effort. Yet, giant clams are present in significant numbers even on home reef areas. Food regulations limit the consumption of giant clam to infrequent occasions, as a means of varying the diet or during those periods when access to other sources of seafood is limited by unfavorable fishing conditions. Giant clams are key symbols in Islander attitudes toward conservation. Their shells should be turned upside down once the flesh has been harvested to serve as a refuge for other life forms. Individuals who fail to observe this practice are labeled *meme kurup*, a person uncouth and uncultured (Scott, under review).

A giant clam crisis occurred when a Taiwanese mother ship, careful to anchor beyond the visual horizons of inhabited islands, was eventually discovered by Islanders and apprehended. Giant clams had however been harvested in such large numbers over an extensive area of reefs that it took more than twenty years for clams to reestablish their former size and abundance.

From the early 1970s to the early 1980s, a turtle-farming program was initiated in the Torres Strait, by a foreign biologist. Large numbers of eggs were collected from nesting areas such as Bramble Cay and Raine Island and brought to Mer (Murray island) for incubation. From there, the hatchlings, which enjoyed much higher survival rates than they would in the wild, were dispersed to farms on various islands to be hand-fed in small pools. Juveniles were to be released to reinforce the wild population. Most hatchlings, however, were to be raised to adulthood, as breeding stock for turtle restocking elsewhere.

Sardines served as the primary food source for the large numbers of growing turtles. Sardines had always been a reliable and easily harvested food staple for Islanders. However, aggressive netting, an essential element in the maintenance of the turtle farm operation, resulted in an unprecedented sardine population collapse at both Erub and Mer. This in turn led to the retreat of formerly abundant species of large fish, particularly trevally, that normally pursue sardines onto the beaches of the home islands. Islander patience ran out when it was proposed that turtle farmers should turn to giant clams for turtle feed. Elders insisted that the project be terminated. According to Islanders, it took fifteen years for sardine populations to recover to former levels, and trevally are again abundant along local beaches.

These resource crises, mostly profit-driven, mostly decided by non-Islanders, have stiffened local resolve to gain management jurisdiction and ownership of their home seas. For both ecological and social reasons, Eastern Island fishers advocate limiting reef fisheries to locally controlled small-boat operations, in pursuit of diversified subsistence and commercial catches – principally tropical rock lobster, coral trout, spanish mackerel, red emperor, sand fish (i.e. sea cucumber), and trochus shell. Rotational use of fishing spots, the distribution of fishing effort over multiple species, and seasonal shifts in wind and weather patterns limiting small boat access to less than six months of the year are principal features in local management. These stand in marked contrast to the approach of larger non-Islander commercial boats targeting one or two species, who can work intensively during all seasons in nearly any weather. There is also a major difference in economic imperative. Relentless accumulation is disparaged by Islanders; in the words of one informant:

> *"them thing he happen on a needs basis, not on a craving for more and more. As soon as we satisfy, we stop and when the need come up again we go again".*

The rare individual who fishes hard at every possible opportunity is more likely to be the object of censure than praise.

BRINGING ABOUT A SEA CHANGE

Islander aspirations to assume primary control of resource and environmental management are being pursued along various avenues simultaneously. First, rights to use and manage marine resources may be reshaped through Native Title recognition. Mer (Murray) Islanders gained High Court recognition of their ownership to land above the high water mark through the landmark Mabo decision in 1992. Through a series of Federal Court determinations on claims subsequently lodged with the Native Title Tribunal, most other Islander communities have gained similar recognition. A sea claim covering the entire Torres Strait region was lodged in late November 2001 on behalf of the Islanders by the Torres

Strait Regional Authority (TSRA)[1]. Recognition of Islander title to reefs and seas below the high tide mark will meet with greater opposition than was the case with land, and elsewhere Native Title rights to the Australian offshore have received weaker recognition than terrestrial rights (High Court of Australia 2001), but Islanders hope that their own case will result in a more beneficial judgment, given the predominance of the sea for their cultural identity and economic prospects.

In the meantime, Islander concerns about the sustainability of certain fisheries, and frustrations with the lack of economic benefits accruing from commercial fishing in their traditional waters have erupted in conflict with non-Islander commercial fishing interests and central government authorities. In the early 1990s, Eastern Islanders declared exclusive economic zones within their traditional waters, in line with demands for economic independence and the management of the seas in accordance with traditional law. Periodically, non-Islander commercial fishing boats have been evicted from this zone, although more recently, a so-called "gentlemen's agreement" has led to non-Islander boats generally avoiding waters within a ten nautical mile radius of home islands. Islanders, however, seek a thirty-mile radius, and there is nothing in official licensing or regulation to prevent entry even into the ten-mile zone, so incidents at sea have continued.

The declaration of exclusive economic zones also reflected Eastern Islander anxieties about potential fishing pressure from some of the larger islands in Western Torres Strait, where Islander fishermen use hookah gear[2] to gain access to sandfish and tropical rock lobster at greater depths. These fishermen are described as more 'cash-driven'. Eastern Islanders believe that these factors, together with insufficient regard for traditional marine territories, led to the 1997 collapse of the Warrior Reef sandfish population in the Central Strait, and subsequent closure of the fishery. For this reason Eastern Islanders are adamant that their community territories must be respected, so that they may regulate access. They express some willingness to share with Western and Central Islanders, but on specific terms, including a ban on the use of hookah gear. For this reason, Eastern Islanders have made their participation in the blanket regional sea claim conditional on respect for community-level traditional territories.

A recent Cairns District Court decision dismissed armed robbery charges against an Islander man who had used a crayfish spear to confront licensed commercial fishermen operating in the traditional fishing territory of Mer. Ben Ali Nona's confiscation of $600 worth of coral trout from the intruders was deemed not to be robbery on grounds that he was acting on an 'honest right of claim'. The acquittal is the outcome of a provision of the Queensland criminal code rather than recognition of Native Title sea rights. But it has fuelled grassroots support for a movement centred on the Torres Strait Fisheries Taskforce (TSFT), a body of young, energetic fishermen determined to take control of fisheries management through the creation of a Torres Strait Regional Fisheries Council.

A Cultural Maritime Summit[3] in March 2001, in the wake of the Nona decision, was the occasion of a regional statement of Islander demands. These included suspension of all fishing by non-indigenous commercial fishermen throughout the Strait within a week. The Commonwealth fisheries minister visited the Strait within days, warning against further interference with licensed fishing boats, but commencing political negotiations on important issues.

Islanders have particularly urgent concerns over the environmental impact of commercial prawning, believed to be a major factor in the decline of tropical rock lobster, a resource that is vital to their own small boat fishery. Over the years, large numbers of lobster on spawning migrations have been caught in prawning nets, and either sold illegally, or returned to the water injured. Islanders for some time have been proposing government buy-back of prawning and rock lobster licenses held by outsiders. On his visit to the Strait, the Minister publicly rejected license buy-backs, professing lack of government funds[4].

Behind closed doors, however, both State and Commonwealth governments have yielded important ground. They have afforded the chair of the Torres Strait Regional Authority (an

[1] The next step involves the subjection of the Torres Strait claim to a Registration Test under the Native Title Tribunal (NNTT) to confirm that all relevant information concerning the claim has been documented. Once this stage is complete, the claim will proceed to notification and mediation. If no agreement is reached during the mediation stage, the claim will then go to trial. The entire process is likely to take several years.

[2] Hookah gear refers to the underwater breathing equipment used by professional fishermen for harvesting lobster, sandfish, and trochus shell.

[3] The Ngalpun Malu Kaimelan Gasaman Cultural Maritime Summit, 22-25 March 2001.

[4] Each prawning license is worth approximately A$ 800,000.

Islander-elected regional self-governmental body) equal authority to themselves on the top-level fisheries decision-making committee – the Torres Strait Protected Zone Joint Authority (PZJA). In addition, an Islander TSFT representative has been granted observer status.

Discussions are also underway on the subject of prawn license buy-backs, and other Islander proposals for dealing with the current crisis in the tropical rock lobster fishery. Current stock assessments indicate that numbers of breeding stock and juveniles are among the lowest ever recorded, and that future recruitment may be too low to support the fishery (Torres Strait Rock Lobster Working Group 2001). Many Islander fishermen regard the total exclusion of prawn trawling vessels as their long-term objective. In the interim, however, they have agreed on a number of trial measures, firstly, a 50% reduction of prawn trawling licenses as a minimal condition for tolerating prawning vessels in their waters. Although the Commonwealth has expressed support for a proposal to buy back 39 of the 79 licenses in the region, there is much disagreement on how this buy-back arrangement should proceed. The Commonwealth has taken the position that the prawning industry itself should purchase any buy-backs, but license owners and the industry more generally are unhappy with this. For the moment the Commonwealth, industry and Islanders remain at loggerheads. One possible approach that has been taken elsewhere in Australia is for the Commonwealth to suspend the prawn fishery as a means of applying pressure on the industry to co-operate. In the interim, Islander fishermen say they are holding the option of escalated direct action in reserve.

Meanwhile, the TSFT has successfully lobbied the regional Islander leadership to rescind a promise of prawn licenses to three private Islander enterprises, and restore them to the common benefit of Islanders. Some Islanders argue that prawning on a reduced scale is environmentally sustainable, and acceptable if Islanders are afforded a stake in the industry. One proposal is to establish an Islander prawning operation with one of the three licenses, while renting the other two licenses to provide financing, training, and other support.

A second Islander demand has been for the seasonally rotating exclusion of all prawn-trawling effort from areas of lobster migration. Currently, trawlers sweep the whole of the prawning grounds from March to December. The Islander fishermen's proposal would have all boats working north of the 10 degree parallel only in the first part of the year, and working only to the south of the line in the second part. Each area will therefore be closed for a full seven months, closures timed to coincide with the clockwise migration of lobster through the Eastern and Central Strait. There has, as yet, been no official action on this demand, although the scientific merits of the proposal have received some consideration of by the Australian Fisheries Management Authority (AFMA).

Islanders have stated that these demands are non-negotiable and served notice of their readiness if necessary to close down the prawning grounds by laying barbed wire across the bottom, or by dumping old vehicles on the grounds to serve as rock lobster sanctuaries, which would incidentally pose an elevated risk of snagging and damage to prawning gear.

Islanders recognize that trawling is only one of several possible impacts on the lobster fishery, and are taking other measures as well. Of particular significance is Islander commitment to a total ban on the use of hookah gear. In the Eastern Islands, deeper waters inaccessible to free divers are regarded as sanctuaries. Eastern Islanders see a causal relationship between the use of hookah gear and the reduction of lobsters moving up onto shallower reef surfaces. Islanders feel that a ban on hookah gear would dissuade most non-Islander divers from participating in reef diving fisheries, so a reduction in total fishing effort would also result. It is extremely interesting that Western Islanders, who do use hookah gear, have joined Eastern Islanders in supporting a total hookah ban throughout Torres Strait.

Similar concerns about the impact of "technology creep" on lobster, coral trout, and other stocks relate to the use of GPS and depth sounders that allow the targeting of specific fishing locations. Restrictions on their use would tend to spread fishing effort, at the cost of increasing the fuel and time costs of looking for specific bottom features. Islanders recognize that the proposed restrictions would be a lesser hindrance to Islander than non-Islander commercial fishermen, who are heavier users of these technologies, and whose local knowledge of productive sites is inferior to that of Islanders.

New arrangements in the rock lobster fishery, effective as of 1 December 2001, go some distance in addressing Islander concerns for rock lobster stocks. These include an increase in the minimum legal size for tropical rock lobster[5], an extension of the existing two-month ban on the use of hookah gear by a further two months[6], and a new two-month ban on all other forms of commercial fishing[7], though still permitting traditional fishing by Islander fishers within the region. While these measures represent only partial fulfilment of Eastern Islander aspirations, they reflect the outcome of a more democratic approach to fisheries management in the region. Of particular significance is the fact that for the first time in its history the PZJA meeting, which endorsed this three-pronged approach to stock management, was held as an open forum with invited stakeholders, including the TSFT, in attendance as observers (Anon. 2001).

Against this backdrop, conflicts continue. In the final weeks of 2001 Eastern Islanders evicted a commercial trout vessel, which anchored out of sight at an uninhabited cay in the northwest part of their marine estate, but then sent dinghies onto reefs close to Mer. The commercial fishermen left peacefully following threats from Islanders that their catch would be confiscated if they didn't clear out. There is growing concern that such confrontations could escalate into more violent action. Younger Islander fishermen have made it clear that they are willing to resort to such action if challenged and if progress on other fronts stalls.

CONCLUSION

From an Islander perspective, local knowledge of marine resources has been continuous and evolving, and responsibility for their sea territories (even if inhibited by successive colonial regimes) has never been surrendered. Principles of resource conservation and management have a deep cultural history, and the application of these principles, together with specific knowledge contents, has evolved with changing conditions across a variety of fisheries.

As scientists we are coming to accept a democracy of knowledge traditions, in the dialogue between indigenous and scientific resource managers. But Islander experience is showing us that this new democracy has little meaning unless set within an institutional framework that restores authority to indigenous owners and governors of their traditional marine estates. The current format of the management structure established under the Torres Strait Treaty[8] is heavily biased towards Western scientific approaches and affords Islanders minority status and a limited advisory role. Current management provides an ineffective platform for them to raise environmental concerns or communicate their knowledge of the resources (Mulrennan and Scott, in press). Addressing these asymmetries will not be easy. Recent recommendations include a proposal to have active Islander hunter/fishers rather than a representative from the regional Islander leadership on the Torres Strait Fisheries Scientific Advisory Committee (TSFSAC). The inclusion of social science research expertise has also been recommended as a measure to enhance the cultural and socio-environmental aspects of natural resource management (Sen 2000). While such changes would likely result in the increased engagement of Islander knowledge and expertise in the research process, the establishment of true partnerships in management decision-making will require more substantial transformations, not just in the openness of scientific managers to Islander expertise, but in political structures of authority.

A combination of knowledge exchange, political negotiation, legal action, and – when progress along these avenues is too slow – direct action at sea, is responsible for the promising recent achievements of Islanders. Substantial political interests from within the Australian mainstream remain aligned against them; but one fact has emerged clearly that should aid the course of future progress: those in central governments who are committed to better fisheries policy, and who support Islander initiatives, are doing so because they know that the current regime is unsustainable. They *are* listening to Islanders, and in the latest round of proposed reforms, for the first time, they appear to have opened themselves to the idea of Islander leadership.

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[5] The minimum legal size for tropical rock lobster is increased from 80mm to 90mm carapace length, or in the case of lobster tails, the minimum legal tail length is increased from 100mm to 115mm.

[6] The ban on the use of hookah gear is extended from 1 October - 30 November for a further two months, to 31 January.

[7] The new two-month ban is from 1 October – 30 November; this closure will commence 1 October 2002.

[8] Specifically I am referring to the Torres Strait Fisheries Management Committee (TSFMC), the Torres Strait Fisheries Scientific Advisory Committee (TSFSAC), and the Environmental Management Committee (EMC).

their meetings, and record their concerns and positions.

I am grateful also to Jeremy Beckett, Henry Garnier, Tony Kingston, and Victor McGrath for the valuable insights they have contributed to this paper. A very special debt of gratitude goes to my husband and co-researcher, Colin Scott (Anthropology, McGill University), for his many contributions to this paper and to this research more broadly.

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Questions

Christina Soto: Why do you think the Western Islanders would agree to the Hookah ban?

Monica Mulrennan: They are concerned. They know if they don't do anything, the fishery will go downhill.

Christina Soto: In a previous presentation, it was stated that in Australia some commercial fishers got licenses as well as the "traditional" fishers. Do you think that the same thing is happening in the Torres Strait? If the islanders have increased power to manage the area, they may go for the fisheries themselves.

Monica Mulrennan: There is a very strong understanding among islanders that the deeper water areas are sanctuaries and if you allow the rock lobster in the deeper areas they will spawn and come up to the shallower areas and keep on producing. They also prefer free diving. They have also witnessed the damage commercial fisheries can do.

Annelore Reisewitz: What is the ethnic mix in the Torres Island? Are they all islanders or are there also whites? Are any of the islanders involved in the commercial fishery?

Monica Mulrennan: The eastern strait is inhabited almost exclusively by islanders whereas in the western strait there is a substantial white population and a commercial fishery. Many commercial fishers have made their homes there. There is limited involvement of the islanders in the commercial fishery. The prawn fishery constitutes 78% of the Torres Strait fisheries, but the islanders are not involved in it. The commercial fishery is incompatible with their preferences. The council is encouraging islander participation in commercial fisheries. It would occur at a very low level. The islanders have a low drive to do that. If there is a tombstone to be opened or a wedding coming up, then they are out there bringing in rock lobsters. Once that is over, they may not fish for several days.

A COLLABORATIVE, CONSULTATIVE AND COMMITTED APPROACH TO EFFECTIVE MANAGEMENT OF DUGONGS IN TORRES STRAIT, QUEENSLAND, AUSTRALIA.

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ABSTRACT

The world's largest known population of dugongs in Torres Strait, Australia, supports an important subsistence fishery by the traditional inhabitants, Torres Strait Islanders, in the region. I obtained updated information on the life history and reproductive ecology of dugongs based on collecting specimens and data from dugongs harvested for food by Islanders. Information on life history parameters will help management efforts to ensure the sustainability of the traditional fishery. Data and specimens for the study were obtained over two years (1998-1999) when I resided in Mabuiag Island, one of the major hunting communities.

The collecting regime was developed within a sampling protocol that was continually negotiated with active participation by community members, especially the hunters. The contribution of hunters in terms of both information and co-operation in specimen collection has been central to the successful collection of data and specimens essential for my research. Hunter knowledge of the spatial and temporal patterns of dugong distribution has provided important insights to annual variability in catch rates and has supplemented information on reproduction such as habitat use by breeding animals.

Being able to live and work within the Mabuiag Island community presented a rare opportunity to build upon the mutual trust, cooperation and commitment by both communities and scientist. The involvement of Islanders as active participants in research, and acknowledgement of the diversity and complexity of socio-cultural factors within the community, has enabled collection of very rare and valuable specimens. Moreover, an individual and community sense of ownership of the research indicates high potential to considerably improve community based management strategies for dugong in Torres Strait.

INTRODUCTION

The dugong (*Dugong dugong*) is a large marine mammal that reaches a length of 3 m and weighs up to 420 kg. It has high biodiversity value as the only extant species of the Dugongidae family and as the only herbivorous mammal that is strictly marine (see Marsh *et al.* 2001). The dugong is listed in The World Conservation Union Red Data Book of Threatened Species as 'Vulnerable to Extinction' (IUCN 2000) and also in Appendix 1 of the Convention on International Trade of Endangered Species (CITES), which regulates trade in listed species. In Australia, the dugong is included as a 'Listed Migratory Species' and 'Listed Marine Species' under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*. Throughout its Australian range, the dugong is also protected under relevant state/territory legislation. In Queensland, the dugong is listed as 'Vulnerable' under the *Nature Conservation Act 1992*.

As large non-aggressive herbivores, dugongs have been hunted for food, clothing and other products by many coastal societies throughout their range (e.g. Reynolds and Odell 1991; Marsh *et al.* 2001; Rogan *et al. in press*). Anecdotal reports suggest that dugongs were once a very important subsistence resource in many countries in the Indian sub-continent and islands, South East Asia, East Africa, Western Pacific and the South Pacific (Marsh and Lefebvre 1994; Marsh *et al.* 2001). Where dugongs were used for subsistence they were also of major economic and cultural significance (see Marsh *et al.* 2001; Rogan *et al.* in press). With the growth of human populations, subsistence hunting of dugongs has probably contributed to the extirpation or severe depletion of local populations in several parts of their former range (Marsh and Lefebvre 1994; Marsh *et al.* 2001).

Today Australia is one of the only countries that has large populations of dugongs and is considered the dugong's stronghold (see Marsh *et al.* 2001). It is believed that the global survival of the dugong will be largely dependent upon Australian efforts (Bertram 1980; Marsh *et al.* 1999; Marsh *et al.* 2001).

Dugongs are of great cultural, nutritional and socio-economic value to coastal Aboriginal and Torres Strait Islander peoples of tropical Australia (Smith and Marsh 1990; Johannes and MacFarlane 1991; Bradley 1997). Globally, the largest population of dugongs is in Torres Strait (Figure 1) (Marsh *et al.* 1997; 2001) where the long-standing subsistence importance of dugongs for Torres Strait Islanders has been traced back at least 2000 years in archaeological deposits (Vanderwal 1973).

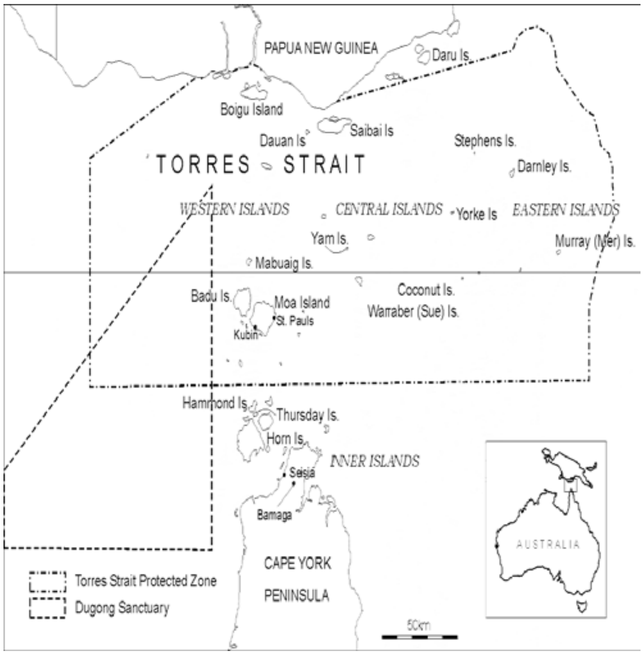

Figure 1. The Torres Strait region showing the boundary of the Torres Strait Protected Zone and the main communities in the Inner, Western, Central and Eastern Islands groups.

In spite of 200 years of profound external influences since contact with Europeans, access to large numbers of dugongs (and green turtles) has enabled Torres Strait Islanders to maintain much of their traditional way of life (Nietschmann and Nietschmann 1981; Nietschmann 1984, 1989). In addition to being an important source of fresh meat, dugongs also continue to sustain vital cultural practices, ceremonial feasting and rites of passage (Nietschmann 1984, 1989; Mulrennan and Scott 2001). This importance continues even though most basic necessities are now provided by a cash economy, based largely on government funding through employment opportunities or social security (see Kwan *et al.* 2001).

The Torres Strait Treaty, an international agreement between Australia and Papua New Guinea (PNG), protects the traditional way of life of Torres Strait Islanders including their right to hunt dugongs (see Kwan *et al.* 2001). The recent recognition of the potential for Native Title rights over the sea and the active pursuit for self-determination by Torres Strait Islanders as well as responsibility for biodiversity conservation means that Australia has considerable responsibility for dugong conservation (see Kwan 2001).

There is mounting national and international pressure to ensure that the subsistence consumption of a globally threatened species, especially the dugong, is sustainable in Torres Strait. Concerns about the sustainability of harvests and the need to reconcile management intervention with the socio-political and cultural needs of Torres Strait Islanders, should the harvest prove unsustainable, have become a priority for managers (Marsh 1996; Marsh *et al.* 1997). However, this debate has not been informed by information on the cultural, social, economic and environmental variables that determine hunting pressure and the dugong catch. Such information is crucial to the development of effective co-management strategies. A community-based management approach should be a major priority for government management agencies particularly as Torres Strait Islanders are demanding greater political and economic autonomy including their right to hunt and manage their marine resources, including dugongs (Kwan *et al.* 2001).

This paper describes how my research was conducted as a process of negotiation with Torres Strait Islander hunters (Figure 2). This process was central to the development of trust between the hunters and myself as a scientist. Such a collaborative and consultative approach provided a rare opportunity to obtain information based on both empirical data and the social context of dugong hunting that will

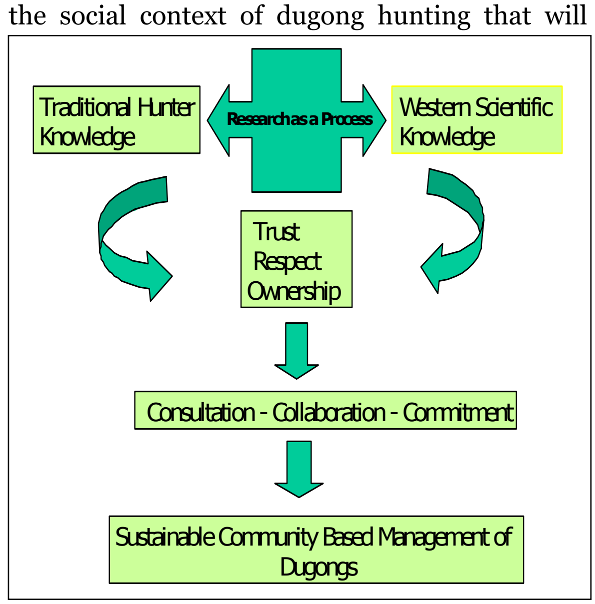

Figure 2. Conceptual diagram showing how the research process which obtained knowledge and established a relationship between hunters and the scientist, can contribute to effective management of a sustainable dugong fishery in Torres Strait.

assist in community based management efforts. The approach highlights the importance of hunter's and scientific knowledge in contributing to our knowledge base to ensure the sustainability of the dugong fishery in Torres Strait by providing insights into dugong movements. This commitment to a sustainable dugong fishery will require integration of scientific frameworks and Torres Strait Islander cultural, social, economic and political perspectives.

A collaborative approach to fieldwork: establishing relationships for the research process

My fieldwork in Torres Strait was mainly based on Mabuiag Island where I lived from September 1997 to November 1999. The success of my fieldwork was attributable in part to good relationships between the Mabuiag Island community and previous researchers, particularly Bernard and Judith Nietschman, who conducted their study on Mabuiag Island in 1976-77 (see Neitschmann and Nietschmann 1981; Nietschmann 1984; 1989). With the exception of Mabuaig Island, most Torres Strait Islanders have had little first-hand experience with researchers. Thus, the favourable experience of community members at Mabuiag Island working with other researchers was of significant advantage to my research.

My fieldwork was also successful because I adopted an approach which acknowledged the range and complexity of the social context of the consumptive use of dugongs by Torres Strait Islanders. Acknowledgement of the socio-cultural and nutritional significance of dugongs to Torres Strait Islanders was crucial in developing my sampling regime. I operated within a culturally sensitive protocol that guided my research activities and required an adaptive research process. My sampling protocol was a continuous process of negotiation in which community members, particularly the hunters, actively participated.

The capacity to recognise, acknowledge and reconcile my obligations to the communities (to respect their decisions) while maintaining the scientific integrity of my data and specimens was crucial to the successful completion of fieldwork. Acceptance of these protocols resulted in an exchange of short and long-term benefits to both the community and the scientist.

The hunters and the community benefited because I obtained critical scientific information required to assist in evaluating the sustainability of their dugong fishery. From my perspective as a scientist, the consultative approach provided an invaluable opportunity to collect important traditional knowledge from the hunters, as well as data and specimens from a species that is very difficult to work on. Moreover, the consultative approach fostered a relationship of mutual trust and respect that allowed:

- Effective explanation of the research aims to the community.
- Careful consideration of the impacts of the research activity on the hunters and the community.
- Opportunity to negotiate any changes to the sampling regime or the research aims (for example to explore the potential impact of high concentrations of heavy metals to the health of Torres Strait Islanders from the consumption of dugong meat and offal).
- Obtaining traditional information of relevance to the research plan and sampling regime.
- Adequate discussions about how the community could access and use the information, which allowed them greater commitment to the research aims.

The relationship established between the hunters, their community and I, was essential for us to work collaboratively. My living within the community, which engendered a sense of 'belonging', facilitated this collaboration and allowed many opportunities for me to exchange information with hunters, community leaders and other community members.

As dugongs caught by hunters in Mabuiag Island are butchered at specific landing sites belonging to individual families or clans, I attended most landings of dugongs to interview hunters. The collection of specimens from dugongs being butchered for food would not have been possible without the voluntary cooperation of local hunters. Most hunters willingly provided access to their dugongs to collect samples. In return, I made every effort to collect samples with minimum disruption to the traditional butchering or 'cutting' method.

Sometimes when it was not logistically possible or culturally inappropriate to interview a hunter at a butchering event (e.g. the dugong was being butchered for a funeral), information was provided later by the hunter, the crew or community members. I did not attempt to pursue sampling of an animal, if hunters indicated that they were unhappy with the sampling for any reason. Even on the rare occasion when hunters appeared to be unwilling to provide specimens or undertake interviews, the information and some specimens would be offered to me later. My awareness and sensitivity to occasions when it was not appropriate to take dugong samples ensured that the hunters remained generally co-operative and willing to provide information on such occasions.

Members of the Mabuiag Island community willingly provided information and advice about how best to obtain samples and information for the project. In addition, Torres Strait Islander staff from the Australian Fisheries Management Authority (the Commonwealth agency responsible for fisheries, including traditional fisheries such as dugong and sea turtle) provided valuable advice, particularly about cultural protocols in individual communities. These protocols included knowing whom to ask permission to sample dugongs, particularly when dugongs were being cut for special occasions such as a funeral feasting or other significant event. Community members from Mabuiag Island I employed as research assistants also provided me with valuable advice on streamlining the sampling method.

The methods for obtaining local knowledge and working collaboratively with hunters required considerably more flexibility than conventional biological research, particularly in terms of sampling regimes, methodology and time frames. Documenting the research methodology has highlighted the potential benefits of recognising the importance of Islander collaboration in research of dugongs in Torres Strait.

Being able to live and work within the Mabuiag community presented me with a rare opportunity to build mutual trust, cooperation and commitment between the community and myself as a scientist. Strong support from the Chairman and staff in the Mabuiag Island Council was crucial to the successful completion of my fieldwork. The involvement of Torres Strait Islanders as active participants in the research, and my acknowledgement of the range and complexity of socio-cultural factors involved were central to the completion of this study.

An example of the benefits from the consultative and collaborative process: insights into reasons for the variability in the Torres Strait dugong catch

The benefits of the collaborative approach were demonstrated by the contribution of hunters' knowledge of the spatial and temporal patterns of dugong distribution in Torres Strait providing valuable insights into the variability of the annual catch.

Dugong hunting in Torres Strait has received considerable attention in the anthropological literature, (Haddon 1935; Nietschmann 1989; Raven 1990), and from geographers (Eley 1989; Schugg 1995) and marine scientists (Hudson 1986; Johannes and MacFarlane 1991). Islanders from Mabuiag have had a long history with researchers and have been involved in recording catch rates of dugongs since the 1970s (Table 1). The catch rate of the dugong subsistence fishery has been monitored by an Australian government management agency since 1991 (Harris *et al.* 1997; Marsh *et al.* 1997). There appears to be considerable variability in catch rates even acknowledging the inconsistency in catch monitoring methods used to obtain these estimates.

Bertram and Bertram (1973) reported an annual catch of only about 24 dugongs in Mabuiag Island while Nietschmann (1984) reported 103 dugongs caught in 1977, while the annual catch recorded in the 1990s ranged between 145 to 274 dugongs in the same community (Table 1). This variability is reflected in catch rates available for other Torres Strait communities. Nietschmann (1984) reported a total annual catch of 274 and 157 dugongs in the Western Island communities of Mabuiag, Badu and Kubin in 1977 and 1978 respectively (Table 1). Johannes and MacFarlane (1991) reported a total catch of only 26 from the same islands between 1983 and 1985. Raven (1990) reported similarly low catch rates (total of 16 animals during September 1986 to January 1987) in Boigu Island at a similar time. The magnitude of the annual catch rate monitored by AFMA since 1991 confirms this interannual variability (Table 1, overleaf).

There have been concerns that the current catch rate of dugong in the Torres Strait Protected Zone (TSPZ) is not sustainable (Marsh 1996, Marsh *et al.* 1997). However, the interannual variability in catch rates and uncertainties in assessing the status of the population (Marsh 1996, Marsh *et al.* 1997) have confounded such concerns. In addition to the apparent interannual variability in catch rates, the lack of up-to-date information on the population dynamics of dugongs, and methodological constraints which allow only relative rather than absolute estimates of abundance, make it difficult to draw definitive conclusions about the status of dugongs in Torres Strait.

While there have been previous concerns that catch rates of dugongs in the Torres Strait have at times been unsustainable, catch rates are highly variable because of a number of biological, environmental, social, cultural and economic factors (Kwan 2001). There is some evidence that large numbers of dugongs migrated into the region in late 1991, resulting in the high catches reported by AFMA in the preceding years (Marsh *et al.* 1997, Table 1).

Information from hunters suggests that dugongs regularly move over large distances from one area to another, presumably in search of food in Torres Strait (see Harris *et al.* 1997; Johannes and MacFarlane 1991; Kwan 2001). Hunters in Mabuiag consistently stated that dugongs stayed close to Mabuiag during the north west monsoon (November to April) and moved to Orman Reef (Figure 3) during the south easterly season (May to October) where they fed on 'new shoots' until they moved on when they had 'finished the food'.

The period May to September is reportedly the 'best' time for hunting because of the high local abundance of dugongs particularly at Orman Reefs. Hunters also reported that dugongs move to the northeast side of Orman Reef between Gariar and Beka Reefs to mate during September to October. Hunters said that dugongs 'move away' from the area after October (Figure 3). This is generally consistent with Harris *et al.* (1997) who reported that hunters from the Western Islands believe that the wind pushes dugongs in a north-south movement between Cape York and the south coast of PNG (see Figure 1). During the south-east season, dugongs apparently move north, but their movements are reversed in the north-west monsoon season when dugongs move south (Harris *et al.* 1997). This corresponds to the onset of the wet season in Torres Strait. Dugong herds in the Gulf of Carpentaria were also reported by Preen (in Aragones 1997) to disperse before and during the wet season.

Information from hunters about the movement of dugongs is consistent with increasing evidence from standardised aerial surveys in both Queensland (Lawler 2001; see Marsh *et al.* 2001) and Western Australia (see Marsh *et al.* 2001) that large numbers of dugongs commonly move considerable distances. In addition, satellite telemetry studies in Queensland (Marsh and Rathbun 1990; Preen 2001; Lawler 2001; see Marsh *et al.* 2001) and Western Australia (see Marsh *et al.* 2001) show that individual dugong journey large distances, making trips of up to 600 km within days (Preen 2001). Many of the movements of dugongs have been return trips (see Marsh *et al.* 2001). These movements may

Table 1. The annual catch of dugongs in Torres Strait Island communities obtained by various methods

Area	Method	Date	Estimated annual dugong catch	References
Mabuiag Is	?	1973	24	Bertram & Bertram 1973
	Continuous	1977	103	Nietschmann 1984
	Limited continuous (5 months)	1983-84	12	Johannes & MacFarlane 1991
	Survey	1994	274 (s.e. 175) 145	Harris *et al*. 1997
	Continuous	1998	160	This Study
	Continuous	1999	183 (s.e. 77)	This Study
	Survey	1999		AFMA, unpublished data
Badu Is	Survey	1994	107(s.e. 80)	Harris *et al.* 1997
	Survey	1999	200 (s.e. 66)	AFMA, unpublished data
Boigu Is	Survey	1994	256(s.e. 110)	Harris *et al.* 1997
	Survey	1999	128 (s.e. 59)	AFMA, unpublished data
TSPZ[1]	Continuous	1976-77	750	Nietschmann 1984
	Limited continuous	mid 1980s	110	Johannes & MacFarlane 1991
	Continuous	1991-92	954	Harris *et al*. 1994
	Survey	1991-92	1095 (s.e. 193)	Harris *et al*. 1994
	Survey	1991-93	1226 (s.e. 204)	Harris *et al*. 1994
	Survey	1994	860 (s.e. 241) 623 (s.e.	Harris *et al.* 1997
	Survey	1994-95	197)	Harris *et al.* 1997
	Survey	1999	692 (s.e. 150)	AFMA, upublished data
Bamaga	Survey	1997	116	M. Bishop pers.comm, 1997
Daru PNG,	Continuous	1976-77	74-120	Hudson 1986
	Continuous	1978-83	463	Hudson 1986

Notes: 1 - TSPZ (Torres Strait Protected Zone), see Figure 1

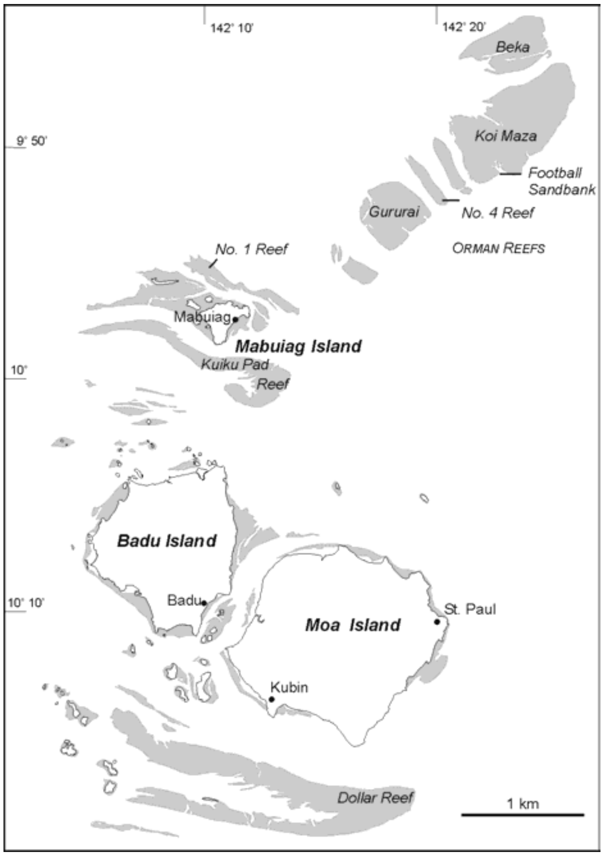

Figure 3. The main hunting areas used by hunters from Mabuiag Island.

be in response to changes in seagrass abundance.

The biomass of *Halophila* and *Halodule* spp., the preferred seagrass food of dugongs, is spatially and temporally highly variable (Walker *et al.* 1999). In light of the reports of the variability in the spatial and temporal distribution and abundance of dugongs noted by the hunters in Torres Strait, it is plausible that dugongs may undertake large-scale responses to cues that indicate suitable food sources in other areas or when locally available food resources are depleted.

Seasonal movement of dugongs reported by hunters in the Orman Reef (Figure 3) area may result from reduced biomass of high quality food due to sustained high grazing pressure over extended periods. The low abundance of dugongs in the area noted after October might reflect a migration out of the usual hunting area in the Western Islands to suitable feeding habitat outside the usual range of hunting activity. The recovery and regeneration of *Halophila* and *Halodule* (Preen and Marsh 1995; Preen *et al.* 1995) in the Orman Reef area may occur rapidly enough to sustain large numbers of dugongs in the subsequent year. Experimental evidence suggests that the recovery of *H. ovalis* and *H. uninervis* can occur within a couple of months to up to a year (Aragones and Marsh 2000).

The above discussion suggests that the interannual variability long noted by hunters in the Torres Strait dugong catch estimates (Table 1) reflect historical patterns of dugong distribution and abundance rather than overharvest. It is interesting to note that Haddon (1935) reported in 1888 that dugongs in Torres Strait had 'dwindled even to vanishing point in the islands'. Community perceptions of poor hunting success in Boigu Island in the late 1980s (Raven 1990; Johannes and MacFarlane 1991) were attributed partly to disregard for prior cultural practices aimed at ensuring success. This period is coincident with a period of overharvesting which resulted in the collapse of the artisanal dugong fishery in Daru (Hudson 1986) in the mid-1980s. Perceptions of Boigu Islanders were that although populations of dugongs are known to vary (noting the impacts of extreme events such as floods), dugongs always return (Raven 1990). The high catch rates reported in Table 1 indicate that dugongs were again abundant near Boigu in the 1990s. Reports of animals vanishing for long periods of time but known to return, is a view shared by the Inuit for many marine mammals upon which they depend for subsistence (see Johannes 2000).

Dugongs may move in response to extreme weather events that affect the availability of seagrass. Seagrass dynamics are prone to extreme fluctuations, resulting in losses over a variety of temporal and spatial scales, as a result of both anthropogenic effects and natural events (Johannes and MacFarlane 1991; Poiner and Peterken 1995). Anthrogogenic impacts include those of enriched nutrient inputs, smothering from increased sediment loads, resuspension and pulsed turbidity (see Marsh *et al.* 2001). Stochastic natural events such as floods and cyclones are also known to cause substantial losses of seagrass habitats (Poiner and Peterken 1995; Preen *et al.* 1995; see Marsh *et al.* 2001).

Some key seagrass habitats important to dugongs have been impacted. Seagrass areas in Torres Strait undergo 'diebacks', large-scale episodic loss and changes in distribution on temporal scales of up to decades (Williams 1994). Torres Strait Islanders widely reported such a massive dieback event in the mid-1970s and in the early 1980s (Johannes and MacFarlane 1991; Williams 1994). The cause of this dieback has not been confirmed although Islanders blamed the "Oceanic Grandeur" oil spill and the use of dispersants. However this has been disputed by some scientists (see Johannes and MacFarlane 1991).

Coincident with the anecdotal reports from Islanders of an extensive seagrass dieback in the 1970s (see Johannes and MacFarlane 1991), Nietschmann (1984) noted that seagrasses were overgrazed in the Mabuiag Island area in 1976-77. Nietschmann and Nietschmann (1981) further noted that Islanders observed that *wati dangal* (lean dugongs with poor-tasting meat) were quite common in Torres Strait during this period. *Wati dangal* were reported to consume higher proportions of algae compared to *malu dangal* (fat dugongs with good tasting meat) who mostly ate seagrasses (Nietschmann and Nietschmann 1981).

Seagrass dieback also occurred in 1989-93 when some 1,400 km^2 of seagrass was lost in north-western Torres Strait. Scientists attributed this dieback to an unusually large but short-lived runoff event from the Mai Kussa river on the PNG coastline north of Boigu Island (Figure 1). The dieback may have been caused by a complex interaction of hydrological and sedimentary factors associated with the runoff event (Poiner and Peterken 1995). Recent modelling of dispersal pathways of sediments from the Fly River shows an increase in sediment load directed towards and through Torres Strait on a seasonal basis. Periods of increased rainfall in the PNG highlands cause increased sediment loads in the Fly River during the south easterly season in Torres Strait (May to October) (Hemer *et al.* 2001). This suggests considerable potential for the runoff from coastal rivers on the south coast of PNG to impact seagrass habitats in Torres Strait (see Figure 1).

The combination of information from hunters and scientific research has allowed considerable progress in our understanding of the factors that affect the spatial and temporal distribution of dugongs in Torres Strait. Knowledge of these factors provided important information to ensure the sustainability of the traditional dugong fishery in Torres Strait.

The commitment: a sustainable dugong fishery in Torres Strait

Recent declines in dugong populations reported in urban coastal areas of eastern Australia (Marsh *et al.* 1999; Marsh 2000) have highlighted the threatened status of this species, even in Australia. The ensuing controversy has caused governments, conservationists, the general public (Marsh *et al.* 1996; 1999) and Indigenous Australian peoples themselves to focus on the sustainability of dugong hunting by Aboriginal and Torres Strait Islander people. The socio-economic and cultural significance of dugongs to Torres Strait Islanders and the global ecological significance of this population, make it imperative that the dugong fishery in this region is sustainable. Furthermore, Torres Strait Islanders are demanding greater political and economic autonomy (Kwan *et al.* 2001). Thus, the development of effective co-management strategies should be a major priority for government management agencies.

Indigenous people, including those in Australia, are actively working with scientists to promote understanding and synergies between their respective knowledge systems. Indigenous and non-Indigenous Australians are becoming engaged in 'two way learning' about how to manage their country in contemporary contexts (Davies *et al.*1999; Baker *et al.* 2001). Research for this study was conducted as a process of active participation and negotiation with community members, especially the hunters. This approach allowed a rare opportunity to establish a relationship of based on mutual trust, cooperation and commitment between the communities and myself as a scientist (Figure 2). Such relationships have considerable potential to enhance the development of effective community-based management of dugongs in Torres Strait as they increase the likelihood of the Islanders trusting the scientist's empirical data.

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QUESTIONS

Melita Samoilys: Have you any idea of what may be driving the periodic loss of seagrass? Have the islanders had any suggestions?

Donna Kwan: It is probably run-off from the Fly River and other coastal rivers of Papua New Guinea. There has been a recent modeling study that has shown that there has been a 10% increase in sediment output from rivers.

Melita Samoilys: Is that likely to have been the cause of the very low populations in the 1980s?

Donna Kwan: Probably. I have a graph of the age structure of animals and there are some gaps in the age structure. The very young haven't come into the fishery yet, but there are age groups that are completely missing. There are no animals between the ages of 16 to 25 years old and this corresponds to the spawning period in the 1970s when the seagrass was low.

Nicholette Prince: Are there specific feasts that require the people to serve dugong?

Donna Kwan: If there is a feast, you have to eat dugong. However, in some areas there is such high abundance of the animals that people would eat it every day when they can go out and get it.

Ron Hamilton: The picture of the dugong carcass on the beach showed some lines along which it was probably going to be cut. I was wondering if those strips would be distributed to all the families and members of the community. We have a similar tradition with whales – when we bring in a whale, we divide it according to shares that belong to different families.

Donna Kwan: Every community has a different way of cutting dugong. The Mabuiag have longitudinal strips that are quite thick compared to others. The Badu have thinner strips, and say that the people from Mabuiag are greedy because they have such thick strips so they don't share much. There is a very strong sense of sharing of the catch.

FISHING FOR ANSWERS
THE INCORPORATION OF INDIGENOUS KNOWLEDGE IN NORTHERN AUSTRALIA: DEVELOPING CROSS CULTURAL LITERACY

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ABSTRACT
In northern Australia, traditional indigenous hunting of turtle and dugong species continues to be a vital part of cultural practice, yet daily attracts media controversy. Both turtle and dugong species have experienced documented declines in the last two decades. A community hunting planning and management initiative in Hopevale community, (now in the process of implementation) was established in 1999 to address some of these concerns and improve the sustainability of hunting practice. This initiative includes the imposition of a locally-decided quota for turtle and dugong take, and a restricted hunting season. This paper argues that the successful implementation of such initiatives necessitates the incorporation of entire cultural perspectives in a two way management process, and the development of multicultural literacy and tool boxes to facilitate effective co- and collaborative natural resource management regimes. Reconciliation of these dynamics is discussed in terms of the ways that local cultural institutions inhibit and/or enhance opportunities for sustainable management and harvest. The stronger the community input and implementation of local knowledge in such contexts, the more effective species management will be.

INTRODUCTION

> *"While working with indigenous hunters in the Aboriginal community of Hopevale in Queensland Australia, debate occurred over the inclusion of a 'protection of cruelty' section in the hunting management plan we were working on. Hopevale hunters argued that this section must include a clause stating that turtles once caught must be butchered while alive and on the beach. Despite having worked with indigenous people for a while, and thinking myself 'culturally in tune' I was upset by this idea. However it was pointed out to me that within indigenous culture, to kill a turtle and then butcher it was to deprive it of an essential right – that to life. It is only through live butchering that the turtle's spirit, through its blood can be returned to the ancestors and the sea."*

This quote reflects an essential difference in perspective between 'western' and indigenous groups when coming together in collaborative management programs, and exemplifies the need for both parties to acknowledge such difference in order to achieve real conservation and cultural protection gains. Reconciling and managing the impact of human use of a species achieves the dual goals of species conservation and indigenous and cultural rights to that species and is an essential management dilemma worldwide.

This paper explores some of the facets of this issue in an evaluation of an Australian indigenous planning exercise designed to manage both human impact on the two threatened species of the Green turtle and the dugong in Australia, while maintaining cultural hunting practices. I argue that the incorporation of indigenous knowledge within management entails the inclusion not only of the culturally charismatic aspects of culture but those that are culturally uncomfortable. The paper is divided into three sections: (i) a brief Australian context (ii) a discussion of the case study and, (iii) an analysis of lessons learned and their implications for future management.

"A Thumbnail Sketch…."
The last decade has been a dynamic one for Australia. Australians have been both challenged and confronted by the politics of self determination and emancipation, on the heels of the legacy left by colonial racial oppression that is deeply embedded in the psyche of indigenous Australia.

The declaration of 'Terra nullius' or 'land of no people' by Captain Cook, in 1788, gave a mandate for 'white' Australians, to ignore indigenous rights. Disease, economic oppression, assimilation, massacres; the establishment of missions and accompanying suppression of cultural practice, the removal of children from their families are all hallmarks of the Australian aboriginal experience (Pearson, N: 2000, Folds, R:1993). The High Court "Mabo" decision of 1992 overturned the concept of Terra Nullius and heralded a new era of 'reconciliation' and recognition for indigenous Australians. The response has included the enactment of new and amendments to existing legislation such as the

Native Title Act (Cwlth 1993), and the establishment of Inquiries and commissions such as the 'Deaths in Custody Inquiry' and the 'Reconciliation Commission' (Nettheim, G. 2001). The "Sorry" movement, which has induced Australians everywhere to apologise to indigenous peoples for the removal of their children or the 'stolen generation', and recent films such as *Radiance*, *Rabbit-proof Fence* and *One Night the Moon* illustrate the extent to which public awareness and appreciation of indigenous issues has changed.

In the field of resource management these changes have been expressed in growing Aboriginal involvement in and control over land and sea country, national parks, and ranger training programs (*Draft Resolutions* 2001). Indigenous protected areas and indigenous land use agreements are being piloted and implemented across the country (Langton *et al*. 2000). The successful determination and return of lands to Aboriginal owners under State and Federal land and Native Title legislation mean that co-management has become more than a catch phrase. It is now a serious management option.

In the Great Barrier Reef World Heritage region in North Queensland, co-management options are crucial management alternatives. Six of the seven species of turtle in the world are found along the reef (Zann and Sutton 1995; Limpus 1995). The region also boasts one of the world's most important dugong populations. (Marsh 1999). Moreover as the largest marine protected area in the world, (345,000 square kilometers), the Great Barrier Reef Marine Park Authority - GBRMPA, (the Commonwealth government statutory management agency for the reef), has the responsibility of managing the area responsibly and in perpetuity. It is also responsible for juggling the different demands of its multiple users (GBRMPA 1994). For the seventeen indigenous communities residing adjacent to the reef, and which use the Great Barrier Reef World Heritage Area, dugongs and turtle are the most highly valued traditional foods (Thompson 1934; Smyth 1997; Benzaken *et al*. 1997). Moreover, hunting is a very real expression of cultural practice.

However, in this World Heritage area, which is cloaked with environmental glamour, indigenous hunting is often perceived as disturbing the vision of 'a wild aquamarine paradise' touted by the tourist brochures. To green and animal rights activists, hunting endangered animals is not part of the environmental equation.

In this context, the development of co-operative management arrangements for turtle and dugong hunting is recognised as a significant first step towards indigenous people managing their own land and sea country, as well as contributing towards effective strategies for species management (Benzaken *et al*; 1997). Accordingly, the GBRMPA has instituted a number of co-management initiatives along the coast relating to indigenous peoples hunting practice within the GBRWHA (GBRMPA 2001). One of these, the indigenous hunting management and planning exercise at Hopevale community, is used as a case study in this paper.

CASE STUDY

Guugu Yimmithirr Bama ii: Turtle and Dugong Hunting Management Plan, Hopevale Aboriginal Community, North Queensland.

Hopevale is a community allocated north west of Cooktown. It has a local population of approximately 1,200 (HVAC 2002). Within the community there are thirty seven clan groups and the language is *Guugu Yimmithirr* (Smith 1987). Originally established as a Lutheran Mission, it is now a dynamic community, run by a local council of seven members, and funded through a variety of programs and initiatives. As for most indigenous people living along the tropical Australian coast, hunting turtle and dugong is an important part of their cultural, social, and economic life (Haviland and Haviland 1980; Smith 1997; Chase and Sutton 1987). The allocation in 1998 by GBRMPA of a grant to develop a hunting management plan was the culmination of a three-year community driven consultation coordinated through the Hopevale Land and Resource Management office (P Gibson, pers comm 2001). Priscilla Gibson was the Indigenous Ranger coordinator from Hopevale who initiated and managed the development of the Hunting Plan process and publication. This consultation identified the hunters' main areas of concern and formed the basis of the final planning document.

This case study review discusses three important dimensions of the planning exercise.

Dimensions of the planning exercise

1. Community Involvement

Community involvement in the plan was secured through several mechanisms aimed at:

a) Incorporating local knowledge about hunting practice and species; and
b) Maximising community ownership.

Children were brought into the process through an art competition that required them to draw images of hunting, which were then included as a backdrop to the final documents produced. Prizes for the winner of each grade were given at a special assembly. Children were also involved in the launching of the plan, singing hunting songs and a community barbecue afterwards. A display of all artwork and images as part of a community anniversary celebration built up community awareness about hunting.

Elders were continually consulted. They gave crucial input to the plan itself, blessed meetings, gave talks to government agencies and helped facilitate and launch community meetings.

Finally, a series of meetings was convened with various interest groups including hunters, women, and land title and management agencies – and the Hopevale Council, all of whom had a say and input into the various stages of the plan. The entire process aimed to *involve* rather than *consult* the community members. As such, it helped facilitate not only their interest and ownership, but charged the process with an integrity that reflected back to the managing agencies the seriousness of community commitment to this enterprise.

2. Protocols

The cultural sensitivities of the hunting process and associated Native Title issues were considered to ensure that several protocol documents and processes were developed. This included a document briefing their consultant on a plan of action, and written endorsements from key community individuals and agencies of the plan and its contents at all stages of its development. Following a series of meetings, a Turtle and Dugong Hunting Management Council was established. Constituent members included representatives from across the community. This Council is the body that now implements the plan, decides on issues of conflict regarding breaches of it, and acts as the point of contact between management agencies and the community on hunting issues.

3. 'Reverse' consultation

Finally, a reverse consultation process was used. In contrast to the convention where management agencies employ a consultant to write a plan and *then* consult the community, Hopevale employed a consultant to do this, and *then* consulted the agencies. A meeting was held where invitees from various departments and interest groups, (including conservation groups) came together and gave their input into the plan. This included discussion of aspects of the plan that made agencies and scientists uncomfortable, but that they needed to engage with if they were serious in committing to a co-management or community based wildlife management program.

In engaging both indigenous and agency representatives, this process revealed interesting differences between perspectives. For example, management agency staff supported the process of consultation, but at times expressed discomfort with the extent to which the process was being run independently of their own operations. The ways in which indigenous people conduct and have meetings, and achieve outcomes is very different from conventional bureaucratic approaches. In some cases the differences between clan groups and Native Title Land Councils caused friction, as even amongst the indigenous peoples involved there was a spectrum of opinion and difference that needed careful navigation.

Content

In determining the contents of the plan, several 'bottom line' principles were mutually agreed upon early on in the process. Crucially this included a decision to work within existing legislation; an interesting choice given a recent Australian High Court determination – the 'Yanner' decision had provided precedent for indigenous peoples to choose to manage their hunting through the exercise of native title rights. Secondly, the community decided to continue with the quota and allocation approach previously established. It was also decided to have both maintenance of hunting practice *and* protection of the species as a joint and primary aim, embodied ultimately in the plan's vision statement. Finally, the community was very clear that the plan should in no way impinge on, or negatively affect, future Native Title rights or opportunities.

Overall, the final contents of the plan (see Box 1) attempted to maintain a balance between upholding cultural practice and adherence to the legislative requirements.

Much heated discussion over content occurred between all parties, resulting in a process of reconciliation of differences over key areas. Issues included questions such as whether there should be a quota or not? Can hunting occur anyway? Does the government have the right to decide on issues that will impact cultural rights? Should there be a Prevention of Cruelty clause?

To what extent should tradition take heed of 'science' regarding the target species? Some of the traditional hunting areas overlapped with 'no take' zones in the park, leading to much discussion over who should give way on this issue.

Given the intricate web of relationships between various members of the community and the managing agencies, the exertion of control over, and punishment of illegal hunting was one of the greatest points of disagreement. Such discussion frequently illustrated the difference between cultural perspectives on management. The issues of enforcement and penalties were especially difficult to solve (see Purnomo this vol). These still remain the most difficult points of reconciliation between indigenous peoples and agencies involved in the issue of hunting, exacerbated by the dialectic between animal rights and cultural rights that underlie any discussion or action in this arena.

Debate over the content also reflected the extent to which agency staff were more comfortable with the culturally 'charismatic' aspects of hunting rather than those that are less 'palatable'. For example, agency staff and scientists could not understand why the plan did not include 'stories', and 'ethno-biological' knowledge about turtle and dugong, as this is what represented (to them*) appropriate* inclusion of the cultural aspects. These discussions also revealed that the agency perspective did not always recognise that in determining to stay *within* the existing legislative frameworks, the community was from the very beginning accepting a situation that they found culturally 'unpalatable'. In their view, the decision to stay within the legislative and therefore cultural mores of a society widely viewed as having suppressed indigenous people for centuries, was a 'big call'.

It has been at the stage of implementation that the differences in perspective between agency and indigenous approaches have produced most strain. It is at this point that the 'warm and fuzzy' stage of the planning process abruptly terminates and the real negotiation of issues occurs. This is a process complicated further by community politics, the political and economic imperatives of government and the reality that each party approaches implementation completely differently.

For example, the political situation has reflected that the rhetoric of support for indigenous hunting rights is not matched by reality. Events such as the Australian position on Indigenous whaling in the year 2000 International Whaling Commission meeting in Australia, and subsequent Federal government support for a whale sanctuary; have revealed a contradiction between support for local community based initiatives, and the political imperative to satisfy public reproach and indignation regarding hunting generally.

The turtle hunting ban imposed by the Federal Minister during 2001 and ongoing negotiations over dugong sanctuaries along the Great Barrier Reef, has underlined the irony of this situation. In this context, it is difficult for management agencies to successfully pursue co-management initiatives without exciting indigenous cynicism. This is particularly challenging when operating within a native title landscape.

Overall, this has had major implications for the implementation of hunting management plans such as that at Hopevale, mainly evinced through delays in the issuing of permits, and insufficient resourcing of the implementation process. In turn, community confusion over government processes and internal politics between clan groups regarding hunting responsibilities has further complicated this situation. It is clear that putting co-management or community wildlife management into practice is much harder than supporting its conceptual articulation. The ongoing evolution of the implementation of this and other such initiatives will be a test of the commitment of both parties to working together within these different cultural approaches, to broker efficient outcomes within the context of these different perspectives – and competing political imperatives each sustain.

Box 1.
Guugu Yimmithirr Bama Wii: Turtle and Dugong Hunting Management Plan

Vision: To develop and implement controlled and sustainable hunting practices that will minimise the impact on and may contribute to the protection and survival of Dugong (Girrbithi) and Turtle (Ngawiya) species for the enjoyment and use of future generations

Aims

1. To develop controlled indigenous hunting regimes for Dugong and Turtle through careful planning monitoring and management
2. To protect dugong and turtle habitat by managing the activities carried out on the land and sea by both traditional owners and visitors according to the desires of the traditional owners
3. To maintain the activity, knowledge and skill of traditional hunting for turtle and dugong, ensuring that this important cultural activity is continued through future generations
4. To assist the community to develop and reinstate customary laws to manage traditional hunting in conjunction with state and Commonwealth legislation
5. To revitalise respect for the law and sea management aspiration of individual clan grope, and identify ways in which these groups can work together to ensure the survival and prosperity of dugong and turtles

Other sections include:-

- Zoning restrictions
- Community Hunting license and conditions
- Compliance and communication
- Permit penalties
- Management group roles and responsibilities
- Cultural and natural resource management office
- Boating license and registration
- Safety equipment
- Details of catch
- Prevention of cruelty
- Seasonal hunting,
- Weddings, birthday parties and funerals
- Transportation of meat to other communities
- Turtle eggs
- Pregnant dugong and calves
- Barter and exchange
- Community education strategy
- Recommendations
- Summarised from; Hopevale Aboriginal Council and Nursey-Bray, M (1999) *A Guugu Yimmithirr Bama Wii; Girrbithi and Ngawiya, Turtle and Dugong Hunting Management Plan,* Hopevale Council

Implementation

The plan was finally launched in November 1999, and subsequently attracted national attention when it was nominated for and won the *Prime Ministers Environmental Award for Community Leadership and Environmental Sustainability, 2000.*

The Pew Foundation, the Australian Research Council, James Cook University, the GBRMPA and Hopevale Community Council have funded the subsequent implementation of this plan over its first and second seasons, with its third currently underway.

Plan implementation has included (i) the allocation of permits by the community, (ii) the establishment of ranger patrols and camps to monitor hunting progress, (iii) a reporting process for take that goes back to the agencies (and which includes information about the species caught - sex, age, number, gender place caught, when etc), and (iv) the imposition of a restricted hunting season. The Turtle and Dugong Hunting Management Council is scheduled to meet during each hunting period and to liaise between agency staff and the community on hunting matters, including breaches of the plan, and to reach decision on penalties.

Discussion – Developing cross cultural literacy

Indigenous peoples in Australia are very diverse and it would be inappropriate to deduce that the process of planning management that worked in Hopevale would automatically work elsewhere. Nonetheless there are a number of lessons that can be drawn from this case study that bear consideration for future initiatives.

Reconciling human need and cultural affiliation, with the biological and ecological needs of the target species is a key challenge. In this context, the concepts of ‘rights’, ‘access’ and ‘equity’, compete strongly with the discourse about the values of ‘wilderness’, ‘pristineness’ and ‘animal rights’.

The importance of local knowledge and involvement in management programs is well illustrated. The need to build mutual trust between management agencies and local peoples - and between groups within the local communities - is vital (Merculieff 1994). In order to broker real collaborations and co-management; mutual trust, cross cultural respect and commitment to the project at hand must exist. This means developing programs that are characterised by a real and respectful engagement with each other.

The need to develop flexible mechanisms that take into account differences in cultural perspective is crucial. This includes the engagement with and incorporation of the *entire cultural perspective*. In this case study, this may mean incorporating the culturally uncomfortable aspects of that engagement. For example (a) management agencies must come to accept and understand culturally uncomfortable practices such as turtle butchering, as quoted earlier, and (b) indigenous peoples, in turn, must recognise that some of the species they hunt *are* threatened and take appropriate action.

To facilitate the incorporation of local knowledge we need to develop multicultural literacy or a 'multi cultural toolbox' (Jacobs and Mulvihill 1995). Through the development of multi-culturally literate resource management systems we avoid the trap of reducing traditional value systems and perspectives into fragmented 'facts' of utilitarian value for 'appropriation' and exploitation as seen fit. Howitt (2001) notes that this approach will need to include an acknowledgment and practice of three aspects: (i) ways of seeing (ii) ways of thinking and (iii) ways of knowing.

It will also need to include a shift in our understanding of what 'local' and 'cultural' knowledge *is*. It entails restructuring and re-negotiation of the different layers engrained within 'knowledge' such as sacred/secret knowledge, male/female knowledge, traditional ecological knowledge, song, stories, experience, laws (tribal or otherwise), cultural mores and social traditions, ideological orientation (Johannes 1989).

In Australia 'knowledge' also comprises the historical appreciation of the history of racial division it has experienced and understandings that the current social and economic conditions prevailing in indigenous communities significantly influence environmental management regimes, and their ultimate success or failure. Drawing a curtain over the past does not make it disappear, and serious engagement by management needs to accept the history and politics from which these initiatives have burgeoned.

The case study used in this paper is a reflection of the important first steps that indigenous communities and management agencies in Australia are taking towards the facilitation of multi-culturally literate resource management in ways that involve and acknowledge the vitality and importance of the community contribution.

In the broader context, this case study is important because it unmasks the 'apoliticising' or 'green washing' about the environment that occurs in so much of the public debate about it. Land and sea management is, and will remain, an essential and political struggle for accession by different stakeholders, a whirlpool of emotion and political connections. At its heart, this example illuminates the fundamental relationship between power and knowledge, and how management regimes must be cognisant and familiar with these relationship dynamics in order to succeed.

There are approximately 5,000 indigenous / tribal local groups in the world, comprising up to 200 million people and 4% of the global population, yet these groups represent in between 90 – 95% of the world cultural diversity (Howitt 2001). In this context, it makes sense culturally, ecologically, legally, scientifically and in terms of management to support and incorporate indigenous and local peoples aspirations for sea country.

The advantages of such incorporation are many. They include decreased impact on the species concerned accompanied by an increased involvement in management by the communities and individuals most affected. Such approaches strengthen the maintenance of cultural integrity, and increase the visibility and viability of different cultural approaches. Finally, and of greatest advantage, is that such as an approach enhances the development of diverse and culturally appropriate management regimes. The development of such regimes is not only cost effective but also ensures a more holistic general management orientation. If the bottom line is sustainability, then management should be able to ensure the maintenance of both cultural practice, while protecting the species for future generations.

As Chief Tom Happynook (2000), concludes in relation to whaling; "The issue is not about whether or not to hunt; it is about sustainable use; if the use is sustainable then protecting endangered wildlife and maintaining cultural practice are perfectly compatible".

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Personal comments from:

Chief Tom Happynook, Chairman, World Council of Whalers Conference, October 2000

Mrs Priscilla Gibson, Hopevale Community, 2001

Professor Helene Marsh, November 2001

Questions

Saudiel Ramirez-Sanchez: You mentioned the possibility of having clear-cut categories for the fishers. However, fishers cannot be categorized as commercial or subsistence. Do you think that you can have the aboriginal people come up with their own categories?

Melissa Nursey-Bray: It is not just a matter of categories; it is more a need to allow people to manage the fishery themselves. Managers have to negotiate with the aboriginal people.

The Use of Traditional Hawaiian Knowledge in the Contemporary Management of Marine Resources

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Abstract

It is traditional for Hawaiians to "consult nature" so that fishing is practiced at times and places, and with gear that causes minimum disruption of natural biological and ecological processes. The Hoʻolehua Hawaiian Homestead continues this tradition in and around Moʻomomi Bay on the northwest coast of the island of Molokaʻi. This community relies heavily on inshore marine resources for subsistence and consequently, has an intimate knowledge of these resources. The shared knowledge, beliefs, and values of the community are culturally channeled to promote proper fishing behavior. This informal system brings more knowledge, experience, and moral commitment to fishery conservation than more centralized government management.

Community-based management in the Moʻomomi area involves observational processes and problem-solving strategies for the purpose of conservation. The system is not articulated in the manner of Western science, but relies instead on mental models. These models foster a practical understanding of local inshore resource dynamics by the fishing community and, thus, lend credibility to unwritten standards for fishing conduct. The "code of conduct" is concerned with how people fish rather than how much they catch.

The Hawaiian moon calendar emphasizes natural processes that repeat at different time scales: seasonal, monthly, and daily. The calendar is crucial to community-based resource monitoring and management. By identifying peak spawning periods for important food fish in a Hawaiian calendar format, traditional closures (*kapu*) can be applied by the community so as not to disrupt spawning behavior and other natural processes.

Detailed mental models have been constructed for several important inshore food species: *aholehole* (*Kuhlia sandvicensis*, a Hawaiian endemic), *moi* (*Polydactylus sexfilis*) and *limu kohu* (the seaweed *Asparagopsis taxiformis*). Conservation principles derived from the models can be verified by the fishermen's own observations and knowledge.

Community self-management of inshore fisheries around Moʻomomi Bay incorporates elements of traditional Hawaiian caretaker (*konohiki*) practices. This approach has been successful in maintaining healthy local populations of most important food species. Other communities are interested in applying the Moʻomomi model to their own localities. Caution is advised because the practices that are successful at Moʻomomi will lose vitality if transferred outside of the specific cultural and ecological context in which they evolved and are effective. The framework from the Moʻomomi model may be derived by other communities but the specific practices need to adapted to each local situation.

Introduction

Fishery management based on Western scientific thought has displaced indigenous knowledge systems throughout the world and, for the most part, Hawaiʻi is no exception. The Western view asserts that management should be left to professionals, and that the users of resources should not also be the managers of these resources (Berkes 1999). This view is fundamentally different from traditional Hawaiian[1] marine resource use and conservation where the resource users were the managers.

Long before any association with westerners, Hawaiians depended on fishing for survival. The need to avoid food depletion motivated them to acquire a sophisticated understanding of the factors that cause limitations and fluctuations in marine resources. Based on their familiarity with specific places and through much trial and error, Hawaiian communities were able to develop ingenious social and cultural controls on fishing that fostered, in modern terminology, "sustainable use" of marine resources. It is important to recognize these practices not as merely traditional, but as adaptive responses to marine resource availability and limitations. Hawaiian traditions incorporate conscious conservation (Johannes 1997) and demand an

[1] The term "Hawaiian" is used throughout to mean the original Polynesian settlers of the Hawaiian Islands and their descendents.

awareness of nature and attention to detail not found in contemporary fishery management.

In ancient Hawai'i, fishing activities and catch distribution were strictly disciplined by rules (*kapu*). Overseers (*konohiki*) enforced the *kapu* on behalf of *ali'i* (chiefs). Community self-management of inshore fisheries in and around Mo'omomi Bay is a contemporary version of the traditional *konohiki* or caretaker system. Education, family, and social pressure have become the means to elicit proper behavior rather than the harsh punishments of ancient times.

The survival of Hawaiian civilization for close to 2,000 years prior to European contact validates the traditional system. This knowledge system is dynamic, not static, and modern influences do not make it less traditional. It is legitimate in its own right and does not have to be recast in Western idiom or verified through Western science. However, the Hawaiian system does need to be communicated more effectively in order to incorporate it into a contemporary management framework. That is the purpose of this.

TENETS OF TRADITIONAL HAWAIIAN MARINE RESOURCE USE

The most significant beliefs and values in Hawaiian culture revolve around three fundamental relationships: 1) the relationship between Hawaiian people and their local environment; 2) the relationship among humans; and 3) the relationship between people and their ancestry. The importance of the first two relationships stems from Hawaiians' dependence on one another and on the environment for survival. The third relationship demonstrates the belief that those who came before knew the correct and proper way.

The traditional practices of native Hawaiians are guided by cultural protocol. Protocol combines knowledge, practice, and belief, fundamental characteristics that evolve over time within a specific cultural and ecological context of most traditional systems (Berkes 1999). Protocol disciplines and brings responsibilities to fishing, as well as to other cultural activities. The most important of the responsibilities are:

Concern about the well being of future generations.

This is the ability to meet present food needs without compromising the ability of future generations to meet their needs. Irresponsible resource use is tantamount to denying future generations their means to survival.

Self-restraint.

Take only what one needs for immediate personal and family use, and use what one takes carefully and fully without wasting. A good Hawaiian fisherman is not the one with the largest catch but the one who can get what he or she needs without disrupting natural processes.

Reverence for ancestors and sacred places where ancestors rest.

Hawaiians inherited valuable knowledge from their ancestors. At one time, this knowledge was critical for physical survival. The "ancestry of experience" (Holmes 1996) stored in the memories of living Hawaiians is still transmitted largely through non-written processes. It is taught to succeeding generations by telling stories, creating relationships, and establishing personal meaning. Ancestors are worshipped because of the dependence on knowledge and skills passed from generation to generation.

Lokahi ("harmony").

Time spent in fishing cultivates intimacy and harmony with the ocean, reinforcing strong ties to specific places and close relationships with marine creatures that are a part of Hawaiian identity and spirituality. In ancient times, fishermen made offerings of fish and said prayer chants (*mele pule*) at a special class of temple known as *heiau ko'a*, dedicated to gods of fishing (Kamakau 1976).

Malama ("take care of living things).

The Hawaiian perspective is holistic, emphasizing relationships and affiliations with other living things. Nurturing and respect, important for good human relationships, are also beneficial in relationships with marine life.

Laulima ("many hands").

Sharing and cooperation maintains family unity and community interdependence. The intensity of subsistence fishing activities is determined by kinship obligations, generalized reciprocity, and communal exchange of productive labor and foods among family, friends and neighbors.

Ha'aha'a ("humility").

Hawaiians are a part of the living world, not superior to it. Excluding people from nature only serves to further alienate humans from other living resources and thus from their responsibilities.

'Imi 'Ike ("to seek knowledge").
The young fisherman was trained to watch for changes (major and subtle) in the condition of marine resources. Before becoming acknowledged as an expert, the apprentice had to understand the life cycle, diet, feeding habits, preferred habitat, and growing conditions of many marine food species.

Handy *et al.* (1972), Pukui *et al.* (1972) and Kanahele (1986) provide more detail about traditional values that guide Hawaiian behavior. The issue for Hawaiian civilization is no longer physical, but cultural survival. "The culture lives on through its practitioners" (Edith Kanaka'ole Foundation, 1995) and their activities have a strong sense of "place". The following case study reinforces the importance of having places where Hawaiian traditions can continue.

CASE STUDY

The northwest coast of the island of Moloka'i (Figure 1) is one of the few places remaining in the Hawaiian Islands where the traditional Hawaiian system still provides a framework for fishery resource use and conservation. Inshore fisheries around the main Hawaiian Islands have declined significantly during the past century (Shomura, 1987; Friedlander and DeMartini, in press). The relative isolation of the coastal area in and around Mo'omomi Bay and community consensus about appropriate behavior have protected local marine resources from overfishing.

Marine resources along a 12-mile length of wave-exposed coast on both sides of Mo'omomi Bay are mainly harvested by a community of native Hawaiians who reside in nearby Ho'olehua Hawaiian Homestead. Residents are far more dependent on subsistence farming and fishing (one-third of the food consumed by the 1,000 residents of this community) (Hui Malama o Mo'omomi, 1995; Pacific American Foundation and Hui Malama o Mo`omomi. 2001), than in most other communities in the state. Opened in 1924, Ho'olehua was the second homestead established after the US Congress passed the Hawaiian Homes Commission Act in 1921 with the intent of returning Hawaiians to the land. The first Ho'olehua homesteaders were selected for their self-sufficiency (Hui Malama o Mo'omomi, 1995) and succeeding generations have endured, despite the harsh land and ocean environment. The coastal area is rich in artifacts and human burial remains dating mostly from prehistoric Hawaiian communities and activities back to the 11th century (Summers, 1971).

The continuation of traditional Hawaiian practices in and around Mo'omomi Bay helps to maintain social and cultural identity and provides reinforcement of values shared by the Ho'olehua community. The repetition of subsistence fishing activities is one of the ways that knowledge, values, and identity are transferred to succeeding generations Cultural survival is thus entwined with resource conservation. The basic elements of fishery management are in place in the Mo'omomi area: a conservation ethic, community support, management knowledge, and a system of monitoring.

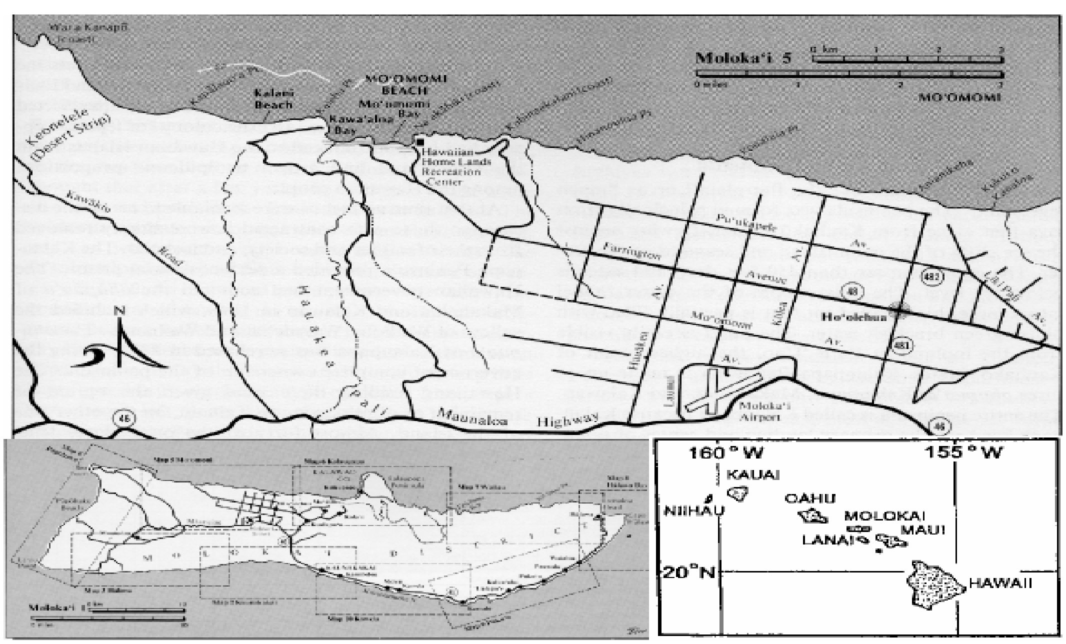

Figure 1. Mo'omomi and Kawa'aloa Bays located on the north shore of Moloka'i (adapted from Clark, 1989).

Conservation ethic

Fishing in and around Moʻomomi Bay continues to revolve around the subsistence use of local marine resources. Harvest practices are adapted to local environmental and ecological conditions. The community has no formal fishery management policies or institutions. Proper conduct of fishing is not controlled through formal rule making, as in Western regulations, but is inferred through internal cultural norms and values that guide and instruct the behavior of the community.

The wisdom and insights of leaders who hold and transmit traditional knowledge are crucial in lending credibility to the traditional system. The "code of conduct" focuses on how fishing should be practiced to maintain regular biological renewal processes, rather than on how much fish should be harvested.

Community support

The communal identity of Hoʻolehua Hawaiian Homestead is defined by a shared cultural heritage and is maintained by a system of interdependence and social reciprocity that is expressed in many ways, including the sharing of seafood gathered through subsistence. This system enables the homesteaders to live well and with confidence in a sometimes difficult environment.

Hui Malama o Moʻomomi was formed in 1993 to revitalize the traditional marine resource conservation system of the area by appealing to Hawaiian cultural beliefs, values, and conservation ethics. The Hui encourages responsible fishing based on individual conscience, social and family pressure, and the training of youths to become "good marine citizens." Networks of social ties and cooperation generated by subsistence activities create a collective interest in resource conservation and foster consensus about the proper conduct of fishing.

Management knowledge

Subsistence is the foundation of traditional Hawaiian knowledge. The homesteaders accumulate information that is essential for adaptation and survival in real life situations. This knowledge is not merely practical perception and "know how" but patterns of thought, understanding, and models of ecosystem workings.

The worldview and resource management perspective of Hawaiians is holistic. Humans are a part of the ecosystem. Land areas and adjacent marine waters are managed as interconnected and inseparable units known as *ahupuaʻa*. *Ahupuaʻa* were subdivisions of larger districts (*moku*). They typically extended from the mountain to the sea, providing the Hawaiian occupants with access to various natural resources for their subsistence (Costa-Pierce, 1987; Meller, 1985).

Despite substantial deterioration of Hawaiian ancestral marine resource knowledge in general, it remains dynamic, capable of being verified, regenerated, and even expanded for specific locations by new generations of Hawaiians. Hawaiian knowledge is a form of adaptive management. It takes a dynamic view of ecosystems, emphasizes processes that are part of resource renewal, acknowledges uncertainty and unpredictability, and stresses the importance of ecosystem resilience. The system continues to evolve through social learning; i.e., oral transmission, imitation, and demonstration.

Resource monitoring

The good Hawaiian fisherman is always watching the ocean, monitoring it for cues that signal what can be fished, where and when, in a manner compatible with local resource "rhythms" and to adapt fishing to changing environmental conditions. Key indicators include tidal cycles, waves and currents, day length, ocean temperature, habitat stability, sand movement, rainfall, wind velocity, and direction.

Many fish species aggregate to reefs for shelter, orientation of social behavior, and for food. Habitat complexity is one of the principal factors affecting spatial distribution of inshore fish abundance. Shallow-water habitats with low bottom relief and limited shelter are often associated with low standing stocks of fishes, whereas highly complex habitats harbor high fish biomass (Friedlander and Parrish, 1998). Native Hawaiians recognized the importance of *koa* (fish houses), special areas where fish were known to aggregate. *Koa* are focal points of fishing and resource conservation. The specific locations of *koa* are carefully guarded secrets of the Hawaiian families who held this knowledge. Western-trained scientists and resource managers acknowledge the existence of *koa* (Grigg, 1994; Friedlander and Parrish, 1998) but the concept remains poorly documented in fisheries science as well as contemporary management of Hawaiʻi's inshore fisheries.

Many natural processes that affect fish distribution are monitored by the community, the most important of which is moon phase. The moon was as essential in scheduling the activities of the ancient Hawaiians as clocks are to modern man. The moon calendar is a predictive tool based on awareness of natural cycles and their relationship to fishing and farming success. Its wisdom reflects lifetimes of observations and experiences by many generations of Hawaiians in their quest for survival (Edith Kanakaʻole Foundation, 1995). Present-day residents of Hawaii still refer to the moon calendar to plan fishing and planting activities and a popular form of the calendar is published annually by the Prince Kuhio Civic Club. Most contemporary users, however, extract only superficial information.

The moon calendar emphasizes natural processes that repeat at different time scales: seasonal, monthly, and daily. Distinctions are made between two general seasons (*kaʻu* or dry; *hoʻoilo* or wet) and three general phases of the moon: *hoʻonui* (nights of enlarging moon); *poepoe* (nights of full moon); and *emi* (nights of diminishing moon). In addition to illustrating seasons and moon phases, Figure 2 also gives the Hawaiian names for the 12 months of the year. Specific names were also given to each night of the Hawaiian lunar cycle (Figure 3)

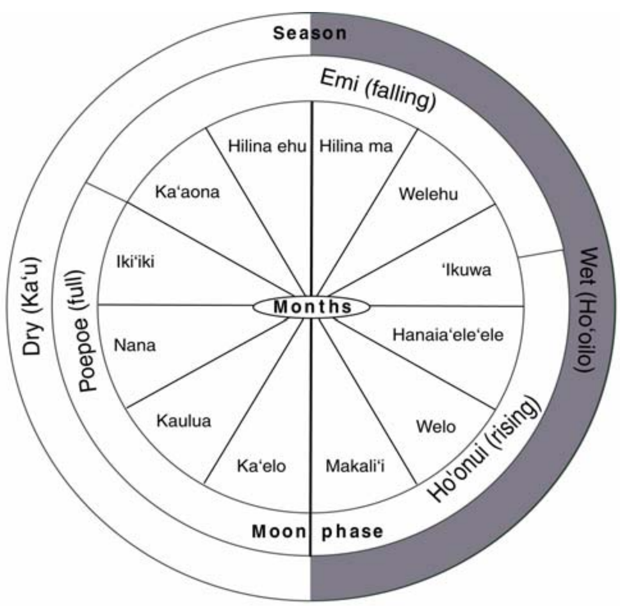

Figure 2. Hawaiian moon calendar showing months, seasons, and moon phases that are used to guide fishing activities. Names used for months in this calendar are specific to Molokaʻi.

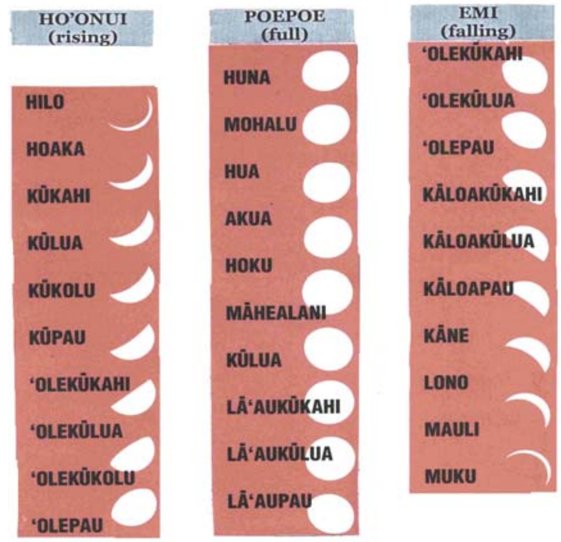

Figure 3. Hawaiian names for each night of the rising, full, and falling moon phases (adapted from Prince Kuhio Civic Club 2001).

Fish Spawning Calendar

By observing spawning behavior and sampling fish gonads, community monitors have constructed a calendar identifying the spawning periods of major food fish species. The Moʻomomi fish spawning calendar for the year 2000 is shown in Table 1. Peak spawning for *ulua*, *moi*, *uhu* and *aʻawa* occurred during the summer months. Late winter-early spring spawning was observed for *aholehole* and *kumu*. Surgeonfishes typically spawned in late winter, as well as in early spring. By identifying peak spawning periods for important resource species, traditional closures or *kapu* can be applied so as not to disturb the natural rhythms of these species.

Due to their local importance as food items, *aholehole* (Hawaiian flagtail, *Kuhlia sandvicensis*), *moi* (Pacific threadfin, *Polydactylus sexfilis*) and the red seaweed *limu kohu* (*Asparagopsis taxiformis*) were examined more closely and models of resource dynamics were constructed.

Applications of Hawaiian Mental Models

The traditional Hawaiian resource use system involved measuring and evaluating natural processes to produce representations of the workings of ecosystems, similar to Western science. Thus, theoretical constructs of Hawaiian scientific thought are mental models that recognize different states or "frames" capturing the essential aspects of dynamics that may apply to the same ecosystem at different times

(Starfield et al., 1993). However, Hawaiian knowledge relies on memory and does not incorporate the rigorous quantitative estimates or writings of Western science. There was no written Hawaiian language prior to the 19th century (Kuykendall, 1938), so traditional knowledge was orally transmitted from generation to generation through chants, stories, and demonstration.

Aholehole

The Hawaiian flagtail (*Kuhlia sandvicensis*) locally called *aholehole* is endemic to the Hawaiian Islands. Young occur in shallow water along the shoreline and may be found in tide pools, streams, and estuaries. They feed mainly on planktonic crustaceans but also on polychaete worms, insects, and algae. Length at maturity is about 18 cm, while spawning occurs year-round, though mainly during winter and spring months. The *aholehole* was used in sacrifices in ancient Hawaiʻi to keep away evil spirits when a white fish or pig was needed (Titcomb, 1972)

At Moʻomomi Bay, *aholehole* spawn during the wet season, typically in late winter-early spring. Much of the distribution of *aholehole* is based on the movement of sand in and out of nearshore habitats (Table 2). During the winter months, sand is transported offshore, providing ample space inside reef holes (*puka*) along the shore for *aholehole* to school. This change in habitat between seasons coincides with, and may be a cue to, the onset of spawning. During the summer months, sand is transported inshore resulting in reef *puka* being filled in and causing *aholehole* to move offshore. The conservation principles developed by Hawaiians to harvest *aholehole* included discouraging catch of sub-reproductive individuals and discouraging harvest during times of peak spawning.

Table 1. Moʻomomi Bay fish spawning calendar for the year 2000 for key resource species. Black boxes indicate months of peak spawning. Grey boxes indicate other months when spawning was observed (Friedlander et al. in press).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ulua (Caranx ignobilis)						Black	Black	Black				
aholehole (Kuhlia sandvicensis)		Black	Black	Black								
moi (Polydactylus sexfilis)					Grey	Black	Black	Black				
ʻuʻu(Myripristis species)							Grey	Grey	Black	Black		
kumu (Parupeneus porphyreus)	Grey	Black	Black	Grey								
aweoweo (Priacanthus species)								Grey	Black	Black		
taʻape (Lutjanus kasmira)						Black	Black	Black				
aʻawa (Bodianus bilunulatus)					Black	Black	Black	Black				
enenue (Kyphosus species)	Black	Black	Grey	Grey	Grey							
uhu (Scarus species)					Black	Black	Black					
uhu palukaluka (Scarus rubroviolaceus)					Black	Black	Black					
ponuhunuhu (Calotomus carolinus)					Black	Black	Black					
pualu (Acanthurus xanthopterus)		Grey	Black	Black								
palani (Acanthurus dussumieri)		Grey	Black	Black								
kala (Naso unicornis)		Grey	Black	Black								
kole (Ctenochaetus strigosus)		Grey	Black	Black								
manini (Acanthurus triostegus)		Grey	Black	Black								

Table 2. Season movement patterns of *aholehole* (*Kuhlia sandvicensis*) in relation to changes in habitat.

Season	**Sand movement**	**Reef holes (*puka*)**	***Aholehole* distribution**
Winter	Offshore	Exposed	Inshore
Summer	Inshore	Filled	Offshore

Moi

The Pacific threadfin (*Polydactylus sexfilis*) or *moi* is a very popular and much sought-after sport and food fish in Hawaii that also supports a small subsistence fishery (Friedlander and Ziemann, in press). In ancient Hawaiian culture, *moi* were reserved for the ruling chiefs and prohibited for consumption by commoners (Titcomb, 1972). Hawaiians developed a number of traditional strategies to manage *moi* for sustainable use. *Kapu* or closures were placed on *moi* during the spawning season (typically from June through August) so as not to disrupt spawning behavior.

Moi are protandrous hermaphrodites, initially maturing as males after a year at about 20-25 cm. They then undergo a sex reversal, passing through a hermaphroditic stage, and finally becoming functional females measuring between 30 and 40 cm (fork length) at about three years of age (Santerre et al., 1979). Spawning occurs inshore and eggs are dispersed and hatch offshore (Lowell, 1971). Larvae and juveniles are pelagic until juveniles attain a fork length of about 6 cm, whereupon they enter inshore habitats including surf zones, reefs, and stream entrances (Santerre and May, 1977; Santerre et al. 1979). Newly settled young *moi*, locally called *moi-li'i*, appear in shallow waters in summer and fall where they are dominant in the nearshore surf zone fish assemblage.

Moi have a readily identifiable aspect of their life history (sex reversal) that has contributed to its decline in Hawai'i: continued overfishing results in relatively few females left in the population around heavily fished areas of the state. Hawaiians understood this, and prior to spawning season, females were normally released. Management was, and still should be, based on a detailed understanding of the life history of the species of interest (see also Barker and Ross, this vol).

At Mo'omomi, *moi* typically spawn near the northwestern end of Kawa'aloa Bay in the sand. *Moi* usually come inshore to spawn from June through August. Sand movement is very important in determining when and where *moi* spawn. In Kawa'aloa Bay, *moi* move inshore to spawn when sand has stopped moving, but before too much sand has moved in to fill in the *puka* in the reef. Shelter is an important controlling factor in reducing the risk of predation during the spawning period. Stable sand leads to higher infauna of *moi* prey (shrimp and crabs). Observation of sand movements and the height of sand waves can give a good indication of when *moi* will move inshore to spawn. As sand waves flatten out, the sand becomes more stable whereas steep sand waves indicate movement of sand.

Hawaiians developed a mental model of the life history of *moi* from which conservation principles and management practices were derived by integrating seasonal movement, spawning aggregation behavior, and the relationship of different life history phases to these behavior patterns. Table 3 is an attempt to construct a written representation of the knowledge concerning the behavior of *moi* and how it relates to Hawaiian conservation principles. Traditional Hawaiian conservation principles for *moi* included restrictions on harvest of *pala moi* (hermaphrodites) *or moi* (females), depending on population structure, and restrictions on harvest during the spawning season. Minimizing the disturbance to spawning and nursery habitats was another important conservation practice.

Awareness of the need to protect both immature moi and the female breeding stock from overharvest is an example of how Hawaiian resource knowledge can validate Western science, which has discovered and named this method of conservation as "slot limits." Not only was almost every basic fisheries conservation measure devised in the west in use in Oceania centuries ago (Johannes, 1978), including closed areas, closed seasons, size restrictions and restricted entry (Johannes, 1982), but some very sophisticated methods, including slot limits, were also practiced in Hawai'i.

Table 3. Seasonal movement of *moi* and related Hawaiian conservation principles

Fish size	Dispersed	Aggregated	Aggregated and spawning
Adults (*mana moi, pala moi, moi*)	Fall through winter	Spring -- in reef holes prior to spawning	June, July, and August -- one spawning per month cued by moon phase
Juveniles (*moi li'i*)	Leave for adult habitat after grown	In fall, as new recruits feeding in sand bottom areas with nearby rocky shelter	N/A

Limu Kohu

Seaweeds, collectively known as *limu* in Hawai'i, were the third component of a traditional, nutritionally balanced diet that also consisted of fish and *poi* (Abbott, 1984). Hawai'i is rich in *limu* species owing to the high volcanic islands and associated rainfall, which provides nutrients for the growth of *limu*. While the uses of seaweeds among other Polynesian peoples were either infrequent in the past or have been curtailed today (Abbott, 1984), Hawaiians continue to consume a wide variety of seaweeds. One of the most prized species is *limu kohu* (the supreme *limu*), or *Asparagopsis taxiformis*. There are several legends relating to how *limu kohu* got its dark red color, each referring to an event connected with legendary or real *ali'i* (royalty) (Abbott, 1984).

Fronting Mo'omomi and Kawa'aloa Bays, *limu kohu* grows in areas of intense surge from the splash zone on intertidal benches (*papa*) to boulder and flat limestone bottoms as deep as 40 feet. This seaweed is well suited to the shallow-water habitat off Mo'omomi, which is wave washed almost year round. There are, however, marked seasonal changes in the distribution of *limu kohu* (Table 4). During *ho'oilo* (wet season), the tides rotate in an opposite pattern from k*a'u* (dry season), when the highest tides occur during the day and the lowest tides occur at night. During the wet season, the coast is exposed to intense wave action generated by North Pacific swell and strong tradewinds. In these conditions, *limu kohu* is able to attach and flourish on long stretches of *papa* that experience less water movement during the dry season.

From January 2000-January 2001, seasonal changes in the distribution, abundance, and reproductive condition of *limu kohu* were studied at the major harvest site (*Kaiehu papa*). Information collected during 12 months of detailed observation is summarized in Table 4. The survey period began during the latter half of the 2000 wet season (January-April 2000), through the dry season (June-Oct. 2000) followed by the start of another wet season (Nov.-Jan. 2001). These data were collected by the authors and community resource monitors. Severe drought conditions later in 2001 severely retarded the growth of *limu kohu* on the *papa* over this time period.

Patterns observed in the relative abundance and height of plants (Table 4) indicate that the wet season provides the best growing conditions on shallow (0-1 m) benches, or *papa*. Marked changes in bench cover by this seaweed occurred during the wet season or after rainfall with young stands of *limu kohu* becoming one to two inches high during one cycle of the moon.

Limu kohu reproduces by spores. Observations during the wet season indicate that shallow-water plants bear spores after they have grown to a height of three inches, and sporing continues until full growth to 4.5 - 5 inches is completed (Table 4). As they grow taller, shallow stands of *limu kohu* are torn by high wave energy, starting with the fronds and eventually cutting off the main stems as they weaken.

Observations during *ka'u* (dry season) indicate that daylight exposure during minus tides, long days and reduced water movement make the shallow *papa* an inhospitable environment for *limu kohu* (Table 4). However, the longer days stimulate lush growths and sporing of this seaweed in subtidal areas of boulders and limestone flats to a depth of about 20 feet. At greater depths, growth is sparser because of limited sunlight.

There is a number of environmental factors that affect the growth of *limu kohu* on intertidal benches and subtidal areas (Table 5). The change of seasons from *ho'olio* (wet) to *ka'u* (dry) exposes growths of *limu kohu* on the intertidal benches to dehydration and sunburn and eventually causes die off. There is no conservation principle to be served by limiting the gathering of seaweed that is under such a "death sentence" and the largest harvest of *limu kohu* is made at this time of the year (May).

The continued availability of *limu kohu* at Mo'omomi Bay depends on the recruitment and growth of new plants. Success in reproducing (through sporing) and in attaching to local substrata are key processes that sustain the supply of this seaweed. Spores attach to suitable sizes of sediment and settle on the bottom wherever the preferred grain sizes are deposited. If particles are too small, they will be removed from the nearshore before settling.

The critical conservation principle derived from the mental model for *limu kohu* is to retain spores so they are more likely to settle out on local substrata (Table 5). That is why *limu kohu* gatherers are encouraged to rub off the root mass of plants against a rough surface (such as the collector's bag) as they are harvested. Many spores are trapped within the root mass and leaving this mass in the water increases the chance that spores will attach and grow near the original harvest location. Observations during the peak harvest period in May 2000 (see Table 4) suggest that *limu kohu* may replant in shallow inshore areas of the *papa* as a result of this practice.

Table 4. Observations of the seaweed *limu kohu* at the major shallow-water (0-1 m) harvest site (*Kaiehu papa*), January 2000 – January 2001.

Time of Observations	Condition of Shallow Plants	Height of Shallow Plants	Condition of Reproductive Spores	Other Information
Wet Season (Hoʻoilo)				
Jan. 2000	Abundant	3-4 inch	Attached	
Feb. 2000	Long plants breaking off, dying back, losing red color	3-4 inch	Large numbers attached, some being released	Wave action breaking off plants
March 2000	Shorter, sparse and pale in color	3 inch	Large number being released from shallow plants; evident on deep plants (20 ft)	
April 2000	Still abundant but long plants have broken off; pale color	2-3 inch on bench; 3-4 inch in pools	Same as March	
Dry Season (*Kaʻu*)				
May 2000	Pale color; what long plants remain are overgrown with epiphytes and dying back; some plants very close to shore	2 inch	Few spores attached to shallow plants; increasing number on deep plants (20 ft)	Time of peak harvest; collecting may spread spores for regrowth
June 2000	Sparse and short growths	2 inch	Not evident on shallow plants; abundant on deep plants	Lack of rainfall
July 2000	Plants getting longer	3 inch	Sparse on shallow plants; abundant on deep-water plants	Less than 0.1 inch rainfall in month
August 2000	Abundant	3-4 inch	Sparse on shallow plants; abundant on deep-water plants	0.25 inch rainfall on 8/25
Sept. 2000	Sparse	2.5 inch	Not evident	0.33 inch rainfall in month
Oct. 2000	Abundant	3 inch	Sparse	
Wet Season (*Hoʻoilo*)				
Nov. 2000	Abundant	3 inch	Increasing on longer plants	0.79 inch rainfall in month
Dec. 2000	Scattered, red color	3 inch on bench; 3-4 inch in pools	Increasing on longer plants	0.11 inch rainfall in month
Jan. 2001	Abundant, dark purple color	3-4 inch	Abundant on shallow plants	0.32 inch rainfall in month

Table 5. Seasonal distribution of *limu kohu* (an edible seaweed) and related Hawaiian conservation principles.

	Limu Kohu Habitat	
Season	Shallow (0-1 m depth)	Deep (1.1 – 10m)
Wet (*Hoʻoilo*)	Growth favored by winter rainfall (introducing nutrients), minus tides at night, short days, ocean turbulence dispersing reproductive spores	Growth favored by water motion dispersing reproductive spores but inhibited by short days
Dry (*Kaʻu*)	Growth inhibited by lack of rainfall, "sunburn" during minus tides, long days	Growth favored by long days

Discussion

How Unified and Transferable is Hawaiian Knowledge?

Traditional Hawaiian marine resource use poses a paradox. Communities in different island areas, on the one hand, are characterized by a unifying worldview and similarities of basic designs or principles that are the result of centuries of continuing experimentation and innovation. On the other hand, the details of practice vary from one area to the next because they are adapted -- fine-tuned -- to local situations. Detail is important because of the "patchy" character and variability of shoreline and nearshore environments in the Hawaiian Islands.

Transferring this knowledge to other places risks losing its vitality. Even writing it down, as in this paper, changes some of the fundamental properties of this knowledge, making it more portable and permanent, but with a loss of vitality. This increases the chances of dislocation and misapplication outside the restricted context in which the knowledge evolved and is effective.

How is Hawaiian Knowledge Different from Other Kinds of "Local Environmental Knowledge"?

Hawaiian indigenous knowledge differs from similar kinds of environmental knowledge held by non-indigenous people in two important ways. First, Hawaiian knowledge evolved in the cultural and environmental context of the first inhabitants of the Hawaiian Islands, where it was essential for survival. Second, Hawaiian knowledge has deeper roots and is the product of many more generations of intelligent reasoning about the marine resources of the Hawaiian Islands than practical knowledge held by non-Hawaiians.

Further Applications

The Hoʻolehua Hawaiian Homestead community is self-reliant in its fishery conservation efforts. Conservation is based on local resources (intellectual and social) as much as possible. Homesteaders work with what they have, with what they know, and what they can do.

Much more could be done to explore the ways to integrate the traditional knowledge of native Hawaiians with contemporary fishery management. But how desirable is this integration? Berkes (1999) cautions that the use of indigenous knowledge is political because it threatens to change power relations between indigenous groups and the dominant society. The example of Hoʻolehua Hawaiian Homestead may, nevertheless, inspire new approaches and suggest more participatory and locally-based alternatives to top-down centralized resource management. There are other rural communities in Hawaiʻi with values and features similar to those of the Homestead. These ideas challenge conventional fishery resource management, but forcing indigenous Hawaiian conservation into the mold of Western conservation is not likely to work:

> *"The resource management systems of indigenous people often have outcomes that are analogous to those desired by Western conservationist. They differ, however, in context, motive and conceptual underpinnings. To represent indigenous management systems as being well suited to the needs of modern conservation, or as founded on the same ethic, is both facile and wrong." Dwyer (1994, p. 91).*

Hawaiian fishermen understand and interpret natural phenomena differently than Western-trained scientists. The Hawaiian system is based on knowledge that is:

- Generated as a consequence of practical needs in everyday life;
- Based on intimate acquaintance with a local situation;
- Linked to specific places and sets of experiences;
- Preserved through the memories of particular individuals;
- Orally transmitted;
- Continually reinforced by experience, trial and error, and deliberate experiment;
- Dynamic and evolving, not static and rigid.
- Transferred through the practices and interactions of subsistence fishermen; and
- Shared in the community to a wider extent than conventional scientific knowledge about marine resources.

The residents of Hoʻolehua Hawaiian Homestead tend to care deeply about what becomes of their subsistence resources, not only as a source of food for themselves and future generations, but also as part of their way of life and identity. Without the unique and highly successful system for community self-management that has been perpetuated, the local fisheries might be in the same state of decline as elsewhere in the populated Hawaiian Islands.

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QUESTIONS

Melita Samoilys: How do we know the Moi were hermaphrodites?

Kelson "Mac" Poepoe: We cut them open and look inside to see the gonads.

Melita Samoilys: So they have both gonads, or are they sequential hermaphrodites?

Kelson "Mac" Poepoe: They can change from male to female. They change when they get to a certain size. If I look at a fish, I can say if it's a hermaphrodite, male, or female.

Michael Phelan: Does anyone stop fishing at the sites when they aggregate to spawn?

Alan Friedlander: There is an intricate social dynamic; you need to have the right proportion of males and females to spawn. If you break up the aggregation, there's no telling if it'll reform within a reasonable period of time to spawn. For the most part, it's understood that in the spawning season, fish are not to be bothered.

Ian Baird: In Laos, the way of passing on knowledge is to get kids to start fishing early. As soon as they can put a net or hook out, they do it. In Hawaiian tradition, it seems to be the opposite where they observe but not practice fishing until a certain age. I've never heard of this practice being done. Why do they do that?

Kelson "Mac" Poepoe: They do that to respect the social structure. If you are a master fisherman, no one interferes with you. If I'm out there fishing and there are fishermen below me, they have to respect me. But we do start fishing at an early age.

Alan Friedlander: On that same topic, there are only one or two places on the Mo`omomi area that are accessible to kids. What people did before and what they still do is leave those places for the kids to experiment and to get their feet wet both figuratively and literally.

Tony Pitcher
This is a fascinating study. I wonder how it's regarded by the official regulatory agency. Here in Canada, we look enviously at the system in Haida'gwaii and that is controversial. How do you make it workable?

Paul Bartram: It's very threatening to government agencies. We try to fly below their radar.

Alan Friedlander: The state came by in 1995 and established Mo`omomi as a place that's legislated. That was a very top-down approach and made rules that the community wasn't buying into. Guys were coming down from Oahu to hammer resources because they are in better shape in Mo`omomi. The state has washed their hands of it because the community washed their hands of the state.

Kerry Prosper: What is the ratio of fishermen and enforcement? Is there a low ratio of enforcement because of the structured value system in the community itself, or is it like here where the enforcement is overpowering the community?

Kelson "Mac" Poepoe: Enforcement comes from peer pressure. We don't approach fishermen with a top down approach. We watch out for each other. We set rules, everyone knows them, and they can tell if their neighbor is doing something wrong

Jeremy Prince: What is the population size?

Kelson "Mac" Poepoe: There are 6000 people on the island. The island is open to everyone. Anyone can fish there if they want.

Alan Friedlander: But there's only one access road that goes in. It is a dirt road. By going down that road, you implicitly accept the rules set by the community.

TWO FISHERS' KNOWLEDGE SYSTEMS AND FRONTIER STRATEGIES IN THE PHILIPPINES

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ABSTRACT

This paper highlights two different fishers' knowledge systems in the Philippines. These fishers' knowledge systems underlie distinct strategies for sustaining a continued livelihood from the sea. They encompass paradigms for success in fishing and are oriented to contend with change and uncertainty. They incorporate ideas about closing or opening resources and sharing or exchanging opportunities with outsiders. What fishers seek to manage are the *conditions* of making a living, which include moral concerns of equity in relation to scarce *opportunities*. Not all resources are well known and some are highly enigmatic. Fishers' relations with resources are linked to the current economic and social values of fish within both market and community economies.

The Davao Gulf fishers can be seen as being caught up in a 'knowledge race' (as in an arms race) where the fishing strategies are adapted to quickly respond to changes in the behavior of fish and of other fishers, as well as of markets. Fish are viewed as instant money and successful fishing is often described as hitting a 'jackpot'. Fishing in the past 20-30 years has been characterized by a rapid rise and fall in deployment of geartypes. The fishers employ a frontier strategy, which results in their 'being well rounded' (i.e. technologically knowledgeable and innovative). Some aspects of this strategy include: 1) the wide repertoire of individual fishers, 2) the phenomenon of *dayo* or fishing visits or sojourns.

In the traditional capture or *mataw* fishery, for seasonal flying fish and dorado in Batanes, efficaciousness or 'luckiness' (*sagal*) is experienced as stemming from the agency of fish that 'go to' worthy fishers. A fisher 'with knowledge' (*mian kasulivan*) knows the ritual technologies of attraction and persuasion in order to maintain relationships with the invisible sector in nature. This knowledge also has a collective aspect aimed at establishing precedents and rules for sharing fishing grounds each season.

The paper does not apply the usual idea of an 'open access' commons as a salient condition in fisheries but rather asserts that potential resources are being approached by fishers as locally defined kinds of 'frontiers'. The 'frontier' seems a particularly helpful conceptual tool since it evokes perspectives on the active construction of 'resources', of 'knowledge', and of 'others', such that temporal frames in the development of the fishery become apparent.

INTRODUCTION

The title of this paper speaks of 'Two Knowledge Systems', in the sense that any one society will always have several kinds of knowledge that are put to work in daily life (Worsley 1997). Fishers' relations with resources are linked with the current values of fish within both market and community economies[1]. What does it mean to be 'knowledgeable'? How do fishers' knowledge systems relate to the economic and social values placed on fish?

In this paper I examine distinct strategies for sustaining a continued livelihood from the sea. Rather than resources, this paper begins with a view that what fishers seek to 'manage' are the *conditions* of making a living. These encompass moral concerns of equity in relation to *opportunities* that are scarce (and not necessarily resources). In fact, fishers are seeking to manage or negotiate *change*. Contending with change and uncertainty is the context for wielding knowledge, or different kinds of knowledge, and different kinds of technologies. Fishers therefore are people that are better described as intent firstly on sustaining *livelihood*, rather than on 'conserving' their resources. Forms of fishers' knowledge are part of particular *strategies* to deal with change. How resources are perceived and exploited depends greatly on the expectations of the market and of major communities.

Fishers are always putting their knowledge to work, and expanding, refining and reassessing it to keep up with changing circumstances. Innovation is primarily motivated by how it may support varying modes of participation in global markets or other systems of exchange. It is for this reason that fisheries are the site of the quickest transformations anywhere. My discussion brings us to a consideration of the fishers' approaches to shared resources as 'frontiers' rather than 'open access' resources. By this I mean that in all cases the general value of 'being first' is underscored as a source of legitimacy and power.

A frontier strategy can involve a process of accelerating change, by intensifying effort, seeking to be at the cutting edge of knowledge and technological innovation, establishing networks and institutions, reciprocal relationships, facilitating access to technology, knowledge, markets and resources, because 'early birds' can benefit most or can establish prior claims. Fishers' strategies may incorporate ideas about closing or opening resources and sharing or exchanging opportunities with outsiders. On the other hand, an adopted frontier strategy may also be collective, concerned with controlling the way that precedents are established, and therefore refining and reemphasizing the value of *tradition*. Two cases from the Philippines (Fig 1) exemplify these contrasting strategies.

Figure 1: Map of the Philippines

The two groups of fishers discussed here belong to two distinct geographical settings. In the Davao Gulf the situation is extremely dynamic. Migrants and natives, and sojourning fishers (especially from the Visayas) contribute to rapid change in this fishery; knowledge is wielded as in an arms race, to keep up with the knowledge of other fishers and of the fish. By contrast, Batanes, a group of ten small islands just below Taiwan, is quite isolated from the rest of the Philippine archipelago, from other fishers (except for Taiwanese offshore fishers with more sophisticated technology), and from markets outside of the province—because of the strong currents of the Balintang Channel and the seas surrounding Batanes. It is apparent that fishers in both places are skilled, experienced, and knowledgeable, but nevertheless it can be seen that not all resources are well-known, or that these can be highly enigmatic.

FISHING IN SAMAL ISLAND: BEING 'WELL ROUNDED'

This was how I often heard fishers I interviewed describe their fishers' knowledge: it is, and they are, 'well rounded'. They meant that they knew more than one kind of technology, that they were not specialized to a single gear type but had tried their hand at many. They possessed different kinds of gear and shifted between them depending on what kind of fish they felt would 'let themselves be caught' ("*ang magpahuling isda"*) at a particular hour, tide, time of day, month, or season. Most said they could catch both 'fish near the surface' and 'coralline fish'; had fished in 'nearshore', 'off shore' and 'out to sea' fishing spaces. In the course of careers as fishers they had handled quite a large variety of gear and had been part of both small-scale and relatively large fishing expeditions. Periods of learning and developments in their technology were closely related to how and when the market links were forged. Meanwhile, being 'rounded' was also a result of the constant technological innovation that has been necessary to keep up with changes in fish behavior.

After putting together several biographical anecdotes of individual fishers, I realized that their wide range of experience was a reflection of intensification of fishing and the remarkably rapid turnover in technology which has taken place in the Davao Gulf. All these changes have taken place since the early 70s, the space of a single generation. In fact, communities along the east coast of Samal Island are themselves about the same age as the fishery; many houses and settlements were established only within the last 20-30 years. Samal was at first sparsely populated by natives not particularly oriented to the sea. As they said, 'fish were easy to catch'. Sometimes, it happens that there are fish that are just thrown onto the sand by the waves and can be picked up by hand (I observed this once).

The common 'original' fishing gear were the thrown net (*laya*), and the fishing spear (*bangkaw)* both of which could be used from shore or by waders, with no need for a boat. Practically all other terminology for fishing gears used today uses Visayan words (Box 1) .

Box 1. According to B, a fisher in Aundanao, his gillnet for *ukihuk* used to have a larger mesh size and was meant to be floating. Then a friend of his tried tying stones to the net so it would sink. The result was amazingly successful. In 1991-92 this method was guaranteed to catch many fish, up to 60 to 70 kilos each time. B, who is also a barangay councillor, proposed acquiring this new technology as a project of the Aundanao cooperative for a loan of P42,000 from the Department of Agriculture. With this money they procured nets for 5 groups of fishers and were able to pay back the loan in record time. For the success of this project the cooperative won a further P25,000 for having the "Best Project in Region 11". (They used the money to set up a *payao*, or fish aggregating device). However after 1992, the winning net design caught much fewer fish. B thinks the fish have learned to see the net and swim **over** it this time.

In the 1960s, (in the part of the island where I did fieldwork) fishing was still mainly practiced to procure food, except for a few avid fishers who brought their fish to sell in markets in Davao City or other towns on the mainland across the sea. By the 1970s, the population around the Gulf was growing from the influx of migrants; fishing was booming. Migrants included Muslim Tausug, and Visayans of all kinds. *Basnig* (box-shaped nets used with lights) enjoyed a heyday, dynamite became prevalent, and beach seines were also productive at this time. Gillnets did not become common in Davao Gulf until the late 1980s. Displacing other technologies, including the use of dynamite, they quickly evolved in size and dimensions.

Within the community where I did my fieldwork, one particular date could be cited as a turning point: in 1980 the first local *comprador*[2] established a fish buying station in the locality. With this, fish became not just of value as *food* but was instantly convertible to money or even other goods (like rice, soap, coffee, etc.) that could be taken from the comprador's store with no need for the intermediation of cash. In effect, fish *became money*; both the value of delivered fish and a fisher's debts would be recorded in the comprador's notebooks and these transactions made fish virtually as good as cash.

The evolution of fish from subsistence to a commercial resource follows in the footsteps of other natural resources such as *abaka* (Manila hemp), copra and logs from the forests which have historically characterized Mindanao as a regional frontier. People from other parts of the Philippines were attracted to migrate in by the perceived opportunities for gathering or producing money from the environment.[3] Government also encouraged migration to Mindanao as a 'land of promise'.

In 1997 there were already 6 'sari-sari store' owners that were also fish compradors in my fieldwork area. Between 1980 and 1997, fishers noted that 'everybody' in the barangay learned how to fish. However over the same time the typical volume of catch also dramatically declined. The transformations are reflected in the following typical statements:

> *'All kinds of ways of fishing are here already.'*
>
> *'Now everybody, including children, know how to fish.'*
>
> *'There was a lot of fish (before), just nearby.'*
>
> *"The fish were large when the compradors started in the 80s, now they are quite small.'*
>
> *'Before it was not unusual to catch 15-25 kilos at a time, now however it is more usual to catch 2-3 kilos, and rarely reach 10.'*
>
> *'Before there was no hunger, life was not difficult.'*
>
> *'Before, night-time fishers returning at break of day would be met on the shore by dozens of "kanaway" (or 'people meeting the boat'). The beach was 'like a city' for sheer number of people; only after distribution among all of the people would the fish be sold to the comprador.'*

In discussing declines in yield however, fishers did not emphasize scarcity (although they do recognize limits in fish stocks relative to increasing populations of fishers), but rather they emphasized the agency of fish, their increasing evasiveness and 'smartness'. The fishers' response to this problem is to constantly figure out how to keep abreast, or ahead, by a strategy of constant innovation in technology. Fishers are engaged in a 'knowledge race', pitting human ingenuity against increasingly elusive resources. In spite of their small catches, many fishers I talked with seemed to feel that they are at the forefront of the technology race.

A kind of natural selection of technology is visible in response to apparent changes in fish stocks and behavior. Lights for attracting fish have become brighter with use of the remodeled 'combination' *Petromax* or *Aladdin* lanterns (See also Hamilton, this vol). (Large fishing boats meanwhile were sighted making use of ultrastrong 'superlites', said to be up to 2,000 watts, which some fishers think affected the minds of the fish.) Simple hook and line gears have become more and more specialized. The original simple *bundak* or small hook and line used to have only one hook attached to it, now it has at least a dozen, and in Peñaplata (a town on Samal Island) some are using up to 800 small hooks on a single line. Artificial baits have also become more sophisticated. Fishers spend their free hours fashioning beads and shiny 'marlon' threads into specialized bait for specific times of day and targeting particular types of fish. Gillnets were originally bought ready-made from hardware stores in Davao City, but most fishers now make their own gillnets, incorporating many innovations in design.

To inquire about successful fishing in Samal is to learn fine points about gear, technology and timing. They speak precisely of the depth of the waters in which they fish, and whether it is best to use a particular method when the current is 'coming in' or 'going out' of the Davao Gulf. The choice of gear depends on the species aimed for, the time of day or night these fish habitually feed, and on the nature of the sea bottom (sand, corals or mud). Most of the technology they use is not broad-spectrum, but highly specialized. Fishing activities are usually referred to using terms which relate directly to the species targeted (e.g. "manulingan", 'to catch tunas"; *"manginhason",* 'to get shells', etc.). Fishers stressed that they are "*suheto"* or possess all the necessary skills, are "*antigo"* i.e. 'experienced' or 'expert' with respect to certain kinds of gears, or that they have certain gears "*cabisado"* ('knowing something back to front') or "*memorized*", or that they are 'round' ('all-around').

> *'Now the nets are all longer—both in width and in length—and now there are many kinds.'*
>
> *'The fish today are just like people, they learn quick.'*
>
> *'You have to think which is the best way to get fish. You have to try different baits the fish might want to eat. If the fish doesn't eat it anymore, then you have to think up another kind that he will like to eat.'*
>
> *"There would be fights out at sea because the pamboats were colliding. Now there are no fights because there are few fish. The tulingan are all being taken by the kubkub, by the Muslims like Haji Yusuf, that's why the Muslims have a lot of money."*
>
> *'Before, there were many "dayo", but those fishers from other places won't be coming back like before because there are already many fishers here.'*

Dayo are visitors or outsiders that have played a very significant role in the development of the technology and market networks in the Davao Gulf. In a substantial way, local fish and fishing grounds become more intimately known through the interest of strangers. Shellcatching for example was initiated in Samal by *dayo* from Cebu. Another kind of visiting fisher is the "Jolohano", Muslim gillnet fishers based their boats on the beach for periods up to one month, especially in May, August, and November in the late 1970s. They caught very many fish near the shore. Locals learned about gillnet technology from observation of these fishers.

Among the dayo I met in 1996-1997 were flying fish fishers from Leyte (in the Visayas). They were using a large net with large buoys, which also necessitated hiring some local help. They had brought four large motorized bancas. According to them, they were the only fishers in the entire Gulf with specialized technology for catching flying fish. They had another base in Davao Oriental across the sea.

From the point of view of locals, most sojourning *dayo* were usually technologically superior and also had the important ties to financiers and buyers. Locals were able to acquire their knowledge and, more importantly, their market links, through hosting and facilitating access to local resources. In a way, exposing the resource to outside exploitation is part of a tradeoff. Especially in the beginning it proved the only way to gain access to particular markets. Dayo try to maintain their welcome by portraying themselves as exploiting only particular economic niches by their specialized techniques, thus appearing not to compete with locals. The interaction between permanent residents and short-staying visitors has had an impact on the consolidation of communities and of larger networks. In this way, locals could participate in markets, exchange information, and enjoy other forms of reciprocity with outsiders who could potentially also be assimilated into the community by settling down and becoming local residents. At the same time, because there is a limited period for outsiders to enjoy these privileges, they will be clearly interested in maximizing exploitation. Intensified exploitation in turn, accelerates the gear turnover in Davao Gulf (Box 2).

Box 2. C's shell harvesting group numbered about 50 people, aged between 10-40, including parents and their children, traveling on four motorized boats. The group used nets to harvest shells. From their original base, they moved to other places around the Davao Gulf, reaching Balut Island, Sarangani. Talikud Island near Samal was where they stayed longest; they settled (*nagpundok*) there for three years. On subsequent expeditions, they also went to small islands in the Visayas, as well as to Bohol and Panlaw, Tagbiliran City. Typically they stayed 2-3 months, as long as shells could still be taken in sufficient quantity to support their daily living, before returning to deliver in Cebu. According to C, they explored every 'nook and cranny' of the coast. Shell harvesting opened and explored parts of the local waters and bequeathed some place names to parts that became known for certain kinds of shells. At present, the other original members of C's group are back in Cebu and have shifted to fishing or construction work. C married a local woman and settled in Talikud, he continues to handle nets for shells but this time these are financed and owned by local and Davao-based buyers.

Thus, individual fishers and local communities learned about their resources through the interest of outsiders. The locus for negotiation and control is the point of passage, rather than the resource itself, which is not fully known, usually not self-contained and has no established limits. It is the small number of opportunities to participate in the market that are subject to claim. However, it seems that in this frontier strategy, transferred to the Davao Gulf from the Visayas, the only way to control change is to participate in processes that would in fact accelerate the pace of change.

KNOWLEDGE/POWER: USING 'KNOWLEDGE' IN TRADITIONAL MATAW FISHING IN BATANES

Mataw fishing in Batanes is a special case. Strong currents separate the Batanes area from the rest of the Philippines. The only regular and frequent form of transport is by Fokker plane (3x a week) and therefore expensive, isolating the region from both national and international markets for fresh and dried fish.

Traditional fishing for dorado (or dolphinfish) in the summer season of March-May involves a special relationship between the fishers and the landscape known as *mataws*. Mataw fishing takes place on the eastern side of Batan Island, in Mananioy Bay or Valugan Bay, although some fishing trips may take them further, to the southern and northern parts of the island. This is an indigenous fishery involving highly formalized protocols in a *collective* strategy of frontier. The motif of 'firstness', and the power of 1st actions and precedents consistently runs through the mataw traditions.

Traditionally, the means of access (called the *vanua*) to these fishing grounds is ritually 'made' and 'dismantled' at the beginning and end of the season. Each summer is a new fishing season that is collectively managed by careful actions. *Mayvanuvanua* is a ritual of sacrifice performed by the group of fishers at the onset of the season. Its object is to negotiate for a season of safe passage and successful fishing, a form of collective contract and request put forward with the unseen powers and with the fish. It is held in their landing site along the coast (the *vanua*). At this ceremony, a 'Firstfisher' or *mandinaw nu vanua* is chosen from among the mataws. His job is to call the fish and to set good precedents by his actions on the first fishing trip and for the rest of the season. He is chosen to represent the group in recognition of his being a good fisher and a 'knowledgeable' person.

Traditionally, 'knowledge', or in Ivatan '*kasulivan'*, is very important in gaining an edge in this formalized frontier. However mataw 'knowledge' is intended to make the self or body of the fisher as well as the vanua into "clean" and therefore attractive things. Fishing is an activity of getting to know and relating well with fish and other natural agents, both as individuals and as members of a group. Fishing is a highly social enterprise.

As one who 'has knowledge' (*mian kasulivan*), a traditional mataw can tap into the invisible potencies that can be found both in the natural environment and within himself, to influence nature: fish, the weather, and good fortune as a whole. In actual practice, *kasulivan* concerns knowledge of how to manipulate certain ritual materials (like sugarcane wine, a coin, a rare bluegreen bead), and of saying special and powerful words that form binding parts of the landscape—'like a curse'. 'Knowledge' is also needed for the rites of 'cleaning' (*maynamunamu*) of gear of individual mataws or of the vanua (which is collectively maintained) in the middle of the season.

The ritually constructed vanua can be seen as an ideal technology enabling one to catch many fish with the least effort, a collective 'technology of enchantment' (Gell 1999). Even if mataw fishing seems a highly individual endeavor, it is done in the context of responsibility for the fortunes of the group as a whole. To be chosen as Firstfisher or *mandinaw nu vanua*, and be the first to pass through the vanua, the first to fish, confers a dangerous power to perform influential actions, and it presumes knowledgeability.

'Firstfishers'[4] are said to be chosen for their proven ability to catch many fish (*sagal*). This is also a reflection of social esteem; they are in fact ideal leaders who do not harbor ill will toward fellow fishers, their character is affirmed by the fish and by nature. Arrogance brings wind and waves; calmness of character brings good seas and attracts fish. Knowledgeability is an innate talent or trait, part of being approachable to both fish and the invisibles.

Although 'knowledge' and relations between fish and fisher, and fish and the fishing group as a whole, may be traditionally a subject of much attention, interviews with retired mataws indicated that the younger generation is much more "masagal" or successful than their elders. Some old and retired mataws of Maratay told me they never equaled the catch totals of this current generation of fishers; compared with their experience, the seasonal catches of up to 100 and 200 fish in a fishing season by the contemporary mataws are simply phenomenal. They cited restrictions that set quotas and limited catch potentials before, and they also attributed this to improvements in the fishing gear. '*Many dolphinfish got away before*.'

Technological improvements have been made to different aspects of gear. Present-day hooks are smaller and lighter. Many mataws use hooks they have shaped themselves as well as commercial hooks. Fishing lines have also been improved, with many alternatives, and personal preferences vary among fishers. The more traditional kind of fishing line is the *tuyungan,* a stranded line (as opposed to the 'solid' or '*tansi*') that was formerly twisted out of *hasu* fiber. It is now much thinner as fishers make it out of drifted rope or fishing net fibers from Taiwanese fishing gear. The nylon version is also often bought commercially. (Much equipment in Batanes, from fishing gear to water containers is crafted out of drifted material from Taiwanese fishing boats: nets, metal clips, buoys, floats, plastic water bottles, etc.). Both the new 'drifted' and commercially available industrial materials made the work of fishing 'easier' as the manufacture of gear from indigenous materials was quite labor intensive.

When one inquires about the details of fishing paraphernalia among mataws, it turns out that there is much individual variation. The fishing line can be prepared with a hook on one end, or made *misamorongan,* that is, with hooks attached on either end. Each mataw has his personal style, and makes a lot of his gear himself, using many found materials. For example, one mataw said his father would bring 8 fishing lines to sea, but he himself takes only 5, and he doesn't like misamorongan because it is 'hard to fix' (arrange neatly in the boat). Another mataw uses 7 hooks: six on three *misamorongan* and one on a 'solid' line.

However, everyday talk is less about differences in gear, than about what part of the Bay they went to, how many flying fish they had, how many dolphinfish went to them, and how they got fish from others. Only when I interviewed several mataws on the details of their paraphernalia, did the discourse about the fish suddenly shift: They talked about fishing as a contest of wits between fisher and fish, and I heard a sentence that could have come straight out of the mouths of the Davao fishers: '*people have become smarter, but the dolphinfish have become smarter too.'*

The fishers of Batanes, including the mataws are no less empirical than the fishers of Davao, but for them, the dilemma of the changing times seems to be how to make tradition and 'knowledge' conform with different ideas about knowledge: 'Knowledge' retains potency, but seems anachronistic, to be known to use it is uncomfortable and sometimes a source of embarrassment.

The reality of mataw fishing is based on the substantiality of an order of power, 'knowledge', and the potential for human negotiation between visible and invisible worlds. An alternative 'modern' reality challenges the mataw traditional world. It is represented in an 'open sea', secular technology, market and different knowledge system.

At the onset of the season, mataws themselves create and reproduce one form of reality carefully. The continuation of tradition depends solely on whether they elect to perform the rites of *mayvanuvanua,* which affect the landscape. Accepting a modern context for fishing converts success into a matter of arbitrary chance, rather than as individual potency where everything is meaningfully interconnected; it means to cease relating to and, by virtue of having 'knowledge', using the power of the invisible that is potentially also inside one. This is the root of the dissonance between traditional and modern orders of time and space as it is being experienced by the mataws in Batanes. The person who decides to be modern must consciously drive a wedge between himself and the invisible parts of the world.

Fishers' knowledges and strategies: on the concepts of 'frontier' vs. 'open access'

A frontier, it has been observed, provides an 'institutional vacuum' for the unfolding of social processes (Kopytoff 1987:16); such processes can be seen at work in the Davao Gulf. By contrast with the Davao material, traditional mataw fishing in Batanes views 'knowledge' or *kasulivan,* in a very specific light. '*Sagal*' – something that some people have more of and which enables them to catch many fish – is a quality that is enhanced through communication and interaction with the fish and with the *anitu* (spirits, invisible beings), and knowing how to 'say things' in particular places. But both these sets of fishers are using knowledge within the context of particular strategies to negotiate with change.

I would like to conclude by discussion of the notion of a local 'frontier'—as opposed to the concept of an 'open access' commons. The concept of frontier presumes dynamic processes, encompassing within it a sense of temporality, phases and precedent, setting or pioneering strategies which also establish claims. This is why fishing is a matter of establishing habituated paths, and especially by getting there first. Competing perspectives are anticipated, given that the seascape must be shared with others. Change and uncertainty must be contended with. Different kinds of knowledge are important and key in negotiating access or setting protocols of access. The Batanes fishery is a very formalized frontier where traditions provide for instituting innovation.

It is appropriate to understand the fishing grounds of the Mataws in Batanes and small scale fishers in Davao gulf as frontiers, to each of which belongs a different system of knowledge. Fishery managers would do well to recognize the social dynamics underlying the generation and utilization of different knowledge among fishers.

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[1] Gudeman (1986) discusses market economy as participated in for individual profit, and where knowledge may be 'owned' individually, while community economy is concerned with the reproduction of the community itself. Commonly held knowledge is part of the base of the community economy.

[2] A comprador is also a member of the community; s/he has a *suki* or guaranteed buyer to deliver the fish to, usually in the market in Babak, the capital of the municipality, which is about an hour away by jeep.

[3] Abaka cultivation in Samal (initiated by the Americans, developed by Japanese businessmen and migrant workers) declined after the war. Many migrants to Samal (usually from the Visayas) in the 50s had come to work in the logging industry. (By the late 60s, deforestation in Samal was nearly total; the forests were replaced by coconut trees.)

[4] I use the term 'firstfisher' to refer to the *mandinaw nu vanua.*

How SASI Practices Make Fishers' Knowledge Effective

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Abstract

Fishers' knowledge is an important component of natural resource management in *sasi* tradition. *Sasi* is a traditional resource management system which is practiced by people in the Indonesian province of Maluku. Harvest restrictions such as timing and fish size limitation, are examples of arrangements that are determined based on sasi traditions.

The fact that fisher's knowledge remains an effective component of *sasi* management in many locations in Maluku suggests that there is something important to learn about what makes it possible. In line with this, a study by the author identifies two causes: (1) the existence of several factors that have encouraged village leaders and the village community, including the fishers, to observe *sasi* management system, and (2) the willingness of the community to adopt modern scientific knowledge to enrich and bring up to date their traditional one. Some factors that support people's observance are local customs, religion/belief systems, and respect for the wisdom of elders. An example of scientific knowledge that people incorporate into their traditional knowledge is the information on contemporary environmental changes that affect their water resources.

This paper concludes with a proposed working model of how resource management should be constructed, especially in the case study area, so that the performance and contribution of local fisher's knowledge in *Sasi* management can be optimized.

Introduction

Strictly speaking, *sasi* is a Malukuan term for regulations or prohibition on doing something. These regulations or prohibition are established by and in an assembly of community members or their representatives, which forms a village council normally composed of *customary elders*[1]. This council is responsible for setting up arrangements, which include details regarding boundary definitions where the regulations are applied, and sanctions and punitive arrangements for those who do not comply with the regulations. Even though *sasi* refers more commonly to a community-operated natural resource management system (Kissya 1993; Rahail 1993), it may also apply to certain kinds of social affairs, such as regulations intended to prevent immoral conduct in the village (Kissya 1993). An example is a *sasi* that prohibits males from going to the area of a village's public water spring assigned exclusively for females, or vice versa (Kissya 1993).

Fishers' traditional knowledge is often adopted to shape resource use regulations, wherein enforcement is carried out using premises given by the *sasi* tradition. Fishing communities, for example, use traditional understanding about the relationship between intensity of harvest and annual fish production, as the basis for the establishment of several fish harvest restrictions. Enforcement mechanisms vary from place to place and may change over time. In some places, a police unit specifically established for *sasi*, may be in charge of monitoring and enforcement. In others, monitoring and enforcement may become the responsibility of all individual members of the village community. Fines and sanctions may also be used to discourage noncompliance and to support enforcement.

Even though arrangements involving traditional knowledge are becoming ineffective in several locations, they still work well in many others. My observation indicates that this might have been connected to the following factors: In places where such arrangements are effective, two features exist and apparently have played roles in making it possible. The first is that *sasi* is, most of the time, respected by people. The second is that while traditional knowledge is always the main element of resource use regulations, modern scientific advice is also considered whenever necessary. This paper presents a discussion which can verify the role of these features in supporting the workability of fishers' knowledge in resource management in the case study area.

Why enforcement mechanisms work in sasi -- the role of cultural factors

Cultural factors have been identified through field observations in Malukuan villages as being important to the formation and observance of regulations employed in *sasi* management. These factors are customs, religion/belief systems, and respect for the wisdom of leaders. For the most part, these factors are manifested

[1] Customary elders are persons selected by all members of clans to represent them in the village council

in the form of a moral power or understanding that encourages both leaders and citizens to abide by the regulations they have agreed upon in common. This finding is comparable with cases discussed in the literature (e.g. Wilson 1982, McNamara and Tempenis 1999, and Edgerton 1985), which indicate that beliefs and/or variations in the way rulings are determined and handed down by leaders are important elements for observance of a regulation in general. The following discussion will show where these cultural elements exist in natural resource management. That is, we will see how these three factors are connected to development and observance of sasi.

As mentioned in the introduction, one of the interesting findings made during my field work was that some *sasi*s are present and functioning in some villages but not in other, neighboring villages. My presumption is that variation in the use of *sasi* is caused by regional differences in the way the three cultural variables mentioned above are present and perceived by villagers in various locations. To see if this presumption is true, I conducted in-depth observations on this matter by using Kei Besar Island, in Southeast Maluku as the focus of the study. In addition, where appropriate, case study examples from other parts of Maluku also are presented to complement the information collected from Kei Besar. In each case a description of local customs, religious practices, and the role of and respect for leaders are cited to illustrate how they have influenced the performance of *sasi*.

The influence of belief

One of the important characteristics of *sasi* is the influence of either religious or local mystical belief systems, or both. The influence of belief can be traced back in time to the period where many people practiced individual property-protection systems that involved mystical belief. People at that time found it effective to involve supernatural power in the property protection system. In *sasi*, evidence of this influence can be found in the prayers delivered in ritual ceremonies marking the closing or opening of *sasi*. Even though the types of prayer vary depending on the religions or beliefs that are found in the different villages, their main message is similar; i.e., an expression of gratitude for the blessings of the year that passed, and a call for more blessings for the future years. In some villages, prayers also include a request for punishment for those who break a *sasi* rule (e.g. in Wattlaar and Hollath). But for most other villages this kind of a request is not normally included.

The following cases are examples of management practices involving the influences of belief which can be observed in Malukuan communities. One of these examples is belief in supernatural power, something beyond human capacity to fully understand, which can be used to help individuals or groups protect their properties. While in some places it is not unusual to hire a person to guard personal property, people in many villages find it more convenient to adopt a form of a supernatural mode of property protection. In other cases, both approaches may be used simultaneously.

Property protection involving mystical belief is widely practiced by Maluku peoples. While this system was initially adopted by their early ancestors, present day villagers still employ it in many locations. For example, in the village of Ler Ohoilim, in the eastern part of Maluku, one can observe bottles of water tied up with a piece of ribbon-like fabric, generally red in color, hanging about one meter above the ground on coconut trees. The people there have a devout person pray over the bottles in the hope that his/her blessing would protect the tree from robbers.

On Hatta Island, in the central part of the province, many villagers believe that one will have his or her stomach inflated and deflated following the rise and the fall of the sea tide if he or she ever disturbs a 'protected' object. They believe that a prayer delivered by an *orangpintar* (lit.: a capable person) makes such an occurrence possible. Further to the west, another example of belief in supernatural powers can be found in the Lease Islands, where the word *pakatang* is quite popular. This word refers to black magic, which is normally used by a person to take revenge or to punish someone whom he or she believes has somehow upset them. In some cases, however, people simply use it as a means of protecting their property. Apparently due to its 'black-side' nature, *pakatang* is less practiced these days than it once was.

Similar influence is also given by modern religions. Prayers delivered by a religious leader, even though rarely including a wish for specific punishments, are often believed to have a magical power too. My research discovered that while religions embrace different prayer contents, the general messages they deliver are similar. In the case of most *sasi*es of the past and some of today's *sasi*, rituals almost always include an offering to mystical objects. But, now that religions have penetrated into the people's social lives, many inappropriate ritual segments have been revised. For example, beliefs that are inconsistent with religious teachings are put aside. And, no mystical practices are maintained in *sasi*. On the contrary, prayers that are more appropriate to modern religion have been adapted. In these cases, no offerings to spirits thought to inhabit rocks, stones, or trees are performed.

There are differences between these practices, and the above examples represent only few of the beliefs that were and still are alive in the communities of Maluku. Yet they all imply a similar phenomenon: that values, especially belief in the Supreme Being or a supernatural power, make a nonphysical, spiritual, control system effective. This suggests that people have found that property protection which takes advantage of people's belief in supernatural power is more practical than employing watchmen. Thus, what can be learned here is that the adoption of a supernatural property protection technique has been perceived by Maluku property owners to provide higher assurance of protection at less cost. Generally speaking, then, it is clear that mystical and/or religious beliefs have strongly influenced the kind of property protection system that the communities have developed, and that they are important in the case of *sasi* collective management systems.

The influence of customs

Some operational aspects of *sasi* are similar while some others vary. What is common for all cases is that a *sasi* almost always connotes a prohibition that follows a certain customary formality, and is assumed to be observed by every single individual who happens to be in the village, either temporarily or permanently. However, the actual forms of customary influence may be different from one *sasi* practice to another. These variations are apparently associated with differences in the way people of different localities adapt their customary laws into *sasi* formulation and implementation. Thus *sasi* practice may differ from village to village even though they may face similar circumstances.

Customs and customary values have involved in shaping the general design and control mechanism of *sasi*. A common characteristic of communities that adopted *sasi* in the past is their dependence on the natural environment for their sustenance. This has created a situation wherein they have had to manage their resources for the common good. Thus all resources that exist within the village domain are perceived to be the common property for all members of the community. In turn, this perception becomes an important customary value that every one in the community, from generation to generation, should respect. This means that every individual also has the right to participate in determining collective actions aimed at maximizing collective benefits. Consultative meetings facilitating the formulation process of *sasi* are an example of the result of the perceived need for collective action. Ideas and arguments are advanced by people, who are the actual stakeholders of the resource. Because of such meetings, many village communities in Maluku end up accepting the idea of *sasi*.

Although spatial and temporal variations might occur, the essence of collective action remains the same in all cases. In the old days, when the population of a village was generally small and their economic activities were limited, all members of the community might easily attend such meetings. However, now that the population has increased, holding an all-community meeting is quite a challenge. Instead, most villages in Maluku have adopted a representative system, where only members of the *saniri negeri* (lit: the village's customary deliberation council), are present at the meeting. There is some variation amongst villages with regard to the composition of a *saniri negeri,* but it normally is composed of *margas* (clans) or *soas* (groups of several clans). For more important cases, the meetings are attended by members of *saniri besar* (the village's customary consultative assembly), which includes all members of *saniri negeri,* village executives, customary elders, and other distinguished persons of the village.

Two things are worth mentioning concerning local variations. The first is the popularity of private *sasi*[2] in Southeast Maluku as compared to that in Central Maluku. Even though private *sasi* is found just about everywhere in Maluku, it is more prevalent in the Southeast. This apparently has something to do with the availability of more clearly stated individual rights in SE Maluku communities: *'hira i ni fo i ni, it did fo it did.'* (Theirs are theirs and ours are ours). What this suggests is that the people of Southeast Maluku are more likely to develop a private *sasi*. The second variation is associated with the past record of property rights transfers,

[2] private sasi is a sasi that is proposed by individuals and approved by the village council, so that enforcement is carried out following the usual arrangements of *sasi*..

which were common in many locations of Southeast Maluku. Granting pieces of land to groups of people belonging to another community was practiced extensively by early inhabitants of Southeast Maluku villages, including many in Kei Besar Island, with the hope that the newcomers would be able to guide the earlier inhabitants to a better life.

My field studies confirmed an important message, which was repeatedly stated by the villagers and their leaders. This message is that sanctions and other control mechanisms are not designed to intimidate people or to collect revenue from the ones who get caught committing violations. Instead, respondents reported that sanctions were established to persuade people not to betray the common interest. It is unlikely that they learned such a view from an external source, because they are generally isolated. Thus, principles that they follow must have come from something that they have acquired from internal sources, such as customary laws and religious values. Besides, as also emphasized by elders, this view is not a new invention. It is a customary value or *pusaka (*an heirloom), as the villagers claimed, which they have inherited from their predecessors. This claim is supported by a customary principle which says '*we carry out public matters according to customary laws*'. Thus, it can be argued that the message mentioned earlier in this paragraph is merely a reflection of their principles, which for the villagers comes from their customs or religious values.

Traces of customs or customary values are also found in primary control mechanisms that communities developed to sustain *sasi*. The following are several case illustrations of how sanctions, adopted by communities to help them as a form of control mechanism, are carried out in practice. In general, sanctions in *sasi* seem to be flexible because it is their effect which is actually the main concern. What is meant here is that a person caught violating a law has the potential to face the most severe punishment / sanction, available under customary law. However, another value in a community's custom allows for a moderate sanction to be considered when there is indication that the person is helpless and requires access to the resources to survive. Sometimes, circumstances might even prompt the leading decision-maker in the village to grant amnesty or pardon. More details on amnesty and other types of tolerance will be provided later.

Primary tools or control mechanisms normally consist of various moral sanctions, alienation, physical sanctions and fines of various kinds. Table 1 lists the types of sanctions that have been adopted by the village communities.

Table 1. Various types of sanction introduced by selected villages

	Shame		**Harvest right revocation**		**Valuable item fines**[2]		**Labor fines**		**Physical punishment**		**Cash fines**[3]		
Village	Past[1]	Pres[1]	Past	Pres	Past	Pres	Past	Pres	Past	Pres	Past	Pres	**Performance**[4]
Ohoirenan	√	-	-	-	√	√	√	√	√	√	-	√	*medium*
Weduar	√	-	-	-	-	√	√	√	-	√	-	√	*low*
Hollath	√	-	-	√	√	√	-	√	-	-	-	-	*high*
Wattlaar	√	-	-	-	-	√	√	√	-	-	-	√	*high*
Banda Effaruan	-	-	-	-	-	√	-	√	√	√	-	√	*low*
Kilwat	√	-	-	-	√	√	√	√	-	-	-	√	*medium*
Yamtel	√	-	-	-	-	-	-	-	√	-	-	√	*medium*
Hatta	√	-	-	√	-	-	√	√	-	-	-	√	*low*
Nolloth	√	-	-		-	-	√	√	√	√	-	√	*low*
Haruku	-	-	-		-	-	-	√	√	√	√	√	*medium*

Notes:

1. Past = implemented in the past, Pres = implemented in present times, after 1970
2. Common valuable items are *lela* (a small antique cannon from the Portuguese colonial era, priced at approximately Rp 300,000 each), some other antiques and gold
3. Cash is normally charged for the cost of the case process and fines, for which the amount is based on the level of the violation.
4. Performance: this category is based on the frequency of the violation within the past ten years, where low compliance is associated with more than ten violations; medium compliance is associated with five and ten violations; high compliance is associated with less than five violations.

Although different villages may introduce similar lists of sanctions to enforce *sasi*, the workability of these sanctions may not necessarily be the same in all cases. Given this, the way enforcement is actually carried out is an important issue. Formally, there are two distinct methods of enforcing *sasi*, depending on the type of customs that apply in the communities where *sasi* is adopted. One method relies on the effectiveness of the traditional police, called *kewang*, while the other is built on the premise of an effective 'community watch' system. Through either one of the two systems a violation might be discovered and reported to an assembly meeting for action.

On Lease Islands, in Central Maluku, most responsibilities for control and enforcement are given to the *Kewang*, whose job is to monitor the implementation of all of the regulations, to apply sanctions against violators, to control territorial boundaries, to place signs of *sasi,* and to arrange and hold both periodic and emergency meetings. To carry out its function, a *kewang* organization normally has the following structure: two *kepala kewangs* (leading *kewangs), kepala kewang darat* (for land resources*)* and *kepala kewang laut* (for marine resources*).* One of them also acts as the coordinator for both. Each of them, assisted by a *kewang pembantu* (assistant *kewang)* and several *anggota kewang (kewang* members), is responsible for their assigned tasks. In addition, the organization is also equipped with a secretary and a treasurer.

In Southeast Maluku, *sasi* control is based on the effectiveness of each individual reminding others about the importance of everyone participating in protecting their common resource. In some ways, this resembles a community watch system in western societies. There also is a strong indication that caste stratification characterizes enforcement mechanisms in this particular part of Maluku. The history of Eastern Maluku community development has made them acknowledge the existence of two[3] major caste categories, *mel* and *ren.* In the old days, outsiders were often invited by the original inhabitants of many villages to help them manage their natural resources. The consequence of this was that the outsiders, later called *mel*, became the first class in the social structure. The first inhabitants, later called *ren*, on the other hand, become the second class. Within this class arrangement, however, villagers prefer to use brotherly terms such as *adik* (younger brother) for the *mel* and *kakak* (older brother) for the *ren.* As a result, even though the *mel*s for all practical purposes are the ruling class, the *ren*s have a position by which their advice must be listened to by the *mels.*

One implication of the social stratification that exists in Southeast Malukuan communities is that, with the authority to rule the *ren*s, the *mel*s have the opportunity to maximize their share of benefits by asserting a more active role in resource management, and by taking advantage of their position. Their *sasi* arrangement shows that this opportunity has been implemented in practice. In Figure 1, it is shown that a portion of the revenue obtained by divers from the village collective sale, has to be surrendered to the village for common purposes including for redistribution. Table 2 shows that the redistribution is to secure the right of those who cannot dive such as children and woman. However, this table also shows that the marginal benefit is higher for the *mel* than for the *ren.* For example, the ruling group receives a larger share of the benefit generated from the resource harvest. Therefore, it can be argued that, given the *mel*'s social position, there is a tendency for this caste to increase its share even higher, by deceitfully taking some of the benefits which should go to the *ren*. This tendency, however is somewhat neutralized by the elder brotherhood status of *ren,* who will always be in the position of giving advice (read: reminders) if the younger brother attempts some irresponsible action. This is possible because monitoring everyone's actions with respect to the resource is not very difficult in many Southeast Maluku village communities. It is ease to see who comes in and goes out of the village, and how much they are taking. So, there is little chance that a person would be able to leave and take anything from the village without other villagers knowing.

Another implication of the existing caste system is that control is also carried out among the members of each group because they understand that the reputation of the group, and hence its credibility in the eyes of other groups, depends on the behavior of each individual member. Many respondents indicated that it would be a shame to have a violation perpetrated by a member of their group or clan. A quote from a respondent demonstrates this: 'Several years ago, I opted not to report a case of poaching which involved my clan member. Instead, I had him return the stolen trochus to the village, and told him not to poach again'. This indicates that from one point of view, the intense kinship relationships of the villagers could have an adverse effect on enforcement of regulations. In their society, however, individual homes are almost always open to everyone in the community, particularly those of the same caste or the same clan. Therefore it is not surprising that, as they emphasized in the interviews,

[3] There is another category of caste called *iri*, but it is not relevant to the discussion in this section.

monitoring other's behavior, both at home and at sea, is functioning well.

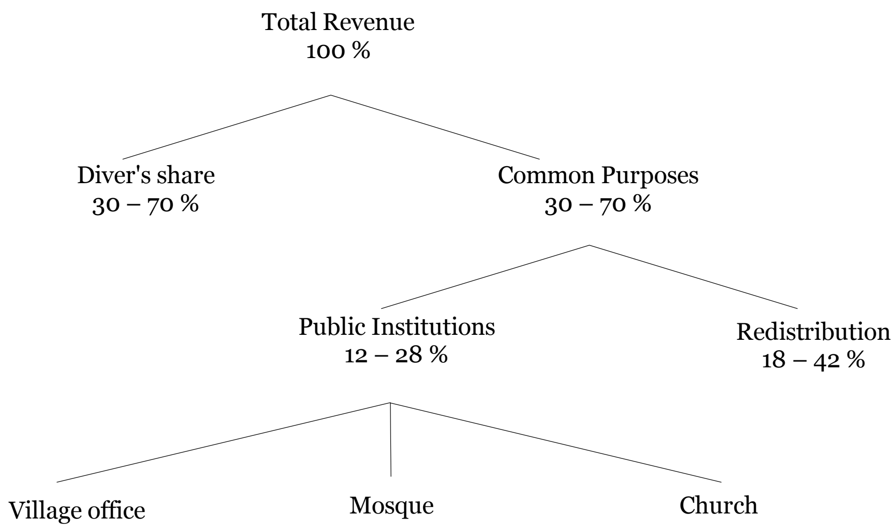

Figure 1. Diagram of revenue distribution in a *sasi* opening

Remark:

- Village institutions receive equal shares
- Redistribution to villlagers is carried out according to a plan as shown in Table 2

Table 2. The Ohoirenan's revenue redistribution (fixed share) scheme

Social category (*i*)[1]	Share factor (f_i)
Village head	5
Village secretary	4
Soa chief	3
Clan chief	2
Household head / widow	1
Unmarried aged 18+	.75
School drop-out	.50

Notes :

1. The benefit share received by a person of social category i is calculated as:

$$IR_i = RR \times \frac{f_1}{\sum f_i n_i}$$, where

IR_i, RR, and n_i are individual share, total redistributed revenue, and No. of people in category I, respectively

In Kei Besar, a good lesson that can be derived from the community watch system is that the system allows the development of awareness among villagers about the importance of observing rules. A friendlier atmosphere exists because 'community watch' is not a system where a guard watches for violations. Instead, it is, as understood by villagers, a system in which everyone is supposed to remind others not to violate local regulations. However, within this system, there are also potential drawbacks associated with the moral condition of the people. The example presented earlier where an individual was unwilling to disclose poaching because the poacher was a close family member is a case in point.

The *kewang system*, on the other hand, is a good alternative to the community watch system when it is unable to function well. Certain conditions need to exist for the *kewang* corps to be fully effective. For example, despite the prestige of being assigned to the corps, a *kewang* member still needs a sufficient source of income to support his family. Recently, many *kewang* members have experienced inadequate incomes due to declines in revenue associated with depreciation in the price of agricultural products. So, becoming a *kewang* member is not as attractive as it once was. Recently, the idea of providing a government subsidy to revive the *kewang system* was introduced (Haulussy, pers. comm.). However, this proposal will not be feasible because the costs that have to go to all *kewang* members may exceed the total revenue of harvest normally received by a village.

Religiousness

In addition to the formal sanctions and enforcement mechanisms, there are several intangibles that determine observance of sasi. One of these is religiousness. It is not unusual for Maluku people to characterize a village by looking at the prevalence of religious followers. A village is referred to as Christian (loc: *Kampung Kristen)* because the majority of its citizens are Christian, and it is called Moslem (loc: *Kampung Islam)* if most of the citizens follow Islamic teaching. When comparing the effectiveness of *sasi* in a number of villages of Kei Besar, in general it looks like the Christian villages were able to maintain *sasi* practices better than their neighboring Moslem villages. Wattlaar (Catholic), Ohoirenan (Protestant), and Hollath (Catholic/Protestant) are villages where the *sasi* management system has been sustained quite successfully, while in Banda Efaruan (Moslem) and Weduar (Protestant/ Islam), *sasi* is not functioning very well.

On the other hand, *sasi* practices in Saparua of Central Maluku provide evidence that it is not the type of religion *per se* that contributes to the performance of *sasi*. The fact that *sasi*es are functioning better in Christian villages of Kei Besar and in Moslem villages of Saparua appears to be an inconsistency. The argument put forward by Wilson (1982) and McNamara and Tempenis (1999) regarding the role of religiousness in law enforcement might provide a plausible explanation for these inconsistencies. Therefore, in the following paragraphs we will examine these religious aspects. Based on my field observation, special attention will be given to the leadership / organizational structure and the comprehension and practice of religious teachings amongst the people.

A distinction in terms of leadership and organizational structure is recognizable between the two major religions in Maluku, Islam and Christianity. The Christians have a more formal / coordinated type of organization, while the Moslems maintain a relatively loose structure. The Christian community form of governance is very effective, because each member is associated with one of the zonal groupings of the community. As a result, messages from a local Christian leader can be transmitted to virtually every member of the congregation within the respective village. A continuing flow of financial contributions necessary to sustain religious services can also be encouraged. The Moslem organizational style, on the other hand, does not have a solid structure. Consequently, Moslem villages do not have the same opportunity to mobilize collective action that Christian ones do.

Despite the fact that most Moslem communities are not traditionally well equipped with a solid administrative organization, there are cases where a devoted Moslem is quite influential in performing effective organizational functions for his fellows. The head of the religiously mixed village of Weduar, for example, notes that there was a period when leaders of the Moslem society in his village were able to establish good interaction with their community so that coordination could work well. Furthermore, the village head elaborated that this will be the case as long as religious leaders have a good appreciation of local history and customs; especially an appreciation of the fact that people in the village have a common heritage. He noted that a priest was expelled from the community recently because he had failed to recognize local customs and history. On the Moslem side, the same community is also facing difficulty because their leader is 'too young', and too immature to understand the customs and history of the village.

These illustrations carry two important messages. The first is that the efficient organizational arrangement featured by the Christian communities has the potential to contribute to the effective communication and administration necessary to mobilize support for public affairs. This may include support for the development of a co-management program such as is proposed in this study. However, the second advises that the actual effect of Christian organizational styles depends on how customary values are recognized, because, to villagers, customs and religions are both important. What this means is that the highly organized administration such as that shown in the Malukuan Christian model, could fail to result in good coordination in the absence of an appreciation of local customs. Conversely, the loose organization common to the Moslems can be sufficient to mobilize people as long as customs are respected. So, it is clear that the significance of the organizational aspect of religions is subject to the incorporation of local customs and values.

Comprehension and practice of religious teachings is another important factor. In Maluku, religious teachings clearly can promote the social behaviors necessary to sustain the collective regulation of common use resources such as *sasi,* because they instruct people to be considerate of each other, a fundamental condition for a collective regulation. However, the extent to which a religion's teachings penetrate the life of its adherents is also a factor, as there is often a gap between the teachings and peoples' actual behavior. More specifically, what matters is whether or not people incorporate religious teachings into their lives. In fact, in several Christian and Moslem villages, only a few people practice what is taught by their religious leaders.

Ay is a village in the Banda Islands where a trochus fishery is a potential venture. In the past, trochus harvests generated a considerable amount of revenue for the village. However, because of poor management in the past, trochus harvest has generated little revenue for the past two decades. Several attempts to rebuild the trochus resource were made by villagers who realized the potential of adopting the *sasi* system, but none of them was successful. A distinguished Moslem educator of the village argued that there could not be a functioning *sasi* system until the people practiced the religion more thoroughly. To emphasize his contention, he pointed to the poor attendance of the village mosque. The statement of Dullah, a citizen of the neighboring island village of Kampung Baru, confirmed the educator's claim: 'The villagers of Ay are frequent champions of the *Kora* boat race held each year in the Banda Islands, but their victory celebrations do not conform to their religious beliefs because liquor consumption is associated with the celebrations, and this is forbidden by the Islamic teaching'.

Wisdom, the leader's improvised approaches

A story of a forgiven trochus poacher has become a legend for the people of Wattlaar Village. It is a story that shows a Rajah's wisdom in using a non-physical, yet effective, punishment on a *sasi* violation. *Bapak Raja* Rahail of Wattlaar is a seventy-year-old, respected leader who has been serving in the traditional role as a Rajah in Wattaar, a 'kingdom' that reigns over 46 kampongs (11 *desas*/ villages) in the northern part of the Kei Besar Island. Even though more stringent alternatives are available, his approach to various cases has been and still is mostly persuasive. Most of the villagers recall a specific case, the theft of *sasied* trochus by a poor woman. Some buried shells were found by a sand gatherer, who reported his find to the Rajah. The buried shells were taken to be the proof of a theft. The Rajah had a respected elder pray that the guilty thief would not escape punishment and announced a three-day grace period during which the thief could confess to committing the crime. The day before the deadline a poor woman admitted that she had stolen the trochus and said that she was prepared for whatever punishment the customary law stated she should receive. Wisely, the Rajah forgave the woman on the condition that she did not repeat the offence, and the villagers agreed with his decision. The people in the village believe that a prayer like the one mentioned in this case would affect the poacher by causing sickness or even death.

Another example of a leader's effective approach to violation cases can be found in Haruku, in Central Maluku. For those who have violated a *sasi* or any other regulation, *kewang* members will consider total forgiveness or at most some moderate penalty such as a gentle lash of a rattan whip, for violators who show remorse over having committed the crime. (Kissya, pers. com.).

Geographical markers such as rivers, big rocks or tips of forelands are often used to define *sasi* boundaries. People usually recognize that a place is under *sasi* when a certain type of sign is placed on those boundaries. These signs may be in the form of stone or leaf markers (Zerner 1990). *Sasi* rules apply to basically everyone, including outsiders who happen to visit or stay in the village. On rare occasions an exception may be made to the *sasi* in an emergency situation. A needy passer-by, for example, might be granted permission to take one or two pieces of *sasi*ed coconut to satisfy his hunger or thirst.

Once the *sasi* markers are placed, a *masa sasi*, which literally means the duration of *sasi*, is in effect, and no one is allowed to harvest the resource. When the time comes again for harvest, i.e., when the *sasied* crops or fish have met a certain level of maturity or abundance, and weather permitting (in the case of marine *sasi*), another procession is held to mark the time to lift the closure. This procession or ceremony is called *buka sasi*, which literally means 'opening *sasi*'.

WHY TRADITIONAL KNOWLEDGE WAS EFFECTIVE – UPDATING BASED ON SCIENTIFIC ADVICE

In the past, communities found no difficulty in adopting and relying on traditional knowledge to manage their natural resources. Traditional knowledge was sufficient for the community to make the right decisions regarding resource use in order to meet objectives that could be both economic and non-economic in nature. An example of a non-economic objective is the ability to maintain their pride of having natural wealth. Ruttan (1995) notes that villagers have a tendency to be proud of the natural wealth of their village. Therefore, they had an incentive to conserve the resource endowment existing in the village in order to maintain their pride. Transforming traditional knowledge into *sasi* restrictions was an effective way by which to realize their objectives. Traditional knowledge helped maintain resources at a sustainable level with economic returns enough to satisfy the need of people at that time.

Changes in external circumstances, however, have left the *sasi* system vulnerable to failure. As happened in many locations, *sasi* failed to maintain its management function. Benda-Beckmann *et. al.* (1995) suggest that economic elements have been a major factor contributing to this failure and cite instances where community leaders often let citizens increase the rate of natural harvest for the sake of short-term gains. Other researchers tend to support Beckmann's concern, for example, Zerner (1994) notes that in the past immature trochus were not taken by traders because they had no commercial value. In my own recent field observations in Maluku market centers, I found traders purchasing considerable quantities of illegal immature trochus. Antunès and Dwiyono (1998) report similar findings.

Nowadays, traditional knowledge is neglected by communities in many locations because they believe that it is no longer enough to enable them to keep up with the current changes in external circumstances. While the traditional knowledge is based on long observations of natural dynamics, the current external changes happen so quickly that harvest adjustments made according to traditional knowledge rarely end up with the expected outputs. As a result, depletion may occur even though *sasi* restrictions are still observed. This never happened in the past because external changes took place gradually so that major adjustments were not necessary.

Nevertheless, people in several other locations still find traditional knowledge worth adopting in resource management. In these locations, communities succeed in neutralizing economic pressure on the *sasi* arrangement by adopting appropriate modifications. A success story regarding this can be found in Ohoirenan Village, where the involvement and advice of modern scientists has led to improvements in the reliability of information acquired from traditional learning processes. For example, people combine the growth prediction based on environmental data provided by local biologists with their knowledge about the spatial distribution of an economic marine commodity called trochus (*Trochus niloticus*). Their harvest strategy, which is based on these two types of information, is a *sasi* arrangement which include spatial harvest rotation based on traditional knowledge and size restriction based on modern scientific advice. The result is that the Ohoirenan village is able to maintain a more sustainable harvest compared to other villages.

The Ohoirenan village example actually represents a practical form of Fong's (1984) 'wedding' between science and tradition. It is a wedding that offers an opportunity to incorporate modern science into the traditional management system so that a community can make proper responses to economic and ecological changes. In the *sasi* context, this means that some of the practical aspects of the tradition are adjusted to allow for the inclusion of external variables beyond their control. As happens in Ohoirenan Village, the closure period would no longer be determined merely by the community's judgment. Instead, it reflects a compromise with various inputs, including those from outsiders.

The above discussion conveys an important message, i.e., that traditional knowledge can be effective in many locations in Malukuan communities due to at least two conditions. The first is that the *sasi* system, by which traditional knowledge is implemented, is observed by community members, and the second is that the communities are willing to incorporate outside knowledge to improve their traditional system.

Furthermore, the study also shows that observance of *sasi* is supported by several cultural factors and some other intangibles. Following this, the author recommends a process of knowledge transfer where knowledge and elements from communities where *sasi* is working, is used to improve conditions in communities where *sasi* is not effective.

CONCLUDING NOTE: A PROPOSED WORKING MODEL

Following from the above, the author proposes a working model, which communities may wish to adopt in order to make their traditional/local knowledge effective in resource management. The building blocks of this model areas follows: (1) operative components of local tradition[4], (2) local and scientific information on biological dynamics of natural commodities that need management and (3) information on local human and physical environment in the place where local knowledge is to be made effective in resource management.

Based on the findings of this case study on the Malukuan local knowledge about certain aspects of growth of *trochus*[5], the development of a working model in a community, as proposed here, may take the following steps:

1. Construct a dynamic model that simulates traditional resource management practice in the community, based on both local and scientific information.
2. Use the community's knowledge of historical records of the dynamics of the resource to calibrate and validate the simulation model.
3. Use the revised simulation model to predict the outputs of different harvest rates.
4. Use model predictions to identify elements of traditional community management that may need improvement.
5. Identify the community's human and physical circumstances, compare them to communities where local regulations are observed, and determine necessary actions which allow modification in management tradition to take place and promote community compliance with the modified management system.

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[4] In the case of Malukuan, this means *sasi* tradition

[5] Trochus (*Trochus niloticus*), is a sedentary marine species whose shells have high economic value