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Inside this issue

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Editor's note

This edition contains articles with refreshingly contrasting points of view. Let's hope we succeed in rattling a few cages and provoking some responses.

In the first article, "Evolution of the artisanal fisher: Case-studies from Solomon Islands and Papua New Guinea", Armagan Sabetian and Simon Foale examine the increases in fishing efficiency brought about by new technologies on Ghizo Island, in Western Province of Solomon Islands, and from Milne Bay Province in Papua New Guinea. These case studies reassert the idea that very low human population densities, rather than some form of "traditional management" or conservation ethic, have so far protected many fisheries in the Solomon Islands and Papua New Guinea. The authors' evidence shows that fishermen are basically unaware of the finite nature of the stocks they are exploiting, so without systematic management interventions the new technologies and the expansion of Asian export markets will accelerate sequential overfishing. "… in the absence of widespread and systematic intervention, the only uncertainty at present is how long it will take for each fishery to collapse." This, their concluding sentence, is sobering: downright frightening in fact, now that we understand that this is a worldwide situation.

Then read and think about the second article, "Traditional marine resource management in Vanuatu: Acknowledging, supporting and strengthening indigenous management systems", by Francis Hickey. The erosion and transformation of traditional concepts and practices related to marine resource management in Vanuatu that began with the arrival of Europeans has more recently been accelerated and deepened by the forces of development and globalization. Now a more commercially motivated system of marine resource management is gradually replacing the culturally motivated regimes. Hickey reviews some traditional marine resource management beliefs and practices, and documents their adaptation to contemporary circumstances. He is aiming "for a greater recognition, strengthening and support for these indigenous systems in Vanuatu and the region."

The theme of technological modernization and related social and cultural change is continued in "Socialisation of fishing knowledge: The emergence and transmission of new fishing technology and marine ecological knowledge in the Republic of Palau, Western Micronesia", contributed by Yoshitaka Ota. Ota examines the emergence of marine environmental knowledge and the application of new fishing practices in three key fishing

methods: speargun fishing, hand-held trolling, and trapping. He demonstrates that technological change does not always undermine the social and cultural elements of fishing; rather they may be reinforced or even augmented by it.

Occasionally we publish a contribution from outside our main region of focus. This time we are pleased to be able to include a short article of interest to readers working on grouper spawning aggregations in other parts of the world. In their article "Local ecological knowledge and Goliath grouper spawning aggregations in the South Atlantic Ocean: Goliath grouper spawning aggregations in Brazil", Leopoldo C. Gerhardinger, Athila A. Bertoncini and Mauricio Hostim-Silva document the first evidence of Goliath grouper *(Epinephelus itajara)* spawning aggregations in the South Atlantic, based on the knowledge of local fishermen and derived from an ongoing local ecological knowledge survey of the bio-ecological and conservation aspects of the Goliath grouper. Basic information on a network of government and non-governmental institutions that form the Brazilian Goliath Grouper Conservation Campaign (http://www.merosdobrasil.org) is included.

Several potential contributors have recently asked if articles in this Information Bulletin are peer reviewed. You should be aware that on an informal basis, I obtain anonymous peer reviews for articles submitted by persons from academic institutions, since they often need to "claim them" for promotion and other purposes. I do not do the same with other articles. However, should they wish them to be, non-academic contributors should request that their articles be reviewed when they are submitted.

This is not intended as any form of discrimination, rather it is simply because some persons feel intimidated by peer review, even if it is anonymous, and might be shy about submitting articles. And I certainly do not wish to discourage excellent contributions from persons with neither the need nor the desire to meet rigorous academic publication standards. On the contrary, in fact!

Kenneth Ruddle

PIMRIS is a joint project of 5 international organisations concerned with fisheries and marine resource development in the Pacific Islands region. The project is executed by the Secretariat of the Pacific Community (SPC), the South Pacific Forum Fisheries Agency (FFA), the University of the South Pacific (USP), the South Pacific Applied Geoscience Commission (SOPAC), and the Pacific Regional Environment Programme (SPREP). This bulletin is produced by SPC as part of its commitment to PIMRIS. The aim of PIMRIS is to improve the availability of information on marine resources to users in the region, so as to support their rational development and management. PIMRIS activities include: the active collection, cataloguing and archiving of technical documents, especially ephemera ("grey literature"); evaluation, repackaging and dissemination of information; provision of literature searches, question-and-answer services and bibliographic support; and assistance with the development of in-country reference collections and databases on marine resources.

PIMRIS

Pacific Islands Marine Resources Information System

Evolution of the artisanal fisher: Case studies from Solomon Islands and Papua New Guinea

Armagan Sabetian[1] and Simon Foale[2]

Abstract

In this article we describe the rapid uptake of technology that increases fishing efficiency in two parts of western Melanesia: Ghizo Island in Western Province, Solomon Islands, and Milne Bay Province in Papua New Guinea. We present evidence that demonstrates a disturbing lack of awareness among fishers of the finite nature of the stocks they are exploiting, and we argue that without corresponding systematic management interventions, the technological transformations we are now witnessing will accelerate the present pattern of sequential overfishing of commercially valuable species.

Introduction

Effective management and conservation of coral reef marine resources in coastal tropical regions is increasingly the subject of discussion within scientific, political and economic realms. Simply put, the fundamental role that marine resources play in the social and economic well-being of developing nations makes it a topic of interest across many academic disciplines. In particular, the impact of subsistence and artisanal fishing is increasingly being investigated both by marine and social scientists.

The economic importance of artisanal fishing to developing tropical countries is increasingly being highlighted (Alison and Ellis 2001; Sadovy 2005). However, even with a growing body of evidence pointing towards adverse ecological and biological effects (Jennings et al. 1999; Hawkins and Roberts 2004; Tuya et al. 2006) there is still a widespread perception that artisanal fishing has little impact, and this is perpetuated by a myth that this form of fishing is pursued by small-scale fishers using traditional methods, which are viewed by some as environmentally benign (Hawkins and Roberts 2004). In this paper we describe the rapidity with which hitherto relatively benign fisheries in Melanesia are transitioning to enterprises that pose significant commercial and ecological threats. Fishers are increasingly incorporating the use of technologies such as outboard motors, handheld global positioning units and scuba, inevitably resulting in much heavier fishing effort.

The idea that some form of "traditional management" or conservation ethic will help prevent overfishing in areas where the "corrupting" influence of modernisation has not yet penetrated is in our view is misguided (Foale 2006). Probably the most important factor contributing to the persistence of many fisheries in the Solomon Islands and Papua New Guinea to date has been the very low human population densities of those countries (12 and 16 people per km^2, respectively: Foale 2005). Despite this, the last two decades have seen the abrupt collapse of a number of formerly lucrative fisheries, including giant clam (*Tridacna gigas*), green snail (*Turbo marmoratus*), sandfish (*Holothuria scabra*) and black teatfish (*H. nobilis*), throughout most of Papua New Guinea and the Solomon Islands. We believe that the combination of increased access to improved fishing technologies and the expansion of export markets will rapidly reverse the protection that low human population densities have afforded fisheries in the region until now.

Scuba spearfishing in the Caribbean has been previously highlighted (NOAA 2002). However, until recently spearfishing on scuba was not considered an issue in the Pacific Islands as access to equipment, logistics and technical knowledge remained outside the reach of most people. Economic development, especially in the tourism sector, and the establishment of many dive outfits are increasingly changing this scenario.

The tourism boom has most notably been evident in Fiji, where in a global report on coral reef fish-

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eries (Wilkinson 2004), scuba spearfishing was highlighted as a serious emerging threat. The expansion of more efficient fishing methods, such as scuba spearfishing, is an inevitable evolution of artisanal fisher behaviour in developing countries where economic realities are dictating changes in the utilisation of marine resources.

In the Solomon Islands for example, where the majority of local artisanal fishers have access to motorised boats, the increasing use of air compressors (hookah) and scuba gear by untrained fishers targeting lucrative bech-de-mer species has been causing concern, and in some instances injury and death according to WWF's Bruno Manele (see also below).

However, the use of methods such as scuba and hookah would presumably be higher around densely populated urban centres, where demand for fish is higher and access to logistical support easier. A decade ago Adams et al. (1996) highlighted the fact that urban centres posed the greatest threat to nearby coral reefs fisheries in the Pacific Islands. However, because "total fishery crashes are unlikely due to excess demand being met from surrounding islands" (Adams et al. 1996), localised crashes in fish stock numbers are unlikely to attract attention from the wider community.

Here we present and discuss the findings of two separate studies carried out in the Solomon Islands and Papua New Guinea (Fig. 1).

Part 1: Ghizo Island, Solomon Islands

Background information

Over the past three years, one of the authors of this paper (Sabetian) has conducted a wide ranging investigation into the status of the parrotfish (Scarid) fishery around Ghizo Island, Western Solomon Islands (Fig. 2). For the purpose of this exercise "Ghizo reefs" refer to areas on the east and southeastern side of the island, which contain alienated lands and adjacent coral reefs that are now administered by the national government. As such, access to these reefs is open to all subsistence and artisanal fishers. Gizo town (note the difference in spelling between the town and the island) is the second largest urban centre in the Solomons, within which the last census in 1999 reported a permanent population of approximately 8000 individuals (Otter 2002).

Typical of urban centres described by Adams et al. (1996), Ghizo's population is gradually increasing through rapid immigration by people looking for employment. This has meant that the percentage of income generated from informal economic activities such as fishing is inevitably increasing (Otter 2002). Gizo town has by far the biggest fish and food market in Western Province. The local economy revolves around services and tourism, but the food market, which is open 24 hours every day, attracts people from all around the area, including fishers and agricultural produce sellers from other provinces such as

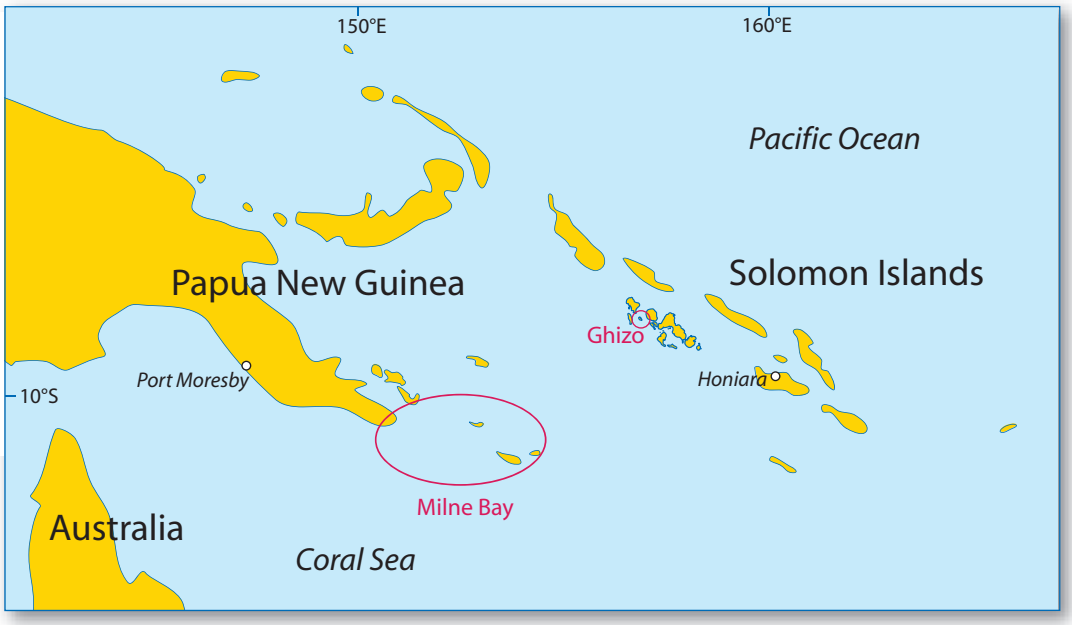

Figure 1. Papua New Guinea and Solomon Islands showing Ghizo Island and Milne Bay Province

Choiseul and Santa Isabel. In simple economic terms, the accumulation of wealth around urban centres such as Gizo is what prompts people to travel very long distances to sell their catches or produce. Furthermore, the ever-increasing necessity for money in a cash economy has inevitably led to the expansion of trading hours around the clock, which a few years ago were not in place.

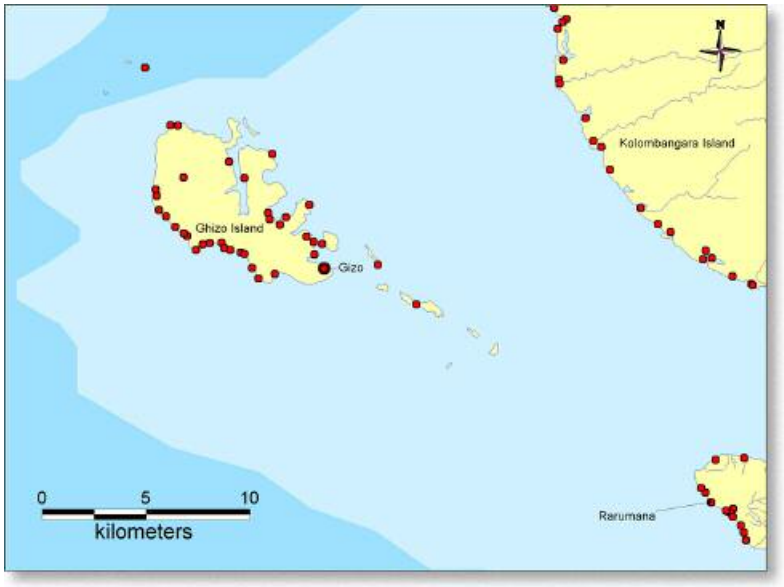

Figure 2. Ghizo Island showing Gizo town and proximity to the large island of Kolombangara and the large village of Rarumana on Kohingo Island.

Comparative analysis of catch and creel data has revealed localised declines in catch numbers, supported by declining estimates of parrotfish abundance and distribution between 2004 and 2005 (Sabetian, unpublished data). As part of this study, a survey was carried out through interviews with 15 artisanal fishers (see questions below). We discuss the results of this survey and investigate the implications of fisher behaviour and perception in relation to localised fishery crashes.

Fisher survey

The purpose of this survey was to engage fishers in dialogue that covered topics such as their skills and knowledge, their perception of resource use and management, and speculation of future trends. Seven questions were asked in a semi-structured interview format and elaborated on where necessary.

Questions:

1. How would you rate your knowledge of parrotfish behaviour, and ecology? Give examples.
2. What is the best method with which to target parrotfish? Why?
3. Are parrotfish popular with customers? Which species?
4. Which fishing grounds have you targeted over the years? Which ones are you targeting now?
5. How would you rate the parrotfish stocks around Ghizo?
6. What do you think of past, current, and future fishing trends around Ghizo?
7. Do you intend to continue fishing as a main source of income? What would you like to do or have to do to increase your fishing capacity?

The first two questions deal with ecological knowledge and most effective fishing methods. Detailed knowledge of parrotfish behaviour was observed. All (n=15) interviewees made reference to the fact that parrotfish are herbivorous and as such, netting and spearfishing are the only techniques that can be used efficiently. Twelve fishers made specific reference to the fact that some parrotfish ate corals, while some appeared to scrape at different surfaces. There was unanimous agreement that parrotfish are most feasibly targeted at night, using spears as they generally aggregate in sleeping groups.

Ten fishers rated parrotfish as equally popular with customers as other fish. All fishers rated the bumphead parrotfish (*Bolbometopon muricatum*) as the most desirable and highly profitable species with locals and commercial food outlets, such as restaurants and resorts. One fisher claimed to have a contract with a local resort, which required him to supply bumpheads to the resort's restaurant on a weekly basis.

Answers to the fourth question were varied, covering nearly all areas of Western Province, from Ghizo to the nearby Hapu Hapu reefs and also the uninhabited areas of Rarumana and north New Georgia. Six fishers claimed to be no longer targeting the Ghizo reefs due to low catch rates, while four indicated that they still accessed Ghizo reefs but also targeted other fishing spots. All fishers indicated that Ghizo was still popular with people who did not have access to motorised boats. Seven informants suggested that non-indigenous Gilbertese fishers were the most brazen at targeting customary owned fishing grounds as far as inner VonaVona Lagoon and even marine protected sites. Although anecdotal evidence appears to support this claim, it needs to be further investigated and validated.

The unanimous perception of the 15 fishers was that the size of fish across all families has been steadily declining over the past decade. Nine fishers claimed that fishing effort has significantly increased in the past three to four years, leading to noticeable declines in size and abundance of fish across the board. The overall sentiment was that more people are now resorting to fishing as a way to generate or supplement incomes. When fishers were asked to elaborate on the reasons for the increase in fishing pressure around Ghizo, the responses were more interesting. The ethnic Malaitan fishers blamed the civil unrest between 1999 and 2003. This event was responsible for significant numbers of Malaitans being intimidated and forced to either keep a low profile or leave their settlement on Ghizo. The Malaitan settlement on Ghizo is referred to as the "fishery" because the majority of inhabitants are artisanal or small-scale commercial fishers and as such are a major driving force behind Gizo's local fish market. The Malaitan fishers claimed that the demographic nature of the fishery changed during the height of violence and lawlessness (June 2000–late 2001) when some could no longer practice their trade. The gap left by the absence of some Malaitan fishers was largely filled by local Gilbertese fishers who met the demand for fish through the consequent intensification of fishing effort on the surrounding reefs utilising night-time spearfishing. Furthermore, night-time spear fishers have an added advantage of being the first sellers on the daily fish markets before the arrival of other fishers in the afternoon.

The next question asked each fisher about their perception of current, past and future fishing trends around Ghizo. There was unanimous agreement that parrotfish had become prominent in fish sales because of an increase in spearfishing. Eight fishers claimed that parrotfish numbers had noticeably declined within the market in 2005, with five fishers claiming to have noticed absence of specific species such as *Scarus ghobban* and *Chlorurus microrhinos*. Three fishers claimed of knowing crews of spearfishers who have spent 12 hours fishing the Ghizo reefs. In local parlance this is referred to as "six to six" where crews of spearfishers visit numerous reefs starting from 6 pm and lasting through to the early hours of the morning. Although we had been told of six to six fishing by a Gilbertese fisher, he did suggest that its persistence would not be long-term due to its strenuous and laborious nature.

When pressed on their perception of the overall productivity of Ghizo reefs, respondents unanimously agreed that fish numbers had declined across all families. However, only three fishers perceived this to be a problem as the others pointed to the fact that demand was being met by an expansion of fishing area to more productive reefs. Four fishers claimed personal knowledge that fish stocks, parrotfish in particular, are still very healthy around the uninhabited areas of Rarumana (20 km by sea southeast of Gizo town), but did concede that the most productive and cost-effective way to target the area was through mobilizing large crews (between 8 and 10 fishers) and utilizing nets as long as 200 metres.

The final question pressed interviewees on their chosen profession. Twelve fishers indicated that they were happy with fishing as a source of income and intended to continue in the future. The remaining three respondents displayed reservations, citing logistical restrictions. Interestingly, no one seemed to suggest that the apparent localised decline of fish stocks around Ghizo would force an early cessation of their fishing activity. All fishers indicated a strong desire for improvements in fishing technology, access to fibreglass boats, and bigger outboard motors. Nine fishers indicated their desire for independence, conceding that their inability to acquire fishing gears such as nets, boats and outboard motors on their own was the major reason why they still persisted with working in crews. One very interesting revelation from six respondents was their desire to learn how to scuba dive and also use hookah equipment. While others demonstrated reservations, these fishers indicated that the use of scuba, for example, would allow them to target known sleeping grounds of large fish such as the bumphead parrotfish and humphead wrasse (*Cheilinus undulatus*). This is an alarming development given the increasing anecdotal evidence of scuba spearfishing in the Pacific (Wilkinson 2004).

The above data point to two very important issues. The first concerns the inherent contradiction between a) the observations made by fishers concerning the marked declines in both size and abundance of fish within their own, often relatively brief careers, and b) their expressed desires to acquire further equipment that would enable them to increase their fishing effort and make more money. The almost complete absence of anything resembling a conservation ethic among the vast majority of fishers in the Solomon Islands is something we cannot emphasise too strongly here. There are of course a few enlightened individuals here and there who can clearly see what is happening to fisheries and are struggling to do something about it, but such people are in a tiny minority.

The second issue concerns access to reefs. Reef tenure around Ghizo Island, as far as we are aware, is quite problematic. Most of Ghizo Island, apart from one or two small parcels at the western end, is part of the 15% of land in Solomon Islands referred

to as "alienated land" (the other 85% is held under various forms of customary ownership, which is endorsed by the state). This means that the land was purchased from its former traditional custodians during the colonial era, and was converted to leasehold land, often a 99-year lease. These leases are presently held by the government of Solomon Islands. Because most of the reefs in question are adjacent to alienated land, their legal status appears to be somewhat ambiguous, and at present most are nominally the possessions of the government. However enquiries to the Lands Department about this issue by the second author in 2000 yielded contradictory and confusing responses. It is very likely that, if large deposits of precious minerals were discovered under any of the reefs around Gizo, a number of competing claims from customary owners would be made. How such claims would be resolved would most likely depend on each individual case (Kabui 1997). Therefore, Ghizo currently represents a situation where there is essentially open access to reefs, and as such there is no customary (nor any other) mechanism for enforcing restrictions. However even if the will existed within the provincial government to exert fishing restrictions over reefs around Ghizo Island, there is no capacity to enforce them.

Part 2: Milne Bay, Papua New Guinea

The material for the second part of our analysis comes from the "Small Islands in Peril Study" (SMIP), which focussed on marine and coastal resource management issues on small islands in Milne Bay (Fig. 3) that have population densities higher than 100 people per km^2. At these densities it is no longer possible to support the population with swidden agriculture, and food produced by subsistence farming is usually therefore supplemented by food obtained with cash, and the cash is mostly obtained by artisanal fishing. The most important artisanal fisheries at present in Milne Bay are beche-de-mer and shark fin.

The people living on SMIP with the highest population densities mostly happen to be those with access to very large marine territories that include vast expanses of coral reefs. The two most important examples are Ware Island in the Bwanabwana group and Brooker Island in the Louisiade group (Fig. 4). Most of the findings from the SMIP study have been published (Foale 2005) but recent unpublished data on catch per unit of effort (CPUE) for beche-de-mer give useful insights on the impact of increased use of modern technologies in artisanal

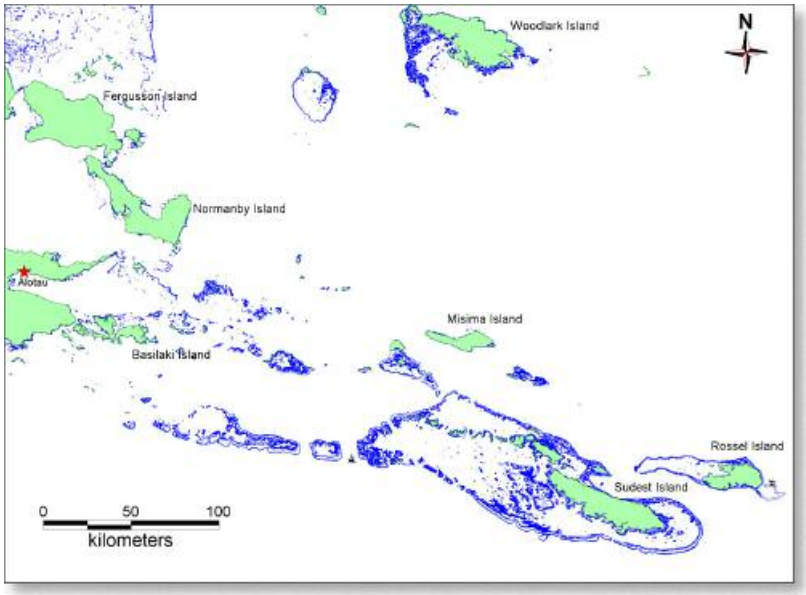

Figure 3. Milne Bay Province, showing all the major islands, with the exception of the Trobriands and Goodenough (to the northwest). The reef layer in this map was kindly provided by Tom Taranto of CSIRO, Cleveland Marine Laboratories, Australia.

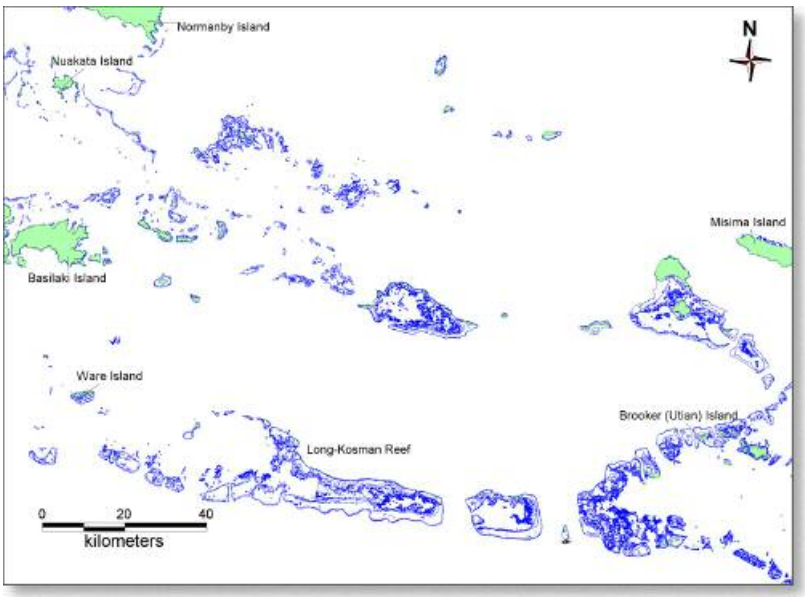

Figure 4. Southwestern Milne Bay showing Ware and Brooker islands, and the very large reef complex stretching between these two islands, which is claimed and fished by people from them. The exact location of the territorial boundary bisecting Brooker and Ware marine territories is still under dispute. The reef layer in this map was kindly provided by Tom Taranto of CSIRO, Cleveland Marine Laboratories, Australia.

fisheries in Milne Bay, which we will briefly summarise and discuss below.

Over the past five to ten years, the beche-de-mer fishery in Milne Bay has undergone rapid modernisation. When Kinch (1999, 2002) measured the CPUE of beche-de-mer fishers from Brooker Islander in 1999 (see also Allen et al. 2003), diving done from traditional sailing vessels, *sailaus*, (Fig. 5), using cheap plastic Chinese goggles and little else apart from the weighted spike that is dropped on the slugs from above. Now the same fishers are diving from far more manoeuvrable outboard-powered fibreglass dinghies (Fig. 6), using modern diving masks, fins, wetsuits, and in some cases (even though it is illegal) hookah gear. Pressure on the remaining high-grade species (mainly white teatfish, *Holothuria fuscogilva*, and prickly redfish, *Thelenota ananas*) has escalated to the point where territorial clashes between Brooker and Ware fishers have become increasingly common, often with violent altercations.

The greater depth range of white teatfish (down to 40 m) has afforded it a significant refuge from fishing pressure, as it is difficult for even the best divers on breath-hold to catch animals at these depths, even in calm conditions with no current. This means that white teatfish stocks will probably take longer to deplete than species with shallower depth ranges, such as sandfish and black teatfish, which are already commercially extinct throughout most of Milne Bay (Skewes et al. 2002). Indeed this is likely to be one of the main reasons (along with the government-enforced six-month closed season) that there are still fishable stocks of white teatfish in Milne Bay. Based on data from 58 diver-days in the first half of 2006, CPUE for Ware Island fishermen was 0.37 white teatfish slugs per diver-hour, with standard deviation of 0.40. The average CPUE obtained by Kinch for Brooker divers in 1999 (Allen et al. 2003, pp. 67–69) was 0.2 white teatfish slugs per diver-hour.

It is worth observing that current levels of beche-de-mer fishing have resulted in the deforestation of several cays along the Long-Kosman Reef complex for firewood. Beche-de-mer are cooked on these small uninhabited islands, which are used as camps for one to two-week-long fishing trips, made mainly by Ware and Brooker Islanders (Geoff Callister, pers. comm.). Apart from the six-month closed season, and what appear to be increasingly frequent and acrimonious territorial disputes between Brooker and Ware Island fishers, the fishery is essentially unregulated. There is very little in the way of local level management initiatives, and one of the reasons for this is an apparent lack of awareness of the limits of stocks. Foale (2005) presents interview data from islands in the Bwanabwana language group (which includes Ware Island) on the topic of perceived limits to fished stocks (reproduced in Table 1 below). Foales demonstrates that there is relatively low awareness of limits to beche-de-mer, even despite the common knowledge of sandfish and black teat overfishing, and an almost total disbelief that there might be limits to finfish populations.

We believe the apparent lack of awareness of the limits to fished populations is largely (though not entirely) related to a lack of knowledge about the ways in which populations of marine organisms replace themselves, particularly the process of broadcast spawning, larval dispersal and settlement. Table 2 below (also from Foale 2005) shows answers to interview questions about modes

Figure 5. Milne Bay *sailau*.

Figure 6. Modern fibreglass dinghy with beche-de-mer divers from Ware Island on board. Photo kindly provided by Geoff Callister.

of reproduction in fished organisms such as beche-de-mer and fish.

Given the high variance in our CPUE data, it is unlikely that the current average CPUE is significantly different from Kinch's data, and without other contemporaneous fishery-independent data on stock densities[3], we cannot quantify fishing efficiency of the more recent, dinghy-based diving system relative to the older *sailau*-based one. However we can at least speculate that since fishing efficiency is almost certainly significantly higher, and CPUE not significantly different, that white teatfish stocks are likely to have declined in density since the late 1990s. This is hardly a surprising conclusion given the recent complete closure of the beche-de-mer fishery in Solomon Islands due to massive and widespread overfishing.

Table 1. Responses to the question: "Are there limits to beche-de-mer (or fish/sharks)?" "Qual" means that the answer was a qualified yes or no (from Foale 2005).

Island, and no. of interviews		Limits to BDM?			Limits to fish/sharks?		
		No	Qual	Yes	No	Qual	Yes
Tubetube	**15**	10	3	2	15	0	0
Kwaraiwa	**7**	5	2	1	17	0	0
Skelton	**5**	1	4	0	5	0	0
Ware	**21**	14	2	5	21	0	0
Anagusa	**11**	5	2	4	9	1	1
Dawson	**5**	0	5	0	5	0	0
Totals (%)		**54**	**28**	**18**	**97**	**<2**	**<2**

Table 2. Answers to the question: "How do fish and beche-de-mer reproduce?"

Island, and no. of interviews		How do fish/BDM reproduce?		
		No idea	Partial explanation	Scientific explanation
Tubetube	**15**	15	0	0
Kwaraiwa	**7**	7	0	0
Naluwaluwali	**5**	5	0	0
Ware	**21**	20	1	0
Anagusa	**11**	7	4	0
Dawson	**5**	2	3	0
Totals (%)		**87.5**	**12.5**	**0**

Shark fin

The artisanal shark fin fishery is expanding rapidly in Milne Bay, and is presently being pushed along by unscrupulous Asian businessmen who are quickly establishing patron-client relationships with local fishers, with striking parallels to the Indonesian model (Fox and Sen 2002). This involves providing vessels, fishing equipment and fuel on loan, and requiring that the debt is repaid in shark fins — this system helps to ensure that the fisher does not sell his product elsewhere, and also generates pressure to continue fishing even after the CPUE drops below a level at which most fishermen might be inclined to earn cash via another activity. It effectively locks fishers into a system that is inevitably destructive of the fishery, and in most cases is unlikely to be of lasting benefit to the fishers.

At the time of writing, it has been impossible to obtain information on the relative impacts of the artisanal shark fishery and the industrial longline shark fleet in Papua New Guinea. Although there are only around nine licensed shark longline vessels on the National Fisheries Authority's records, there is considerable anecdotal evidence from residents of small islands in Milne Bay that many tuna longliners may still be using shark gear and fishing in close to reefs to target sharks at night. Many people comment on the common sighting of longliners closely approaching reefs such as the Long-Kosman reef complex and the Conflicts reefs at night in Milne Bay. While a number of the artisanal shark fishers in the Bwanabwana group have obtained their shark lines, hooks and floats from traders in Alotau, a surprisingly large number obtained their gear from an Asian longline vessel that ran aground on one of the reefs in the area and was abandoned by the crew. The vessel also had a large quantity of shark fin on board, hidden underneath the tuna catch.

Discussion

Pressure on Melanesian reef fisheries has been extremely low until very recently, and this can be attributed in the main to the unusually low human population density of the region, combined with the relatively weak penetration of Asian marine commodity markets. Some commodity markets, such as trochus, beche-de-mer and pearl-shell, have been around for a very long time, but since the embrace of capitalism by mainland China over the

3. Skewes et al. 2002 provide the best available data from surveys conducted in late 2001, but there is no subsequent or earlier data to provide a time-series comparison.

last decade, these markets have accelerated rapidly, and the shockwaves of this titanic increase in consumption is now being felt throughout the region. Melanesian aspirations for development, combined with a widespread lack of awareness of the limits of coastal fisheries, are willing but disastrous bedfellows of the increased Asian demand for marine products. A sobering aspect of this global market system is that as the supply of each commodity declines with dwindling stock densities, the demand drives the price up, providing greater incentive for fishers to wipe out the remaining vestiges of each fishery. When the sandfish fishery was destroyed by overharvesting in Milne Bay in the late 1980s, the price was a paltry 12 kina (PGK)[4] per kg. Now it is over PGK 150 per kg, but there are very few sandfish to be found any more.

The past decade has also seen the rapid uptake of various forms of technology that make fishing more efficient, and inevitably increase pressure on stocks. In the absence of any form of routine stock assessment and management (compare the level of inshore fishery management in Melanesia with the Aitutaki trochus fishery: Nash et al. 1995) such developments do not bode well, and in the absence of widespread and systematic intervention, the only uncertainty at present is how long it will take for each fishery to collapse.

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Traditional marine resource management in Vanuatu: Acknowledging, supporting and strengthening indigenous management systems

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Abstract

Much of the marine related traditional knowledge held by fishers in Vanuatu relates to increasing catches while managing resources of cultural, social and subsistence value. Traditional beliefs and practices associated with fisheries and their management follow natural cycles of resource abundance, accessibility, and respect for customary rules enshrined in oral traditions. Many management related rules that control fishers' behaviours are associated with the fabrication and deployment of traditional fishing gear. A number of traditional beliefs, including totemic affiliations and the temporal separation of agricultural and fishing practices, serve to manage marine resources. Spatial-temporal refugia and areas of symbolic significance create extensive networks of protected freshwater, terrestrial and marine areas.

The arrival of Europeans initiated a process of erosion and transformation of traditional cosmologies and practices related to marine resource management. More recently, the forces of development and globalisation have emerged to continue this process. The trend from a primarily culturally motivated regime of marine resource management to a more commercially motivated system is apparent, with the implementation and sanctioning of taboos becoming increasingly less reliant on traditional beliefs and practices. This paper reviews a number of traditional marine resource management beliefs and practices formerly found in Vanuatu, many of which remain extant today, and documents the transformation of these systems in adapting to contemporary circumstances. By documenting and promoting traditional management systems and their merits, it is hoped to advocate for a greater recognition, strengthening and support for these indigenous systems in Vanuatu and the region.

Introduction

Vanuatu is a Y-shaped archipelago, roughly 1000 km long, located in the western South Pacific (Fig. 1). There are 82 islands, mostly volcanic in origin, 70 of which are inhabited. Most are surrounded by narrow, highly productive fringing reefs, which are relatively small due to the steep nature of volcanic islands. There are only a limited number of other highly productive aquatic ecosystems such as mangroves, estuaries and lagoons (Cillaurren et al. 2001).

There is great linguistic and cultural diversity among Vanuatu's lush tropical high islands, with approximately 113 Austronesian languages spoken by a predominantly Melanesian population (Tryon 1996). There are also a number of Polynesian outlier islands and villages throughout the group and many other islands exhibit varying degrees of Polynesian influences (Spriggs 1997).

A number of factors affect food security on the islands. Volcanic eruptions, cyclones, tsunamis, earthquakes, landslides, storm surges, floods and droughts all affect crops and reefs. Various mitigating strategies were traditionally employed, including the creation of the complex network of refugia and other fishery management strategies described in this paper.

To ensure a successful communal harvest of fish, a taboo was placed on the area to be fished prior to harvesting. Such taboos could forbid anyone to swim or even walk by on the shore. This would both maintain the sanctity of the taboo and make the fish less wary of entering the area, an important consideration when harvesting resumed.

While the season for a communal harvest was clearly prescribed by local custom (which in turn was based on seasonal resource abundance and/or annual tidal cycles and therefore accessibility), specialists determined the actual timing of the harvest. Optimal tidal conditions, clearly recognized to coincide with lunar phases, were carefully chosen for fish to migrate shoreward over the tidal reef flats from the deeper waters beyond the reef edge.

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The optimal reef-gleaning season was also determined by annual tidal cycles whereby reefs were fully exposed during daylight hours.

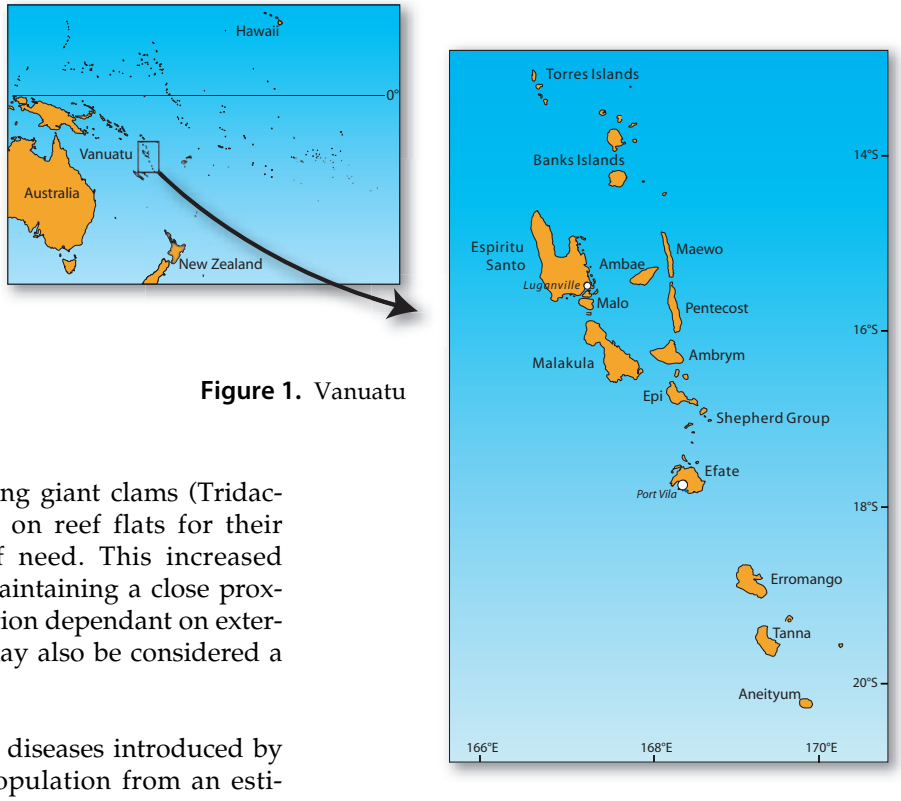

Figure 1. Vanuatu

Methods of overcoming food shortages included storing fermented fruits and utilizing alternative foods (such as wild yams and cycad fruits) not normally eaten. Another strategy was to create "giant-clam gardens", with fishers gathering giant clams (Tridacnidae) into discrete areas on reef flats for their exclusive use in times of need. This increased reproductive success by maintaining a close proximity of a breeding population dependant on external fertilization. Thus, it may also be considered a management strategy.

Starting in the early 1800s, diseases introduced by Europeans reduced the population from an estimated half million or more in the pre-contact period to 45,000 by the 1940s (Bedford 1989). By 1999, the population had rebounded to 189,000 (National Statistics Office 2000). Christianity, primarily the Presbyterian, Anglican and Catholic faiths, was introduced some 150 years ago and overlaid and influenced island traditions to varying degrees. The diversity of traditions, coupled with extensive migration from inland to coastal areas, the introduction of modern fishing gear, and the commercialization of resources, often makes it difficult to generalize about customary fishing beliefs and practices. Clearly though, despite the impacts of the colonial period, Vanuatu has maintained a strong cultural heritage of traditional resource management.[2] While some traditions have been severely undermined and transformed by contact with Europeans, others are still extant and much cultural knowledge remains in living memory.

The Vanuatu Fisheries Department emphasizes the fundamental role of traditional management practices, while also introducing some national regulations; these include measures such as setting size limits for some commercialized invertebrates, protecting turtle nests and eggs, and banning the harvesting of berried spiny lobsters. However, the monitoring and enforcement of these regulations in rural areas remains extremely difficult and cost prohibitive, and the regulations are rarely enforced outside urban areas due to logistical and financial constraints. Their main value is to control the export of commercial fisheries products such as trochus from the two urban centres.

The increasing population, concentrated in coastal regions, and the global market pressure for Western-style economic development make the strengthening of traditional management of marine resources critically important to ensure sustainability.

Traditional fisheries

Traditional fishing methods vary somewhat among islands and cultural groups. Most traditional harvesting, however, is focused on nearshore reefs. Reef gleaning for various fish and shellfish, crab, octopus, sea urchins, spiny lobsters and numerous other invertebrates provides a significant portion of the catch. Women and children's contribution in providing sustenance through reef gleaning is significant and often under-acknowledged. Other methods, including fish poisoning, spearing and shooting fish with bow and arrow from reef edges, hook and line fishing, netting and fish trapping, and communal harvesting methods like coconut leaf-sweeping, fish driving, and weir fishing are commonly used in different areas. However, hooks and lines were apparently not used everywhere in former times.

2. The term traditional here is meant to refer to practices, beliefs and knowledge considered to have a foundation in the past, particularly before European arrival.

There are also fisheries for marine turtles and, in the past, for dugongs (*Dugong dugon*), as well as the annual harvesting of the palolo seaworm (Polycheata). In some areas, there are traditional offshore fisheries for deepwater Eteline snappers, breams (Lethrinidae) and groupers (Serranidae), as well as for flying fish, tuna and tuna-like species, although the latter were fished mainly in areas of Polynesian influence. All of these fishing methods are based on extensive traditional ecological knowledge (TEK) of the various resources so as to optimize catches, and encompass a significant corpus of traditional beliefs and practices, including numerous prohibitions controlling fisher behaviour.

Most of these fishing practices are still in use today. However, their modern counterparts have largely replaced traditional nets and hook and lines. Newer methods, such as the use of snorkelling gear, spearguns, underwater torches and long gillnets have become increasingly common. Outboard motor boats are now widely used for pelagic and deepwater fishing and interisland transport. However, the outrigger canoe, with styles varying among islands, still serves most coastal villages for nearshore fishing and transport (Hickey 1999).

Traditional resource management

Cosmology

Marine resource management was never formerly compartmentalized. The knowledge, beliefs and practices that contributed to the management of resources pervaded all facets of life. Numerous beliefs, practices and protocols governed much of the activities and behaviours, not only of fishers but of all clan members engaged in any of the traditional activities of life. Arts such as weaving baskets and mats, making ceremonial carvings and headdresses, preparing traditional medicines or making canoes, all involved following strictly prescribed protocols based on area-specific cosmologies.

These protocols, encoded and enshrined in oral traditions, were often derived from island deities/cultural heroes and sanctioned by the ancestors as "the way". The way was orally transmitted to subsequent generations as a holistic approach to life on the islands, including the synergistic management of resources. Following the way specified by island deities led to a fruitful life on the islands, where people were also ritually part of that sanctified world and were symbolically one with the gods and ancestral spirits (Eliade 1957).

Consequently, it is important to consider the context in which management measures, as well as harvesting techniques, were practised: that is, within the framework of the cosmology or belief system held in ancient times. Life in the islands of Vanuatu had, and still largely has, an inherent sanctity stemming from the animistic cosmological belief that "all things have a spirit" and that all things and events, are inherently connected through this spiritual medium. By extension of that belief, people may hope to influence natural forces otherwise beyond their control by the use of sanctified rituals, and so mitigate against various threats to food security.

Many practices stemming from this underlying cosmology are highly ritualized and are undertaken by specialists who received this knowledge from elders. Most involve the use of sacred stones and leaves often used synergistically, along with other rituals whose secrets are closely guarded as revealing them undermines their power. In many cases, the power of the omnipresent ancestral spirits that live "on the other side" is evoked to achieve the desired influence over nature and worldly events. Communication with these spirits was often ritually enhanced through the use of a narcotic drink prepared from kava (*Piper methysticum*) (Lebot et al. 1992).

Evoking the power of the ancestral spirits or island deities to intervene and increase resource abundance was an integral part of traditional taboos placed on resources. Reef taboos were never formerly static, but were always accompanied by ritualized practices underpinned by cosmological beliefs invoking ancestors/deities to increase resources. Today the abandonment of these practices is sometimes cited as the reason for resource depletion.

Environmental knowledge and indicators

Tidal patterns are important, since much of the nearshore marine resources come from reef gleaning or communal fishing activities requiring good low tides. The overall maximum tidal amplitude in Vanuatu is roughly 1.5 m. The annual lows, often zero or negative tides, generally occur during the austral winter months of June and July. Extreme low water of the winter spring tides occurs at midday, so reefs are optimally exposed for gleaning during daylight hours around the new and full moons. During the summer months, extreme low water occurs at midnight during the new and full moons, but these low tides rarely get as low as those of the winter months.

Winter is also the optimal season for communal fish harvesting methods such as the traditional leaf sweep, fish drives, use of fish weirs and fish poisons in tide pools. These techniques all depend on spring tides that are high enough to allow fish to come inshore over reef flats to feed, yet low enough

to strand fish in pools behind natural barriers or those created by these methods. The winter season also coincides with the period when many nearshore resources are not reproducing but are fattening up.

The flowering of *waelken* (*Miscanthus* sp.) in late summer is the environmental cue that indicates the seasonal spawning of many reef fish in the southern islands of Vanuatu (where seasonal temperature variations are more pronounced). As the flowers swell up in maturation, the fish also swell up with eggs. When the flowers burst in late February and March, the fish release their eggs. The post-spawning period is considered good for hook-and-line fishing, as reef fish feed hungrily to recharge fat reserves depleted through egg production, and are quick to take bait. Other species, such as Siganids, have spawning peaks earlier in summer, from October to January, and are indicated by the onset of flowering of the coastal tree *Excoecaria agallocha*.

In the "colder" winter months, when the reefs are optimally exposed for harvesting through gleaning, many of the nearshore resources charge their fat reserves, and are thus preferred for their taste. A commonly cited environmental cue is the flowering of *narara* (*Erythrina variegata),* when reef fish, crab and lobster are said to be full of fat. This time is also known to be best for catching octopus, which are said to come out of their holes to see the bright red *narara* flowers. The appearance of the constellation Pleiades on the western horizon after sunset (in April) is used on many islands to herald the New Yam season, and the return of the seasonal low tides.

Some islands (such as Ambrym) cite Orion's Belt, which follows about a month later in the same position, as symbolic of a fisher returning from the exposed reefs with baskets of shellfish to be prepared with yam puddings of this season, while for other islands it is symbolic of people returning from the gardens with baskets full of yams. The annual cycle of tidal patterns that determine optimal reef gleaning and communal fishing methods is thus synchronized with the annual agricultural cycle of yam production.[3]

Communal fish harvests in the winter months capable of producing large catches were thus part of an annual cycle of ceremonial feasts or ritualized exchanges with inland villages in return for resources such as yams or fruits from island interiors. These practices served to redistribute a seasonal abundance of resources between different island biomes while strengthening alliances and maintaining peaceful trade relations between kinship groups.

Seasonal cycles

Seasonal abundance — the occurrence of spawning migrations and aggregations — in addition to harvesting method constraints such as tidal patterns, also determined which species were targeted at particular times. Nearly every marine resource had a discrete season when it was targeted, often encoded by an environmental cue such as a flowering plant or other cue. This is expressed by village elders who say: "Everything has its own time." Many species would, for example, primarily be targeted when their fat reserves were at a maximum and thus, when they tasted better. As this was also generally the time preceding spawning peaks, this cycle minimized fishing pressure during reproductive periods and assisted significantly with their management.

Nearly every month of the year, different resources would be considered ripe or become abundant; an example is the annual seasonal appearance of the marine Palolo worm. In later months, sharks would come ashore to bear live young. Shark pups remain inshore for some time and are easily harvested using hand spears. In the early summer months, with the return of the rains, terrestrial crabs (*Cardisoma* spp.) would intensify their foraging activity near the coast, fattening up prior to aggregating to specific coastal areas to release their eggs in the sea, making them easily harvestable. Summer months would also see flying fish (Exocoetidae) and their predators, the tunas, come inshore where they could be harvested. Later, the pelagic scads (*Selar* spp.) and small mackerel (*Rastrelliger* and *Scombrus* spp.) would mature, forming large schools in inshore lagoons and bays. Sardines (*Sardinella* spp.) would also form large shoals inshore where they could be easily harvested, and rabbit fish (Siganidae) would migrate to a known location to aggregate for spawning purposes. All of these smaller species would, in turn, attract larger predators such as jacks and trevallies (Carangidae) and barracuda (Sphyraenidae) that could also be harvested.

This annual cycle of different resources becoming plentiful at different times clearly indicated the season to target them. In this way, fishing pressure on various resources was concentrated on a given resource for only a brief period of the year on a

3. Communal fishing methods such as the coconut leaf sweep is still ritually practised on some islands, but the introduction of long monofilament gillnets now allows for large catches with much less communal effort. However, the optimal tidal pattern for large catches of reef fish on diurnal migrations from drop-offs to reef flats using modern nets largely remains as described for communal harvesting methods.

rotational basis. Even if some were harvested during a spawning migration or aggregation, there would be only minimal pressure on the population in the remainder of the year.

Traditional management in transition

Except for a few high-value benthic species, tropical, small-scale, multi-species fisheries in places such as Vanuatu are prohibitively expensive and notoriously difficult to manage using Western models that require extensive data collection (Johannes 1998a). Johannes (1998b) suggested that unrealistic emphasis on quantitative management ideals, such as optimum or maximum sustainable yields for these fisheries, could justifiably give way to a new paradigm that he called "data-less marine resource management", emphasizing that it is not management in the absence of information. The use of reproductive and lifecycle information, coupled with TEK of resources and traditional marine tenure, is invaluable for achieving management objectives. The qualitative monitoring of resources by communities through direct observation has always been part of Pacific fisheries and serves to increase the TEK held by fishers.

Traditional marine tenure

The fundamental management strategy for nearshore reefs in many parts of the Pacific, particularly in Melanesia, is based on traditional marine tenure (TMT) and the accompanying traditional beliefs and practices that prohibit or restrict the harvest and consumption of marine resources. The principle underlying TMT is the ability of families, clans, chiefs and/or communities to claim exclusive rights to fishing areas, exclude outsiders, and regulate activities in these areas. The benefits of their restraint may then be realized at a later date, thus providing the motivation to protect resources. The systems of TMT in the Pacific have been relatively well documented by Johannes and MacFarlane (1991), Ruddle (1994, 1996) and Hviding (1996) among others. The well-entrenched heritage of TMT is legally recognized in Vanuatu and continues to provide an ideal framework for a decentralized system of village-based management of marine resources.

TMT effectively devolves responsibility for marine resource management to traditional leaders, communities, clans or families; that is, to those with the most intimate knowledge of the resources and the greatest motivation to manage well. Devolution of management responsibility is possible, as the government of Vanuatu recognizes and supports TMT[4] in the constitution of the republic, and traditional leaders and resource custodians continue to see the introduction of village-based prohibitions as their traditional right and responsibility.

However, a growing concern is that contemporary taboos tend to be less firmly rooted in tradition, and consequently command less respect than traditional ones. The ancient traditional taboos, as outlined below, were associated with elaborate traditional practices and ritual underpinned by traditional cosmology's and sanctioned through supernatural forces. Contemporary taboos tend to be less ritualized and therefore less steeped in tradition, with a consequent decrease in reliance on supernatural sanctioning. The influence of the church, particularly the notion that traditional beliefs are "heathen and uncivilized", makes this ritualization and reliance on supernatural sanctioning less acceptable in some communities.

Bans and taboos

The earliest transformations of traditional marine management systems stemmed from the introduction in the late-1800s of an export trade in nearshore resources for dried sea cucumbers (Holothuroidea) and later included trochus (*Trochus niloticus*) and green snail (*Turbo marmoratus*). Traditionally derived taboos began to be regularly placed on these resources in response to commercial pressure. This trend in protecting commercially harvested resources through the use of taboos has continued into the present, as more resources are targeted for commercial purposes for export to urban centres and overseas.

Contemporary village-based management prohibitions, often referred to by villagers today as "bans" to distinguish them from ancient traditional taboos, continue to be locally monitored and enforced by village leaders. These bans are enforced through the traditional institution of the village court which, although not legally recognized, continues to effectively adjudicate on most offences occurring in rural areas, as it has for centuries.

Fishers recognize that fish often retreat into areas under taboo when being pursued. Taboo areas, even when they are not particularly large, if widely distributed act as a mosaic of refugia or sanctuaries for mobile marine life. Turtles are found to become accustomed to the presence of divers observing

4. More recently, the forces of development and globalization are increasingly eroding government recognition and support for TMT as new legislation is introduced affecting land tenure and more land titles (which affect reef accessibility) are transferred to foreigners for development purposes.

them in areas where hunting is taboo for sufficiently long periods (pers. observ.). Dugongs (*Dugong dugon*), protected from hunting for some years now, have even been tamed to swim with humans, and along with unwary turtles are used to attract tourists to generate revenue. The knowledge that fish and other marine life increase in abundance and lose their wariness in areas under taboo is put to good use by the regular placement of closures for a variety of resources in most coastal villages of Vanuatu today (Hickey and Johannes 2002).

Traditional marine resource management practices of Vanuatu

The categories of traditional marine resource management practices vary significantly among cultural groups in the archipelago, reflecting their cultural diversity. Some of these practices are extant today, while others survive only through oral histories. Many of the marine management strategies described are also applied to freshwater and terrestrial resources. Reefs were viewed as extensions to the land, and their custodianship was generally, but not always, the responsibility of the adjacent land custodians. The information below summarizes research conducted by the author in collaboration with the Vanuatu Department of Fisheries and Vanuatu Cultural Centre over the preceding decade. Virtually all of the traditional strategies described below have direct parallels in modern resource management strategies founded on Western scientific principles, but long predate them. The Western classification terms are used below to highlight these parallels.

Privileged-user rights

The right of reef custodians to control and restrict fishing and other activities is fundamental to the principle of TMT and is reflected in the modern management strategy of limited access. Under TMT, there may also be complex tiers of user rights for different groups, based on historical connections with reef areas. Groups arriving later in an area may be accepted, but only with secondary rights by the original founding group who retain primary rights. Also, neighbouring, often inland, groups may retain tenure over original canoe-landing sites or may in the past have bartered for user rights to defined reef areas, and these rights may remain in effect for ensuing generations.

Respect for TMT is said to have been universally very high in the past, and transgressions would be dealt with harshly, as well as through supernatural intervention. While remaining flexible through consultation among allied groups, the system thus controlled and limited fishing effort within nearshore areas.

Species-specific prohibitions

In most areas it was taboo to eat turtle or turtle eggs if one planned to go to the yam garden in the next couple of days. It is said that to do so would result in one's yams being stunted like the fins or eggs of a turtle. In some areas, equivalent prohibitions applied to octopus, lobsters, giant clams, certain species of fish and other foods, including oily fruits and nuts. These prohibitions also applied to working in water taro (*Colocasia esculenta*) and other types of gardens, such as those for bananas. In some areas, it was taboo to go to gardens if one's leg had made contact with the sea, as doing so would risk damaging crops.

Food prohibitions could sometimes be overcome by making a small "devil's garden", distant from the main one, after consuming one of the prohibited foods[5]. Yams from the devil's garden would then be offered to the spirit responsible for stunting the yams, and the yams from the main garden would thus be spared.

Various informants suggest that these prohibitions may relate to the negative effect of introducing oily substances from turtles and other foods to gardens, as these could attract wild pigs or insects to food gardens. Making small devil's gardens prior to working in the main yam gardens would result in most of the oils being deposited in the devil's garden, though it would require additional time and energy. Salt also harms many garden crops, which may explain the negative association between seawater exposure and gardening. These effects apparently led to a temporal separation of gardening and fishing activities throughout many areas of Vanuatu and are elaborated on below in the section on seasonal closures.

Another species-specific prohibition is the practice of showing respect to the memory of recently deceased clan members by placing a taboo on their favourite food or the last food items they ate. For example, a taboo may be placed on a certain type of fish, spiny lobster, octopus, shellfish or fruit in honour of a deceased clan member for a year or more. The time period is generally commensurate with the respect shown to their memory. This relieves fishing pressure on that resource within the clan's area during that period.

Additional species-specific restrictions include prohibitions against children and pregnant women

5. The term "devil", introduced by early missionaries, is commonly used today to refer to various manifestations from the spirit world.

eating turtles, as this was found to result in children developing sores. In some areas, those with asthma were also prohibited from eating turtle as it aggravated their condition. In other areas it was taboo for young girls to consume giant clams (Tridacnidae) until after their first menstruation, while young boys were forbidden to consume many species of large angelfish (*Pomacanthus* spp.) until they were circumcised. These prohibitions stemmed from area-specific cosmological beliefs and resulted in reduced fishing pressure on these resources.

In some areas, size limits were imposed on certain species, as it was taboo to collect small gastropods (e.g. *Turbo* spp.) that had no encrusting growth on them to avoid taking immature ones.

Seasonal closures

During the summer months when yams were being cultivated and many reef resources were restricted by gardening taboos, as well as by the tidal cycles outlined above, a wide range of fruit and nut trees ripened to provide alternative sources of nutrition. When new yam gardens were prepared, there was considerable labour involved in clearing garden plots and planting tubers. With the coming of the spring rains, weeding and training the vines required frequent trips to the garden. The production of yams was a central aspect of food production and featured prominently in the customs of most areas of Vanuatu. Cultivating yams was thus treated as a serious endeavour. Given the importance of agricultural production in Vanuatu (Weightman 1989), it is apparent that gardening restrictions that limited fishing activities also served to reduce fishing pressure on nearshore reefs during the months of yam production. As noted above, the tides of this season are also less suitable for reef-gleaning activities, and thus reef gleaning and communal harvesting methods were further separated temporally from gardening activities by tidal cycles.

The yam production period, starting as early as August/September, and extending until April/May, covers the entire hot season. This period includes the nesting season for turtles, the time when they are most vulnerable to exploitation by humans. It is also thought to be the season when many nearshore reef species are at their spawning peaks. Fishing prohibitions during the main agricultural season thus have highly significant management value because they reduce fishing pressure during peak reproductive periods. The yam production season also encompasses the period when trade winds collapse and winds become light and variable. Johannes (1978) highlights the advantage for fish of spawning during periods when prevailing winds and currents are at their weakest, which will reduce the transport of larvae far from their point of origin.

In areas such as Futuna, Tanna, Aniwa, Paama and Ambrym Islands, the consumption of nearshore resources is considered to be taboo from the time yam gardens are initiated until the New Yam Ceremony some six months later. This would ensure a good harvest of seafood for New Yam celebrations as well as during the subsequent months of ongoing yam harvesting. As this summer closure coincides with the time when most nearshore fish and invertebrates are believed to be at their spawning peaks, the annual half-year taboo serves to protect resources during this vulnerable period.

However, the hot months are the best season for fishing offshore for flying fish, tunas and other pelagic species. Deepwater snappers found far from nearshore waters may also be fished during these months. The seasonal abundance of pelagic fish and lighter winds during summer months allowing easier offshore fishing thus compensated for the restricted fishing of the nearshore during summer months.

An additional incentive to limit consumption of nearshore reef fish during summer months is that oral traditions record that they are more frequently found to be ciguatoxic during this period when new coral growth is observed to be highest.

Food avoidance

Many cultural groups in Vanuatu are associated with different totems that include specific types of fish, octopus, giant clams, turtles, sharks and moray eels as well as various terrestrial resources. The practice of not consuming one's ancestral totems out of respect and reverence for them serves as a management strategy by reducing or controlling fishing pressure on those resources. In some areas, highly controlled, ritualized harvests of totemic species are undertaken for exchange to other areas, thereby limiting fishing pressure.

"Protected areas"

In virtually all parts of Vanuatu there were formerly numerous coastal protected areas, known locally as "taboo places", that had spiritual significance and which people had the greatest reverence and would respectfully avoid. These taboo places were also common in terrestrial and freshwater areas and were often associated with areas of high biodiversity. Examples of such areas include burial places, and places where spirits resided or island deities were based. Volcanic lakes on Ambae and Gaua Islands are two such large inland freshwater areas high in biodiversity. Many rivers and creeks

were also considered taboo areas and were thus protected, as they were considered to be paths of spirits travelling between the sea and inland areas.

These permanently taboo areas, or areas with very restricted access, were commonly found along coasts, as well as at offshore islands and reefs. Access to them was restricted or controlled at all times, unlike spatial-temporal refugia. The taboo areas formed a network of marine and terrestrial protected areas whose management benefits included the production of larger, more abundant marine organisms that export larvae (and marine plant propagules) as well as spillover effects. By protecting a number of different habitat types colonized by species unique to them, taboos also preserved and enhanced biodiversity.

These areas were, by their very nature, protected and sanctioned by the spirits residing there. Compliance was thus very high, as the enforcement of these areas was endogenously based on the belief system of supernatural sanctioning. This is unlike the Western counterpart of marine protected areas that is sometimes promoted in Vanuatu, which relies increasingly on state sanctioning. While many taboo places are no longer respected by the younger generation, primarily due to the influence of Christianity, Western education and development pressure, many others continue to protect resources in areas where respect for them remains.

Behavioural prohibitions

The numerous customary protocols associated with the fabrication and deployment of traditional fishing gear and techniques were integral to the traditional resource management regime. Once certain fisheries were initiated with the fabrication of, for example, a spiny lobster trap, a fisher's behaviour became regulated by protocols associated with that fishery. Taboos could vary among cultural groups and depended on the fishery type.

A widely known example of a behavioural prohibition is the requirement for sexual abstinence before engaging in fishing activities as well as during the fabrication of fishing devices. This reduces fishing pressure within a clan's area while providing additional benefits relating to birth control. Other examples of behavioural prohibitions that reduce fishing pressure follow:

- In some areas, it is taboo to swim or remain on the shore during sunset, as certain spirits are known to be active then. As spawning aggregations are known to occur at sunset, this prohibition protects them (Johannes 1978).
- Fishers cannot be seen departing, or at least others must not know they are joining a fishing expedition, as this brings "bad luck" and so the trip may be aborted. Also, it is taboo to call out or make noise when embarking on a fishing trip.
- If a visitor arrives and spends the night, then it is taboo to go fishing the next day.
- It is taboo to eat certain foods or drink kava or go to certain places when one is involved in the fabrication or deployment of certain fishing devices.
- Pregnant or menstruating women, and men with pregnant wives, are automatically excluded from most fishing activities. This taboo relates to the belief that the spirit of an unborn child has a negative effect on fishing activity.

Thus, there is an extensive and complex web of taboos associated with fishing that act synergistically with other traditional management measures to reduce fishing effort. A fisher who is unable to respect any behavioural taboos must refrain from fishing for the following day or two, thereby reducing fishing effort in a given area. As there are ways to find out who has not followed the rules, this puts shame on offenders, affecting their reputations as fishers, and is thus avoided.

Spatial-temporal refugia

Some of the cultural practices that created spatial-temporal refugia throughout Vanuatu are outlined below. These refugia allowed for an increase in abundance and diversity and provided spillover benefits, decreasing the wariness of resource species while also protecting spawning activities and increasing biodiversity. Events associated with such spatial-temporal refugia are described below. These areas would be open to fishing once the taboo has been removed so as to make use of resource abundance in line with Pacific peoples' strong social, cultural and subsistence links with resources (Fig. 2).

Death of a traditional leader

In some areas, such as the Banks Islands, the death of a traditional leader ("chief" or highly ranked member of a hierarchical society) would be honoured by the placement of a taboo on the reef of the leader's clan. Depending on the degree of respect, this total closure could last for many years. This taboo is associated with the enactment of many rituals. When the reef is re-opened, a final communal feast is held to honour the deceased, using in part the resources harvested from the closed area.

Death of any clan member

The death of any individual of a clan — man, woman or child — may mean that the clan's area of reef is put under taboo, or closed to all harvesting for one to three years, as is the case on northern Epi.

Figure 2.
A *namele* leaf recently placed after a pig killing ceremony used to indicate a reef tabu at Mangaliliu village on Efate.

Grade-taking

In areas of north and central Vanuatu, the all-important rituals of grade-taking by men, and in some areas women, as part of ascending a social and spiritual hierarchy (Layard 1942; Bonnemaison 1996) are accompanied by taboos placed on terrestrial, freshwater or reef resources from one to four years, and often for as long as six years in the case of marine taboos. These practices include multiple pig killings, kava drinking, dancing, singing, feasting and other rituals.

Passing on of a hereditary chief's title

In the Shepherd Islands of central Vanuatu, the practice of hereditary chiefs' passing title to their progeny is associated with a reef taboo. The taboo duration may be the time taken for a young pig to develop a full circle tusk, some six to seven years. Offerings to ancestors are also traditionally made to evoke their assistance in monitoring and enforcement. The tusked pig will be sacrificed to remove the taboo, and marine resources harvested from the taboo area are used as part of the ordination feast.

Yam season

As outlined above, in some areas of Vanuatu, most nearshore reef resources are annually closed to harvesting during the summer months from around the time of yam planting until the New Yam celebrations approximately six months later. In other areas the taboos are species specific, but nearly all areas protect turtles. These agricultural related taboos are now less commonly respected, while some areas continue to limit fishing during this period because of the management value of doing so during spawning periods. It is also generally acknowledged that yams produced these days are much smaller than in former times due to the loss of respect for traditional practices and knowledge.

Circumcision

Cleansing rites that are part of circumcision rituals are sometimes associated with reef taboos, which are generally of a short duration, sometimes one month. These short closures are particularly effective in conserving resources if their timing coincides with spawning migrations or aggregations.

In preparation for specific feasts or other traditions

In most areas, specific feasts or other traditions, such as the harvest and exchange of marine resources to inland villages, are preceded by a reef taboo. Ritual specialists then evoke the ancestors to increase resources and ensure a good catch. Inland villages would later reciprocate with foodstuffs from their areas. This highly ritualized system of exchange effectively controlled fishing pressure on resources both spatially and temporally while redistributing resources during periods of seasonal abundance and strengthening trade and peaceful relations. These taboos are still found in some areas and are sometimes integrated into Christian rituals, for example, celebrations of a saint's day.

Marine resource management through a mosaic of spatial-temporal refugia

The variety of traditional area closures ensured a number of areas were closed at any one time. When visiting north Pentecost in northern central Vanuatu in 1998, the author was informed of 11 marine closures associated with grade-taking ceremonies. These closures formed a mosaic of spatial-temporal refugia across the top end of this relatively small area, protecting various marine habitats. In 2005, the number of areas closed due to these rituals had increased due to the strong adherence to traditional grade taking practices in this area.

Consequences of violating traditional taboos

The consequences of taboo violation included supernatural retribution from island deities and ancestors. This curse could also be ritually removed once the offender revealed their transgression. Individuals who repeatedly broke these taboos could be set adrift or given a sign that their leader had sanctioned their death, giving them a brief period to escape.

Traditional leaders, under the auspices of the *nakamal*, or village court, also imposed fines of pigs,

kava, woven mats and other traditional wealth items as an additional deterrent and means of removing the "wrong" in the eyes of ancestors and other clan members. Typically, ancestral spirits would punish transgressors, or their family members, by making them ill, sometimes terminally so. Some were capable of assuming various forms, including sharks or barracuda that could directly enforce a marine taboo. Practices to ensure the participation of ancestors in enforcement included placing culturally specific taboo leaves in the area to symbolically monitor and enforce the taboo (Fig. 3). Communication with the spirit world was often enhanced by ritualized kava drinking.

Figure 3. A traditional leader in the Banks Islands placing the taboo leaves unique to his cultural group to indicate a reef taboo.

Ancestral icons may also be concealed in the area to symbolically invoke their participation. The killing of pigs at the initiation of the taboo also serves as a symbolic sacrifice to ancestors for their part in monitoring and enforcing the taboo. The killing of another pig is thus required within some cultural groups to remove the taboo and make it safe to harvest again in the area. In other areas, additional culturally significant gifts (such as pigs, kava, yams or white fowl) were offered, sometimes set adrift on a raft, to ensure the ancestor's role in monitoring and enforcing the taboo. This system of sanctioning was considered highly effective in the past, and remains so in numerous areas where traditional belief systems remain strong.

Discussion

Traditional leaders and reef custodians in Vanuatu increasingly use their rights under TMT to put resources, fishing areas, seasons or fishing methods under taboo for varying periods of time (Johannes 1998a; Hickey and Johannes 2002; Johannes and Hickey 2004). Some of these taboos are extant versions of ancient traditional practices. Through the Vanuatu Cultural Centres' network of over 120 fieldworkers working voluntarily throughout the archipelago, these traditional practices are strengthened by the fieldworkers reviving, encouraging and supporting their communities in continuing to practice their traditional taboos.

Many taboos imposed today, however, are more contemporary expressions of earlier ones that have integrated modern issues and concerns including introduced gear and the cash economy. The Fisheries Department, Environment Unit, and Vanuatu Cultural Centre have supported these traditionally derived contemporary taboos through a programme of cooperative management. Cooperative management of marine resources was initiated by the Fisheries Department Research Section in the early 1990s, initially targeting trochus resources (Amos 1993). It provides relevant biological knowledge and awareness to communities for use in conjunction with traditional knowledge in the management of nearshore reef resources. These cooperative management efforts quickly spread to include other commercially important resources as well as those important for subsistence. This programme was later introduced to the Department's Extension Services by providing appropriate training to rural-based Extension Officers.

Part of this process included raising awareness among rural communities of Department regulations about size limits and other state prohibitions on resources. Once villagers were aware of the regulations and understood the rationale behind them, they generally adopted the regulations as part of their village-based management regime (Johannes 1998a). Village leaders and villagers then took over monitoring and informally enforcing these regulations on behalf of the government.

The knowledge gained of the management value of traditional practices, including area and species closures and other prohibitions on harvesting marine resources, has thus been adapted and applied in the expression of contemporary taboos. If the taboo was of sufficient duration, resources were observed to become larger, more abundant and less wary, leading to increased catches after the taboo is lifted. Also, taboos placed during periods of spawning activities assisted recruitment processes.

Another aspect influencing respect for closures is that the benefits of traditional taboos were generally distributed to the entire community through communal feasts and distribution of resources. Today, however, individual reef custodians often expect to prosper from the sale of trochus and other resources. Thus, there is often less incentive for the entire community to respect the taboo. In former times, the paramount traditional leader of an area would have the right, through consensus, to put large reef areas controlled through different clans' tenure under taboo for traditional purposes. In this way, management of large areas was harmonized for communal benefit. Many reef custodians recognize the relationship between respect for taboos and communal benefit sharing, and allow reef access to the entire community to promote widespread respect for taboos placed on individual clans' reefs.

Many communities recognize that the decrease in respect for contemporary taboos is exacerbated by a general decline in respect for traditional authority by youth influenced by Western education or individualistic ideals learned in urban centres. Disputes over land or reef tenure as well as village leadership are also found to weaken respect for village-based taboos (Hickey and Johannes 2002; Johannes and Hickey 2004). In response to these factors, some communities endeavour to strengthen and revitalize traditional beliefs regarding resource management by emphasizing the inclusion of more traditional practices in their implementation. Others, in areas where traditional beliefs are more influenced by introduced cosmologies, choose also to integrate Christian beliefs and practices in implementation, and this is often effective in assisting with management; still others look increasingly toward the state for assistance in sanctioning village-based taboos.

The trend towards greater state sanctioning, as well as Western notions of conservation that may ignore traditional links to resources, have been assisted by aid donors, regional and volunteer organizations and NGOs. These groups often have limited appreciation of ancient traditional resource management systems, and are primarily familiar with Western models from their own countries. Some outside groups take village-based taboos and repackage them in Western forms such as "conservation areas and MPAs", but these models are poorly understood and are largely viewed with suspicion by rural communities (Bleakley 2004). In most cases, Western models are unsustainable once outside assistance is finished. A traditional village leader sums it up by saying: "European conservation approaches always seems to cost a lot of money, whereas our traditional system of sustainable management is within our own means." However, government policy makers and bureaucrats, often educated in industrialized countries and increasingly isolated from rural communities, often acquiesce to the introduction of Western models, following the locally entrenched notion that "the West knows best".

This recent trend towards Western repackaging of traditional practices is of concern as it implies that Western models are superior, when in fact parallels to Western science-based resource management strategies already exist in Vanuatu's traditional systems, as documented above. Reliance on state sanctioning of village-based resource management also has significant limitations, as government capacity to perform this role is severely limited in an archipelago with so many coastal villages. It also raises community expectations and fosters a mentality of depending on the state to solve rural community problems, which rarely respond well to legislation. The application of Western law in villages is seen as divisive, with a win/lose outcome that further erodes social cohesion necessary for cooperation in village-based management (Johannes and Hickey 2004). Recognising and supporting the existing strong cultural heritage of decentralized village-based resource management and strengthening efforts to adapt it to contemporary needs would be much more effective. This could be facilitated by continuing to build the capacity of traditional leaders and communities to manage resources under their tenure by promoting consultation with all stakeholder groups to increase understanding, consensus and compliance prior to implementation of taboos. In many cases, it is simply a matter of strengthening traditional leadership and governance systems and facilitating traditional conflict resolution options to settle existing community divisions.

In cases where enforcement remains problematic, legal recognition of traditional village court systems, where village-based transgressions including those related to resource management are adjudicated, would be an effective means to assist with enforcement. Legislation to empower traditional leaders and communities to manage resources under traditional tenure would be more effective and economical than creating a parallel system that transfers that power to the state and serves to undermine traditional authority. Fa'asili and Kelokolo (1999) report that legal empowerment of the Chief's Council in Samoa has been successful in supporting the community-based management of resources while reinforcing traditional authority.

Conclusion

Vanuatu has a strong cultural heritage of traditional resource management, and a well-entrenched and legally recognized system of TMT to draw upon in continuing to adapt its indigenous

system of resource management to contemporary needs. Many elements of traditional systems and authority remain extant and are well respected by the majority of the rural population. Some community elders still retain a large corpus of TEK that is useful for resource management, but this number is now dwindling rapidly. Culturally appropriate awareness and education programmes, including the use of popular theatre directed towards traditional leaders, fishers and communities have been shown to be highly effective in facilitating the adaptation of traditional systems to contemporary needs (Amos 1993; Johannes 1998a; Hickey and Johannes 2002; Johannes and Hickey 2004).

Further support is needed to continue to develop the capacity of traditional leaders and communities in the decentralized management of resources under their tenure through the strengthening of traditional leadership and governance, village-based consultation, consensus building and conflict resolution mechanisms. It is also particularly important that young people are made more aware of the practical value and modern-day relevance of traditional management systems and TEK held by elders, as the value of this knowledge is rarely promoted in the western educational system they are now primarily exposed to. This can best be achieved by the active involvement of elders in curriculum development and formal education and the inclusion of traditional activities as part of the school curriculum as well as through informal educational channels. This will enhance the intergenerational transfer of knowledge and promote greater appreciation, pride, self-reliance and transmission of such knowledge and practices. Mobilising local TEK for use in resource management also assists to empower communities with the use of their own knowledge while fostering a stronger sense of ownership of a resource management initiative. TEK is often much better understood and trusted than science-based knowledge in many communities. These factors have been observed to enhance the long-term sustainability of village-based resource management initiatives in Vanuatu.

Government policy makers, foreign donors, NGOs, volunteer and regional organizations working in the environment sector could all benefit from greater awareness of the value and efficacy of supporting and strengthening traditional management systems and the risks of blindly introducing foreign conservation methods originating in industrialized countries without TMT or a strong cultural heritage of traditional resource management. The trend away from working to strengthen TMT and existing traditional resource management systems by limiting marine resource management efforts to primarily promoting MPAs, as seen in the Pacific in recent years, ignores the value of a wide range of existing traditional resource management systems available that operates synergistically. The widely promoted and donor-supported uni-dimensional MPA approach driven by the Western ideal of optimizing biological conservation is likely to remain an object of suspicion by rural communities who rely on their resources for food security and other needs on a daily basis. In contrast, traditionally managed areas (TMAs), as widely seen in Vanuatu, provides the sustainable management of nearshore areas through a balance of various restrictions placed on fishing areas, seasons and gear but with the option to harvest resources to satisfy socioeconomic requirements (such as payment of school fees and other community needs).

Harvest openings are also possible when resources are perceived as over-abundant and benefits may not be realized due to the impacts of cyclones and other threats that periodically destroy nearshore areas. Living with such devastating threats as cyclones, tsunamis, storm surges and coral bleaching have taught people not to let their resources go to waste. Instead, an ethic of sustainably managing resources to maintain ecosystem integrity *with people as an integral component*, is a primary feature of the Pacific approach to resource management. TMAs are not only flexible in dealing with, and integrated into rural socio-cultural-economic norms but also are based on natural cycles of resource abundance, tidal influences, agricultural and resource reproductive cycles and is underpinned by locally based corpus of TEK of the environment and resources.

The current trend seen in the promotion of MPAs in the Pacific is also moving increasingly towards devolving resource management authority from community leaders under TMT to the state through legislation. This trend risks raising community expectations, while fostering dependency on governments that often lack the capacity (both human and financial) to deliver. The repackaging of existing village-based taboos as Western conservation models, often for the edification of tourists and development agencies, is likely to tacitly erode remaining traditional resource management practices found in the Pacific. Attempts at introducing the Western ethos of conservation inherent in MPAs is perceived as ignoring the strong social and cultural links of Pacific Islanders with their resources and the efficacy of existing traditional systems of management. Eroding traditional rights of communities of autonomy over land/reefs and resources is not likely to solve problems in Melanesia, but is more likely to create them. Strengthening existing traditional systems not only reduces the burden on governments (and aid donors) but also offers other spill-over benefits such as stronger community governance systems, increased long-

term community capacity and self-reliance and more sustainable marine resource management.

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Socialisation of fishing knowledge: The emergence and transmission of new fishing technology and marine ecological knowledge in the Republic of Palau, Western Micronesia

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Abstract

Catch rates and access to fishing locations have changed in contemporary Pacific fishing owing to newly introduced technologies such as speedboats and dive gear. At the same time, fishermen have also acquired new ecological knowledge of the marine environment and have developed new fishing skills. In this article I provide ethnographic examples from the Republic of Palau, Micronesia on the emergence of marine environmental knowledge and the use of new fishing practices in three key fishing methods: speargun fishing, hand-held trolling, and trapping. Fishermen develop different knowledge and skills through their individual experiences of the sea, as well as through the collective and traditional understanding of the marine environment by elder fishermen. The transmission of this knowledge and the use of new skills are enacted through kinship, and fishermen are often motivated to acquire this knowledge and skill in order to achieve status and prestige, rather than to simply increase their catch. Thus, technological change in contemporary Pacific fishing does not always undermine the social and cultural elements of fishing; rather these elements may be reinforced or even augmented.

Introduction

To understand the marine ecological knowledge of fishermen in the contemporary Pacific, it is important to account for the effect of new technology on current fishing practices, however modest they may be in comparison with industrial fisheries. A few examples from my recent study on fishing in Palau, demonstrate the extent to which modern technological inputs in small-scale fishing in the Pacific region are used outside of the "traditional management system". In turn, they may have reduced the sustainable use of marine resources, although some knowledge is transmitted through specific social networks of fishermen, which are governed by chieftainship and kinship structure.

In *Words of the Lagoon*, the landmark ethnographic account of Palauan fishing, Johannes (1981) showed that fishermen in Palau possessed detailed ecological knowledge of the marine environment, accumulated through generations of fishermen; but that this knowledge was fading away because the youth no longer fished as frequently as the elders. Johannes also found that some types of marine ecological knowledge were increasing because of new technologies. For example, fishermen had gained a greater understanding about fish behaviour by using dive masks, and learned more about the various marine environments because of speedboats, which allowed access to more fishing areas.

Similarly, significant changes in the amount and depth of fishermen's marine ecological knowledge have been reported from elsewhere in the Pacific. Some authors refer to these changes as simply the "erosion" of traditional fishing skills (Donner 1995), whereas other researchers take the view that fishermen are collecting new kinds of knowledge in order to fulfil the "wealth of ideas" (Carucci 1995). Overall, the scientific literature suggests that either the possession or the process of acquiring fishing knowledge continues to add important elements to people's social lives and identity, despite changes in the form and depth of the knowledge. Nonetheless, many ethnographic details remain to be investigated about the use and transmission of this knowledge, particularly knowledge that is highly specialised and has emerged from the adoption of new technologies (Hviding 1995; Feinberg 1995; Howard 1995).

Focusing on the ethnographic details of newly emerged knowledge and skills, this article provides some of those details by describing three different types of marine ecological knowledge attached to three different fishing methods. These

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are speargun fishing, fish trapping, and hand-held trolling from a boat with large outboard engines. Understanding the details of new fishing technology and fishermen's knowledge of the sea contributes significantly to the discussion of marine conservation, because the transmission of such knowledge is an indicator of the social control over fishing grounds. Hence, in this the article I emphasize the importance of comprehending the socialisation of new fishing technology — which takes place in the process of fishers' acquisition of marine ecological knowledge — and the application of this knowledge to actual fishing practices.

Contemporary practices of different fishing methods in Palau

Palau (Fig. 1) is known for its rich marine-based culture and the intricate ecological knowledge of traditional fishermen (Masse 1989; Kubary Kramer 1927; Johannes 1981; Parmentier 1987. In the late 1970s, however, Johannes (1981) pointed out that many youth had abandoned village life, and so fishing knowledge was no longer being transmitted by "traditional means", namely through direct experience and through the collective knowledge provided by elder fishermen. At the same time, he also reported (Johannes 1981:15) that some fishing knowledge was expanding because of the arrival of "modern technology", including speedboats with outboard engines, and underwater diving equipment. Johannes (1981) observed that eight fishing methods were in regular use at the time of his research: daytime and night-time speargun fishing, hand-spear fishing, barrier net fishing, line fishing, trolling, portable trap fishing and dynamite fishing. Except for the use of dynamite, which is legally banned, the other seven methods were still widely used at the time of my fieldwork in 2001. I examined the extent to which each of these fishing methods were used, along with the social and cultural occasions for which each method was practiced. I also recorded the catch size from each method (Ota 2006a, b).

Between the 1970s and 2001 the most significant technological change in Palauan fishing practices was reportedly the increased use of "speedboats" for inshore fishing; the approximate number registered in 2001 was 1450, of which more than 300 were considered to be used for inshore fishing (JICA 2001). During my interviews, fishermen said specifically that boat numbers increased rapidly in the late 1990s — several years after the country's independence in 1994 — because of increased cash flow into the country.

Johannes (1981) pointed out that the increased use of speedboats increased fishermen's access to hitherto unknown fishing grounds, which enabled them to expand their ecological marine knowledge. However, my ethnographic data suggest that the process of knowledge acquisition and the application of this knowledge to actual fishing practices involves more than a simple mechanistic response to technological advancement. Hviding (1995) points out the importance of understanding the depth of this knowledge, as it can be either general

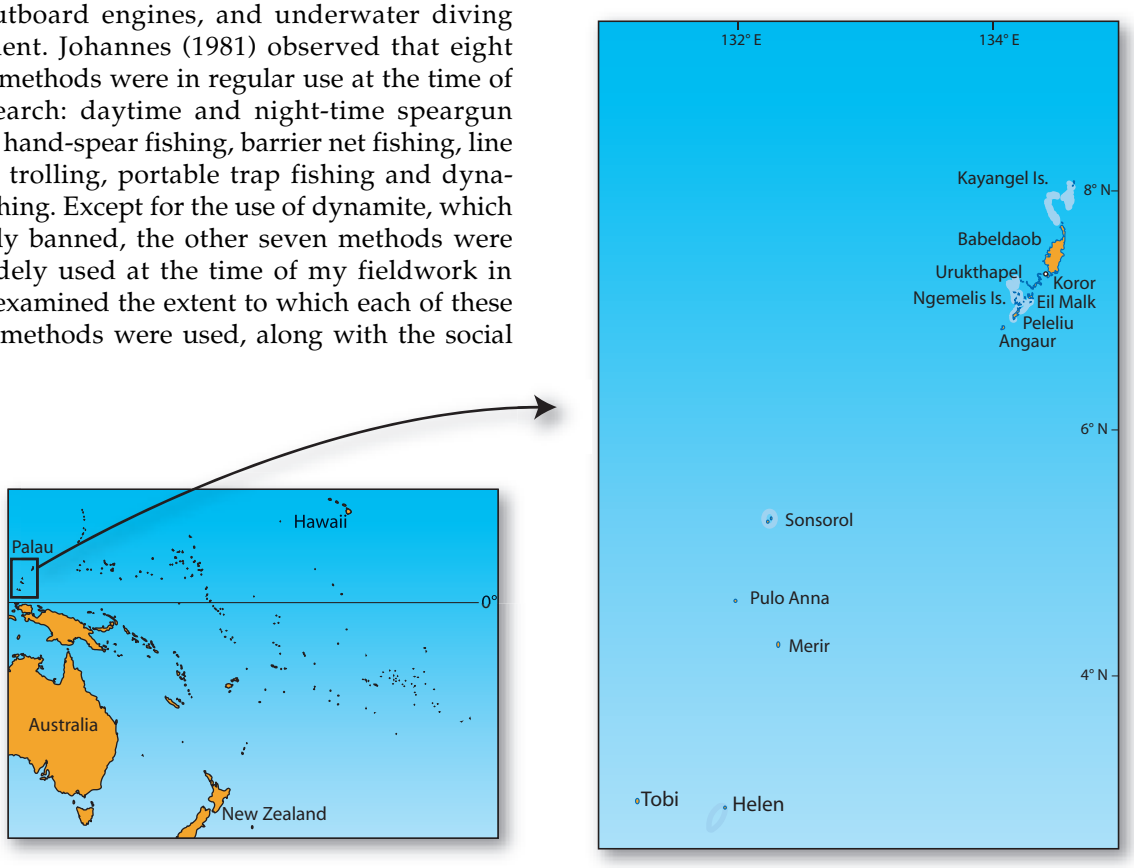

Figure 1. Palau

or specialised, and that this difference determines the emergence and transmission of knowledge in the Marovo communities of the Solomon Islands. Differences in knowledge regarding the Palauan marine ecosystem is apparent; some aspects of marine knowledge are known to many fishermen, while other aspects are known to only a few fishermen, and even fewer can successfully use this knowledge for fishing. It is this specialist knowledge that is my concern. In my view, the specialist knowledge that emerges from the application of newly introduced technology often requires appropriate social and cultural contexts, such as kinship structure or hereditary status.

Underwater speargun fishing and the division between reefs

In Palau, spearguns are locally made using mainly foreign materials, and they are used in conjunction with imported dive masks and flippers. Fishermen who practise speargun fishing collect their oceanographic knowledge by both individual quests to new areas, and by repeated visits to familiar reefs. In Koror, the capital of Palau (2002)[2] where more than half of the population lives, most fishermen use speedboats to access their fishing grounds. They travel some 10–30 minutes each day to reach reefs appropriate for daylong diving. Speagun fishing is done exclusively by men, and is currently the most popular method of providing fish for household consumption, even though the community's lifestyle is no longer based on subsistence. However, fishing is essential for the maintenance of tradition because fish is still used for customary gift exchanges and served at feasts and ritual gatherings. Moreover, the practice itself contributes to the formation of a strong sense of masculine identity, since it is the traditional obligation of men to provide female kin with the catch (Ota 2003, 2006c).

In the Palauan language, the sea is generally called *daob* and is in opposition to *beluu*, the land. These two structurally opposed foci are often depicted as constituting the balanced cosmos of the Palauan world conception (Ferreira 1987; Force 1960; Barnett 1960). These two geographic terms, however, do not apply when one refers to going to the ocean in order to fish. Then the word *chei* is used instead of *daob*. *Ak mora chei*, the general expression in Palauan "to go fishing", refers to the first person singular, "I", and "*mora*" means to go. *Chei* is often translated as the area between the shore and the edge of the reef, the common area for local fishing (Josephs 1990). Johannes (1981) explains that the word *chei* probably suggests a specifically located area of the sea (i.e. the lagoon), as opposed to *daob*, which refers to the sea in general. However, this distinction was not explicitly explained by fishermen during my fieldwork, because they rarely use the word *chei* on its own. Rather, the word was always used as part of the sentence, *Ak mora chei*: I am going fishing. If one goes fishing in the area near the shore, a person would say, *Ak mora kmeed*, referring to the nearshore. If one goes farther away from the reef, then a person says, *Ak mora chei cheroid*. The word, *cheroid* means far, and can be used outside the context of fishing. Moreover, the term *chei*, which is used to describe lagoon, should be understood as "the place they can go fishing" as opposed to *daob*, which refers to the sea, since fishermen say that "wherever you go to fish is the place called *chei*. Because *chei* is used by a Palauan fisherman to announce his will to go out fishing, saying *A mora chei*, other fishermen would then ask where the fisherman is heading to, *Komo ra*? In response to this question, the fisherman may provide an anonymous answer, (*Ak mora*) *basho*: I'm going to the place. In the context of fishing, *basho* refers to an anonymous fishing spot, known only by a limited number of fishermen. Using *basho* requires more detailed comprehension about the oceanographic settings of the reef, because fishing practices involve learning about winds, current directions, and other weather conditions and combinations of geographical variations.

For underwater speargun fishing, two types of *basho* are selected for diving: the lagoon edge and inside the lagoon. Fishing near the edge of the lagoon, near the reef dropoff, increases the risk and difficulty because of the relatively deep water (for skindiving: between 10 m and 25 m) and strong currents. Access can be further limited by weather conditions. Nevertheless, fishermen prefer to dive in such areas, which yield larger fish and a greater total catch. In contrast, fishing areas inside the lagoon and in saltwater lakes created by the extensive protected lagoon — which contains a great number of limestone islands (locally called Rock Islands) — are relatively safe. This is partly because currents within the area circulate inwardly, whereas in areas near the lagoon edge the strong current could easily carry a fisherman out to sea. But within the reef, the water is calm because the limestone islands and reefs shelter the area from external climatic influences. These nearshore areas are used mostly for short fishing periods, say an hour or two in the evening (nonetheless fishermen still use a speedboat to reach their *basho*). The only disadvantage is that catches tend to be smaller, due to the shallower water depth.

Besides of these oceanographic differences, the two areas are also distinguished from one another by

2. The capital was changed from Koror to Melekeok in October 2006.

the level of skill and knowledge required to dive and catch fish successfully. In the first location in particular, which is near the edge of the lagoon, fishing is restricted because of the strong currents; fishermen diving here must have a good understanding of the complex water flow. Therefore fishing here demands specialised knowledge of sea conditions, particularly currents, in order to carefully plan a diving route[3].

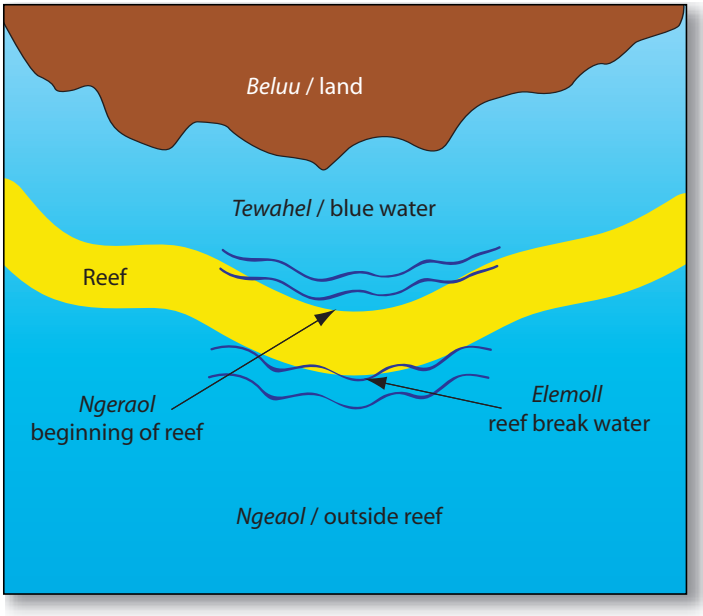

Figure 2. Sea map for underwater speargun fishing

Because of the need for specific marine knowledge about currents and appropriate diving routes, speargun fishermen have an understanding of reef gradation, from the shore to the deep water, including the seabed and fish distribution. To explain the general structure of the lagoon, a fisherman draws a map of the lagoon water emphasizing the line where the reef starts and ends (Fig. 2). In this map, waves are considered only as an indicator for the fishing point between the reefs, since the wave-break is an obvious visible seamark in the lagoon. Fishermen stress that those lines indicate the change of the seabed as the division imposed between reefs and the outside reef, which fishermen divide into three areas: *ngeraol*/beginning of the reef, *elemoll*/reef break water, and *ngeaol*/outside reef. However, this general map of the lagoon does not contain enough practical knowledge for successful fishing in the area known as *elemoll* — the reef break near the outside reef.

More intricate knowledge is required for diving. Fishermen must have a general understanding of the lagoon structure and, more specifically, about dive routes through areas with strong currents. Such practical knowledge is acquired not simply by visually observing target fish and the underwater topography of the reef while diving, but is also transmitted between individual fishermen as they fish together. Hence, at the beginning of their fishing experience, younger unskilled fishermen are taken only to the Rock Islands (limestone islands near the shore), which are surrounded by patch reefs. As the young fishermen's skill levels and physical strength increase, they are taken to the area near *ngeaol* (outside the reef) to be taught current movements. Knowing the basic seascape of the fishing area has no practical application to actual fishing, because the direction of the current and the routes to avoid must be learned from other fishermen.

This ethnographic observation on underwater speargun fishing presents a different view from Johannes (1981), who describes the expansion of marine ecological knowledge through the use of dive gear; having an ecological comprehension of fish habitat derived from direct visual observation of the underwater world. The intricate knowledge of underwater currents that is required for successful and safe diving is acquired through both lessons from other fishermen and through the direct experience of diving and swimming through the complex water flows.

Since the introduction of speedboats, however, the distinction between these two fishing areas has been slightly obscured. Some fishermen are now accompanied by another person who controls the boat while the fisherman fishes underwater. A fisherman no longer has to swim against a current going back to the boat after diving for fish; he can now let the current take him as he continues fishing and then the waiting boat will pick him up. Nonetheless, fishermen do not neglect learning the direction of the current and the condition of the reef, because they must carefully design the route for fishing, knowing the distance between the starting and ending points, since it is difficult for the boat operator to follow the underwater movement of a fishermen when there are strong waves accompanied by wind. In other words, using speedboats has not rendered obsolete fishermen's skills and knowledge. The difficulty of diving through the area near the outside reef still conveys the cachet of

3. However, wind direction is not considered because it does not affect underwater conditions in such small-scale environments (This is quite unlike other fishing methods, such as handheld trolling).

being a "skilled fisherman" and it subsequently brings a limitation of access to such areas. Thus, in the practice of underwater speargun fishing, both individual skill and knowledge socially institutionalises the distribution of fishing grounds.

Trap fishing and underwater oceanographic setting

The combination of individual input and given knowledge is also seen in more passive fishing methods, which do not come with direct physical risks and challenges. Contemporary fishermen have modified the design of fishing traps to make it more suitable for the oceanographic conditions of their local fishing grounds. In this case, knowledge comes more from the individual fisherman, rather than to the development of personal skills and a relationship with more experienced fishermen. However, the ability to use the newly invented design — in terms of fishing rights — is considered through the fisherman's social status, namely chieftainship and kinship relationships.

The practice of trap fishing depends directly on a fisherman's knowledge about the habitat and migratory movement of fish. Therefore, knowledge about the fishing spot and the way the fisherman sets the trap is considered as an essential and intricate skill. This intricacy is also transferred to the technological modification of fishing gear, particularly for the design of trap entrances. The design is adapted to the specific environmental settings of a particular area, taking into account oceanographic conditions and fish behaviour because the success of trap fishing depends largely on how much fish are led towards the entrance of the trap, following their usual movements through the water.

The significance of the correlation between profound oceanographic knowledge and the design of the fishing trap is observed in the use and setting of *beng*, which is made of iron wire mesh, is about 30–50 cm long, and is attached to the entrance of the trap as a kind of wing device. This device is employed mainly on the east coast of Babeldoab Island, in traps used for catching mid-sized reef fish. As a fisherman explained to me, *beng* works as the "arms" to the trap entrance, which leads fish inside only when the curved shape is set appropriately. In other words, the opening direction of *beng* needs to be arranged in accordance with the direction of water flow, calculating the swimming route of fish that is determined largely by the current movement.

An area in Melekeok district provides an example (Fig. 3). At a point near the channel, parallel to the district's shoreline, there is a strong surface current that runs from the south side to a point slightly north. Between the southern and northern points there is a steep dropoff as the shallow seaweed bed at the south point inclines to a deep reef. This results in a strong surface current in that direction (current A). There are also tidal currents coming from the direction of the shore, which is east of the south point, to the deeper water, which is west of the south point (current B). The current simply moves from deep water to the shallows as the tide floods, and runs in the opposite direction as the tide ebbs. Taking both current movements and fish following those movements into account, the fisherman sets the fish trap at the position near the dropoff between the south and north point, and faces the trap entrance slightly towards the shore. In this way the entrance faces the south point so that it opens to the fish following the current from the south point to the deeper north point. To maximise the catch, the fisherman attaches two *beng* to the entrance of the trap, luring not only the fish coming from the direction of the shore, but also those following the tidal currents from the deeper water.

Most other fishermen share his same knowledge of current movements and seabed conditions, including the location of the steep dropoff. One fishermen said to me, however, that his father set the specific position of the trap, but that he then continually modifies new traps for the same location, although the specific design was passed on to him from his father. As a result, he realised that by attaching the *beng*, the trap enabled him to attract fish that moved from both current directions. The fisherman credits his oceanographic knowledge to his father, but

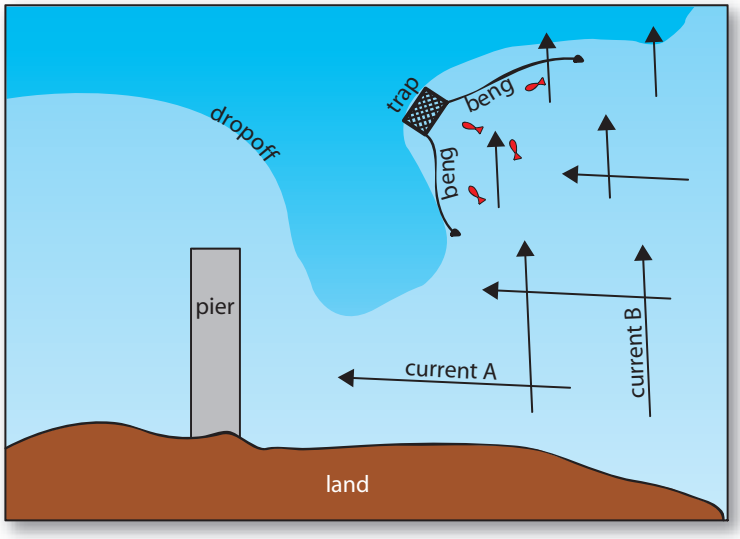

Figure 3. *Beng* setting in relation to current movements.

attributes the success of his trap with the attachment of *beng* to his continuous trials and modifications, readjusting both the length and the curve of the *beng* until it worked successfully.

Although the use of traps has declined, owing to a decline of traditional practices or the weakening of general community ethics, trap fishing for mangrove crabs has developed in recent years. This has been stimulated in part by the increased commercial value of crabs (by the tourist sector), and also by modifications to the trap design, which has improved its efficiency and has increased catches. The change resulted from altering the design of a fishing trap used elsewhere, and which did not originally target mangrove crabs.

Mangrove crabs are predominantly found around the large mangrove tracts in Ngatpang district, located on the south part of the east coast of Babeldaob Island. At the time of my fieldwork, seven groups of fishermen specialised in this trap fishing. Among them, an elderly fisherman worked alone by setting about 100 traps; the chief of the nearby village set more than 30, and each of the rest of the five groups, local youth trying to earn pocket money, set 20 traps.

Fishing changed recently because the chief of the district began using a new box type fishing trap with a small square fish net, instead of the circular crab net that needs to be constantly pulled out of the water. The chief, the inventor of the method, explained that the idea of using the small box type fish trap evolved from the fishing he did near Melekeok district, where these traps were quite common. After he moved to the N district he applied this standard fish trap to catch mangrove crabs, by modifying the size of the trap and other details. He explained that the most significant difference between the previous trap and his is the reduced effort required to check the catch, since it is no longer necessary to check the traps as frequently as every half day or more, because crabs can be kept for a day in the new trap. However, although the newly "invented" trap reduces fishing effort, only the chief and the elderly fisherman, the chief's brother-in-law use the new type. This has enabled the chief's family to capitalise on the regional stock of mangrove crabs, while his right to conduct this fishing was provided by his title and his generous attitude toward the community. (For example, he always supports both materially and financially to ritual gatherings from the region held within the family residence.) Several residents from the region clarify this link between the chiefly title and the use of the new device by saying that this chief circumvents complaints about his family's monopoly over the skill and the catch of crabs because he uses the money gained for the district. Thus, although the fishing knowledge is not "traditional", the way the chief exercises his social institution to access the fishing ground and evade other's concern and blame over the monopoly of this fishing is traditional to the extent that he uses his position to make it possible to do so.

Handheld trolling and wave movements

This example shows that a combination of previously collected knowledge given to a fisherman and the fisherman's own modification and improvement of it with new technology has produced not only a profound understanding of a complex oceanographic setting, but also the skill and knowledge to handle new equipment efficiently. However, the fisherman's motive for this learning and knowing is not simply economical, based on catching fish or simply exploring new fishing locations, but also satisfies his pride to possess the highly specialised knowledge.

In general, except sports fishing for tourists, only a few elderly fishermen are known to be skilful and knowledgeable at handheld trolling. This is in direct contrast to those who conduct sports fishing and who are technologically well-endowed with various types of equipment and who spend excessive amounts on fuel. Instead, these knowledgeable fishermen had a propensity for economising their fishing cost as well as for seeking new fishing locations. Their knowledge about exact wave movements serves a dual purpose: using oceanographic dynamics to move their boat and gaining access to locations without using a powerful outboard engine. My fishing experience with an elderly fisherman and an anecdote from him reveal his ability to observe and develop oceanographic knowledge about particularly perplexing fishing locations.

The purpose of the trip with the elderly fisherman was to troll for barracuda. The location of the fishing spot was only about 70 m offshore, on the east coast of Babeldaob Island. He drove his boat along the line of the dropoff, the point where the shallow reef drops down and the deepwater begins. We reached the point slightly before sunset, so the surface of the water was still visible. The fisherman pointed to the water surface closer to the shore and explained that there were three different currents and waves moving in different directions. He told me that he could see the change in the current and waves, as they reflect light differently on the surface of the seawater. At the fishing location, the waves and wind were moving towards the shore near the coastline, while they changed direction slightly diagonally towards the coast a little farther from the coastline. At the place where he situated his boat, the directions of wave and current altered completely from the area near the coastline; they stopped facing against the coastal line and instead

ran parallel to it. The fisherman explained that he knew from long experience that it was in this current that the barracuda would be found (Fig. 4).

This same fisherman explained to me his more profound knowledge of the sea environment concerning the reef between Angaur and Peleliu, the two southern islands of the Palau Archipelago. The narrative of his fishing experience and his knowledge of the reef begins with the general rule that the wave movement changes as a result of hitting the shore; as it hits land, a wave made by strong wind would create another smaller wave moving in a 45-degree angle (Fig. 5). He then explained that it is commonly known that the area around Angaur Island has no extensive lagoon as in other areas in Palau, and this oceanographic setting causes high waves in the area. Hence, any fishing activities in the area with a small boat and outboard engine with limited horsepower are considered a high-risk activity.

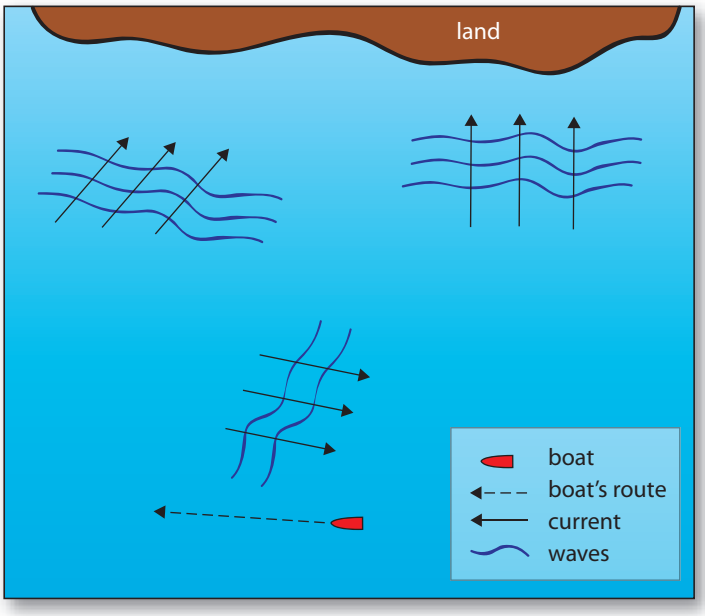

Figure 4. Currents and waves for handheld trolling.

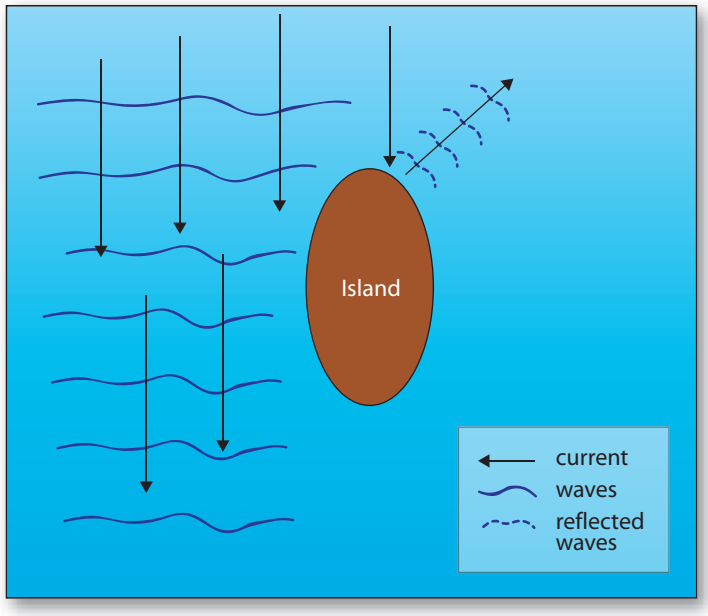

Figure 5. Current and wave reflection in relation to an island.

According to the fisherman, two different winds blow from the direction of Peleliu Island. One blows from east to west, striking the bottom end of Peleliu Island; then as it hits the island it curves and blows in the direction of Angaur Island. Another wind comes from the southern end of Peleliu directly to the north of Angaur Island. The first wind is not powerful enough to create strong waves, whereas the second can move boats in the direction of the shore of Angaur. As he trolled in the area, the fisherman let his boat be taken by the second wind to reach a point a couple of hundred metres from the shore, a similar distance from the shore to the fishing point where he fished for barracuda on the east coast of Babeldaob Island. The high waves and strong wind made it risky to be at the point so close to the cliff. But redirecting the boat is easily done by riding on the reflected wave, which goes slightly west in the opposite direction to the strong wave at this particular point. He explained that he was required to move the position of the boat slightly west across the strong wave, using minimum engine power (since it would have been impossible to move against the wave with that size of engine). Then, as the boat moved towards the west, the returning wave supported it in reaching the middle of the area between the two islands, where two waves — one produced as it is returned from the shore of Angaur and the other from Peleliu — crashed into each other, creating a high and rough ocean surface. At this middle point, the peculiar wave movement is not difficult to avoid since the meeting of the waves is based on only a moderate current running under the sea surface (Fig. 6).

The elderly fisherman told me that he was given some basic knowledge about this complex oceano-

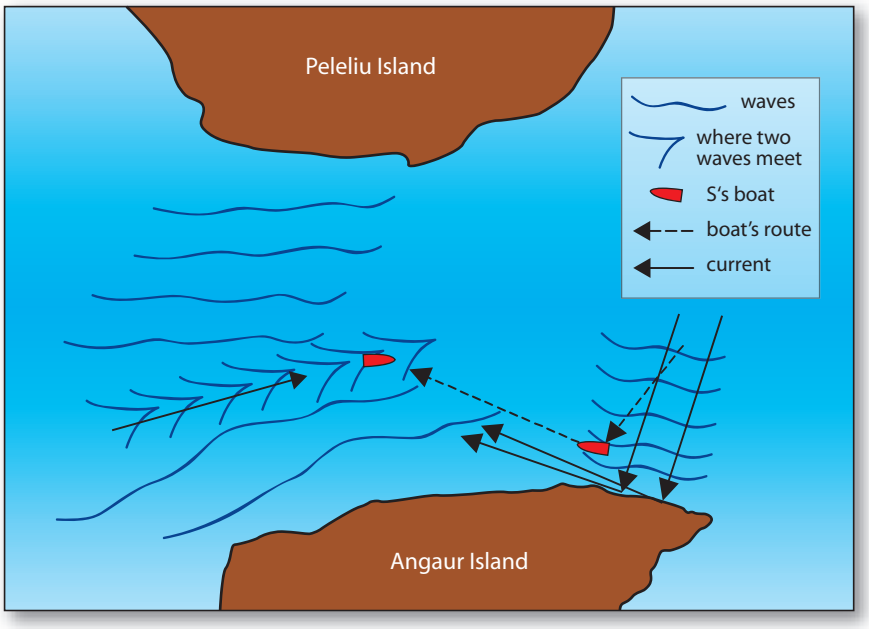

Figure 6. Sea map of different current and wave directions between Angaur and Peleliu islands.

graphic setting by his wife's "uncle" (she has her genealogical association with the region). As he relayed the initial source of this information, he proudly noted that it was only possible to ask this uncle about the fishing location because he was related to him and knew what he needed to ask specifically about the reef. Then he emphasized that the complexity of the location and the intricacy of the oceanographic setting were known to him ultimately through his own challenging trials during his own fishing activities.

Conclusion

Four main ethnographic findings emerge from these three ethnographic examples about marine ecological knowledge of Palauan fishermen.

1. A profound understanding of marine environments is not enhanced simply by the use of new technologies, such as speedboats or diving equipment or newly designed fishing traps;
2. The knowledge and skills used in contemporary Pacific fishing are partly acquired through the transmission from other fishermen, but are also largely supported by fishermen's actual experiences;
3. What fishermen understand and know about complex marine environments, including the movement of currents, reefs and waves, is attained through their active and individual investigation and contrivance of fishing skills and equipment, but the use of this knowledge can be socially limited; and
4. Some knowledge emerges from extremely challenging experiences, which can cause serious physical harm to fishermen; nonetheless, the challenge does not directly result in increased catch. Fishing remains difficult but the knowledge becomes a symbol of the fisherman's prestigious skill.

These findings offer new perspectives for the study of the emergence and transmission of contemporary marine environmental knowledge in Pacific Island small-scale fishing communities. These findings suggest that all fishermen do not easily apply the acquisition of the knowledge; hence, the use of their skills and knowledge is limited. Moreover, in practice, the use of this knowledge and these skills is restricted by the fishermen's social network and therefore, the acquisition of this body of knowledge does not necessarily lead to an increase in catch, but it may relate more to the socioeconomic elements of fishing, such as the social prestige of a fisherman. Although it is true that a fisherman's profound understanding of the oceanographic settings is coupled with his versatile attitude in searching for applications of new technology in contemporary Pacific Island fishing, nonetheless the emergence of new knowledge and skill does not always undermine either social and cultural elements of fishing, nor their relevance in conservation and use of marine resources, particularly when the knowledge is specialised. And the knowledge must always be specialised if a fisherman wants to apply it beneficially.

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Local ecological knowledge and Goliath grouper spawning aggregations in the South Atlantic Ocean: Goliath grouper spawning aggregations in Brazil

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Abstract

In this paper we report on the occurrence of Goliath grouper *Epinephelus itajara*, spawning aggregations in the South Atlantic Ocean (south Brazil), as indicated by surveys of fishermen's local ecological knowledge. Insights on Goliath grouper behaviour within aggregations and prospects for species conservation and research in Brazil are also provided.

Goliath groupers *Epinephelus itajara* (Lichtenstein 1822) occur throughout tropical and subtropical waters in the Atlantic Ocean (Fig. 1). This large grouper can attain a weight of more than 400 kg, and has an estimated lifespan of over 38 years, strong site fidelity, passive behaviour towards spearfishers, late sexual maturity (five years), and aggregates to spawn (Bullock et al. 1992; Sadovy and Eklund 1999). Though all of these life history traits represent serious conservation concerns, identifying and protecting spawning aggregations is considered one of the key targets for fish species conservation (Colin et al. 2003). Few Goliath grouper spawning sites have been mapped in the Northern Hemisphere, including the coast of Florida (still requiring spawning observation), Hobe Sound and Palm Beach, off Belize (extirpated), and Colombia (Sadovy and Eklund 1999; Frias Torres pers. observ.). Although Goliath grouper spawning aggregations have been reported by fishermen in the Gulf of California, no individuals have been observed or caught since 1995.

Here we provide the first evidence of *E. itajara* spawning aggregations in the South Atlantic. Preliminary outcomes of a current local ecological knowledge survey for Goliath grouper bioecological and conservation aspects (Gerhardinger et al. 2004), indicate that these large schools of fish (up to 60 individuals) aggregate for spawning purposes, as fish caught on these occasions had well developed gonads (in advanced maturity phases). These transient spawning aggregations are usually observed in December, although they were already seen in January and February, and are always associated with a full moon, according to our informants in the State of Santa Catarina.

The following intriguing observation was made by the elderly informant (83 years old):

> "…the male, he would stay taking care of the females, and when we dived the male would come after us to see what was going on. We already knew, the female would stay down there, quiet. There were always more females than males. The male had no eggs, the females had eggs, and when we caught them, we saw their large bellies with eggs, already knowing that it was a female, the male was thinner."

This interesting observation of how different sexes behave within a spawning aggregation indicates a female biased sex-ratio in these events. Unfortunately, only this particular fisherman had acquired such detailed knowledge of this subject. Although this is considered preliminary information (which gave rise to an interesting hypothesis for our Goliath grouper conventional ichthyologic studies), it builds on Hamilton's (2005) point about how the knowledge and experience of only one fisherman can reveal original and extremely detailed information on a given species.

Nowadays, a network of government and non-governmental institutions is consolidating a nationwide Goliath Grouper Conservation Campaign (http://www.merosdobrasil.org), which

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3. UFSCar - Universidade Federal de São Carlos – PPGERN - Rod. Washington Luiz, km 235 Monjolinho CxP.676 São Carlos SP 13.565-905, Brazil
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includes research, policy and environmental education issues (Hostim-Silva et al. 2005; Ferreira et al. 2006). Within the core of this partnership lies the conservation of the species as well as its essential habitats, such as mangroves, rocky and coral reefs.

By recognizing that conventional ichthyological science alone cannot satisfy the demand for ecological information on the vast Brazilian coast, and that fishermen possess intrinsic knowledge about their own local marine environment, ethnoecological methods will be utilized as a major component of this partnership. Because groupers have been targeted by Brazilian communities for generations, they are likely to be an integral part of fishermen's traditional knowledge.

In addition to the scientific study of fishermen's knowledge, we will also engage expert fishermen in our workshops and discussion forums, in a clear attempt to create a good atmosphere for constructive cooperation among scientific experts and holders of traditional ecological knowledge.

Acknowledgements

We are sincerely thankful to all fishermen participating in the "Meros do Brasil" project (www.merosdobrasil.org), for sharing their time and knowledge with us, and to all those fishermen and divers who are increasingly supporting the project with relevant information on Goliath groupers and other marine species. We are indebted to the professional underwater photographer Marcelo Krause (http://www.marcelokrause.com.br), who kindly offered us this important picture of a Goliath grouper aggregation. We also thank Ravi Sachdev for his English review of the manuscript.

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Figure 1. An *Epinephelus itajara* aggregation in south Brazil. Eleven large-sized fish can be seen in the photo (by Marcelo Krause).

Noteworthy publications

traditional marine resource management and knowledge

Pre-publication announcement

The collected works of R.E. Johannes: Publications on traditional marine knowledge and management

The International Resources Management Instiute (IRMI), located in Hong Hong, announces that this publication will be available for download beginning in February 2007. This book consists of 25 familiar and not-so-well-known articles by the late Robert Johannes. It has been arranged and introduced by Kenneth Ruddle.

The contents include:

Introductory works

1977 Traditional law of the sea in Micronesia

1978 Traditional marine conservation methods in Oceania and their demise

1982 Implications of traditional marine resources use for coastal fisheries development in Papua New Guinea

2002 The renaissance of community-based marine resource management in Oceania

Knowledge

1978 Reproductive strategies of coastal marine fishes in the tropics

1980 Using knowledge of the reproductive behaviour of reef and lagoon fishes to improve yields

1981 Working with fishermen to improve coastal tropical fisheries and resource management

1987 Knowledge possessed by native Australian fishermen could aid seafood technologists

1989 Spawning aggregations of the grouper

1990 Contribution of traditional knowledge to environmental science

1990 Fishing for traditional knowledge

1993 Integrating traditional ecological knowledge and management with environmental impact assessment

2000 Ignore fishers' knowledge and miss the boat

2000 I-Kiribati knowledge and management of Tarawa's lagoon resources

2003 Fishers' knowledge and management: Differing fundamentals in artisanal and industrial fisheries

2003 Use and misuse of traditional ecological knowledge and management practices

Management

1982 Traditional conservation methods and protected marine areas in Oceania

1984 Marine conservation in relation to traditional lifestyles of tropical artisanal fishermen

1989 Managing smallscale fisheries in Oceania: Unusual constraints and opportunities

1993 The plight of the osfish, or why quantitative sophistication is no substitute for asking the rights questions

1994 Cooperative fisheries management: Major changes in training required for government fisheries personnel

1994 Design of tropical nearshore fisheries extension work beyond the 1990s

1997 Grouper spawning aggregations need protection

1998 The case for dataless marine resource management: Examples from tropical nearshore finfisheries

1998 Government-supported, village-based management of marine resources in Vanuatu

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Prepublication orders may be placed by using the "feedback page" on that website.

Prices will be: Download USD 5.99; CD only USD 30.00 (including postage); CD + print copy for libraries USD 100 (including postage).

IRMI is a research and consulting organisation based in Hong Kong. IRMI focuses on the Asia-Pacific region, and on development problems in coastal marine communities and environments. This particular website has been established to make available online publications at low cost, so that they are within reach of any user.

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