ISSN 1025-7497

Secretariat of the Pacific Community

TRADITIONAL

Marine Resource Management and Knowledge

Number 12 — December 2000

INFORMATION BULLETIN

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Note from the editor

I apologise for the delay in getting this issue to you. We had several contributions lined-up from Fiji, but then none materialised, owing to political turmoil there. Instead, we are going to press with another issue focussing on Solomon Islands, a reflection of the great interest that nation has for this "Special Interest Group".

The first of the three articles is by Daisuke Takekawa of the Kitakyushu University, Japan. His paper, "Hunting method and the ecological knowledge of dolphins among the Fanalei villagers of Malaita, Solomon Islands" is based on nine months field research in Fanalei village, during the early 1990s. In the Solomon Islands, men of particular villages hunt dolphins to obtain the teeth, which are used as the traditional currency, for bride price and for personal adornment. Dolphin teeth are one of the items used to form a network among the people of the area. The Fanalei villagers produce some 100,000 dolphin teeth, almost all of which are sent to other parts of Malaita and neighbouring islands. Fanalei village is intimately concerned with the circulation of dolphin teeth. To hunt dolphins, groups of men go by dugout canoe to the open sea early in the morning, and drive individual schools of dolphins to the beach by hitting two stones together below the water surface.

In the second article, "Women, rural development and community-based resource management in the Roviana Lagoon, Solomon Islands: establishing marine invertebrate refugia", Shankar Aswani notes that in some places, historical use, cultural affiliation and societal attitudes can provide a basis for modern management of marine areas. This idea has been widely promoted. But, in practice, different systems of marine resources governance and management can co-exist in a single

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region. This then raises the fundamental question of which institutional arrangements are best able to produce precautionary management programs, such as marine reserves and spatio-temporal refugia? Aswani, who is from the University of California, Santa Barbara, attempts to answer that question by summarising a case study from Roviana Lagoon, Solomon Islands. The case elucidates variables between different sea tenure institutions and core historical and social tenets that distinguish adaptable and successful regimes from those that are not. Dr Aswani also examines a small-scale women's rural development project that is involved in the establishment of spatio-temporal refugia and a marine reserve in a mangrove habitat. The project's initial success indicates sea tenure governance arrangements that may favour the establishment of successful management regimes. Further, the case shows how anthropologists can integrate their empirical research results with the objectives of local people for the purpose of participatory environmental management.

Robert E. Johannes and Edvard Hviding complete the contributions to this issue with their article "Traditional knowledge possessed by the fishers of Marovo Lagoon, Solomon Islands, concerning fish aggregating behaviour". In May 1987, Johannes was asked by the Marovo Area Council to record important aspects of the exceptionally rich traditional knowledge of Marovo Lagoon fishermen concerning their marine resources. His fieldwork was done with the assistance of Edvard Hviding. Hviding, then a graduate student at the University of Bergen, Norway, who had been living in Marovo for a year and was studying other aspects of traditional fishing and marine resource management, including customary marine tenure and its associated knowledge. Marovo people have a very impressive knowledge of sea animals. Some of their most important practical information concerns where fish and other marine organisms are found in large numbers; when they are found there (that is, season, lunar period, tidal stage, time of day); and their behaviour and movements. Many reef and lagoon fishes come together in large numbers during particular months, during particular moon phases and at special places. Some of these aggregations are described in Marovo by such names as *bobili*, *baini*, *rovana*, and *sakoto*. Knowing this makes it easier for the fishermen to be at the right place at the right time for good fishing. Sometimes these aggregations form for the purpose of spawning, as when groupers mass in certain reef passes, or mullet school and swim in tight circles. In other cases, fish aggregate for the purpose of feeding, or for protection. In other cases, neither Marovo fishermen nor biologists know why the fish come together.

Kenneth Ruddle

Hunting method and the ecological knowledge of dolphins among the Fanalei villagers of Malaita, Solomon Islands

Daisuke Takekawa[1]

Introduction

In the Solomon Islands, men of particular villages hunt dolphins to obtain the teeth, which are then used as the traditional currency, for bride price and for personal adornment. Young girls are decked out with beautiful shell beads and dolphin teeth, and young boys and their parents collect many teeth to take these girls for wives. Dolphin teeth are one of the items used to form a network among the people of the area. There is an exquisite sense for the shape of dolphin teeth.

There are five specialised dolphin-hunting villages on Malaita Island, all occupied by Lau-speakers (Figure 1). The Lau are renowned fishers. Fanalei is one of these villages. The Fanalei villagers are "saltwater people" (*wane i asi*). To hunt dolphins, groups of men go by dugout canoe to the open sea early in the morning, and drive individual schools of dolphins to the beach by hitting two stones together below the surface of the water. They usually live by the beach and possess a profound knowledge about the sea. Such knowledge, specifically concerning dolphin hunting and the dolphin itself, demonstrates how the Fanalei villagers perceive their biological and physical environment, and especially the dolphin.

Dolphins are called *kirio* in the Lau language and fish are called *ia*. The terms *ia* or *ika* are widely used in Malay-Austronesian languages. People in Malaita categorise dolphins as a kind of fish, and the word *ia* sometimes denotes only the dolphin. (For example *nifo ia* is literally "the teeth of fish" but to Lau people it means "dolphin teeth".) Thus, the dolphin is thought to be "the fish of fishes" by Malaita people.

I observed 38 different fishing methods at Fanalei. As always, a particular fishing method is selected according to time, place and target species (Takekawa 1992). Dolphin hunting is but one of these methods, although it requires more skilled team work and heavy labour than other kinds of fishing. If a Fanalei villager goes fishing instead of dolphin hunting, he can easily get enough fish for his family. On the other hand, the probability of success in dolphin hunting is low, and is risky for those who subsist mostly on local foods. Although about 100 dolphins can be taken at one time, frequent failure results in a total absence of meat.

Nevertheless, Fanalei villagers still go hunting when the season begins. Prior to the introduction of Christianity, only Fanalei and Bita'ama were the places for dolphin hunting on Malaita. Even today Fanalei is the only village that constantly catches dolphins. The villagers are proud of their tradi-

Figure 1. Location of study area.

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tional status and their annual collection of some 100,000 dolphin teeth, almost all of which are sent to other parts of Malaita and neighbouring islands. So Fanalei is a special village intimately concerned with the circulation of dolphin teeth, and equivalent to a few Langalanga villages for red shell money (Cooper 1971).

Others have written on dolphin hunting in the Solomon Islands. Ivens (1930) described it and Dawbin (1966) reported on hunting at Bita'ama village in north Malaita. Both of them mainly examined the courtesy of dolphin hunting.

In the former studies the term "porpoise hunting" was used. But it is more appropriate to use "dolphin hunting", because in the Solomon Islands only ocean dolphins are hunted. It therefore becomes important to distinguish between porpoises (Family Phocoenidae) and ocean dolphins (Family Delphinidae).

Data for this study were collected during a total of nine months stay in Fanalei village, from July to October 1990, from December 1992 to March 1993 and from January 1994 to April 1994. I went dolphin hunting with Fanalei fishers several times during my research, and this article is based on information obtained during those periods.

Dolphin hunting

Brief history of dolphin hunting in Fanalei village

According to village oral history, a Polynesian woman named Barafaifu introduced dolphin hunting to Malaita from Ontong Java Atoll, which lies 500 km to the north. She traveled around Malaita to find the best place for hunting, and finally settled in Fanalei. She gave the Malokwalo clan, already settled there, the magic stone (*taraa*) capable of gathering dolphins with the spell of the sea spirit. They started hunting from that time, although then dolphins were not hunted every year, unlike now.

The clan ceased hunting in the mid-19th century, when Maesiora and his son Baena of the Malokwalo clan were the only transmitters of the spell. One day they were killed by a devil and the spell of hunting was nearly lost. Fortunately Oikada, a young man who belonged to Fanalei's chief clan, Ngora, had overheard Maesiora and Baena talking about dolphin hunting. Oikada held a dolphin hunt only once, when the Suraina clan demanded 10,000 teeth in compensation for a Suraina man's death. After that the people of Fanalei stopped dolphin hunting for about 50 years.

The oral history does not tell exactly why hunting stopped. But Christianity had been introduced during this period, and as a consequence many traditional customs were prohibited. It is possible that dolphin hunting was also prohibited at the same time. In addition, however, the most valuable dolphin, locally known as *robo au*, the melon-headed whale (*Peponocephala electra*), was becoming very rare. In 1948, during the Masina Rule Movement, William Masura, the vicar of Fanalei together with other chiefs revived dolphin hunting under Christianity. In 1958 Father Martin Fia introduced dolphin hunting to Walande, the sister village of Fanalei located 10 km to the north. He also initiated other Lau villages in North Malaita, including Ata'a, Felasubua, Sulufou, Mbita'ama, where dolphin hunting also started. However, Fanalei was and remains the preeminent dolphin hunting village.

Hunting tools

Malaitans use only simple tools made of local materials to hunt dolphins. Single canoes, without an outrigger, are used. Large canoes, such as *saralaku*, *beroko* or *olaisula* were used in former times, but today small canoes (*aigalua*) are the most common. To drive dolphins, hunters hit two 15-cm diameter stones (*nagi*) together beneath the sea surface. The very hard, unsplit flint from which they are made is obtained from Rauafu Island, about 50 km north off Fanalei. Signal flags (*boko*) are used to communicate among canoes dispersed more than 2 km apart. These are a strikingly coloured piece of cloth of about 80 cm^2 attached to a 4-m length of bamboo. Nets are sometimes used to catch dolphins in mangroves.

Searching for dolphins

Dolphin hunting is called *oto asi kirio* (lit."to go out into the open sea") or *ala ni kirio* "(lit. to surround something"). The canoe formation when driving dolphins is called *ala* and the usual group of 20–30 dolphin hunters is also called *ala*. The 52 households in Fanalei are organised into one *ala*.

Most adult male villagers hunt every day during the season when the trade winds do not blow (*ara*). Figure 2 shows events for the entire 1994 hunting season of 99 days. Bad weather and two tropical cyclones affected hunting, but fishers hunted for a total of 56 days. They found dolphins on 24 of those 56 days, and half the time they succeeded in catching them. During 12 days of hunting 865 dolphins were caught. These annual numbers fluctuate little. Average monthly harvest rates and frequency of hunting over a 7-year period are shown in Figure 3.

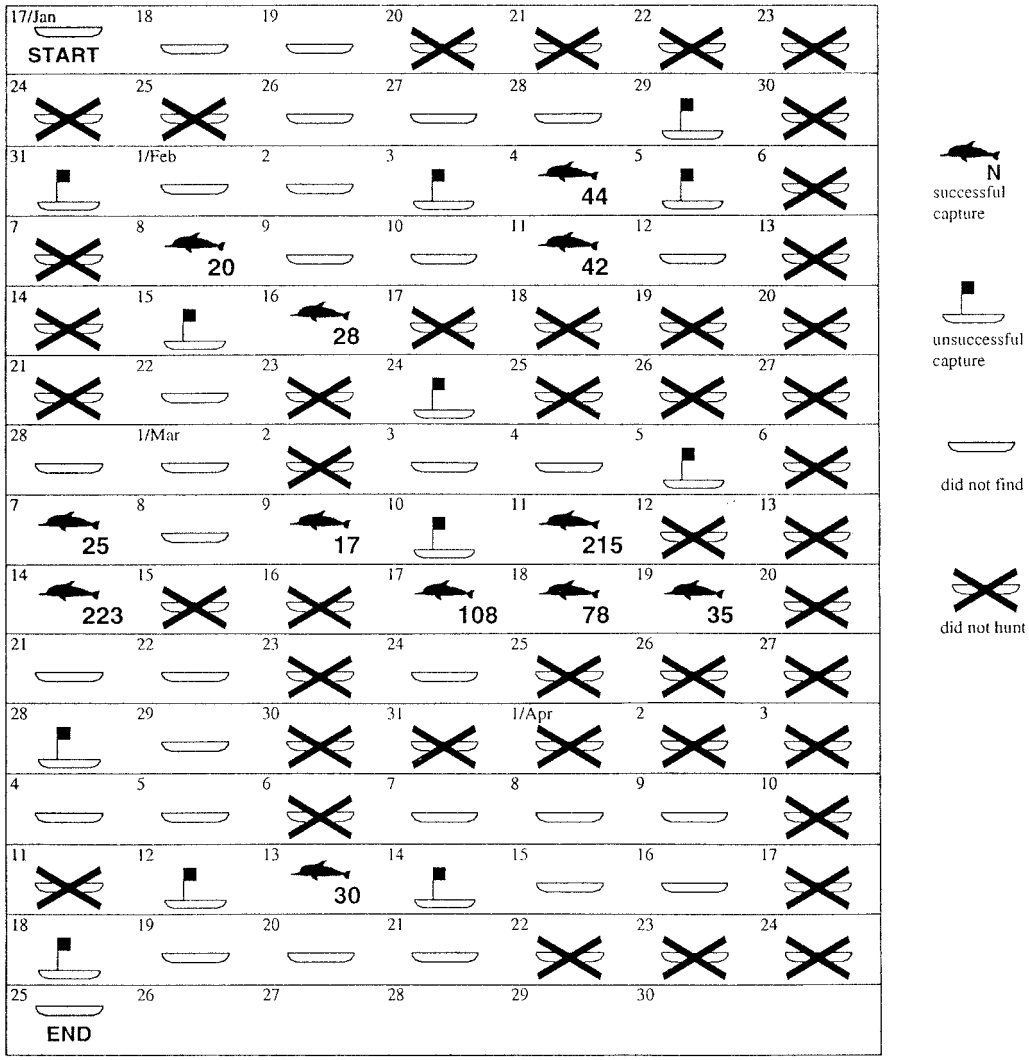

Figure 2. **Record of the 1994 dolphin hunting activity.**

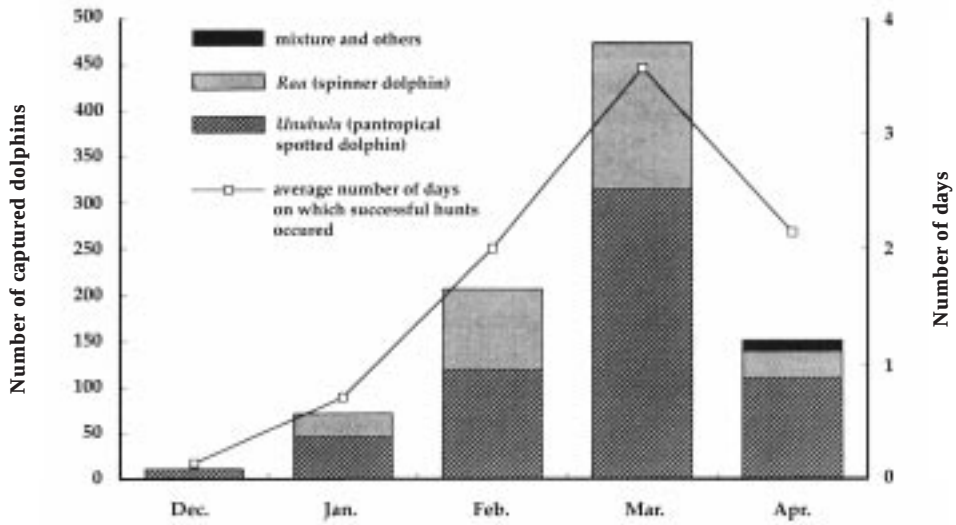

Figure 3. **Monthly dolphin hunting records.**

Hunting starts at about 04:00 hours. A large trumpet shell is blown in the village to summon all hunters to the meeting house (*tofi*), where they pray for success. Then they paddle as far out as possible in the calm sea of the pre-dawn darkness.

Dolphins are sometimes found near the shore. These schools are called *Raa fafonafo*. But in many cases dolphins are located more than 10 km offshore. After moving out to the open sea, canoes are deployed to wait for the dolphins. The distance between canoes is more than 1 km (Figure 4), and visibility among them depends on the weather or waves. At most it is 2 km. No one knows when and where the dolphins will come. The solitary hunters float on the sea until midday waiting for them.

If a hunter finds a school of dolphins, he quickly follows it and moves his canoe outside of them. Then he raises a flag to signal the others. The next hunter to see the flag then raises his, and so information is transmitted among all canoes. (The flags can be seen for about 5 km.) By using the flag, hunters can recognise the most distant canoes. Each man must then decide his proper direction of movement by his relative position and by the location of other flags. Great skill is required to properly organise a "U" shaped formation in which each canoe will maintain an approximately 1-km spacing.

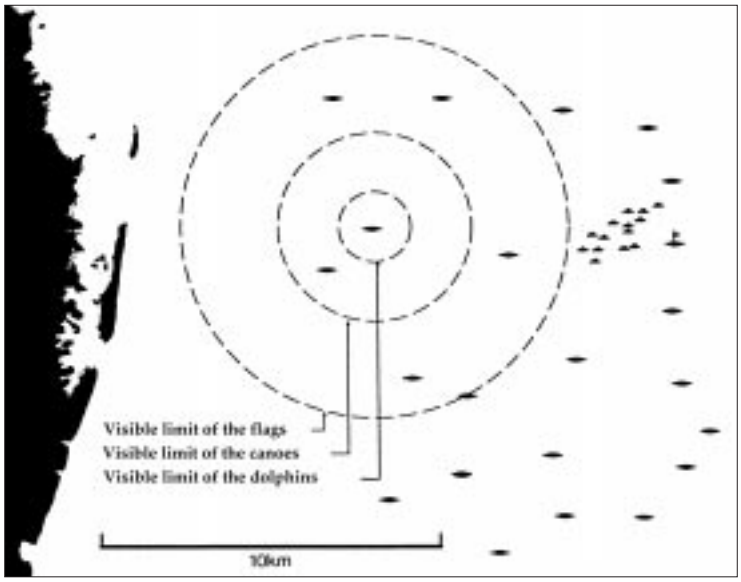

Figure 4. Visible range of a dolphin hunter from his canoe and other canoe positions when searching for prey.

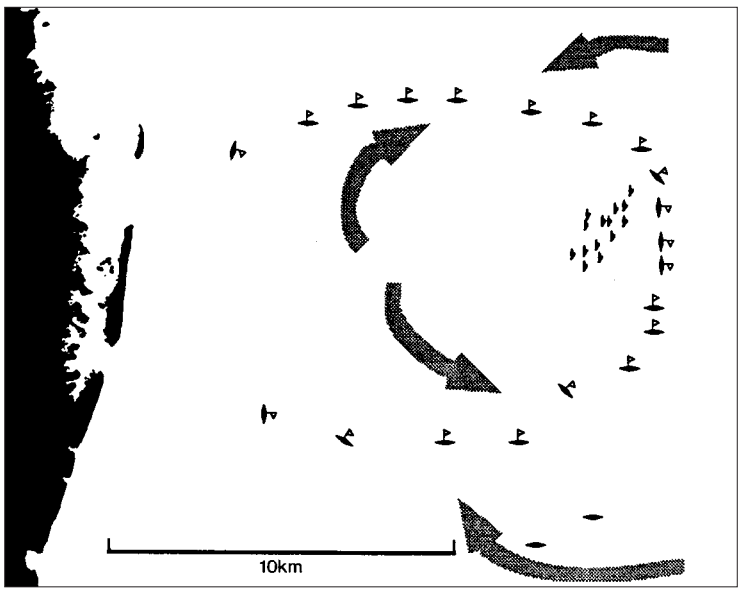

Figure 5. Canoes following dolphins and making the *ala* formation.

For example, if dolphins are found by an offshore canoe as in Figure 5, the other hunters must not move straight to the flag. The canoes to his landward side should move parallel to the shore and those seaward of him should move in the direction of the village. This manoeuvre could be easily understood were a bird's eye view possible. But the hunters cannot see the complete shape of the required formation, and only a few canoes are barely visible. Hunters must therefore envisage the actual situation based on very limited information.

Canoe formation for hunting

The "U" formation of canoes is called *ala* (Figure 6). *Oga na ala* is the main position to hit stones for driving the dolphins. During the hunt the dolphins usually swim near the *oga na ala*. *Ana ala wane baita* (lit. "the big man of the hunt"), commands all the canoes in the middle of *oga na ala*. Fanalei hunters do not have a particular leader, but a very experienced hunter occupies this position.

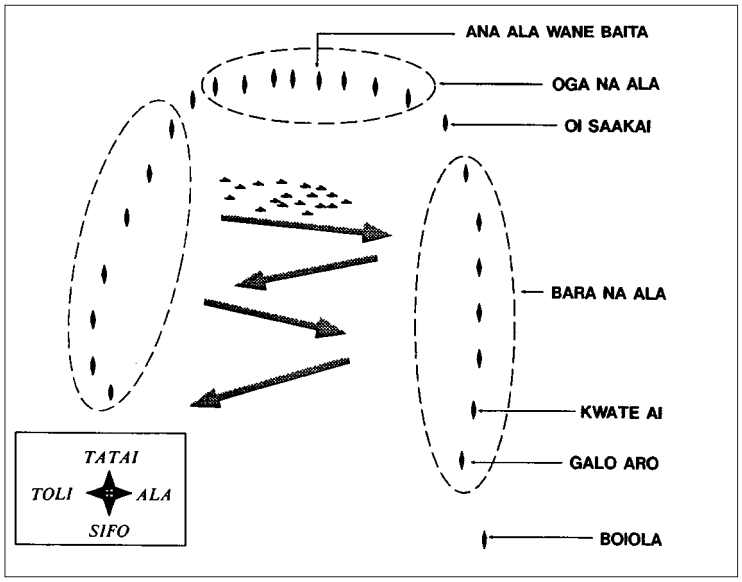

Figure 6. The canoe formation of *ala* during dolphin hunting.

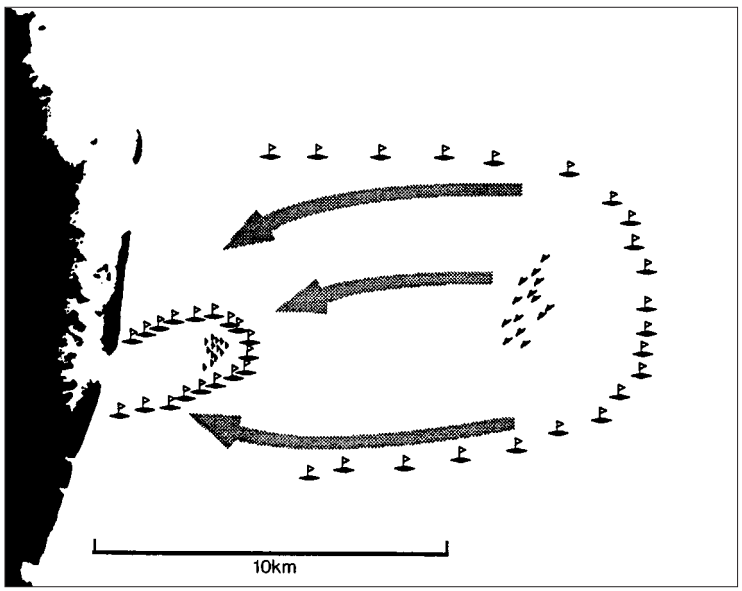

Figure 7. Driving dolphins to the Fanalei passage.

The next canoe at both ends of the *oga na ala* are *oi saakai*. These two canoes work as a joint of *oga na ala* and *bara na ala*. *Oi saakai* indicate the lining up direction to *bara na ala*.

The wings of the *ala* formation are *bara na ala*. *Bara na ala* controls the shape of formation to keep the dolphins inside *ala*. It is claimed that "If any canoe of *bara na ala* lies in a zigzag position the dolphins can escape from that place." *Bara na ala* must line up straight. When only a few canoes stand by and they are still far from the shore, *bara na ala* close both ends and make an "O" formation (*lo gosi ala*). If the range of vision is limited because of fog or waves both *bara na ala* keep a short distance and make a "V" formation (*koko fono*)

The landward canoes of *bara na ala* are called *kwate ai* and *galo aro*. Both *kwate ai* men of each wing lead *ala* in the correct direction, and the other canoes follow *kwate ai*. *Kwate ai* is also an important position next to *ana ala wane baita* ("big man of the hunt"). *Galo aro* assist *kwate ai*. When a school of dolphins swims very fast and nearly goes out of *ala*, *galo aro* move in front of the school and force them to turn back.

Boiola are canoes that come from the village after hunting has started to help in driving the dolphins. They usually weave into *bara na ala*.

Driving the dolphins

After the formation is set, the hunters start driving the school of dolphins. A hunter located by the side of the school hits two stones together under the sea (*alu fou*), thereby producing a sound that confuses the dolphins' echolocation system. The dolphins rush directly away from it. When the school approaches another canoe, the hunter in it starts to hit his stones. He must make a sound by the side of the school so as not to split it into groups. Thus, as in a football game where the ball is passed and directed toward a goal, hunters drive a school of dolphins toward the Port Adam passage in front of Fanalei village. It usually takes one to four hours to accomplish this (Figure 7).

The passage entrance is one of the critical points in the hunt, because dolphins often hesitate to go inside. Once inside the passage many other villagers, including woman and children, join to help the hunters and they finally succeed in getting the dolphins to swim into a mangrove bay located in

the passage. Then everyone jumps into the sea to catch them. They hold a dolphin gently by its mouth and swim with it toward a canoe, in which they are transported back to the village.

Traditional knowledge

Knowledge of seasons and winds

Dolphins are hunted only during the period January through April. For the rest of the year villagers usually fish in the shallow waters inside the coral reef. For the eight months from May through December, the trade winds (*ara*) blows constantly from the Southeast, generating rough seas that prevent small canoes to go to the open sea. The only exception is the turtle-hunting season, mostly in July, when the strong trade wind known locally as the *malafalisi* blows. Sea conditions are generally bad in this season, except when the weak easterly winds (*nonofolo*) blows.

During the dolphin-hunting season the northwest wind (*koburu*) usually blows in the afternoon. But in the early morning it stops and the sea becomes quite calm. Villagers regard this season, especially during the periods of week-long westerly winds (*balaitolo*) interspersed with calm, as the best time for dolphin hunting.

Knowledge of the lunar calendar and tides

Tidal movement is an important consideration in fishing, and dolphin hunting is no exception. Villagers recognise the lunar phase by the shape and location of the moon, and know that the 5th to the 9th (*singali bala*) and the 20th to the 24th day of the lunar calendar (*fulu fane*) are good lunar phases for hunting. During these periods low tide ends in early morning and high tide occurs around midday.

Dolphins are said to approach the land early in the morning to feed. For this reason, the dolphin hunters set out before sunrise, and return after midday. When the tide ebbs during the night, flotsam and seaweed are carried offshore (*rama*) and dolphins congregate. Moreover, if the tide is rising during the hunt, the canoes will be assisted by the current, which makes it easier to drive the dolphins. When the waning moon (*fulu fane*) remains in the sky until morning, dolphins often feed on the sea surface under the moonlight. Overall, this is the best time for hunting.

Current (*afe*) must also be considered. School of dolphins are known locally to move along the current. Off the coast of Fanalei, the currents flow south to north when the tide rises, and in the opposite direction when it ebbs. While hunting, every hunter keeps in mind the direction of the current and the time it will change. For example, even if dolphins run to the south, hunters should not persist in following them, because they will sometimes return after the current direction changes.

Knowledge concerning the sea

Shallow sea and open sea

The sea surrounding the village is classified into the shallow sea *(asi hara)* and the open sea *(asi matakwa)*. The former is highly varied in topographical and other features, for example, in the shape of the reef, the types of bottom deposits, depth, current and wave condition. Each feature and condition has various local names (Akimichi 1978).

The open sea and area of the dolphin hunting

The open sea is classified by distance from the land. *Fafo nafo*, literally "on the wave", is the area where the bottom of the sea is visible from the canoe. Depth in this area is at most 20 m. It is called *asi ni aole* (lit. "the sea of flying fish"), and is about 20 minutes from the land by canoe. The area where white waves breaking can be seen from the canoe is called *nafo sina*, and that where only the white sand beach is visible is *onetarau*. The area from where the tops of coconuts trees are seen to be the same height is called *niu gere*, and that where the high hills are seen on the horizon is called *tolo dama*. In *lua folosia* only the tops of high mountains can be seen, and in the area of *tolo saufini* the land is no longer visible. *Asi dadala*, which means "the very middle of the open sea", is still further out. Hunters search for the schools of dolphin from the area of *nafo sina* to *niu gere*, i.e. about 5–20 km from land.

Terms for relative direction are also used during the hunt: *sifo* is the landward side of the sea from one's canoe, and *tatae* is the opposite side. *Toli* is the right side of the sea when a hunter faces the land, and *ala* is the left side. These terms are often used when the dolphins are driven. When paddling in the open sea a dolphin hunter sometimes becomes lost, but can locate himself by triangulation.

Knowledge concerning dolphins schools

Composition

Dolphins usually move in groups, and every hunter must recognise the individual schools, because the driving method is different for different species. I will describe this using the example of their main targets, the Spinner dolphin (*Stenella*

longirostris) and the pantropical spotted dolphin (*Stenella attennuata*).

Naonao ia means "the first dolphin of the school" or "the individual leading the school". The last is called *bulibuli ia.* When the school is driven by the sound of hitting stones, hunters pay close attention to these first and last individuals. If they can successfully control the *naonao ia* and *bulibuli ia*, they can easily control the others.

One school can range from 30 to 600 dolphins. The average capture is about 80. A large school is called *ia ofu*, and when the view of swimming dolphins extends as far as the eye can see, this even larger school is called *sina afu*. A villager often uses the word "*sina afu*" when relating old stories or dreams. Schools the size of *ia ofu* and *sina afu* are difficult to drive, so the hunters use their canoes to force the school to divide, a technique called *oba.*

A school composed of only mature individuals is called *susu bora*. *Susu bora* is considered good because it is easily driven and includes many large individuals. A school that includes immature dolphins is called *le fai gale*. *Ia dolola* is a school composed of two or more species. The false killer whale (*Pseudorca crassidens*) will sometimes swim with the pantropical spotted dolphin. The last two types of school, *le fai gale* and *ia dolola*, frequently split into small groups while being driven toward the land. These split groups are termed *unu*. Sometimes *unu* will rejoin the main group, but in many cases the hunt is not completed once a school has divided. So hunters are very cautious when driving such schools.

Behavioural states of dolphins

Skilled hunters are also very conscious of the dolphin's behavioural state. When dolphins play by spinning or jumping in one spot, it is called *asi kale*. Hunters say that when dolphins are doing this the density of the school is high and there must be many dolphins.

Dolphins unaware of the presence of a canoe and swimming slowly before the start of the drive are said to be in the state of *oirau*. If a hunter finds *oirau* dolphins, he raises a signal flag and follows them until the hunting formation has been arranged.

When hunters who are following dolphins think that every canoe is ready, they simultaneously start to hit two stones under the water. The dolphins are surprised at the sound of the stones and their echo location system becomes confused. They will rush directly away from the noise in a state called *tolo.* When they tire, the dolphins float and swim around on the surface of the sea. This state is called *fa ngata.* When dolphins are *fa ngata*, hunters can easily recognise the location of the school, and will cease hitting the stones and only watch over the dolphins. *Tolo agatai* is the state in which dolphins panic and swim in many directions. In this condition it is very hard to control and drive them.

Su munumuno is the state in which all the dolphins remain submerged for a long time, generally more than one minute. When hunters drive the school near the land, *su munumuno* is liable to happen. When dolphins are *su munumuno*, the hunters cannot judge where the school will emerge. In this case, all the hunters will hit stones to make the dolphins surface.

Tara means stranding. One elderly man told me that when a dolphin is getting old, it would go to a particular beach to die. (Old tunas do the same.) The beach in front of Fanalei is one such place.

Knowledge concerning the dolphin species: their classification and characteristics

In Fanalei Village dolphins are classified into 15 types related to the type of teeth. Each type and its characteristics attributed by the village people are listed below. Species are identified in some cases.

Raa is the spinner dolphin (*Stenella longirostris*). It has a long beak, a small body, a white belly and a black back. Its teeth are the smallest of all dolphins in this area and number about 160. It swims relatively close to shore, can twist in the air, and occasionally does not flee from the sound of the stones.

Raa matakwa is a colour variation of the spinner dolphin (*Stenella longirostris*). Its characteristics are almost the same as *raa*, however, the belly is red and it swims relatively offshore. (The word *matakwa* means "open sea".)

Subo raa is also a variety of spinner dolphin with a slightly bigger body but with the same coloration. It swims relatively offshore.

Unubulu is the pantropical spotted dolphin (*Stenella attenuata*). The body is larger than *raa*, has many spots and the belly is sometimes white. The teeth are also a little larger than those of *raa.* It swims in the open sea, and when it jumps, the caudal fin bends strongly. It flees quickly at the noise made with stones, to which it appears to be sensitive.

Robo tetefe is the striped dolphin (*Stenella coeruleoalba*). The belly is white, and the roundish, smooth-skinned body is striped on both sides. The

beak is small. It has flat-sided teeth, and it is said to jump the highest of all. Each school of *robo tetefe* has an individual who appears to lead the others when they attempt to escape. It flees quickly in the open sea when stones are hit together, but is very hard to drive into the shallow water.

Robo manole (*Delpinus delphis*?) has a beak like that of *raa* and *unubulu*. The body is the largest among the types, and it has a slightly backward-curving dorsal fin. When it flees, the hunters describe it as sometimes splashing on the surface of the sea like a garfish (*manole*).

Robo au, also called *robo tafungai* or *robo gou tori*, has the most valuable teeth. *Au* means sharp, *tafungai* means "real" and *gou tori* means "flat head". The last *robo au* catch was recorded in 1978 by Walande and Sulufou villagers. For the last 100 years *robo au* have been hunted very little. From some sample teeth I identified *robo au* as the melon-headed whale (*Peponocephala electra*).

The melon-headed whale is a very rare species. They often strand in a group and show no evidence of migration (Martin 1990). It was reported that melon-headed whale were killed in fisheries in several regions, although human activities do not have a significant impact on this species (Northridge and Pilleri 1986). However, off Malaita hunting may have reduced the population of melon-headed whale.

In the old stories, Fanalei villagers say that the school size of *robo au* was usually more than one hundred individuals and when fleeing they sometimes leap a very long distance. The colour around the mouth was said to be pink and the back black. This suggests that *robo au* represents the melon-headed whale. Villagers also say that the beak of *robo au* is only the size of a human hand, and there is a white stripe on both side of the body. This suggests that *robo au* may be Fraser's dolphin (*Lagenodelphis hosei*), and recent studies found that melon-headed whales are occasionally associated with Fraser's dolphins (Perryman et al. 1994). These two dolphins have very similar teeth, so possibly *robo au* is the local name for both the melon-headed whale and Fraser's dolphin.

The teeth of the following dolphins have no value for the Malaita people, apart from the To'ambaita-speaking people in the northern area. So these dolphins are not hunted in Fanalei. They are occasionally seen stranded on the beach or are inadvertently caught with other valuable species. Descriptions of these unimportant dolphins types vary from hunter-to-hunter, especially in regard to the following *robo* (big tooth) type dolphins. The following descriptions of these dolphins were mostly related to me by experienced hunters.

Olo folosi walo is the bottlenose dolphin (*Tursiops truncatus*). It has a flat, duck-like beak and a large body. The teeth are also large and spindle-shaped. Usually 2–5 individuals swim together near the coral reef, and they are not often seen jumping. The hunters say they cannot catch *olo folosi walo* because they are not frightened by the sound of stones. *Olo folosi walo* means "stay near the reef", this dolphin is also known by the name of "*dakdak*", which means "duck" in Solomon pidgin.

There remain some *robo*-named dolphin teeth, as in *robo baa*, *robo*, *robo fouboso*, *robo matakwa*, *robo sarae bina*. Fanalei villagers say that both the shape of the teeth and the types of dolphins are different. However, they cannot distinguish them as well as the other types, such as *raa, robo tetefe* or *unubulu*. I identify these *robo*-named teeth as variants of bottlenose dolphin teeth.

Gwou mudu is Risso's dolphin (*Grampus griseus*). It is sometimes seen to remain quiet on the surface of the sea for more than one hour and it lands on its belly after jumping. The body exceeds 3 m and the teeth are large.

Ga ia robo may be the false killer whale (*Pseudorca crassidens*). The body length exceeds 5 m. It seldom jumps, but rather raises its head above the surface of the sea and moves up and down.

Acknowledgements

The material presented here is based on two earlier papers (Takekawa 1996a and 1996b), both published in *Senri Ethnological Studies No. 42*. I am most grateful to Professor Akimichi Tomoya and the Editorial Board for granting permission to use portions of it here, as well as to reproduce all the Figures used in this article.

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Women, rural development and community-based resource management in the Roviana Lagoon, Solomon Islands: establishing marine invertebrate refugia

Shankar Aswani[1]

Introduction

Marine protected areas (MPAs) and spatio-temporal refugia can be effective fisheries management initiatives, particularly for multi-species tropical fisheries where absolute yields are difficult to predict and where there are multiple users and fishing techniques (Man et al. 1995; Russ 1994; Russ and Alcala 1996; Wantiez et al. 1997). Researchers broadly agree that MPAs are beneficial in enhancing spawning stock biomass, and allowing for larval dispersal and export of adults to adjacent non-protected areas (Bohnsack 1993; Johnson et al. 1999; Roberts and Polunin 1991; Russ and Alcala 1999). Likewise, spatio-temporal refugia alleviate pressure on stocks by allowing depleted populations to recover during seasonal or episodic no-take periods; they may also allow for increased larval dispersal, particularly if the area is dotted with permanently closed source population zones (Quinn et al. 1993).

Robert Johannes (1998) has recently supported the application of "data-less" precautionary management in the tropical Indo-Pacific region where fisheries biologists have failed to forecast inshore fishery dynamics with any certitude. Johannes argues that the best way to manage inshore tropical fisheries is to partly devolve managerial responsibilities to local communities, since it is not cost effective for poor tropical countries to conduct science-based fisheries research. Local communities who still have customary control over their waters can enact managerial initiatives, such as restricting gear, protecting spawning aggregations, establishing temporal or permanent marine reserves, and imposing minimum size limits (see also Johannes 1978, 1981). This strategy, referred to as sea tenure, not only regulates marine resource use in *lieu* of limited scientific biological data, but also serves the social objective of guaranteeing traditional resource use (Agardy 1997). It empowers local communities by recognising their customary entitlements and by

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ensuring their participatory involvement in management. In fact, sea tenure is slowly gaining acceptance among some government and many non-governmental organisations. They view this type of property governance as having the potential to achieve sustainable resource use while empowering local communities. Anthropologists and experts in related fields are being drawn into grassroots participatory planning of regional projects owing to this awareness (Sillitoe 1998). This planning design assumes that the vested social and environmental interests of local populations supersede those of central governments or foreign agencies. It recognises that it will be impossible to enforce any managerial initiative if local stakeholders are not included and their resource stewardship acknowledged.

Sea tenure, however, like other forms of common property or community-base management systems, has a range of meanings to experts and can have diverse outcomes depending on the sociocultural, historical, political, economic, and ecological contexts in which an initiative is situated. Like other types of property governance (e.g., private or state property), common property institutions can successfully regulate resource use and access in some circumstances, but may not succeed in others (Bromley 1992). The key is to discern the factors that determine different sea common property institutions and the parameters that produce either their robustness or vulnerability. In the Solomon Islands, for example, diverse endogenous and exogenous processes have created deep-seated asymmetries between sea tenure institutions that were more homogeneous in the past. Underlying tenurial transformations and peoples' ability to articulate their systems of property governance with effective management are various historical processes that emerge from the settlement patterns of regional populations, and from their dynamic systems of indigenous sociocultural rules (Aswani 1999). These variables can have significant environmental and policy repercussions, and understanding how different combinations of property governance contribute to environmental protection is an essential prerequisite to establish-

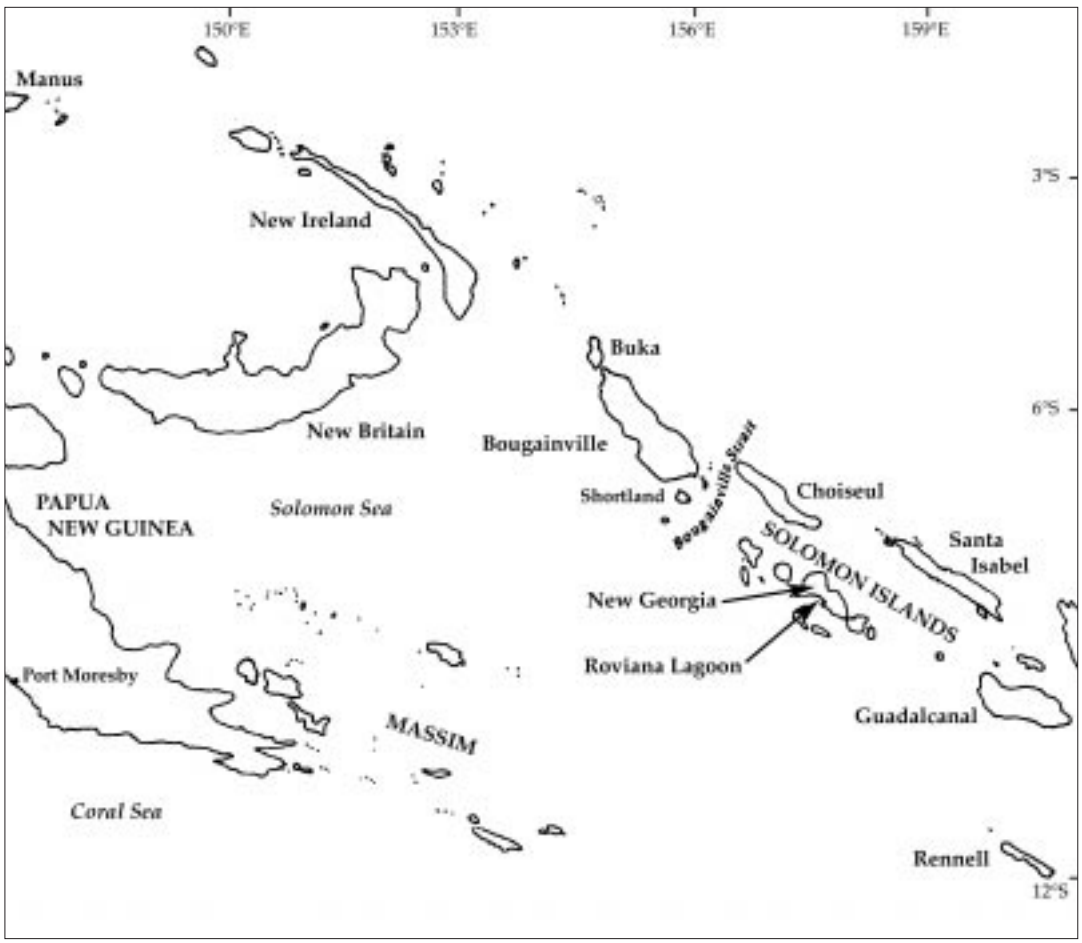

Figure 1. **The Solomon Islands**

ing managerial initiatives. Agardy (1997: 46) notes that there are areas of the world "where historical use, cultural affiliation and societal attitudes do set the stage for future effective management of marine areas", and she cites sea tenure in Oceania as a clear example. In practice, however, different forms of sea governance and management can coexist in a single region, and this raises a fundamental question: which institutional arrangements are best able to produce precautionary management programs such as marine reserves and spatio-temporal refugia?

To answer this question, I summarise a case study from Roviana Lagoon, in the Solomon Islands (Fig. 1). The case elucidates variables between different sea tenure institutions and core historical and social tenets that distinguish adaptable and successful regimes from those that are not. In addition, I examine a small-scale women's rural development project that is involved in the establishment of spatio-temporal refugia and a marine reserve in a mangrove habitat. The project's initial success indicates sea tenure governance arrangements that may favour the establishment of successful management regimes. Further, the case shows how anthropologists can integrate their empirical research results with the objectives of local people for the purpose of participatory environmental management.

Sea tenure

Sea tenure is a situation where a group of identifiable people have some form of informal or formal entitlement to sea space and where use and access rights are excludable, transferable, and enforceable (Ruddle 1996). This form of common property governance is a response to problems emerging from the use of common pool resources (CPR) in coastal marine environments. Research in this area has concentrated on Pacific Island institutions and their role in fisheries management (e.g., Johannes 1981; Foster and Poggie 1993; Ruddle 1998). Authors have generally accepted the assumption that sea tenure institutions are overwhelmed by wider global political and economic contests over natural resources (e.g., Graham and Idechong 1998; Mantjoro and Akimichi 1996), or by situations where the difficulties of exclusion and the subtractability of benefits are intensified. National and transnational political and economic processes are seen as profoundly shaping local environmental practice (Peluso 1992). It is assumed that the political and economic hegemony of state societies, articulated through disparate forms of juridical discourse and actions, disintegrate local common-property institutions transforming them into open-access systems. And yet when we closely examine people's concrete actions and concomitant events (Vayda and Walters 1999) within specific sea tenure institutions, we find that these are shaped by, and are embedded in, particular cultural and historical contexts. Indigenous practices combine with foreign economic influences to generate varying forms of governance and management. These institutional differences are not merely conceptual as they can have significant managerial implications and environmental repercussions.

Two main parameters identify resource sustainability or depletion in any form of property governance, and particularly in common property institutions: the difficulty of exclusion and the subtractability of benefits (Becker and Ostrom 1995). The first refers to a group's ability to control access to resources by its own members or outsiders. This ability depends on the social, economic, and political costs and benefits of defending a resource or territorial estate; on the group's ability to legitimise territorial claims through their validation by neighbouring groups; and their ability to enforce these claims via either formal or informal means. Subtractability of benefits refers to a situation where individuals will obtain the benefits of harvesting finite resources – particularly under public good institutional circumstances – while concurrently decreasing their subtractability for other users. If resources are located within a bounded common property regime where participants can prevent non-member resource access while enforcing limits on resource use among themselves, the regeneration rate of resources is more likely to be sustainable (Aswani 1999; Becker and Ostrom 1995).

Elinor Ostrom (1990) has proposed a set of institutional characteristics that, when present, can mitigate free-riding, subtractability, and self-enforcing problems. These include: 1) the clear definition of boundaries; 2) equitable costs and benefits for all inclusive members; 3) participatory decision-making by all stakeholders; 4) the capacity to monitor; 5) the enforceability of collective action decisions; 6) the presence of conflict resolution mechanisms; and 7) the availability of formal or informal means for users to secure tenure and organisational rights. Institutions displaying all or most of these traits are generally robust and enduring (Bromley 1992; Becker and Ostrom 1995). Often, neighbouring tenure systems appear to have uniform use and access rules of governance, but the feasibility for the development and implementation of any of these regulatory mechanisms will depend on the historical, socioeconomic, political, and environmental conditions in which each common property institution is embedded. This context determines whether or not individuals can translate

governance (i.e., peoples perceived rights) into effective management regimes (i.e., the activation of those rights). Rational actors will choose to either free-ride or not depending upon a group's potential to develop monitoring and controlling mechanisms. This fluidity leads to various degrees of uncertainty and produces complex interactions between existing systems (Ostrom et al. 1999).

In the Roviana Lagoon (Fig. 2) several historical and cultural variables form a backdrop to peoples' contemporary choices within the existing sea tenure regimes. These include: 1) population mobility over the last two centuries and the resulting variegated distribution of those who hold title to various land / sea estates; 2) the political expansion and contraction of regional polities; and 3) a fluid cognatic kinship system (see Aswani 2000). The conceptual models of "territorial-enclosed entitlement," "mosaic-entitlement," and "transitory-estates" describe the tenurial differences across the region (Aswani 1999).

The territorial-enclosed entitlement model represents a condition where territorial boundaries are circumscribed, entitlement holders are nucleated, jurisdictional power over estates is centralised under a traditional authority, and sea entitlements are regionally recognised. This model consists of various villages whose members have, through intermarriage, pooled their entitlement rights to the ocean and vested their village leaders and their polity's chiefly authority with control over their marine holdings. Participating members exploit resources without restraint, and non-members are generally allowed access to resources for subsistence purposes only. However, when valuable resources, particularly those that are predictable in space and time are commercialised, members become territorial and impose access and use restrictions on non-members (membership is defined by various kinship rules). Such a shift in strategy – from "cognised" recognition of entitlements to "effective" action – occurs because regional settlement patterns have lead to the nucleation of entitlement holders adjoining their marine holdings. This nucleation allows for the bounded enclosure of the commons and the development of monitoring and sanction mechanisms to address collective action problems.

The mosaic-entitlement model portrays a situation where territorial boundaries are contested, entitlement holders are dispersed, jurisdictional control over estates is decentralised, and different groups contest sea tenure entitlements. The core elements

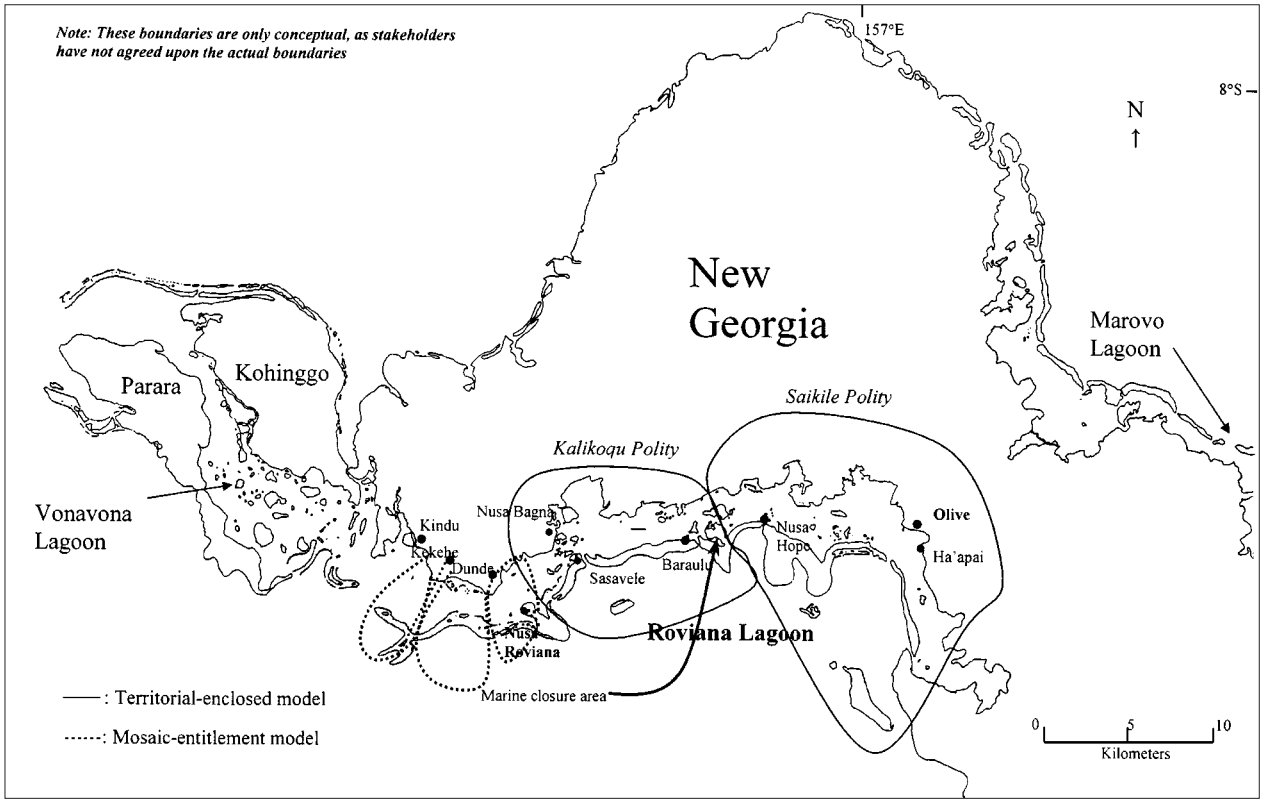

Figure 2. **The Roviana Lagoon**

in this model are single villages that unambiguously demarcate their marine holdings, which are controlled by a committee of local elders. However, because other stakeholders residing in neighbouring areas have use and access rights, tenurial authority is decentralised and boundaries are porous. Like the previous model, participating members exploit resources without restraint and non-members are generally allowed to use resources for subsistence purposes. Shell fishery commercialisation propels traditional authorities to try to enact control strategies. However, a shift in territorial strategy from cognised to effective action cannot take effect because past regional settlement patterns, political processes, and dynamic kinship rules have resulted in the dispersal of numerous entitlement holders away from their marine holdings. These stakeholders have increased their jurisdictional demands and interloping activities in waters that they consider to be theirs also. The regional variegation of entitlement holders not only engenders tenurial uncertainty, it also arrests the effective enclosure of the commons and the implementation of monitoring and sanction mechanisms to control resource subtractability and excludability. Lack of controls encourages both members and non-members to overexploit resources.

Finally, the transitory-estates model incorporates organisational elements of the other two models of sea tenure. This model depicts the situation in neighbouring Vonavona Lagoon, while the lagoon's western side fits within the mosaic model and the eastern sector the territorial-enclosed model. Vonavona can be portrayed using a transitory model because jurisdiction to sea space there is being conveyed and renegotiated as eastern and western polities continue to intermarry, changing the flow of entitlements and claims[2]. This situation has several possible outcomes: inner lagoon polities may fuse and form a large territorial-enclosed chiefly district; village-centred territories might strengthen in response to increased fishery commercialisation; or the system may collapse due to sustained boundary transgressions and disputes, leading to a de facto open-access system (Aswani 1999). This model suggests that the other two conceptual regimes in Roviana are transitory and bound for further transformation and hybridisation, but this will not be pursued here.

Institutional differences are not only conceptual – they cause real environmental repercussions. In what follows, I compare time allocation, household income, and foraging returns data from Roviana villages that fit within the two major sea tenure models. The result shows that even under similar economic and, in part, ecological circumstances, local perspectives and actions regarding use and access to marine resources vary between sea tenure regimes[3].

For instance, people in Olive, a village located within the Saikile territorial-enclosed regime, are quite adamant about not allowing interlopers access their commercial marine resources (Fig. 2). Economic activities here are less diversified than in other villages and most households depend on a single marine resource, *Nassarius camelus*, for income (Fig. 3). The shells are harvested from nearby reefs and sold to local buyers. They are then marketed to the Tolai of New Britain who use them as a traditional currency. Adult members (between 17–65 years) of most families dive four to five times a week with a weekly average of twelve hours labour for men and fourteen hours for women. The greater effort toward this activity has resulted in neglected gardens and coconut plantations and a greater reliance on imported foodstuffs. Results show that 86 per cent of households participate in diving and that for 75 per cent of them this is the most important economic activity. Subsistence fishing returns are high with an estimate mean return rate of 2360 kilocalories per hour of fishing (Aswani 1997). Hamlets are quite territorial and 84 per cent of households assert that neighbouring villages (within the Kalikoqu polity) should ask chiefly permission before accessing their commercial marine resources. Fishery commercialisation has transformed peoples' enactment of territorial rights from a mere recognition of sea tenure rights to actual territoriality, thus strengthening the common property institution and possibly mitigating resource abuse.

Nusa Roviana, by contrast, is a village we would classify within the mosaic entitlement model (Fig. 2). Like Olive, many adults dive often for trochus shells, with an average of twelve hours labour for men and three hours for women[4]. Fully 88 per cent of households participate in diving

2. Contemporary intermarriages between members of the illustrated models in Roviana are not yet having the same jurisdictional effect as in the smaller Vonavona Lagoon (see Aswani 1999).

3. These data represent a summary of research conducted from March 1994 to December 1995 in the Roviana and Vonavona Lagoons. Additional research has been conducted since 1998 until the present. Detailed research results will be published later.

4. Women at Nusa Roviana do not dive as much as women in Olive because many work at a nearby cannery, making wage labour an important source of income. However, most of these are young women who independently spend their money, and only a fraction of their incomes enters the household.

Figure 3. Drying *Nassarius camelus* shells at Olive village.

and that this activity is paramount for 76 per cent of households. Fishing returns are relatively low in this part of the lagoon owing to widespread intrusion by neighbouring villages, with an estimate mean return rate of 891 kilocalories per hour of fishing (Aswani 1997). Marine environments are overexploited and people have reported a significant decrease in catches. Notwithstanding the importance of shell diving to the local economy, hamlets are hardly territorial, with only 10 per cent of households asserting that neighbouring villages should ask chiefly permission before accessing commercial marine resources. Shellfishery commercialisation has in effect resulted in a weakening of the common property institution and has lead to *de facto* open-access and attendant resource degradation. This has not resulted from fishery commercialisation per se, but rather from the local inability to effectively close their commons.

Olive and Nusa Roviana villagers' economic dependence on commercial shell should make them reluctant to allow outsiders to exploit their resources. Naturally, there are other variables that pattern peoples' economic activities and their concomitant opportunity costs, including seasonal economic and ecological changes which affect the cost–benefit ratio of territorial behaviour. But considering that the exploited resources in both villages are available throughout the year and are predictable in space and time, we would expect that both villages would implement regulations to control use and access to their marine resources. But instead there exists a clear asymmetry between each village's territorial strategies and the villagers' cultural attitudes regarding use and access to marine resources. This is despite the fact that people in both areas cognise their entitlement rights to sea space in a similar fashion. The differences have resulted from different historical trajectories that have shaped diverse institutional situations: in one, systems of governance can translate into systems of management; in the other, they cannot.

This example indicates that when territorial-enclosed sea tenure regimes are confronted with economic and social pressures they do not inevitably fall into institutional decay evolving into open-access. It further suggests that in the case of mosaic-entitlement sea tenure institutions the open-access commons are not necessarily the result of institutional breakdown caused by the market economy, but can result from endogenous processes.

In other words, the present asymmetries between these common property institutions manifested in their varied organisational and managerial responses to exogenous agency, challenge the assumption that fishery commercialisation will linearly transform community property governance into open-access. Further research will be needed to develop a comprehensive account of

common property institutions and their contemporary transformations.

To that end, myself and students at the University of California, Santa Barbara and University of Otago, New Zealand, in partnership with WWF-Solomon Islands, have begun a multidisciplinary research project funded by the John D. and Catherine T. MacArthur Foundation that will study the following:

- changing regional demographic patterns and their impact on sea tenure;
- spatial patterns of settlement;
- cultural competence regarding tenure across the region;
- time-allocation and income generating patterns;
- correlations between Western science and indigenous ecological knowledge; and
- spatio-temporal patterns of marine harvest efforts.

It is expected that this research will result in a theoretically driven understanding of how common property institutions are transformed in situations of rapid demographic, economic, and political change. The study will also elucidate relationships between indigenous and Western ecological epistemologies, and will contribute to the development of a comprehensive theoretical model of human adaptive foraging strategies in marine ecosystems.

What are the local environmental and policy repercussions of the documented variation in sea tenure? Understanding how different combinations of property governance contribute to or perhaps hinder environmental protection is an essential prerequisite to establishing any form of effective management. Conservation practitioners must ask which institutional arrangements are most appropriate for creating marine reserves and spatio-temporal refugia. Preliminary results indicate that of the three arrangements modelled here, the territorial-enclosed model of sea tenure is most suitable because it is not adversely affected by fishery commercialisation. Indeed, in this system such pressures can actually strengthen resource use and access controls. Its power centralisation, nucleated stakeholders, and uncontested boundaries facilitate co-managerial schemes between conservation practitioners and local people. Moreover, managerial success in these areas is likely to encourage villagers living in other areas that are more vulnerable to resource overexploitation to negotiate with neighbouring groups toward natural resource management.

Policy makers in the Solomon Islands and elsewhere where customary sea tenure persists can make informed managerial decisions by recognising that different tenure arrangements may exist within their countries. For example, by identifying differences between local tenure regimes and how these come into existence and respond to changing circumstances, policy makers can better determine where formal codification of customary law and resource use and access rights is necessary for better resource management. Further, this can provide a road map to identify economic and social circumstances that generate tenurial regimes that are most and least vulnerable to transformative processes such as economic development and population growth. This, in turn, will facilitate implementation of sounder regional economic schemes such as aquaculture and ecotourism.

Finally, by recognising the importance and variation of tenure systems, planners gain a better basis on which to select sites where managerial initiatives are more likely to succeed. As described in the next section, in Roviana the ethnographic study of sea tenure has been useful towards selecting an institutional context that is less vulnerable to resource abuse and is more likely to produce sound resource management in conjunction with a small-scale development and conservation project. The project has a better chance of success due to the institutional stability provided by the community's territorial-enclosed model of sea tenure. The lack of territorial disputes and interloping together with demarcated territorial boundaries and traditional power centralisation can assure the success of closures if monitoring and sanction mechanisms are developed and enforced to address collective-action problems.

Women's rural development and the establishment of marine invertebrate refugia

The fishing activities of Pacific Island women are, without a doubt, crucial in providing a source of protein and income to thousands of coastal villages in Oceania (Chapman 1987). Regional fisheries development plans, however, have usually focused on men and ignored the role of women in artisanal and small-scale commercial fisheries; this notwithstanding that in many areas women spend as many hours fishing and gleaning as men do. Because women are so important for household resource procurement, any attempt to develop long-term sustainable artisanal fisheries in the region will require their participation (Bidesi 1994). Certainly, sustainable development can only be achieved through the social and economic empowerment of women and other marginalised groups

(Overton and Scheyvens 1999). And yet, women's voices concerning sustainable development, the environment, and the health of their communities continue to go unrecognised (Griffen 1994).

Roviana women's fishing and gleaning activities are vital to the nutritional and economic needs of most lagoon households (Fig. 4). The maritime activities of men and women merge in the angling inner lagoon fishery, but they diverge when conducted in the barrier islands/outer lagoon (*vuragarena*) and in the mainland or barrier island mangrove forests (*petupetuana*). The former is the domain of men, where big game fishing is carried out, while the latter is where most significant women's gleaning activities take place. These, however, are only generalisations since women frequent barrier intertidal zones for gleaning and angling and men do visit mainland mangrove habitats for spearing, netting, and line fishing. Roviana women have a deep awareness of the biological rhythms of their lagoon and the creatures that inhabit its numerous habitats. This ecological knowledge is rooted in the maritime experiences of the ancestral coastal peoples who inhabited the lagoon. Their close contact with the environment has lead women to recognise the ill effects of logging on estuarine invertebrates and coral communities, and has made them increasingly aware of human-induced decreases in shell stocks. In particular, women have noticed a significant reduction in the abundance and size of *Anadara granosa* (blood cockle) (*riki*) and various *Polymesoda* (mud clams) (*deo*) bivalves (e.g., *Batissa fortis*) (Aswani 1997; Hviding 1995).

This growing awareness has prompted some women around the lagoon to encourage traditional authorities to impose some form of management regime. In July of 1999, I, in collaboration with WWF-Solomon Islands, established "The Baraulu/Bulelavata Women's Sewing Project" to assist women in this effort[5]. This is a small-scale sewing project designed to provide local women with a measure of financial independence to support local enterprises such as the construction of a permanent facility for women's activities, sending local women to nursing and vocational schools in Honiara and other initiatives. The proposed activities are directly linked to a resource-management plan, but unlike most conservation initiatives that focus exclusively on conservation it also works towards local developmental needs. The project is linked to a resource-management initiative concerned with the temporal closure of selected mangrove habitats to protect various crustaceans and

Figure 4. Roviana women fishing

bivalve species. The long-term goal is to create a permanent marine reserve. The income that women lose by not selling shells is compensated for by the sewing project's cash profits. Because of this incentive and their genuine concern for their resources, women have agreed to temporarily ban from September to May the collection of overexploited mud clamshell, blood cockles, oysters, and all other invertebrates in this habitat (for a trial period of two years). The closures began in September of 1999 and reopened in May of 2000, and then closed again in September of 2000 to reopen in May of 2001.

The restricted areas are Rereghana and Duduli near Baraulu village, which encompass several km^2 of mangrove habitat (Fig. 5). Mangrove ecosystems are well established in the region and are extremely important as nurseries for juvenile fish, as spawning grounds for numerous species, and as major feeding zones for reef and pelagic species alike. The most prevalent mangrove species found in Roviana and Vonavona are *Rhizophora* species in the low mangrove forests, and *Rhizophora* mixed with *Dolichandrone* and *Bruguiera* species in taller stands (D.O.S 1974). The substrate of adjacent waters is fine silt and clay with colonies of *Thalassia* and *Enhalus* sea grasses.

5. The New Zealand High Commission, Solomon Islands, WWF-Solomon Islands, and Danish churches have provided funds for this project.

Scattered dead and living *Porites* coral colonies dot these areas and provide good spots for fishing for small reef and pelagic species. These areas are regularly used for several activities, including gleaning shells, spearing fish, collecting crabs, and finding bait. Women frequently visit them for gleaning during the *masa rane* season from mid-May till the end of August (Aswani 1998). The closed sites are the most frequented and overexploited of the harvesting areas available to Baraulu/Bulelavata women[6]. The period of habitat closure, however, coincides with a decline in gleaning activities (although the areas are still heavily exploited), making the initiative more acceptable to local women. Further, other mangrove areas remain open throughout the year to compensate for the loss of access to Rereghana and Duduli grounds.

Roviana women have a staggering understanding of the invertebrate fauna with which they interact, including knowledge on spawning seasonality, feeding habits, and temporal periodicity. Their anecdotal accounts suggest an increase in abundance and size frequency of both mud clams and blood cockles as a result of last year's closure. However, at the time of the ban no studies were conducted to determine the conditions of the shellfish grounds or the potential outcomes of the spatio-temporal refugia. Moreover, there is little scientific data on the demography and life history of the targeted bivalve species. This year, UCSB students and WWF personnel will conduct field studies to assess population abundance and distribution prior to the opening, during the harvesting season, and after the closure in September. A control site that has not been subject to any closures will be also monitored. In addition to studying harvesting patterns within the closures, field studies and a literature review will explore the aptness of placement and size of the preserve and other biological factors. We hope that this will help enhance the initiative and prepare the way for a permanent marine reserve to harbour a source population.

This initiative, however, is not without risks. Poaching by participating members could undermine the project's managerial goals. Through the involvement of traditional and church authorities, members of the community have been encouraged to respect the women's project and to endorse the resource-management initiative. To foster this process, WWF, the Western Province Fisheries Division, and UCSB will develop a series of workshops to assist local communities in monitoring and enforcing the closures and to check for changes in the resource base. There are also social risks to this project. A myriad of problems may arise ranging from disputes among women to a boycott of the project by men. In fact, there are signs amongst Baraulu/Bulelavata women of a dependency on capital assets and growing tensions and disorganisation. To mitigate this tendency, WWF personnel are helping Baraulu/Bulelavata women to improve their finance management, equipment maintenance, and leadership skills (Simon Foale, pers. comm.). What is more, Baraulu/Bulelavata men have agreed: 1) to medi-

Figure 5. Rereghana and Duduli marine closure areas (far left)

6. Baraulu village is the core community while Bulelavata is a nearby settlement formed by Baraulu people.

ate any internal disputes; 2) to support their spouses; 3) not to interfere in the project's finances, except when women request their assistance; and 4) assist in constructing a permanent facility for women. This project has the potential of empowering local women by encouraging them to manage their shellfish resources while developing a long-term community-cash enterprise. Overall, we are optimistic that the project will attain its goal of better resource management, primarily because the closure is in a sea tenure regime where boundaries are well defined, where there are no poaching pressures from neighbouring groups, where there is a capacity to monitor and enforce rules, and where the closures have been established through the participatory decisions of all stakeholders.

Conclusion

Pacific Island sea tenure systems are presently being promoted by outside experts and increasingly by national fishery policy makers, as alternative managerial tools to state centralised systems of coastal management. Many governments are slowly realising that it is more cost-effective to keep inshore artisanal fisheries management decentralised; under the control of local people rather than understaffed and poorly funded government agencies (Ruddle 1998). The endorsement of sea tenure institutions and indigenous knowledge as managerial tools, however, has often proceeded without adequate consideration of their transmutability. If we attribute the transformations of sea tenure exclusively to exogenous agencies, we ignore the centrality of local praxis, embedded as it is in local culture and history. By carefully analysing local practices and events and the circumstances that may encourage individuals to free-ride, a clearer picture emerges of the causative chains that transform sea tenure governance and management rules. Researchers must avoid the temptation to simply cast sea tenure as a single model of "community-based resource management." Sea tenure systems have emerged from diverse historical trajectories, and the result has been wide-ranging and dynamic managerial systems.

The essentialisation of sea tenure systems by some conservation practitioners is a flawed framework upon which to base resource-management policies. Roviana sea tenure regimes are institutional hybrids that are dynamic in nature and enmeshed in complex interactions. This recognition has allowed for the informed selection of a tenure regime where management initiatives are more likely to succeed. The initial success of the temporal closures in Baraulu/Bulelavata, Roviana, suggests that the territorial-enclosed model of sea tenure is the form that is most stable, and thus more amenable to precautionary management programs such as marine reserves and spatio-temporal refugia. Future research must develop an adequate data baseline and the means to integrate indigenous institutional and ideational frameworks with government and non-government group's plans to protect insular Pacific marine ecosystems.

Acknowledgements

I am grateful to the people of Baraulu and Roviana and Vonavona Lagoons in general for allowing me to work with them for all these years. I also want to thank the National and Provincial Governments, and the Roviana Lagoon Area Council for their support. The John D. and Catherine T. MacArthur Foundation (#60243) funded this research. The Royal Society of New Zealand, the National Geographic Society and the University of Auckland, through the New Georgia Archaeological Survey project (NGAS), as well as the National Science Foundation (SBR-9320498), Sea Grant (University of Hawai'i R/MA1 and NA36RG0507), WWF-Pacific and ICLARM granted previous support. I wish to thank David Akin, Pam Weiant, Deborah McArdle and Hillary Haldane for their editorial comments.

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Traditional knowledge possessed by the fishers of Marovo Lagoon, Solomon Islands, concerning fish aggregating behaviour

by Robert E. Johannes and Edvard Hviding

Explanatory note

Bob Johannes was asked by the Marovo Area Council to record important aspects of the traditional knowledge of Marovo Lagoon fishermen concerning their marine resources. His fieldwork was done during the last three weeks of May l987 with the assistance of Edvard Hviding. Hviding, who had been living in Marovo for a year, and was studying other aspects of traditional fishing and marine resource management, including customary marine tenure and its associated knowledge base (cf. Hviding 1988, 1996), had already gathered important information relevant to Johannes' study, so they combined forces to write the report on which this brief article is based.

Marovo marine lore is so exceptionally rich that full study of it would require an appropriately trained marine biologist to spend at least l8 months living in the Marovo area and in daily contact with Marovo fishers. However, because of the friendly and enthusiastic help of Marovo fishers and the village communities of Chea, Ramata, Keru, Tamaneke, Bili and Vakabo it was possible to make considerable progress during the necessarily short period of this preliminary study.

Introduction

The Marovo Lagoon of Western Province, Solomon Islands includes a wide range of marine community types, from mangrove estuaries and mudflats, to sandy or coral lagoon bottoms to the barrier reef, including the biologically important passages through the barrier reef, and the oceanic waters beyond. A great many different kinds of fish and shellfish are found in these different environments (cf. Hviding 1995). Marovo people probably eat or otherwise use a greater variety of species of marine animals than 99% of the world's fishers. Their knowledge of sea animals is therefore very impressive. Recently, Hamilton (1999) has shown, through a detailed, representative study of subsistence fishing for trevallies (Carangidae), that the knowledge of the fishers of nearby Roviana Lagoon is similarly rich.

Some of the most important practical information fishers possess concerns:

- where fish and other marine organisms are found in large numbers;
- when they are found there (that is, season, lunar period, tidal stage, time of day); and
- their behaviour and movements.

Many reef and lagoon fish come together in large numbers during particular months, during particular moon phases and at special places. Some of these aggregations are described in Marovo by such names as *bobili, baini, rovana,* and *sakoto,* the meanings of which are discussed below. Knowing this makes it easier for the fishermen to be at the right place at the right time for good fishing.

Sometimes these aggregations form for the purpose of spawning, as when groupers mass in certain reef passes, or mullet school and swim in tight circles (see below). In other cases, fish aggregate for the purpose of feeding, or for protection. In still other cases neither Marovo fishermen nor biologists know why the fish come together.

Marovo terms for different types of fish aggregations

Marovo fishermen have names for many different types of aggregations of fish. These names are based on the appearance of the aggregation, its apparent purpose, its movements, and the movements and behaviour of the fish within it. This system of names is more diverse than that used by marine biologists to classify fish aggregations.

Different villages in Marovo sometimes use different names for the same type of aggregation. In addition, the term for a certain type of aggregation by fishermen in one area will be used to describe a different type of aggregation in another village. Here we have chosen the names that, in our experience, seem to be most commonly used. These 15 major aggregation types are, listed alphabetically:

• *Ajara*

This word describes often large schools of fish, heads down sucking in sand (and filtering out and eating tiny plants and animals that live in it). Such fish include mullet and goatfish.

• *Avara*

Describes sea birds and skipjack or other tuna moving together close to the sea surface in pursuit of baitfish.

• *Baini*

Baini refers to moving, non-feeding schools of parrotfish, jacks (trevallies) and some surgeonfish. The term is specified according to type of fish, such as *baini mara* (trevallies) or *baini malakihi* (a certain type of parrotfish). Such schools swim in more or less straight lines, but sometimes reverse direction. When such schools stop to feed they are described by other terms such as *umoro, tupitupili* and *tore* (see below).

• *Bobili*

Bobili is a term that describes non-feeding schools in which the fish mill slowly in a tightly packed circle, sometimes rising and falling as a group in the water column. Often the individual fish in such aggregations seem rather unconcerned about approaching danger, making them easy targets for sharks or spear-fishermen. In many instances, fish involved in *bobili* are ready to spawn; fishers notice that they are full of eggs or milt, although only a few fishermen we talked with had actually seen spawning occur. *Bobili* aggregations frequently occur only at special times and places. Fish involved in these aggregations are mullet, scad (*Selar* sp.), milkfish, bonefish, bony bream (*Nematolosacome*) and certain parrotfishes. More details about *bobili* are given below in sections concerning some of these fish.

• *Chapa*

Chapa refers to large schools of predatory fishes that patrol an area or drift near the surface apparently looking for food. *Chapa* typically occurs along the outer reef drop-off and in channels through the barrier reef. This behaviour is shown by garfish, barracuda, Spanish mackerel, (*Scomberomorus commerson*) and some shark species, and is sometimes indicated by frigate birds circling high above, waiting for the *chapa* to break into feeding action. When feeding starts, *chapa* is often replaced by *umoro* (see below).

• *Keli pajara*

This term refers to the aggregation in shallow water of groupers, at special places, times of the year and moon phases. It is described in more detail below under “groupers”.

• *Melamela*

This refers to small schools of fish whose heads can be seen breaking the surface as they feed on plant scum that has floated to the surface in certain seasons. Fish that do this include a large yellow-headed surgeonfish.

• *Rovana*

This refers to schools of mullet, usually numbering in the thousands, that migrate in long, narrow schools. Johannes was shown one of these in open water in the middle of the lagoon; the mullet swam past his canoe just below the surface in a

continual narrow stream only l–3 fish wide. Unless they are disturbed, mullet in *rovana* usually travel in one direction without pausing. *Rovana* is the form of aggregation that these fish take when they migrate between where they normally live and where they spawn. When they reach the spawning area they form *bobili* aggregations (see above). *Rovana* involving fish returning from the spawning ground were unknown.

• *Sae*

When fish move up from deeper water and aggregate this is referred to as *sae*. Such fish include red snapper (*Lutjanus bohar*) and blue-lined sea-bream *(Symphorus spilurus*). *Sae* aggregations appear to form, say fishers, for the purpose of spawning. The spawning aggregations called *kelipajara* (see above) are different from *sae*, however, in that the fish are spread out more and stay closer to the bottom.

• *Sakoto*

This term means 'mortuary feast' in the Marovo language, and describes quiet, almost motionless, resting schools of certain fish looking, say fishers, like a gathering of mourners. Certain snappers that feed at night, including Moses perch (*Lutjanus russelli*), are often seen during the day in such schools under the over-hanging branches of trees near shore, especially around new moon. Such aggregations are often attacked by barracuda. Small hussars (*Lutjanus amabilis*) and some other small red lutjanids form *sakoto* aggregations at middle depths on reef slopes, typically around full moon.

• *Tore*

When individual or small groups of predatory fish such as barracuda or jacks (trevallies) break the surface in shallow water near shore in pursuit of baitfish or aggregations of fish such as small snappers, it is known as *tore*. In some villages it is referred to as *rereghe* (a term from the neighbouring Roviana language) and applied to the specific predators giving chase, as in *rereghe mara*, 'trevallies in chase of baitfish'.

• *Tupitupili*

This term is applied to schools of parrotfish when they periodically stop moving along as *baini* (see above) in order to feed by nibbling at stones and coral, heads down and tails up.

• *Udumu*

Udumu is the name given to a large, tightly packed school moving slowly and looking almost like a single object. Several species of surgeonfish move in such packed groups, usually over sandy bottom. These schools stop periodically and members spread out a little to feed on the bottom. While *udumu* always involves periodical feeding, *baini* (see above) does not. Experienced Marovo fishermen reckon that some *udumu* schools of surgeonfish may consist of up to 1000 fish.

• *Ukuka*

Ukuka describes the behaviour of groups of fish when individuals drift, circle and float as if drunk. One form of *ukuka* occurs when a heavy rain is followed by hot, still weather. At such times, many types of fish (including also large fish such as trevallies) drift in shallow water and act as if drunk, or as if they have been poisoned by custom leaves (*Derris* sp.). At this time they can easily be caught by hand. On other occasions fish such as a species of small black surgeonfish are seen behaving "drunkenly" in pairs within a school. We think this form of *ukuka* may be courtship and spawning behaviour.

• *Umoro*

This term describes schools of predatory fish when they are in the act of driving baitfish to the surface that will be fed upon both by their pursuers and seabirds overhead. Fish that do this include tuna, schooling jacks (trevallies) and leatherskins (*Scomberoides commersonianus*). Watching the behaviour of the birds provides clues concerning what predatory fish and baitfish are involved and whether they are accompanied by sharks. The *umoro* concept integrates Marovo knowledge of seabird and fish behaviour (especially the many different types of tuna school) with knowledge about baitfish seasonality and availability.

Some of the species that aggregate: times and locations

Marovo fishers' knowledge of the whereabouts and timing of predictable fish aggregations applies to a substantial number of important food species. The following selection briefly exemplifies the extent of this knowledge:

• Blue-finned jack (*Caranx melampygus – marabalibalighutu*)

Blue-finned jacks are usually seen swimming alone. But for two to three days around the new moon throughout the year some do form groups. These are commonly seen in and near passes through the barrier reef and along the outer edge of the barrier reef. At this time the fish are full of

eggs and are unusually easy to approach and spear underwater.

• Giant jack (*Caranx ignobilis – marabatubatu*)

Normally this fish, like its smaller cousin *C. melampygus*, travels alone or in pairs. But for two or three days, starting around new moon, these fish can be seen travelling in groups of around ten. Such groups may be seen in any month but are especially numerous in March.

• Rabbitfish (*Siganus punctatus* and possibly *S. vermiculatus – dudu*)

These rabbitfish form *bobili* type aggregations at certain locations in shallow water near mangrove areas in the lagoon. At this time, usually only on the seventh day (*juapa ta omina*) of certain lunar months, their schools may contain thousands of fish. The fish are swollen with eggs.

• Barracuda (*ghohi*)

There are at least four types of barrracuda in Marovo. The two largest species (probably *Sphyraena jello* and *S. barracuda*) are often found in passes through the barrier reef or along the outer reef drop-off. They take bait best at night starting at full moon for the next three or four days, whether the moon is shining or hidden by clouds. During this time schools of barrracuda are often found near the edges of the barrier reef passes at the seaward end during ebbing tides. As the tide changes and starts to flood, they move slowly through the pass to the inner end. They are full of eggs during the period around full moon in September to December. Then they are caught at shallower depths than at other times.

• Hussar (*Lutjanus amabilis – heheuku*)

These fish are said to come together in large numbers along the edges of passes through the barrier reef and along the outer reef drop-off for two or three days around full moon during certain months. At this time they are easy to spear. When one is speared, the others crowd in to eat fragments of flesh from the spear wound. When the tidal currents stream through a certain shallow passage between two islands in the lagoon, hussars will often aggregate at the downstream end of this current where it slows down. When the tide changes the fish will move, over a period of about half an hour, through the channel and will stop again on the other side where the current slows down. Good Marovo line fishermen know this and thus know where the good fishing spots for hussar can be found.

• Moses perch (*Lutjanus russelli*, as well as perhaps certain similar species – all *koasa*)

This fish forms *sakoto* aggregations during the day underneath the overhanging branches of trees near the shore especially along the lagoon-facing beaches of the barrier reef. When the tide drops the fish move into deeper water. Around new moon the aggregations of these fish can easily be approached without disturbing them. Once they cease to *sakoto*, move to deeper water and spread out, they regain their wariness. These aggregations are referred to as *sakoto koasa* and occur predictably during three days from the Marovo 'new moon' (*ta omi paleke*), during four days around full moon, and during the final three days of the last quarter.

• Maori seaperch (*Lutjanus rivulatus – sina*)

These snappers aggregate starting on full moon, for one to three nights inside passes through the barrier reef and at particular places along the outer and inner edge of the barrier reef. During this time they have well-developed eggs. February to May and (particularly) September through December are said to be the best months for these aggregations.

• Red snapper (*Lutjanus bohar – ringo*)

Red snappers come together in large *sae* aggregations in the passes and at certain places along the outside edge of the barrier reef from the eleventh through the fourteenth days of the lunar month. Aggregations break up after the night of the full moon. During this time they are full of eggs. June and July are said to be the months of the biggest aggregations of this fish in some parts of Marovo.

• Emperors (miscellaneous smaller lethrinids – several Marovo names)

Unidentified small- to medium-size emperors of perhaps more than one species form *sakoto* aggregations in daytime around new moon (for about two days), over sandy bottoms near river mouths. This especially occurs during the months of May and June. They are full of eggs and are very easy for fishers to approach at this time. At other times these fish are usually easily frightened, although some such aggregations may also occur around full moon.

• Blue-lined sea bream (*Symphorus spilurus – hirapa*)

These fish form *sae* aggregations in mid-water over sandy bottoms near passes through the barrier and along the outer reef for long periods of the lunar month from about August to January. These

aggregations usually develop at the first quarter (*juapa ta omina*) and break up at the time of full moon. The largest *saehirapa* aggregations are said to occur in November and December. The fish contain plenty of fat at this time, as well as developed eggs. They are unusually easy to approach and spear, especially during the last three days of the aggregation period just before full moon. (Palauan fishermen gave Johannes (1981) very similar information about this species, and Johannes observed one such *sae*-type aggregation there). Certain aggregations of this fish have disappeared in Marovo in recent years. This is probably a result of overfishing with spearguns. In Palau spawning aggregations of this fish have disappeared for this reason, according to fishermen (Johannes, unpubl.).

- Mullets (Mugilidae – *lipa*, several types)

There are several species of mullet in Marovo, and it is clear that Marovo people know a great deal about their movements. (Johannes encountered similar extensive knowledge about mullet among nearby Roviana fishers in 1998). But because different names seem to be used for the same species of mullet in different villages, we did not have time to sort out all the information we received. But this much is clear: some kinds of mullet make migrations around the time of full moon and new moon. Such migrations take the form of *rovana*, described above. One very large type of mullet migrates into river mouths and some distance upstream as the tide rises on the nights around full moon. This species also aggregates at certain spots in the wider, shallower parts of the lagoon, to spawn in certain months. At least one, and probably more than one type of mullet migrates to special areas near barrier reef passes or into pockets of deeper water on the outer barrier reef flat, where they form *bobili* and spawn. Some mullets make similar migrations around the time of the full moon.

The mullets are extremely important food fishes in the tropics, especially for low-income coastal peoples. Most, if not all the species of mullet found in Marovo Lagoon are widely distributed in the tropics. This fact, plus the extensive knowledge of mullet habits possessed by Marovo (and Roviana) fishermen provide an outstanding opportunity to increase scientific understanding of the biology of this important group by carrying out the appropriate research there.

- Yellowmargin triggerfish (*Pseudobalistes flavimarginatus – makoto lilio*)

This large triggerfish gathers in large loose aggregations over sandy bottoms in barrier reef passes and near the inner and outer entrances of these passes. These aggregations commonly occur during the seven days leading up to new moon. The aggregations are for the purpose of nesting. At this time the fish behave in a 'playful' manner called *varikilihi*. They dig nests in the sand and lay fist-sized clusters of eggs in them. Some nesting also occurs just before full moon. At these times the fish are unusually easy to catch with a speargun, line or trap.

These spawning aggregations reportedly occur somewhere in Marovo during every month except February through April. In the southern Bili area they are particularly large during the months of May through October. Farther north, along the barrier reef, the largest aggregations reportedly tend to occur progressively later in the year.

During the nesting period the fish protect their eggs from being eaten by other fish during the day, and will even rush divers that come near their nests. They sleep at night. They have become more cautious over the years since underwater spearfishing has made this behaviour dangerous to them. (Very similar behaviour was reported by fishers and observed by Johannes (1981) in Palau).

- Oxeye scad (*Selar boops – mamanga*)

Schools of oxeye scad move into shallow water, especially near islands in the lagoon, throughout the year starting three days before new moon. The fish form *bobili*-type aggregations at this time and they are full of eggs. Around the time of the full moon during the months when land crabs come down to the shore to release their eggs into the water, schools of oxeye scad come into shallow water at night to feed on the larvae that hatch from these eggs.

- Groupers (Serranidae; coral trout, coral cod – *pajara*, more than 20 Marovo names for subtaxa)

For several days before new moon several species of groupers (especially *Epinephelus fuscoguttatus*, *E. polyphekadion* and *Plectropomus areolatus*) come up into shallow water in large numbers. They always come up at the same places. At this time they are full of eggs or milt. This phenomenon is known as *keli pajara*, or 'rising of groupers'. Probably the best-known fish aggregation in the southern and central parts of Marovo is that of *P. areolatus*. This species comes up in large numbers, along the edges of the outer part of certain deep passages through the barrier reef. This occurs for about seven days during the last lunar quarter, during which time these fish are unusually easy to

spear, especially at night. On the day of new moon (*omia mago*, cf. Note 7) these fish leave the area.

Because of heavy spearfishing since just after World War II, these fish are not as 'tame' as they used to be during aggregations, and do not come into water as shallow as they once did. In the mid to late 1990s the spawning aggregations of these species have come under extremely heavy fishing pressure in Marovo due to the live reef food fish trade (Johannes and Lam 1999).

The spawning aggregation months for *P. areolatus* at the deep passes of central Marovo are February to June, with March to May being the best months. Aggregations form at a northern passage two or three days later than they do in the southern passes, but disappear on the same day as they do in other passes (Johannes (1989) describes these aggregations in some detail). Surprisingly, the season for spawning aggregations of this and the other two species mentioned above is quite different only a few tens of kilometers away in Roviana Lagoon (Johannes and Lam 1999).

- Goatfish (Mullidae – *pakao*)

Pakao, large goatfish, aggregate near coral reef areas in the middle of shallow sandy areas in groups of 20 to 30 around new moon. At this time they are full of eggs.

- Sweetlips *(Plectorhinchus gibbosus* and *P. obscurus* – both *pehu*)

Both species are said to form *sae* aggregations in and near passes through the barrier reef over coral bottoms for about three days around full moon. During this time they are full of eggs. The largest numbers are found in these places between March and May.

- Bony bream (*Nematolosa come – susuri*)

Bony bream aggregate in the *bobili* form over shallow sandy areas around new moon near mangrove areas. They move into rivers along with mullet around full moon.

- Spanish mackerel (*Scomberomorus commerson – tangiri*)

In the northern part of Marovo Lagoon a particularly good time for catching Spanish mackerel is after heavy rains and flooding. At this time, baitfish that normally live close to shore inside the lagoon move out (probably to escape the layer of muddy freshwater on the lagoon surface) and into the passes through the barrier reef. The Spanish mackerel move into these passes to feed on the migrating baitfish and are easy to catch by trolling. In general, Spanish mackerel are most abundant and easy to catch when 'the moon is small', during the final and first days of the lunar month, over a period of about eight days.

- Bumphead parrotfish (*Bolbometopon muricatum – topa*)

During the first seven nights of the lunar month bumphead parrotfish come in groups into shallow water in certain coral reef areas to sleep. At this time they are very easy to spear using a short speargun with the aid of an underwater torch. During the rest of the lunar month this species usually sleep in deeper water where they are harder to find. In daytime, slow-moving groups of large bumphead parrotfish (referred to as *hebala topa*, the former word meaning 'band of warriors') may be encountered along the barrier reef drop-off around new moon and around the first and last quarters.

- Sharks (*kiso*)

Many Marovo fishermen say that during the period of the lunar month, during which there is bright moonlight, sharks of several different species bite more than at other times. This period is known as the time when these sharks *vilu livono* ('sharpen their teeth'). At this time they tend to make line fishing difficult by stealing hooked fish, and to act more aggressively toward spearfishers.

Conclusion

Clearly Marovo fishers possess a great deal of practical knowledge concerning the fishes of their waters that is unknown to science, putting them in the same league with Palauan fishers (Johannes 1981) and, for that matter, the nearby fishers of Roviana (Hamilton 1999).

It should be noted that the knowledge of predictable patterns in fish behaviour, held predominantly by men, has a counterpart in Marovo: women's knowledge about important shellfish resources gathered mainly by them, such as mud crab (*Scylla serrata*) and the mangrove bivalves *Polymesoda* spp. Additional field work in 1987 by Hviding among villagers of mangrove-rich northern Marovo gave insights into how women make accurate predictions in the changing availability of these resources, perceived to be migratory on a seasonal, lunar and tidal basis.

For example, mud crabs are known to occur in large numbers at certain places during the full

moon nights of months characterised by low tide at night; they then sprawl passively on exposed mud flats and can easily be caught (see also Hviding 1996: 195). Interesting patterns of mobility and aggregation are pointed out by Marovo women for the two species of *Polymesoda* bivalve which are abundant in mangroves; they move in and out of the mud and migrate across submerged mud flats on a diurnal basis to follow the tides and to escape the hot sun. Locations and times are pinpointed for the most efficient gathering of these far-from-stationary molluscs, which can be caught in huge quantities over and over again from select sites at the right time, yet appear to be almost non-existent in mangrove areas chosen arbitrarily. Later fieldwork in Marovo, together with Karen Leivestad, has expanded this focus on molluscs (Hviding 1993; Hviding and Leivestad 1992).

Obviously, the study reported here just skimmed the surface of what Marovo people know about their marine resources, and we hope it will encourage others to follow up with more detailed research in this biologically diverse region, such as that represented by Hamilton's work (1999) concerning Carangidae in Roviana Lagoon and the wide-ranging investigation of artisanal fishing, also in the Roviana area, by Aswani (1997). Time is of the essence: some of this knowledge is disappearing as the older people who possess it in its richest form are dying.

Acknowledgements

To the fishers of Marovo and the many other Marovo people who helped us, taught us, and made us feel welcome, our gratitude is enormous. Special thanks to Harold Jimuru and Vincent Vaguni who organised so many things including logistics. We are also very grateful to the Commonwealth Science Council which, through it SOPACOAST Programme, made this work possible, and to Graham Baines who conceived, arranged and helped organise it.

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New publications

Traditional marine resource management and knowledge

Protected marine reserves: a guide

By Callum M. Roberts and Julie P. Hawkins

Fully protected marine reserves are areas of the sea completely protected from fishing and other extractive or harmful human uses. Since the first fully protected reserves were established, more than two decades ago, they have stimulated a wealth of research and intense interest. Recent scientific evidence indicates that reserves are not only powerful tools for conservation, but can also provide much needed support for fisheries. There is an urgent need for more reserves in order to address the developing crisis in the oceans. Worldwide, fisheries are in trouble, and habitats and species are being lost at an alarming rate. However, decision-makers need good scientific information on how to make reserves work successfully. Questions such as 'how do reserves function?', 'how many should we have?', and 'where should we put them?' are challenging the minds of scientists, conservationists and managers everywhere. The case for marine reserve establishment gets stronger with every new study published and scientists are making good headway in developing a detailed theoretical basis for fully protected reserves, supported by good quality data.

People responsible for establishing marine reserves are rarely scientists. Few of those who lobby hardest will have a doctorate in fisheries biology or ecology, nor will the people who decide whether or not to implement protection. People who fish and whose livelihoods will be directly affected by reserves, are educated by the sea itself. Yet all of them, be they fishers, conservationists or government ministers, need clear answers to basic questions and concerns about reserves. For any non-specialist, whatever their level of education, this can be problematic. Scientific papers are difficult to read and can be hard to acquire. Scientific research can also take years from completion to publication as it grinds through peer review, then joins the queue for a journal slot. The most recent research, while much talked about among scientists, is thus generally inaccessible to those who need it most. The aim of this information pack is to summarise the scientific case for fully protected reserves in a way that is easily understood by everyone. Our objective in producing it is to speed up the process of translating scientific research into action. The pack is particularly aimed towards people who need information to inform and persuade others of the benefits of reserves. They include, for example, those working to set up community-based management of marine resources, park or fishery managers, and policy makers. Since people who will be affected by reserves must be willing to place their faith, and possibly risk their livelihoods, on conclusions

drawn by scientists, they should be in no doubt about why they are doing so.

In addition to explaining the theory behind fully protected reserves this book is also intended as a practical guide. The main text of the book provides much of the background to reserves. This is supplemented by a series of case studies showing some of the most interesting reserves from around the world. Each of them highlights key findings and identifies lessons from those cases. Two other features of this pack are designed to help people trying to establish reserves in the field. A collection of 30 slides and accompanying descriptions showcase marine reserves and their benefits. They can be used as the basis for a presentation on reserves, either in their entirety, or split into shorter presentations highlighting particular uses of reserves for different audiences. A series of 12 overhead transparencies, with accompanying text, can also be used as the basis for one or more tailored presentations, and could be used to accompany a slide-based presentation.

As new information is constantly emerging, the authors intend this book to be a living text that they update regularly, adding new case studies and sections. These updates can be downloaded from the website that accompanies the book (which can be accessed via a link from www.panda.org/endangeredseas/). The authors welcome your suggestions for new sections, or case studies that you would like to see covered. These can be emailed to them at crl0@york.ac.uk

Contents:

Copies can be obtained from:

WWF Endangered Sea Campaign
1250 24th St NW
Washington D C 20037, USA

The performance of customary marine tenure - final technical report

This is a CD-ROM containing the final report of the UK Department for International Development (DFID) project **"***The Performance of Customary Marine Tenure in the Management of Community Fishery Resources in Melanesia*" (1999) and authored by Dr C.C. Mees and J.D. Anderson

Copies may be obtained by contacting MRAG Ltd, 47 Princes Gate, London SW7 2QA

This final technical report is a concise document laid out in the prescribed DFID format. It provides a summary of the purpose, activities and results of the study (new knowledge generated). General conclusions from the study are drawn and a summary of co-management guidelines, which form the principal outcome of the research, is given. Detailed results of the study are presented separately in five volumes, which should be read in conjunction with this Final Technical Report (FTR), and which are referred to throughout the FTR.

Volume 1: Project Background and Methodology describes the demand and need for this study in the context of the RNRRS, and outlines significant research previously carried out. The methodology employed is described.

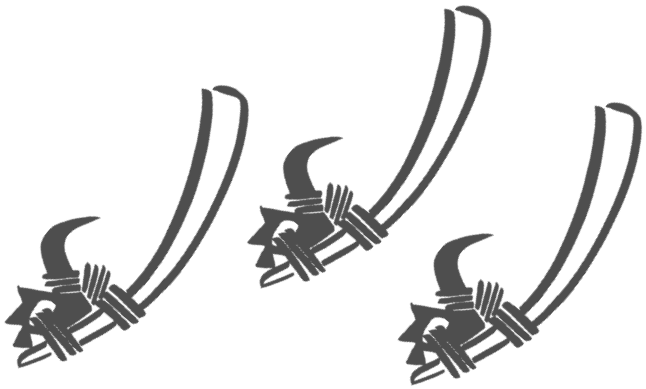
Volume 2: Fiji and Vanuatu country reports. The purpose of this project was to describe and evaluate the performance (social equity, and ecological sustainability) of a number of extant Customary Marine Tenure (CMT) regimes in Fiji and Vanuatu, and to identify the ways in which cooperation with government (co-management) could enhance the current system. Volume 2 describes the results of fieldwork and summarises social, institutional and ecological outcomes for each of Fiji and Vanuatu.

Volume 3: Biological Outcomes provides detailed analyses of the data relating to the fishery resources and of their customary management, which were summarised in Volume 2. A separate volume of annexes (see 6.1.2 of this report) provides detailed analyses by species and sub-area, which are not given in full in Volume 3. The annexes are an internal MRAG document that may be referred to for further information.

Volume 4: A Bayesian Approach to Stock Assessment of Coral Reef Fisheries. During 1998, DFID allocated additional funds for a supplementary study entitled 'A Bayesian Approach to Stock Assessment of Coral Reef Fisheries'. This volume presents the results of that work.

Volume 5: Co-management Guidelines synthesises material from the preceding volumes of work, and presents co-management guidelines for fisheries subject to tenure arrangements.

In addition to these reports, a number of publications have arisen from the study, or are planned. These are described in Section 6 of the final technical report.



New projects

Traditional marine resource management and knowledge

The economics of cultural complements: the impact of a culture of sharing on sustainable development and the persistence of the status quo

Research project outline

Historical evidence suggests that the changing availability of renewable resources has caused several economies to experience a pattern of rapid growth followed by a period of (sometimes catastrophic) decline. On Easter Island, for example, a rising population overused a local palm species for centuries, which led to a substantial decline in population and economic activity before the first Europeans arrived (Brander and Taylor 1998).

However, other civilisations exist that have experienced a different pattern. In several island economies in the Pacific region, population and aggregate renewable resource harvest grew without major fluctuations and stabilised at certain levels (Brander and Taylor 1998). The question arises about what factors determine the patterns of renewable resource harvest, production, and population growth along which an economy evolves.

Brander and Taylor (1998) identify differences in the physical attributes of island economies as the cause of different patterns of growth. Their analysis is based on a Ricardo–Malthus general equilibrium framework. Labour is the only factor of production, which is employed either for harvesting a renewable resource or for producing a composite consumption good.

The productivity of labour in the production of the composite good is constant. However, the productivity of labour in resource harvesting is constant as the labour input varies but declines as the resource stock declines. No human-made capital is accumulated and no technological change is assumed to occur. Following the Malthusian hypothesis, population growth positively responds to the per capita consumption of the resource.

The authors demonstrate that the historic evolution of small Pacific Island economies can be interpreted in their model as a process of adjustment of the population level and the resource stock towards their long-run equilibrium values. They identify the intrinsic growth rate of the resource as the factor that can account for differences across islands in the patterns of population growth and resource use. If the intrinsic growth rate is small, population and the resource stock adjust cyclically to their equilibrium values, which generates a pattern of initial population growth with a subsequent decline.

The decline in population also causes aggregate economic activity to fall. Brander and Taylor consider the historic experience of Easter Island as being consistent with this scenario. If the intrinsic growth rate of the resource is high, however, population and the resource stock adjust monotonously to their equilibrium values: the population rises and the resource stock declines. Brander and Taylor interpret the historical evidence of several other Pacific Islands as being consistent with this case.

Our research project adopts a different perspective, as it aims to explore whether cultural rather than physical variables can explain differences in the growth patterns that were observed in the Pacific region. The focus is on social norms that require resource harvesters to share their harvest with the entire community. Such norms do not explicitly address the problem of natural resource scarcity but nevertheless have an impact on renewable resource extraction because they alter the allocation of labour to resource harvesting. This approach differs from the analysis of institutions that explicitly address resource scarcity by restricting access to natural resources through an appropriate allocation of property rights (Ostrom 1990).

The focus on culture has been inspired by empirical evidence on the existence of a "culture of sharing" in the kingdom of Tonga in the Pacific region. On the island of Lofanga, for example, a rule exists that prescribes that each fisherman share his catch with all other members of the island's population (Bender et al. 1998).

On the island of 'Uiha, in contrast, such a rule is absent, as the fishermen share their catch only among themselves and with their families. At the same time, the stocks of fish have been depleted more strongly around 'Uiha than around Lofanga. This suggests that the culture of sharing catch (possibly unintentionally) promotes the conservation of fish stocks, which represent an important resource to the local economies. Furthermore, it suggests that differences across islands in the occurrence and intensity of sharing norms may explain differences in resource conservation and growth patterns.

A simple way to model the economic impact of a ''culture of sharing'' is to interpret the sharing rule as an implicit tax on the resource harvest, the proceeds of which are redistributed equally among all members of the community. Under the project, the Brander-Taylor model was therefore extended to an environmental tax. The theoretical analysis revealed that differences in tax rates can account for differences in growth patterns across island economies. An economy that adjusts cyclically in the absence of environmental taxation can always attain a trajectory of monotonic adjustment (i.e. avoid a collapse of economic activity) by choice of a sufficiently high tax rate.

As a next step, it is intended to apply the model to the local economy of the Ha'apai region and, if possible, to other Pacific islands. To this end, it is intended to collect data on the population dynamics of fish species that are important to local island economies in the Pacific. It is also envisaged to consider other key resources than fish, such as forests.

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The Roviana & Vonavona Lagoons Marine Resource Management Project

In December 1999, Dr Shankar Aswani, in conjunction with WWF, received a MacArthur Foundation grant to conduct research and establish a management regime in the Roviana and Vonavona Lagoons, Solomon Islands.

The project officially started in June 2000 and should continue until 2002 or 2003. It will be conducted by Dr Aswani and several students in tandem with WWF-Solomon Islands (with Simon Foale and Seri Hite as co-investigators).

The objective of this project is to establish sustainably managed marine areas under customary tenure in the Roviana and Vonavona Lagoons, Western Province, Solomon Islands.

This will require:

- the study of institutional responses of sea tenure regimes to a transforming socio-economic and environmental context caused by population growth, changing consumer demands, and coastal and marine fishery commercial developments;

- the documentation and incorporation to management of indigenous environmental knowledge, particularly knowledge pertaining to fish spawning aggregations;

- the study of fishing techniques and marine harvest effort; and

- participatory involvement of local communities in conjunction with Solomon Islands Government agencies in developing and implementing sound management plans.

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Conferences & Workshops

Traditional marine resource management and knowledge

Putting Fishers' Knowledge to Work
University of British Columbia, Vancouver, Canada
August 27-30, 2001

Small-scale traditional fisheries are often set in environments where scientific knowledge is poor and conventional remedies are prohibitively costly. Yet local fishers often know much about where and when marine animals migrate or aggregate, how they behave and how fishing and marine environmental conditions have changed over time. Understanding this knowledge and how fishers act on it, can contribute very substantially to marine resource management, environmental impact assessment and the size and siting of marine protected areas.

In developed commercial fisheries local knowledge includes elements of the above, but other factors also come into play. Market constraints and technology changes, for example, can have major influences on fishing behaviour.

Conference format and topics

An international conference about how fishers' knowledge can improve the management of fisheries. The meeting will be relevant to fishers, fishery managers, marine environmental researchers and social scientists.

Featured speakers

- Bob Johannes, *R.E. Johannes Pty Ltd., Tasmania*
- Barbara Neis, *Memorial University, St. John's Canada*
- Tony Pitcher, *UBC Fisheries Centre, Vancouver, Canada*

Suggestions for submitted papers:

- The use of fishers' knowledge and fishing practices in environmental management
- The relationships between fishers' expertise and modern management science.
- Methodology. Methods for obtaining fishers' knowledge differ strikingly from those of conventional biological researchers, yet have seldom been described adequately in the literature. This conference focuses on methods for applying this information to management.
- How to incorporate fishers' knowledge into fisheries science and marine environmental curricula
- Ethical issues relating to collaboration between TEK practitioners, managers, academics and industry.

- Valuation of fishers' knowledge an Ecological / Economic / Social approach.

Abstract submission

To contribute either an oral or poster presentation, submit an abstract no later than March 31, 2001 by email to Events@fisheries.ubc.ca

Abstracts must include:

- Title
- Author(s) names as they should appear for publication, full affiliation and mailing address, and phone, fax, and e-mail address.
- Text of abstract (300 words maximum)

Indicate whether for oral or poster presentation

Organising committee

- Dr Bob Johannes
- Dr Barbara Neis
- Dr Tony Pitcher
- Mr Nigel Haggan
- Chief Simon Lucas
- Mr Arnie Narcisse

Details

The conference is to be co-hosted by the University of British Columbia (UBC) Fisheries Centre, the UBC First Nations House of Learning and the British Columbia Aboriginal Fisheries Commission.

Parallel with the conference, the exhibition 'Aboriginal and Community Art Related to TEK' will be held at the UBC Museum of Anthropology or First Nations House of Learning.

Information and registration

For more information and / or to obtain a registration form, please see our website at:

http: / / fisheries.ubc.ca

or e-mail: events@fisheries.ubc.ca

All meeting sessions will be held at the University of British Columbia. Registration fee is US$ 270 (student rate US$ 70). A limited number of hotel suites (from US$ 93) will be available for participants at the UBC Conference Centre on the UBC campus. See http: / / www.conferences.ubc.ca / , or request a list of off campus accommodation at the e-mail address given above.

Sponsors (To date)

- UBC Fisheries Centre
- Department of Fisheries and Oceans
- BC Ministry of Fisheries

Conference proceedings

- A book (eds. Johannes, Neis and Pitcher) in the new Blackwell Science "Fish and Aquatic Resources Series" for selected and peer-reviewed papers from the conference, possibly supplemented by additional commissioned papers.

- Fisheries Centre Research Report including all papers and rapporteured discussion.

Work to begin on the production of a methods manual.

Traditional Ecological Knowledge

Knowledge about the environment, special places and inter-species interactions gathered from indigenous peoples cultural history and experience
(Osherenko 1988)

Traditional halibut hook

Circle hook

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PIMRIS is a joint project of five 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 South 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