Indigenous ecological knowledge and its role in fisheries research design: A case study from Roviana Lagoon, Western Province, Solomon Islands

by Richard Hamilton[1] *and Richard Walter*[2]

Introduction

Over the last two decades the island states of Melanesia have experienced a rapid increase in coastal development activities. These include the large commercial tuna pole-and-line fisheries, ecotourism, aquaculture, coastal logging and, in recent years, the live reef fish trade. These activities make significant contributions to local and central economies but concerns have been raised about their impact on local ecosystems, and their long-term environmental sustainability (Chadwick, 1999; Mathews *et al.*, 1998; Veitayaki, 1997). In response to these concerns increasing pressure has been put on government agencies to develop coastal management plans and on developers to utilise these plans in the design of sustainable management practices (Olsen *et al.*, 1997). Unfortunately the implementation and success of such policies has been limited. In part this stems from the difficulties and cost of acquiring the high quality scientific data that most management plans and monitoring programmes rely on. As Johannes *et al.* (1993:1) point out for coastal fisheries, 'The cost and complexities of effectively monitoring and managing small, multi-species, multi-method reef and lagoon fisheries along conventional lines have generally proven prohibitive'. Nevertheless, in many cases extensive ecological information on the relevant coastal environments already exists within the knowledge base of the local communities. Further, these same communities are often operating management and monitoring programmes of sorts, within the context of customary marine tenure (CMT) systems (Foale, 1998a; Foster & Poggie, 1993; Hviding, 1991; Johannes, 1981).

This cultural information, often referred to as traditional ecological knowledge (TEK), is widely recognised as potentially useful to fisheries researchers and managers, especially when used in conjunction with conventional scientific data, 'Local knowledge combined with specialised knowledge of the outside researcher is considered by advocates of the PAR [participatory action-research] to be more potent than either knowledge alone in understanding reality' (Christie & White, 1997:172). However, indigenous cultural information is useful in coastal management for more than its role in providing the baseline ecological data required for planning purposes. Frequently, development projects are set up within the territories of indigenous communities and those communities are directly and indirectly involved on a number of different levels (Alcala, 1998; Ruddle *et al.*, 1992). In these cases the successful operation of development projects depends on a proper understanding of local political and subsistence economies, ideology and social structures. In fact, the failure of development projects in the Pacific is probably more commonly the result of a failure to understand local cultural systems than of inadequacies in ecological, technological or market research.

Unfortunately, indigenous knowledge is usually either ignored or used inadequately by fisheries researchers. There are two fundamental problems. The first is that TEK and other types of indigenous knowledge exist as inseparable parts of complex cultural systems, and it requires anthropological methods to describe and interpret this information in a meaningful manner. These skills, however, are usually difficult, time consuming and well beyond the professional training of most fisheries scientists, resource planners and project managers working in island Melanesia (Christie & White, 1997; Clark & Murdoch, 1997). The second closely related problem, is that frequently, when scientists have attempted to incorporate indigenous knowledge into their baseline research, the result has been a naive reporting of interview data or observations taken out of their cultural and historical context. The results are often misleading and misrepresentative. 'The romantic and uncritical espousal of traditional environmental knowledge and management is an extreme almost as unfortunate as that of dismissing it' (Ruddle *et al.*, 1992:263). A particularly good example of this is the common practice of interpreting CMT systems as conservation strategies. Although CMT systems can have conservation outcomes, it has recently been demonstrated that in most cases this is a side effect of systems designed primarily for 'gain, not

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restrain' (Ruttan, 1998; Aswani, 1998; Polunin, 1984). An integrated approach to coastal resource planning is required, in which the specific skills of anthropologists and fisheries scientists are properly utilised. In particular, cultural information needs to be gathered systematically and treated with the same critical scrutiny that is applied by scientists to any other data set.

In this article we take three premises as our starting point:

1. TEK contains complex ecological information obtained through generations of observation and experience;

2. TEK is culturally structured and if it is to be taken out of its original context and used in an empirical western scientific framework, its appropriateness to this framework should be established through systematic testing; and

3. One of the most powerful ways in which TEK can be used in fisheries or other types of ecological research is in the establishment of research designs.

We present below a case study in the development of a model for testing TEK, and in establishing the parameters within which it can be used in a scientific research design. The work is situated in Roviana Lagoon, on the island of New Georgia, Western Province, Solomon Islands. Roviana marine ecologies and local communities have already felt the impact of development activity in the form of forestry, and of the Solomon Taiyo tuna and baitfish industry (Nichols & Rawlinson, 1990). Several other small-scale coastal ventures have been set up over the last few years, and more are planned for the near future. In this study, we examine local knowledge of aggregating behaviours of the Carangidae fishes in a confined part of the lagoon ecosystem. Carangids, or trevally, are a diverse family of reef and lagoon fish which are important in the local subsistence and artisanal fishery. In this study, detailed ethnographic data on Carangidae behavior were collected from local informants using traditional anthropological techniques of interview and participant observation. This information served as a basis for designing hypotheses on the tidal movements and aggregating behaviours of Carangidae within Roviana Lagoon, which were then tested using scientific field observations. The purpose was not to test the accuracy of local ecological knowledge, but to show how it can assist in the development of fisheries research designs.

Environmental background

The Solomon Islands lie between 7° and 10°S and extend 1400 km eastward from New Guinea (Figure 1). The islands display remarkable diversity in both terrestrial and marine environments. The dominant island forms are volcanic, but examples of atolls and raised reef islands are also present. Extensive lagoon systems occur in Western Province.

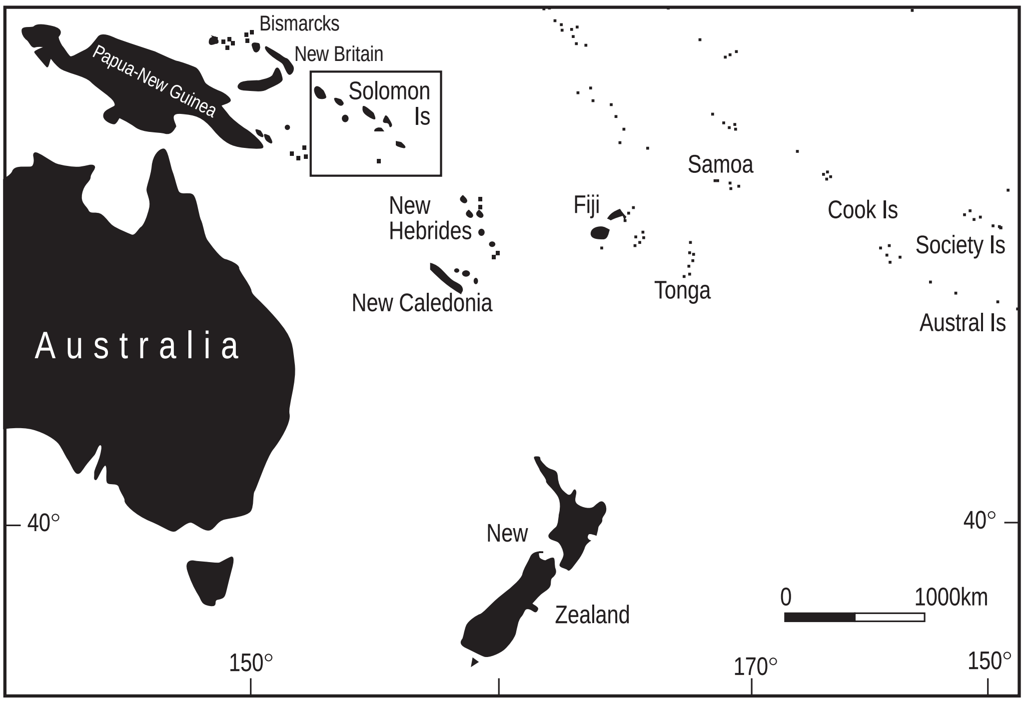

Figure 1. **The Solomon Islands in the Pacific (Survey and Mapping Division, Honiara)**

The New Georgia Group, in Western Province, is made up of nine main islands that extend for approximately 270 km. The largest island is New Georgia which is fringed by Roviana Lagoon to the south-west and Marovo Lagoon to the north-east (Figure 2).

Roviana Lagoon is a body of shallow water approximately 50 km long enclosed between the New Georgia mainland and a series of uplifted coral reef islands lying 2 to 3 km offshore. The lagoon supports a wide range of micro-environments including: estuaries, mangrove forest, river mouths, mudflats, coral atolls, barrier reefs, marine lakes and sea-grass beds (Aswani, 1997:245). Each of these, as well as the adjacent offshore zones, provides unique opportunities for the fishing communities of Roviana Lagoon. A number of major passages connect the open sea to the lagoon. These are remnants of earlier river systems that flowed through the now-flooded coastal plains. These passages contain a relatively high biodiversity and are consequently of especial significance in local fishing systems. Their rich biodiversity occurs partly because they connect several different ecological zones and many species utilise them to move between feeding areas.

Roviana Lagoon is occupied by a number of closely related tribal groups occupying a dozen or so large villages scattered along the mainland and barrier islands as well as a number of smaller residential clusters. Roviana is the most homogeneous linguistic region of New Georgia, where the Austronesian language of Roviana is spoken in all the villages. Elsewhere in New Georgia the 30,000 inhabitants speak at least seven major languages, including several non-Austronesian languages. The Roviana subsistence economy is based on shifting horticulture with an emphasis on the recently introduced sweet potato and cassava, as well as the traditional crops: taro, yam, banana and sago. The main protein intake is from marine sources (Aswani 1997:189) but pig and chicken husbandry and small-scale hunting also takes place. Today, these subsistence activities are often subsidised by waged labour and copra production.

Carangids were selected for this case study for several reasons. First, the ecology of carangids in tropical settings is poorly studied (Sudekum *et al.*, 1991). Second, the carangids are important in the Roviana subsistence fishery and thus the local body of knowledge was expected to be detailed and accessible. Third, there are potentially important trophic interactions between the Taiyo bait-fishery and carangids which were investigated as part of the field research, but are not reported here (see Hamilton, 1999).

The Carangidae is a family of strong swimming, open water carnivorous fishes known variously as trevally, kingfish, queenfish, jack, scad, mackerel, and rainbow runners (Gunn, 1990; Randall, 1990). Their habitats range from brackish water estuaries to deep offshore reefs, with a few species being pelagic in the open ocean (Holland *et al.*, 1996). At least 17 species of carangid are present in Roviana Lagoon, and all are important food fishes. In this

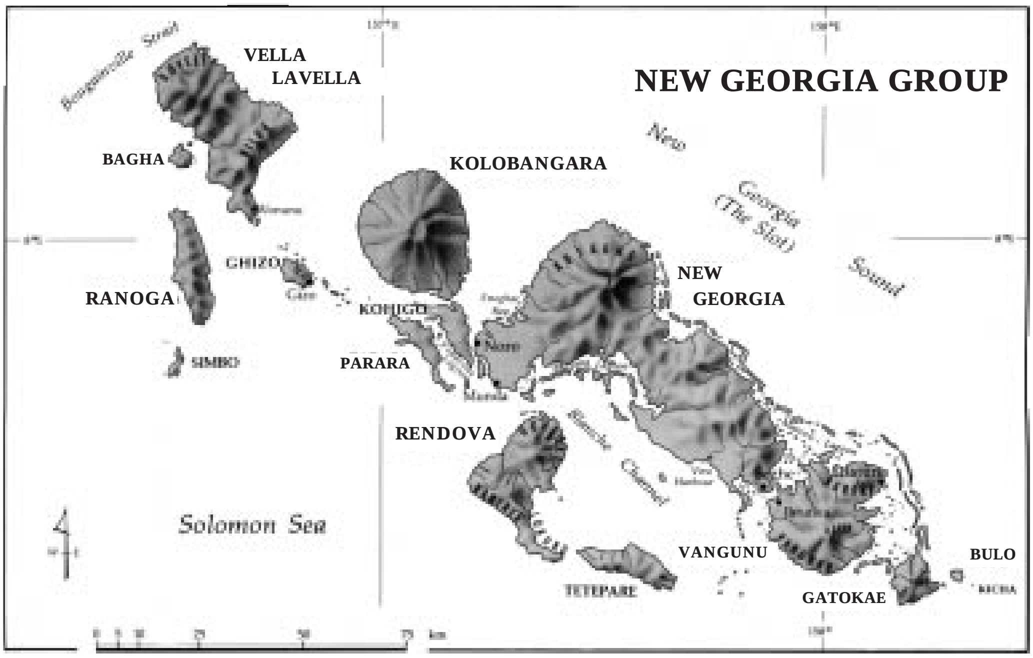

Figure 2. The New Georgia Group (Survey and Mapping Division, Honiara)

study we concentrate on three species, Bluefin trevally (*Caranx melampygus*), Golden trevally (*Gnathanodon speciosus*) and Bigeye trevally (*Caranx sexfasciatus*). with additional observations on other members of the genera Caranx and Carangoides.

Study area

The research was carried out in Honiavasa passage from a base in Nusabanga village, in the western part of Roviana Lagoon (Fig 3). Nusabanga village is a sister village to Sasavele village, located on the western bank of Honiavasa Passage. The two villages share very close ties, often participating in common fishing trips and other economic activities.

Honiavasa Passage is one of the main deep water passages connecting the inner lagoon to the outer sea. It is approximately 600 m across at the sea entrance and narrows to around 150 m at its narrowest point. The coral walls of the passage are nearly vertical, and descend to a maximum depth of 42 m. The passage environment is characterised by mainly dead corals to a depth of 15 m, although the submarine coral walls support large and diverse migrant vertebrate communities.

The field work reported here is a part of a larger project on fish ecology and indigenous subsistence practices carried out in 1996–1997. The full results of the complete project will be reported elsewhere. The field component of this study had two parts. The first involved gathering indigenous information on the behavioural ecology of Carangidae in Roviana Lagoon. This information forms the basis on which the traditional Roviana Carangidae fishery is structured. Using this data, a set of hypotheses linking environmental variables with Carangidae behaviour was established. The second part of the research involved testing these hypotheses using standard field survey techniques.

Ethnographic methods and results

The field component of the research discussed here was carried out from early- August until late-October, 1997. During this period one of the authors (RH) resided at Nusabanga village, where he participated in the daily life of the village and worked regularly with the local fishers, to gain as wide an understanding as possible of the local fishing system. This followed the viewpoint that empirical facts about biology or ecology can not be

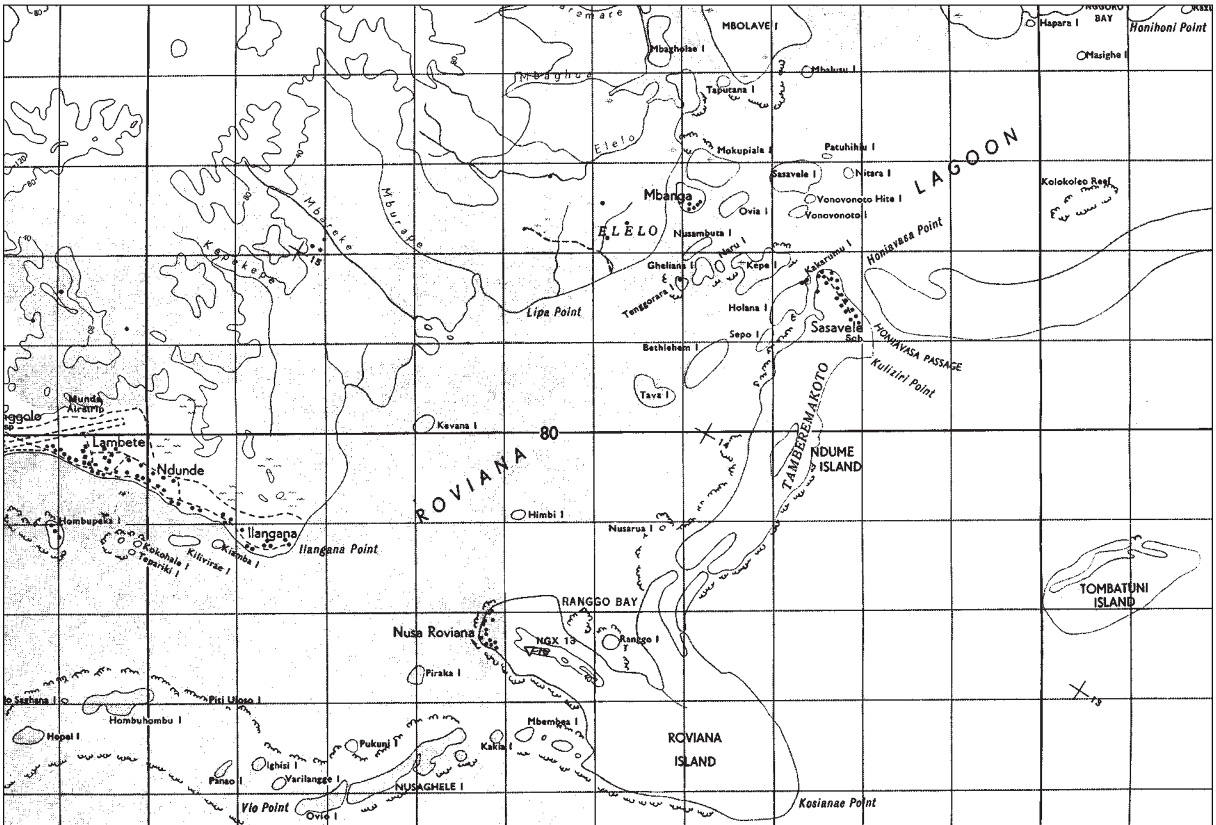

Figure 3. **The western part of Roviana Lagoon, showing Honiavasa Passage, Munda township and Nusabanga (Mbanga) and Sasavele village (Survey and Mapping Division, Honiara)**

extracted from TEK without an understanding of the structure and ideology of the wider cultural and subsistence systems of which it forms a part.

During the fieldwork period records were taken of 51 fishing trips. Information was recorded on Catch Per Unit Effort (CPUE) and on the technological, meteorological and environmental details of each major fishing trip. Basic information on indigenous taxonomy and fish names were acquired through formal interviews conducted in Solomon Island Pidgin, the local lingua franca. Local fish names were collected and then cross checked against standard fish guides (Allen & Swainston, 1992; Randall *et al.*, 1990). Local informants were also asked to identify species seen on underwater video footage taken in Honiavasa Passage. In addition, formal interviews were conducted with 11 fishers from Nusabanga and three from Sasavele. These persons were selected according to their recognised status as fishing experts within their respective villages. All interviews were conducted in both Roviana and Solomon Island Pidgin, and were recorded on videotape. Each fisher was asked to identify his main fishing locations, fishing methods used and the target species. Particular attention was paid to the spatial, temporal and technological structure of Carangidae fishing practices.

On the basis of the field participation results and interview data we can define the basic parameters of indigenous fish taxonomy and the Roviana fishing calendar. For the most part, we observe only minor deviation from the more detailed study recently reported in Aswani (1997). We can also describe aspects of Roviana folk ecology of Carangidae, with emphasis on tide related movements and lunar aggregations in Honiavasa Passage. These results are summarised below and reported in more detail in Hamilton (1999).

Taxonomy

The structure of Roviana fish taxonomy is almost identical to that of Marovo, well described by Hviding (1996), and also to that Nggela (Foale,1998b). All these systems differ considerably from Linnaean taxonomy, in that the level of classification reflects the value of the fish within the subsistence system, as well as basic morphology. For example, the small Damselfishes (Pomacentridae) are not eaten in Roviana and are all referred to using the generic term *kipa*. Although Roviana people are well aware of the variation within the Pomacentridae family, no further attempt is made at finer taxonomic discrimination. One the other hand, some members of the family Scaridae are very important in the subsistence economy, and this is reflected in their taxonomic treatment where different names are assigned to different size classes (Aswani, 1997:425). The actual names assigned to a fish taxa often reflect behavioural characteristics shown by that fish.

At least 17 species of Carangidae are recognised as taxonomically separate within the Roviana system. These names are listed in Table 1 below. *Mara* is a generic name covering a range of Carangidae species, each of which is additionally named using a more specific suffix. For example, the Orange spotted trevally (*Carangoides bajad*) is named *mara liu*. *Liu* (derived from Solomon Island Pidgin) translates as 'loiter', thus *C. bajad* is named 'the trevally that loiters', owing to its commonness in Roviana Lagoon.

Table 1. **Local Carangidae taxonomy**

Indigenousname	Commonname	Scientific name
Mara	Generic: Trevally	Carangidae
Balubalu	Rainbow runner	*Elagatis bipinnulata*
Ganusu	Smooth tailed trevally	*Selaroides leptolepis*
Lasilasi	Double-spotted queenfish (and perhaps other queenfish species)	*Scomberoides lysan*
Laqu belama	Tille trevally	*Caranx tille*
Mara batu batu	Griant trevally	*Caranx ignobilis*
Mara batu papaka		undetermined
Maaru hipu gele	Gold-spotted trevally	*Carangoides fulvoguttatus*
Mara hobu	Blue trevally	*Carangoides ferdau*
Mara labe	Pennantfish	*Alectes ciliaris*
Mara lamana	Bluefin trevally	*Caranx melampygus*
Mara liu	Orange-spotted trevally	*Carangoides bajad*
Mara madali	Bump-nosed trevally	*Carangoides hedlandensiis*
Mara popana	Golden trevally	*Gnathanodon specious*
Mara roba	Snub-nosed dart	*Trachinotus blochii*
Moturu	Bigeye trevally	*Caranx sexfasciatus*
Moturu kove	Black trevally	*Caranx lugubris*
Paki pakete	Black-spotted dart	*Trachinotus bailloni*

The Roviana lunar cycle

The lunar cycle plays a major role in the Roviana fishing system since there is a well-understood correlation between lunar phase and Carangidae (and other species) behaviours which can be exploited by local fishers. Many of the days of the lunar month are given specific names. A version of the Roviana lunar calendar collected in Nusabanga is included as Table 2. This example is based on a 30-day lunar month. A more detailed version has been collected by Aswani (1997:238) and Hviding (1996) provides a similar calendar from Marovo Lagoon.

Tidal movements of Carangidae

According to local informants, Carangidae movements within Roviana Lagoon correspond to tidal flows. The following species of Carangidae are said to move into the inner lagoon regions through Honiavasa Passage on the rising tide, and then move back into the passage and outer reef areas on the falling tide: *Carangoides ferdau, Carangoides fulvoguttatus, Carangoides bajad, Caranx tille, Caranx lugubris, Caranx sexfasciatus, Caranx melampygus* and *Gnathanodon speciosus*. Informants further state that these predictable movements are due to a predator-prey interaction. The carangids are following their prey species, the very small baitfish named *hinambu* (members of the families Engraulidae, Clupeidae, Apogonidae, and Atherinidae) and the large baitfish, *kutukutu* (*Herklotsichthys quadrimaculatus*).

The baitfish are said to move up into the inner lagoon to spawn among the mangrove roots on the high tide, and retreat back to sea on the falling tide, when the shallow inner lagoon areas become exposed. Thus the tides are considered to be one of the most important factors regulating the likelihood of a successful catch:

> Before I go fishing I must watch the movement of the sea, there are two good times for fishing, *pado gore* when the tide starts to fall, and *pado sage* when the tide starts to rise, close to flood or ebb tide the fish do not eat (pers. comm., Harry Kama, Nusabanga village, August 1997. Translated from Solomon Island Pidgin by the authors).

These two tidal terms, *pado gore* and *pado sage*, refer to the first 3–4 hours after flood and ebb tide, respectively. Nine of the fourteen fishers interviewed stated that the best times to catch carangids are during *pado gore* and *pado sage*.
The state of the tides not only influences the timing of a fishing event, but also its precise location within the lagoon:

> At high tide the baitfish move up into the mangrove areas, and they are followed by the trevally. So at high tide I fish for trevally in the inner lagoon, near the sea grass in the deep areas close to the mangroves. At low tide the baitfish move out of the mangrove and go to the passage, so I go and fish for trevally there (pers. comm. Diliva Dava, Nusabanga village, August 1997. Translated from Roviana by Gaudry Kama).

Eight of the fourteen fishers interviewed also made the observation that on the rising tide carangids often swim near the surface in the passage, but on the falling tide they dive deeper into

Table 2. **The Roviana lunar cycle**

Roviana term	Lunar phase	Translation
Taloa Sidara	New moon	***Taloa*** : No ***Sidara*** : Moon
Tada Keke	Day 1	***Tada*** : refers to the first quarter, when the moon is first seen in the West and drops quickly below the horizon (before midnight).
Tada Karua	Day2	
Tada Ngeta	Day 3	
Tada Made	Day 4	
Tada Lima	Day 5	
Tada Onomo	Day 6	
Tada Zuapa	Day 7	
Noma Sidara	Days 8-14	***Noma*** : Big ***Sidara*** : Moon
Hobe Rimata	Full moon	***Hobe*** : Change ***Rimata*** : Sun. The moon changes the sun. As soon as the sun sets it is replaced by the moon.
Pae	Days 16-30	***Pae*** : "it is dark before the moon rises". The moon rises after 12 pm

the channel. Because of this, carangids are harder to catch by trolling or casting in the passage on the low tide, and alternative techniques must either be adopted, or other fishing locations selected.

Lunar-related aggregations

The subsistence fishers of Nusabanga and Sasavele recognise two main periods of the lunar cycle as ideal times for catching carangids. The first of these 'Carangidae seasons' is during the early part of the first quarter of the lunar cycle, and the second is around the full moon:

> *Mara* have seasons, so whenever we want to catch *mara* we must wait for its time. If you fish for *mara* when it is not the right time, you will not have much success (pers comm. Harry Kama, Nusabanga village, August 1997. Translated from Solomon Island Pidgin by the authors).

Thirteen of the fourteen fishers interviewed gave very specific and consistent information relating to passage and inner lagoon fishing in the first quarter of the lunar cycle. On *Tada keke*, *Tada karua* and *Tada ngeta*, fishing for Carangidae is highly productive, with all species being readily caught. Twelve of the fourteen fishers interviewed also recognised *Tada zuapa* as being a good time for catching *mara batubatu* (*Caranx ignobilis*). *C. ignobilis* appear within Honiavasa Passage of Roviana Lagoon several times during the first quarter of a lunar cycle between the months of June through to December.

> You can catch *mara batubatu* on *Tada keke*, *Tada karua* and *Tada ngeta*. From *Tada made* till *Tada onomo* you will not catch *batubatu*. On *Tada Zuapa* you will catch *batubatu*, and they will come in groups (pers comm., Simon Bae, Sasavele village, August 1997. Translated from Roviana by Gaudry Kama).

In the early hours of the morning on *Tada zuapa, C. ignobilis* are said to aggregate in large schools along the walls of Honiavasa Passage. The largest of these aggregations is reported to occur off the point of Honiavasa Island, where large groups gather in the shallow reef area on the eastern side of the channel, close to Site 3 (see below).

> In the early morning of *Tada zuapa*, before the sun is up, they start to arrive in groups. They don't all come in at once, you will see one group arrive then 5-10 minutes later another group will join them, then another group, and so on. I have never tried to count them, but in the end there is often over 100 fish. They aggregate between Honiavasa Island and Nitara Island, on the right-hand side of the passage. They also move up the left-hand side of the passage, but they do not go up as far as Vonovonoto Island, instead they will move into the small passage that breaks off before Vonovonoto Island. By the time the sun is up the schools will have gone (pers comm., Simon Bae, Sasavele village, August 1997. Translated from Roviana by Gaudry Kama).

All the persons who recognise these aggregations believe that they form as a result of a feeding opportunity when schools of *medomedo* (*Siganus argenteus*) and *suliri* (*Nematalosa come*) form. Jack Kari and Harry Kama both said that during *Tada zuapa* groups of *C. ignobilis* travel far up into the inner lagoon to feed, often travelling right up into the rivers which empty into the lagoon. This observation is consistent with reports from the Philippines, where *C. ignobilis* have been caught far up rivers (Manacop, 1952, cited in Westernhagen, 1974).

The second 'Carangidae season' occurs around full moon, a time which all the fishers interviewed recognised as being particularly good for carangid fishing. During this lunar stage *C. sexfasciatus* and *C. lugubris* are said to aggregate in the lagoon, often in schools. These species are predominantly targeted at night by droplining using *ganusu* (*Selaroides leptolepis*) for bait, or by casting non-weighted lines with *hinambu* (small baitfish) as bait. *C. fulvoguttatus*, the gold-spotted trevally, is also said to aggregate in schools during this lunar stage.

In addition to these two main 'Carangidae seasons' other minor periods of aggregation are known to local fishers, and exploited accordingly. Six of the fishers stated that *mara batu papaka* (unidentified Carangidae species) aggregate within the lagoon in large schools after the full moon, during *Pae*. Simon Bae of Sasavele stated that large schools arrive mainly during the last quarter, and that during this time they travel far up into the inner lagoon. It is also important to note that some of the Carangidae species that inhabit the lagoon are reported by local informants *not* to have a specific lunar season. For example, *C. bajad* is said to be constantly present within the lagoon, regardless of the lunar stage.

Marine survey methods and results

On the basis of the ethnographic survey we can define three testable hypotheses relating to

Carangidae behaviour in and around Honiavasa Passage:

1. Carangidae species move in and out of the passage with the tides;
2. *C. sexfasciatus* will be at their highest densities within the passage around full moon; and
3. *C. ignobilis* will aggregate in schools alongside Honiavasa Island before sunrise on *Tada zuapa*

To test these hypotheses a dive survey was carried out using Instantaneous Area Point Counts (IAPC) during flood and ebb tides at six sites in Honiavasa Passage. For the purpose of site selection, the passage was divided into three areas: Outer, Middle and Inner. Two sample sites were allocated within each area, one on the left-hand and one on the right-hand side of the passage (Fig 4). The three separate areas were chosen in order to determine if distance from the open sea influenced the distribution and abundance of fish. Two sites were allocated within each area in order to determine whether passage side had a significant effect on the abundance or movements of Carangidae.

This survey spanned two lunar cycles and was conducted using standard IAPC visual census methods. IAPCs were recommended by Thresher and Gunn (1986), who assessed the usefulness of many underwater visual transect and point count techniques for estimating biomass and abundance of Carangidae. The IAPC method used here involved underwater visual census carried out by two divers at selected times, locations and depths using SCUBA. In addition, underwater video footage shot from a fixed station was taken for identification and reference purposes. A total of 48 hours of video was recorded. A fibreglass canoe powered by a 15 hp motor was used during the field surveys.

On arriving at a site, visibility was determined in order to define differences in average visibility between the six study sites. At a depth of 5 m a plastic silhouette of a fish (49 cm in length) was located on the bottom. One end of a fibreglass tape measure was attached to the silhouette, a diver then swam horizontally away from the silhouette reading the distance off the tape measure at which the silhouette became difficult to distinguish. Both divers then stationed themselves with their backs to the reef wall and fifteen point counts were carried out over 15 minutes. At 60-second intervals, the entire 180-degree area of the passage visible to the diver was scanned (a procedure taking 5-10 seconds) and all individuals in that area were recorded by species. Observations of the number of individuals of a given species, their length and their direction of movement (up or down the channel) were recorded. The amount of error in the length estimates was calculated throughout the field observations by periodically recording the 'estimated' and 'actual' length of coral heads. A total of 120 dives were carried out during the months of September and October 1997. These consisted of twenty dives at each site, ten on the falling tide and ten on the rising tide.
The analysis of the IPAC data looked for interactions between the following five variables:

1. State of tide (rising, falling);
2. Direction of fish movement (in, out);
3. Lunar stage (new moon, first quarter, full moon, second quarter);
4. Area (Outer, Middle, Inner); and
5. Side of passage (left, right).

Presence-absence data for the three most frequently sighted species of Carangidae, *C. melampygus*, *G. speciosus* and *C. sexfasciatus*, were analysed

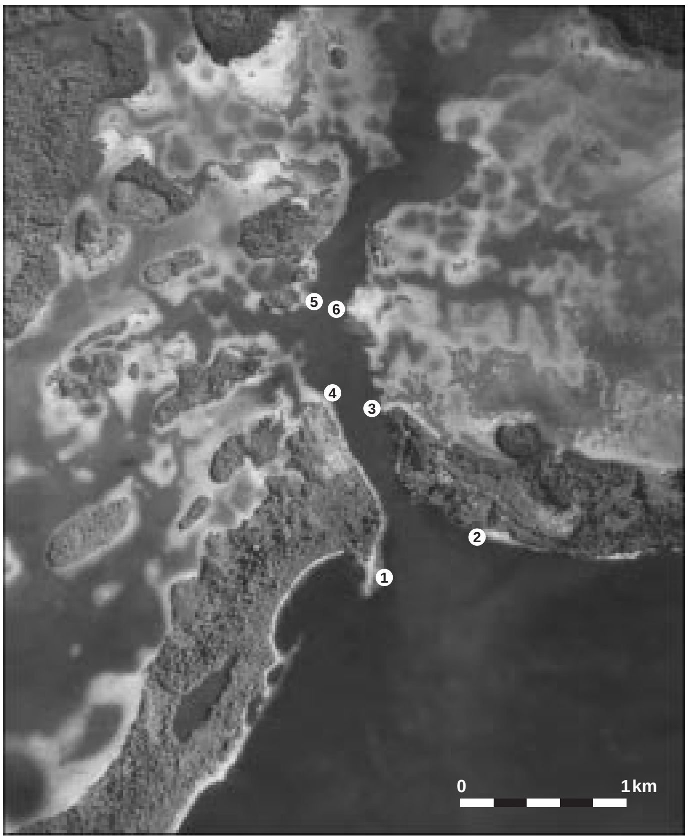

Figure 4. **Aerial photo of Honiavasa Passage showing the location of the six sites**

using a logistic linear model in the software package JMP™ on a Macintosh™ computer. A model of best fit was determined for each data set, then the significant terms in the chosen model were examined in detail.

Total abundance data for *C. melampygus* were transformed from dive log records using the standard log 10 transformation. These abundance data were then analysed using a general linear model, ANOVA, involving all main effects and interactions. This was carried out using DataDesk™ software on a Macintosh™ computer.

Carangidae movements with respect to tidal flows

The two most commonly sighted species of carangid, *C. melampygus* and *G. speciosus*, both showed a strong tendency to move in the direction of tidal flow. Analysis of the *C. melampygus* log data revealed a significant two way interaction between tidal flow and direction of fish movement (DF = 1, SS = 1.03, MS = 1.03, F-ratio = 11.76 and P value < 0.01) (Fig. 5).

Analysis of *G. speciosus* presence / absence data also revealed that the movements of fish within Honiavasa Passage correlate strongly with tidal flows (LR Statistic = 50.56, 1 DF; P < 0.01) (Fig. 6).

Lunar aggregations of Carangidae

C. sexfasciatus was the third most commonly seen Carangid in the dive survey. Presence / absence data analysis revealed that lunar stage influences their relative abundance within the passage (LR Statistic = 8.33, 3 DF; P = 0.04). *C. sexfasciatus* were

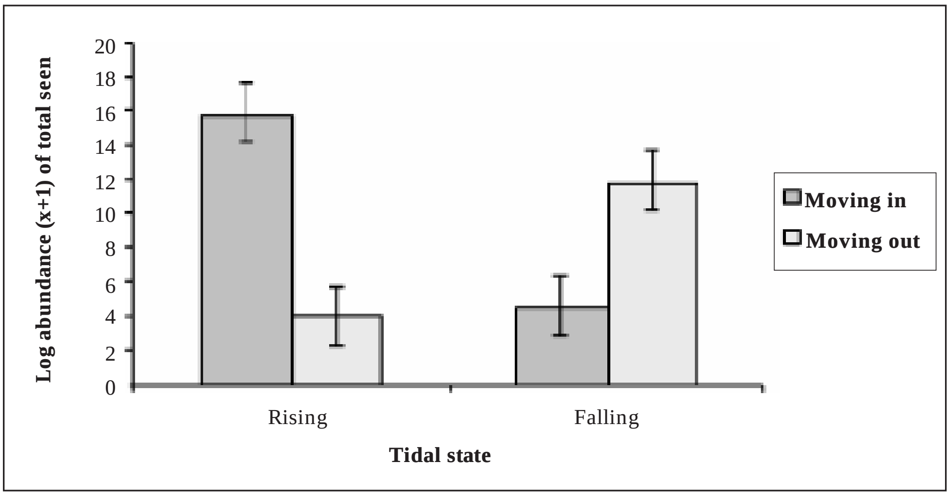

Figure 5. **Log value of the total number of *Caranx melampygus* seen moving in and out of Honiavasa Passage on 60 rising and 60 falling tides (Error bars = ±1 SE)**

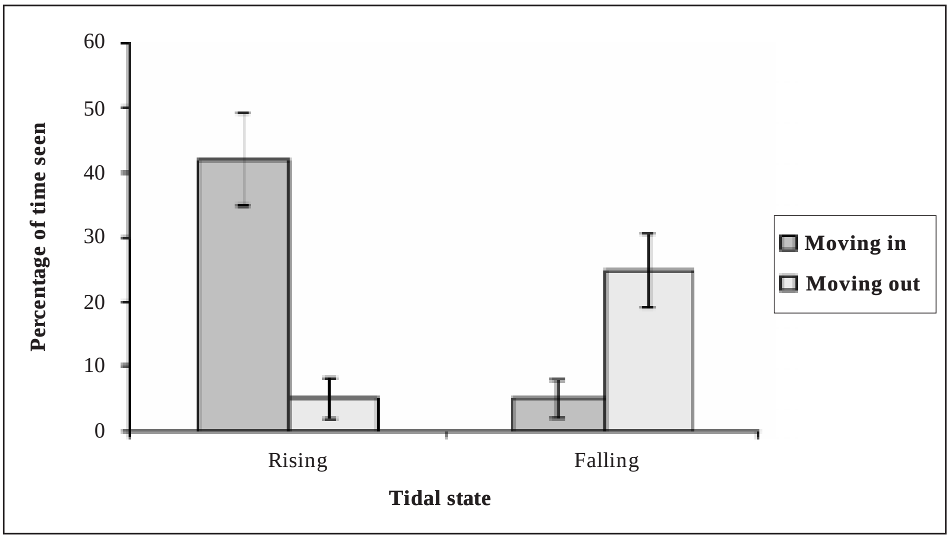

Figure 6. **The percentage of time that *Gnathanodon speciosus* were seen moving in and out of Honiavasa passage on 60 rising and 60 falling tides (Error bars = ±1 SE)**

seen the highest percentage of the time (15%) during the full moon lunar phase (Fig. 7). In the new moon and first quarter they were seen approximately 5% of the time and during the second quarter they were seen only 2% of the time.

There were insufficient sightings of *C. ignobilis* and *mara batu papaka* to warrant statistical analysis, but observations made during the dive survey and during other field exercises support local predictions about their aggregating behaviours. *C. ignobilis* were seen only once out of 120 survey dives, and this sighting occurred on *Tada zuapa* the lunar day that *C ignobilis* schools are reported by local fishers to form within Honiavasa Passage. The sighting occurred at Site 6 in the late afternoon of 10 Sep. 1997 on a rising tide. Further, the predicted aggregations in the early morning of *Tada zuapa* were observed the following month, on the 10th of October. The CPUE data also demonstrated *C ignobilis* aggregations around *Tada zuapa*.

Mara batu papaka were sighted only on three occasions out of a total of 120 survey dives. These sightings all occurred during *Pae*, the period following full moon. Again, this accords well with CPUE data and with the statements made by informants during the ethnographic survey (see above).

Discussion

As this study demonstrates, TEK systems contain knowledge that is relevant to many of the types of question asked by fisheries research scientists. In this case we were interested in carangid movements and aggregation patterns, a question of potential relevance in coastal resource management and development planning. Through anthropological field techniques we were able to acquire a ready-made model of these behaviours which could then be quickly and easily tested using standard marine science field methods. Through participant observation and interviews we identified two specific categories of Carangidae behaviour well understood by Roviana fishers. These categories pertained to the temporal and spatial patterning of fish activity at different scales. First, there was the relationship between tidal change and Carangidae movement. Second, the relationship between fish aggregating behaviour and the lunar cycle. We were then able to create a research design that would maximise the likelihood of us observing these predicted behaviours. In this case, the dive survey results verified local statements on marine ecology. Other, more complex, research questions are likely to reveal a more complex relationship between traditional and scientific knowledge systems.

In summary, we review in brief a number of benefits and motives for researchers to consider indigenous knowledge systems, and conclude by reiterating the argument for an holistic approach to coastal research in Melanesia.

1. TEK contains baseline information on local ecologies including information on what is present in the local ecosystems, and its temporal and spatial patterning.
2. By drawing on TEK at the early stage of research, scientists are able to develop testable models, and so target their research and efficiently budget their time and other resources.

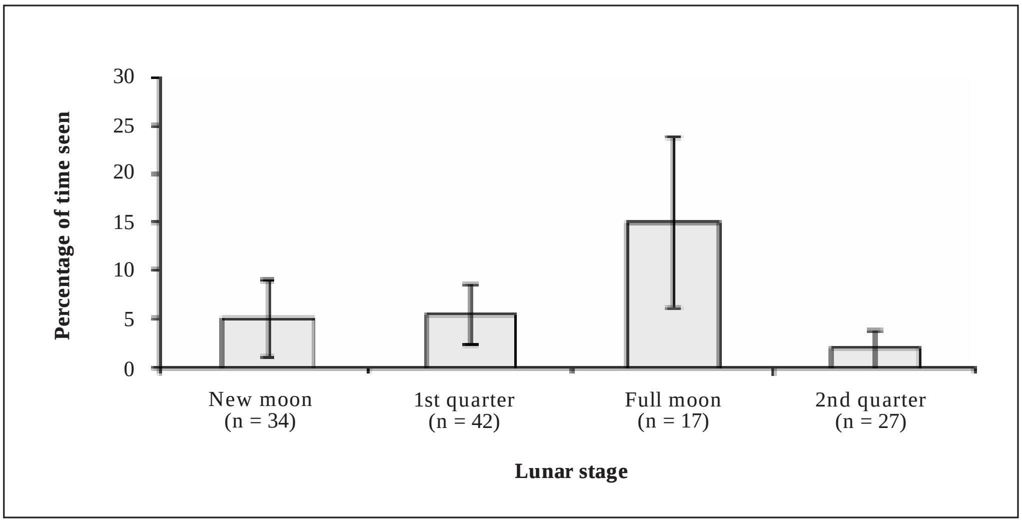

Figure 7. **The percentage of time that *Caranx sexfasciatus* were seen in Honiavasa Passage during the four lunar stages (Error bars = ± 1 SE)**

3. TEK and CMT evolved over generations of direct interaction between human communities and their environment and are likely to contain information and ideas not currently contained within scientific models (Lalonde & Akhtar, 1994).
4. If properly understood, there is a potential for resource managers to use CMT systems directly to manage stocks in development projects (Hviding, 1996; Ruddle *et al.*, 1992).

Conclusions

All knowledge systems, including scientific knowledge systems, are culturally structured and there are potential dangers in extracting information from one system, and applying it in another. For that reason, research scientists working with TEK should attempt to develop a holistic understanding of those systems, so as to understand the context of the information they hold. In coastal research, this would include information on folk taxonomy and ecology, fishing technologies and the social and symbolic context of fishing activities.

Knowledge is often stratified by gender, age and geographical location (Hviding, 1996; Christie & White, 1997). For example, in Roviana Lagoon, women fishers hold traditional knowledge on mangrove clams, as it is almost exclusively women who collect these food species. It would thus be difficult for male researchers to gain access to that information, and potentially misleading if they were to ask only male members of the community about the exploitation of mangrove clams (although they would undoubtedly get an answer).

We also note that in Roviana, knowledge pertaining to specific families of fish is sometimes restricted to fishers who specialise in targeting those species. Several of the fishers in this study when asked questions on the ecology of Carangidae made statements similar to that of Enele Garata: 'Oh no, I don't know about *mara*, I only know about *pazara* (Serranidae) and *pipo* (Sphyraenidae), ask the old man Simon Bae at Sasavele, he knows about *mara*' (pers comm., Enele Garata, Nusabanga village, August 1997. Translated from Solomon Island Pidgin by the authors).

It is also important to appreciate that most indigenous knowledge of marine ecologies is ultimately directed towards identifying patterns which maximise capture success. Thus some details of fish behaviour which may be irrelevant to a local knowledge base (since they have no influence on subsistence practice) may be of immense importance to a marine biologist studying reef ecology. Further, whereas indigenous knowledge of fish behaviour will often be very accurate, local explanations for the mechanisms underlying these behaviours may not be compatible with scientific paradigms.

In Nusabanga, local fishers believe that *mara* movements through the passage relate to predator–prey relationships with baitfish (see above). Our research shows, however, that while the predicted movements of fish is accurate, the explanation probably varies amongst species (Hamilton 1999). Ruddle *et al.*, (1992:262) make a similar point, 'In some places declining yields may be attributed to sorcery or a failure to propitiate the gods'.

In conclusion then, indigenous knowledge is an enormously valuable resource base but one which is often treated in a far too casual manner by research scientists. We advocate an holistic approach incorporating the strengths of anthropological and marine science methods and techniques. In a cross-disciplinary approach, each discipline provides the other with a degree of accountability and more accurately represents the knowledge base of the indigenous peoples of Melanesia who have been living and acting in these landscapes for up to 30,000 years.

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New publications

Traditional marine resource management and knowledge

Community-level sea use management in the Grenada beach seine net fishery: current practices and management recommendations.

by J.A. Finlay, M.Sc.Thesis, University of the West Indies, Cave Hill, Barbados (1996).

This study identified and characterised a community level, self-regulating Territorial Use Rights in Fisheries (TURF) system within the Grenada beach-seine fishery. The TURF system serves as a useful example of an alternative management system and involves 41 large beach seines and 289 fishers, operating at 97 shallow water fishing sites (hauls) along the coasts of the islands of Grenada and Grenadines. Although all hauls are open to all seine nets, nets are observed to cluster in nine fairly discrete zones along the coast and tend not to move far from the fishers' places of residence.

The beach-seine fishery targets a multi-species stock of mainly juvenile coastal pelagics. Two species of Carangidae (big eye scad, called jacks, *Selar crumenopthalmus*; and red tail scad called 'round robins', *Decapturus tabs*) account for 90 per cent of catches. The remaining catch comprises juvenile oceanic pelagics (6%) and other small-sized coastal pelagics (4%). Although species vary in abundance seasonally, a fairly constant overall abundance of seine fish maintains a year round fishery with relatively constant fishing effort.

Ten traditional rules are identified within the TURF system and these effectively allocate fishing opportunity to beach-seine nets through the recognition of temporary exclusive ownership at hauls. A number of conflicts are presently threatening the TURF system. These include intra-fishery conflicts between beach-seine fishers and relate to non compliance with TURF rules; inter fishery conflicts, between seine fishers and other fishers generated by competition for sea space (by anchoring boats, motorised trolling boats, motorised fishing boats landing catches ashore); and competition for the target fish by ringnets operating adjacent to the haul; extra fishery conflicts, between beach seine fishers and mainly tourist-related activities which are now being viewed as having greater economic importance. Beach-seine TURF fishers view these conflict situations as devaluing their traditional property rights.

Suggestions for solutions from both seine fishers and their competitors for sea use, indicate that government should initiate urgently some form of localised management. Seine fishers felt strongly that legalisation of the TURF rules would serve to legitimise and enhance their property rights. Both seine fishers and their competitors for sea use felt that a rationalisation of entitlements, expectations and obligations within the context of a co-management approach was needed.

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