

2. clothing. Name probably connotes the long, bending appearance of this soft-fleshed sea cucumber.

Plants

Ahoaho: *Premna corymbosa* (Family Verbanaceae). A beach-side tree, the leaves and small branches of which are often taken by women on long canoe trips to ward off sea-devils (**Asi**).

Alite: *Terminalia catapa*. Also called **Tahile** and **Lengga**. A calendar plant. The presence of red leaves on this semi-deciduous species (usually twice a year—around June and December) indicate a time when 'red fish' aggregate and/or have oily flesh (**mona**). This might include holocentrids (**Sori**, **Talaa**, etc.), serranids (**Sivari**, **Taburara**, etc.) and lutjanids (**Koukoru**, **Uvoro**, etc.).

Buburupoto: *Oplismenus compositus* (A grass which is common in disturbed areas, such as the fringes of gardens). A calendar plant. The presence of the sticky seeds of this species (March, April, May) indicate a bad time for fishing. Etymology: **Buburu** = grass; **poto** = generic for some types of Damselfishes. The name connotes the sticky, clinging nature of the seeds of this grass, which is likened to the pugnacious behaviour of **Poto**.

Koga: a species of mangrove (No identification)

Kulikuli: (Seagrass {generic}).

Busu: a type of green alga preferred by hawksbill turtles (possibly *Chlorodesmus chloroticus*).

Tongo: (Mangrove {generic}).

Tongo bua: a species of mangrove (No identification).

Tingale: a species of mangrove with small leaves.

The use of optimal foraging theory to assess the fishing strategies of Pacific Island artisanal fishers: A methodological review

by Shankar Aswani¹

In this paper, foraging theory and its methodology are presented as a complementary framework to the study of Pacific Island artisanal fisheries. It is expected that such inclusion will allow for the development of a clearer anthropological model describing the relationship between human foraging and fishery management.

Introduction

Artisanal fisheries play a major role in the social, cultural, and economic life of most Pacific Islanders, particularly in rural communities where people are highly dependent on marine resources for subsistence and commercial purposes. Yet, marine resources are being threatened by pressure from exploding human populations and the increasing commercialisation of the subsistence fishery—circumstances which are now forcing researchers to find novel ways to examine issues of coastal management and marine resource conservation. Among the most recent approaches to coastal management has been to study marine ecological processes in conjunction with those of the contiguous shoreline and upland habitats, or what has been termed Integrated Coastal Zone Management (ICZM).

From the standpoint of maritime anthropology, any comprehensive study of the integration of marine and terrestrial biotic components requires the parallel consideration of human activities, including existing property regimes, resource access and distribution rules, and resource exploitation strategies. Although numerous studies have concentrated on the social aspects of Pacific Island artisanal fisheries (e.g. Johannes, 1981; Hviding, 1996; Lieber, 1994), few have dealt explicitly with the micro-ecology of daily human-marine interactions (see Aswani, 1997; Bird & Bird, 1997). Such neglect has hampered attempts to fully integrate studies of environmental coastal processes with those of human activities.

In this paper, I examine the utility of optimal foraging theory and its methodology, as applied to the study of Pacific Island artisanal fishers. The inclusion of foraging theory can contribute to

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building a clearer anthropological model to describe the relationship between human foraging and fishery management.

Theoretical review

Since the mid-1970s, a growing number of anthropologists have employed optimal foraging theory as developed in evolutionary ecology to study the subsistence practices of indigenous peoples. Evolutionary ecology explains human behavioural adaptations in ecological context through the use of natural selection theory. Briefly summarised: individuals exhibit genotypic variation that affects their capacity to survive and reproduce. Certain adaptive traits will dominate over time and become prevalent in a population. The objective of evolutionary ecology is to examine the phenotype of an organism (i.e. biological and behavioural traits) and to explain *why* certain phenotypic traits (e.g. foraging strategies) evolve in a given ecological context (Smith & Winterhalder, 1992).

Evolutionary theory is too abstract to explain the presence of specific human traits, so a 'middle-range theory' is required to link observed behaviour and general theory (Smith, 1991). In this respect, optimal foraging theory provides a conceptual link between empirical reality and theory. The purpose of foraging theory is to formulate testable predictions that can account for foragers' decisions (choices) with regards to the types and abundance of food they consume (diet breadth), the areas utilised (patch choice), and the time spent foraging in these areas (patch use). Optimal foraging models assume that a forager's decisions made *during foraging* are formulated to maximise short-term energy gains (Stephens & Krebs, 1986). This is an evolutionary approach, because if foragers successfully adapt to a long-term foraging strategy that maximises food returns and minimises resource harvest time, their Darwinian fitness may be enhanced. (For readers feeling uncomfortable with the Darwinian fitness postulate, stripping foraging theory from its evolutionary implications still leaves a operationally-defined set of cost-benefit models capable of empirically measuring particular foraging choices.)

Foraging models have four identifiable elements (Stephens & Krebs, 1986):

- the participating actors,
- a set of choices made by the foragers,
- a currency, and
- a set of intrinsic and extrinsic constraints faced by the forager.

All participating actors display a set of decisions and/or choices while foraging. Ordinarily, foraging theory models have examined two decisions:

- what prey (or patch) to consume, and
- when to abandon a patch.

The former choice is examined by diet breadth and patch choice models (Charnov & Orians, 1973; MacArthur & Pianka, 1966; Stephens & Krebs, 1986) which solve for the decision component of food harvest, or the probability that a forager will select a given prey or patch upon encounter. The two main model components are *search time*, or time spent looking for prey or patches, and *handle time* or time employed following, capturing, and processing prey.

The second choice, time spent in a patch, is addressed by the patch time allocation model (Charnov, 1976) which examines the decision variable for how long to forage. The two main components of this models are *travel time*, or time spent looking for adequate patches, and *residence time*, or time spent in a given patch (Stephens & Krebs, 1986).

Another significant axiom of optimal foraging theory, and perhaps the most polemical, is the model's currency assumption. In determining the optimal choice facing a forager, a currency, or the cost and benefit decision variable, must be selected for the model.

Typically a currency can be expressed as units of maximisation (e.g. kcal per hour of foraging), minimisation (e.g. time, risk), or stability (e.g. energy versus risk). Most researchers using foraging theory have employed a maximisation criterion to evaluate foraging decisions (Stephens & Krebs, 1986).

If maximisation is the criterion, however, what are foragers maximising? (e.g. survivorship, fertility, energy or protein intake, or even money). Anthropologists have commonly used energy optimisation as a proxy for reproductive fitness (e.g. Alvard 1995; Hames & Vickers 1982). Energy optimisation can be expressed as 'net acquisition rate,' 'net rate of energy capture,' 'return rate,' or 'foraging efficiency' (Smith, 1991: 46). Following Smith (1991), this concept is best expressed as the 'net return rate' per capita, or equivalent to the energy gained during foraging (the kcal value of the catch) minus the labour input (labour cost incurred during foraging including travel, search and handling times) divided by the total residence time at a patch. The utilisation of calories as units of energy maximisation permits the operationalisation of the foraging models without relying on nebulous concepts like 'utility' and 'fitness' (Smith & Winterhalder, 1992).

Notwithstanding the conceptual value of energy as a unit of maximisation, numerous social anthropologists have vehemently opposed the idea of reducing human food disposition to mere caloric values. The general complaint is that foraging models do not account for cultural and ideological preferences of food (e.g. taste, or prestige foods) (Smith, 1991). The objective of foraging models is not to determine human proximate deci-

sions (i.e. food choice based on ideology) but to elucidate the underlying causal structure of those decisions. In fact, the idea of calories as the unit of maximisation may not be so removed from the indigenous view of prey value. For instance, Pacific Island fishers generally rank prey desirability according to its fat content.

A more problematic and challenging issue is selecting a unit of maximisation in a monetised economy. The classical foraging models focus on energy as a proxy for 'reproductive fitness,' and do not include 'utility' measured in a monetary currency in their predictions. Yet it seems unrealistic to deal exclusively with energy when evaluating foraging practices in an increasingly monetised global economy. Time spent foraging for food is time that could be employed to produce income.

This raises an important question: which currency are foragers actually trying to maximise when foraging—cash (per unit of effort) or calories? If the population under study, as is the case with some Pacific artisanal fishers, primarily engages in subsistence fishing, then calories are an appropriate currency. Alternatively, if fishers equally engage in subsistence and commercial fishing (i.e. small-scale) a common currency can be developed by converting all foraging inputs and outputs (including cash) into a single currency such as net energy capture per hour of labour (for further discussion see Smith, 1991, 357–397).

The final tenet of optimisation models is of *constraint* assumptions. Briefly defined, constraints 'are all those factors that limit and define the relationship between the currency and the decision variable(s)' (Stephens & Krebs, 1986: 9). Constraints can be extrinsic and/or intrinsic to an organism. Extrinsic factors which limit a fisher's foraging ability include constraints such as changing patch productivity, changing weather patterns, and even social constraints such as religious bans on working on Sundays. Intrinsic constraints are those which physiologically limit the capacity of an organism to interact or tolerate environmental variables.

The foraging models: two examples

Foraging theory's analytical value is evaluated in this paper by presenting two complementary models: the patch choice (MacArthur-Pianka, 1966; Charnov & Orians, 1973), and the marginal value theorem (Charnov, 1976) patch time allocation models.

The general theoretical objectives of these models, as applied in a marine context, are to understand the daily and seasonal movement of marine foragers. The first model is designed to forecast a fisher's habitat selection, whereas the second complements the former by predicting the time that a fisher should spend harvesting prey in a fishing ground or set of grounds. These models, although

similar in several respects, differ because they analyse different decisions: where to forage versus for how long.

The patch choice model predicts that patches (e.g. habitats) will be selected by a fisher according to the mean productivity of that patch. Patches are added to the foraging range until an increase in travel time (i.e. a cost) lowers the mean return rate for foraging in that patch (Winterhalder, 1981).

The marginal value theorem predicts that if a fisher is foraging optimally, a patch (e.g. fishing ground) should be abandoned when the marginal rate of return for fishing in that ground is equal to the mean return for the entire habitat or set of visited patches. The model also forecasts that if habitat productivity decreases without affecting the yield of a specific patch (i.e. within the habitat), then foragers should spend more time on that patch, and that if productivity increases, less time should be allocated to each ground (Smith, 1991).

The combined predictions of the models suggest that as seasonal productivity of a habitat type (e.g. outer-reef drops) increases, more overall time is assigned to the habitat, but less time is spent at each particular fishing ground within it. Frequent mobility between accessible grounds allows fishers to sustain considerable catches before any of the visited grounds undergoes resource depletion. Conversely, as seasonal habitat productivity decreases, less overall time is assigned to the habitat and, when visited, more time per bout is spent at a fishing ground. It does not pay for fishers to move elsewhere within the habitat if they cannot do better. Alternatively, fishers can search for more productive habitat types (e.g. inner-lagoon reefs) as long as they are accessible and travelling costs are not too high.

Analysing Pacific Island artisanal fishers: A case study

This section describes the methodology employed to test the foraging models outlined in this paper. The case study presented here is based on my own research conducted at the Roviana and Vonavona Lagoons in South West New Georgia, Solomon Islands from April of 1994 through December of 1995 (see Aswani, 1997).

A major objective during this research was to describe the behaviour of fishers and to account for the temporal variability of their activities. This required my direct participation in fishing forays as well as that of my assistants. Participation in the fishing activities of Islanders allowed me to understand the complexities involved in their daily choices, which could never have been attained by interviewing alone.

To elicit detailed comparative behavioural data for other fishers, self-reporting diaries were hand-

ed out to men and women² in villages across the lagoons. These were important to understand regional variation in foraging strategies.

Direct participation by my assistants and me in fishing forays produced records on 372 fishing trips to 978 fishing grounds, encompassing a total of 751.4 hours of fishing. Including the self-reporting diaries, a total of 2,203 fishing trips encompassing 5,920.7 hours of fishing in 4,445 visits to fishing grounds were collected. Data compiled during fishing forays included data categories such as:

- name, sex, and age of participants,
- date and village,
- total time allocation and time-motion records for all behavioural categories conducted at each ground,
- name and environmental characteristics of exploited grounds,
- name and number of captured species,
- total weight of catch by species and areas visited,
- fishing methods employed,
- mode of transportation,
- expenses incurred (e.g. petrol cost when using outboard motors, hooks lost, etc.),
- income, if any, and
- weather patterns, including tidal cycle, lunar stage, wind direction, and other environmental variables.

Moreover, during fishing trips I was able to elicit other types of information such as the ethno-historical characteristics of the seascape, localised temporal events (e.g. fish aggregations), and specific data on prey species.

The data collected during the focal analysis and foraging diaries form the basis to test the foraging models presented in this paper. Foraging effort (labour input) and foraging outputs (the catch) data are essential to estimate the foraging efficiency of Roviana fishers. Although measuring the output of fishing activities was not too difficult, figuring out the labour input of fishers was more complex. The primary analytical tool employed to calculate labour inputs was time-motion analysis (see Nydon & Thomas, 1989).

Time motion analysis

Time motion analysis is a research strategy used by ecologists and some anthropologists to determine the time and energy that an organism spends in an activity. The first analytical step is to break down observed patterns of behaviour into work categories (e.g. paddling, walking, etc.) and to measure the specified behaviours by timing individuals while they conduct them (e.g. sitting

in a canoe). In figuring expenditure rates for labour input, the recorded times for behavioural categories are multiplied by standardised indirect calorimetric measures. This procedure will be explained below. During analysis of fishing forays, work categories for each participating individual were broken down into two groups: travel and within-ground activities. These two were further subdivided into their respective behavioural categories. Several stop watches were used concurrently to time observed behaviours.

In addition to recording the behaviour of observed fishers, these detailed measurements served to calculate the behavioural ratios for each fishing method. These, in turn, were used as a proxy to figure out the behaviour of fishers in trips that neither me nor my assistants had observed (i.e. foraging diaries). For instance, anglers generally spend 27 per cent of their within-patch time in some handling activity (casting, bating, unhooking fish etc.) whereas 73 per cent is spent waiting. This ratio was applied to the foraging diaries, which did not have as much detailed information as the focal diaries. If a fisher stayed 50 minutes in a patch, it was assumed that 13.5 minutes had been employed in handling, while 36.5 minutes were used in waiting (search time).

The diary method

To complement my own observations and to attain detailed comparative behavioural data for other fishers in different areas of the Roviana and Vonavona Lagoons, the diary method was employed. This method was indispensable in accessing data on regional variation in habitat selection, differences in methods used, seasonal influence on fishing strategies, and the 'foraging histories' of particular individuals. Most importantly, the use of this method allowed for the examination of seasonal cross-regional time allocation to various habitat types and the correlation between time allocation and relative resource abundance (i.e. as measured from recorded yields).

The diary method consists of randomly selecting subjects to keep diaries of their foraging activities. In this study, random selection of informants was not always achievable. Selecting the appropriate subjects was hard because many fishers were either unwilling to keep a log of their activities or simply could not handle the provided materials. Also problematic was the fact that many fishers were only interested in the provided materials and did not care about the project. Those fishers willing to cooperate were given a watch, a scale, a pen, and a set of standardised forms. Approximately one hundred wrist watches and

2. Only nine women participated in writing the foraging diaries. Nevertheless, my assistants and I recorded the activities of over one hundred women across the region.

scales were handed out in hamlets throughout the Roviana and Vonavona Lagoons. Each subject kept the material if they satisfactorily completed at least 25 fishing events. Fishers were not told that they could keep the materials to prevent people from falsifying their diaries. Diaries where I suspected cheating (e.g. a record of ten full moons in a single month!) were discarded. Notwithstanding the possible sampling bias, my own observations of fishing patterns indicates that the chosen fishers (both male and female) were a representative sample of the fishing population. Despite the problems, many fishers were interested and keen to cooperate in this project. In the 20-month duration of this project, 1915 foraging diaries were collected from more than one hundred participating fishers. To make sure that fishers in my village were being accurate in their self-reporting, I frequently recorded their movements while out fishing to cross-check their reported times.

Estimating the 'foraging efficiency' of fishers

Energy maximisation as a unit of foraging efficiency is best expressed as the 'net return rate' per capita. This rate (R) is equivalent to the energy acquired (E_a) during fishing (the kcal value of the catch) minus the labour input (E_e) (labour cost incurred during foraging including travel, search, and handling times) divided by the total residence time (t) at a patch multiplied by the number of participating foragers. This is mathematically expressed in the following equation (Reproduced from Smith, 1991: 186):

$$R = \sum_{i=1}^n (E_a - E_e) / (t) (n)$$

Estimating labour costs

The labour energy expenditures were calculated by taking the time-motion records for each visited fishing ground and multiplying them by established calorimetric values.³ Estimating energy expenditure rates from time-motion data is a proxy method to calculate human energy expenditure. Reliable energy expenditure rates for a Melanesian population have been provided by Norgan, Ferro-Luzi, and Durnin's (1974) study of energy expenditure amongst the Kaul, a Papua New Guinea coastal population. Measures attained from this study were complemented with FAO's (1985) energy expenditure tables for subsistence societies. Because these tables only offer mean energy expenditure measures, it was necessary to calibrate for age, weight, and sex of each

participating individual. To do that, the standard measures for BMR, or 'basal metabolic rate,' for different age, sex, and weight groups in the FAO report (1985) were utilised. For instance, if the Papuan study tables indicated that the energy expenditure for 'paddling canoe' for a male between 25- and 65-years-old weighing 65 kg is 3.2 kcal per minute of labour, and I had to correct for a woman weighing 50 kg and 32-years-old, the following was carried out. If the BMR for that individual was 1,290 kcal per day (FAO, 1985: 72), this number was divided by the number of minutes in a 24-hour period, or by 1,440. The result was then multiplied by the standardised expenditure rate for males to adjust for the age, weight, and sex of the subject. Therefore, the energy expenditure for 'paddling a canoe' for a 32-year-old female weighting 50 kg was equal to $1,290 \div 1,440 \times 3.2 = 2.87$ kcal per minute. Using the Papua New Guinea study and other sources, coupled with the BMR calibration for specific age, sex, and weight provided by the FAO (1985) tables, a range of energy expenditures for Roviana and Vonavona fishers was determined.

Estimating output—catch values

Energy outputs harvested during fishing are equivalent to the edible weight of the catch multiplied by standardised caloric values. In this study, the energy returns of each catch varied according to the caloric value of the constituent species. When possible, the catch harvested at each visited fishing ground was separated by species. For small catches dominated by multiple species of small reef fish, an averaged measure was used to determine the energy value of the catch. The literature on fish nutrition and seafood (e.g. Nettleton, 1985) indicates that the edible portion of a whole fish is about 60 per cent (for shellfish and crustaceans this measure varies between 10 and 40%). However, these measures are for edible portions considered by Western consumers, and do not include parts of fish and crustaceans eaten by other populations (e.g. head, liver, eyes etc.). To adjust for difference in feeding habits between Western and Melanesian populations, a 10 per cent edibility portion was added to fish, crabs, and crayfish.

Estimating the net return rate

Once the energy input (labour costs for an activity) and the energy outputs (value of the catch) were solved, the unit of foraging efficiency, or 'net return rate,' was determined algebraically. As an example, if a male in his 40s weighing 65 kg

3. Labour expenditure for fishing at a fishing ground also includes energy expenditures incurred during searching for bait. If the fisher visited more than one ground, bait-search labour expenditure was factored among all visited grounds.

paddled for 12 minutes, stayed in a fishing ground angling for 47 minutes, and caught a barracuda weighing 2.3 kg, and then paddled back to the village in 10 minutes, the net return rate was calculated as follows: The labour cost is equal to a total of 22 minutes \times 3.3 kcal per minute of paddle (at regular speed) + 47 minutes \times 2.1 kcal per minute of angling time. This is equal to a labour cost of 171 kcal.

The next step was to calculate the energy output of the catch. If the barracuda weighed 2.3 kg but only 70 per cent of it was edible, the actual usable portion was equal to 2.3×0.7 or 1.61 kg. The caloric value was then calculated by multiplying 1,610 g (1.61 kg) by the energy value for Pacific barracuda, or 118 kcal per 100 g edible portion, so that $1,610 \times 118 \div 100 = 1,899$ kcal. Subsequently, the labour output was subtracted from the input to figure the net energy return, or $1,899 - 171 = 1,728$ kcal. To convert this measure into a rate, the net return was divided by the time spent foraging, so that $1,728 \div 47$ minutes = 37 kcal per minute of foraging, is the *net return rate*. This, in turn, was multiplied by 60 minutes to find the hourly rate. Whereby $37 \times 60 = 2,206$ kcal would be the hourly rate gained for fishing in this fishing ground of a habitat type at that specific season and time of the day.

Calculating mean return rates for fishing methods, habitats and fishing grounds

The previous section has shown the general method employed in this study to factor the net return rate. In this section the methodology employed to calculate *mean* net return rates for all fishing methods, habitat types, and grounds are outlined. The initial step was to code all foraging events and to enter each respective visit to fishing grounds as separate cases (4,445 cases). Once the data was coded, the next step was to find out the seasonal mean net return rates for each fishing method, the major habitats, and for specific fishing grounds within each habitat. Finding the seasonal return rates for each method revealed the effectiveness of each technique, and the geographical disparities in yield and effort for each method. The environmental productivity (i.e. measure of relative abundance only) of each habitat was assessed by sorting all bouts by habitat type and attaining their mean return rates. Subsequently, each habitat type was sorted by the three main tidal seasons in Roviana (see Aswani, 1997) to attain seasonal yields and overall foraging effort allocated to each. The overall time allocation results for each habitat type illustrated whether fishers were allocating more fishing effort to habitats experiencing an increase in seasonal productivity. In fine tuning the analysis of seasonal pattern, individual fishing grounds within a habitat

type were sorted by indigenous name and their mean return rates determined. Each ground was further sorted by tidal season to see if patterns of time use simultaneously changed with seasonal shifts in localised mean productivity. A Pearson correlation coefficient test was utilised to analyse return rates and concurrent time use across seasonal variation for habitats and specific grounds to check for negative and positive correlations in the data. A positive correlation between overall time allocation and habitat seasonal productivity indicated that the most productive habitats received the most attention in a given season. Concurrently, a negative correlation between per-bout foraging time in fishing grounds within the habitat type and their seasonal mean productivity indicated an inverse relationship between time spent in a ground and its yields. A *t*-test was conducted on all data sets to check for statistical significance.

It should be noted that to uncover the behavioural patterns of Roviana and Vonavona fishers, data sets for each village were sorted in many different ways. For instance, data were sorted by 'special events' (e.g. fish aggregations) to explore the effects of sudden changes in patch productivity on indigenous selection of fishing grounds and subsequent uses of time. In assessing individual responses to changing productivities, several fishers were analysed to trace their monthly selection of fishing methods, habitats, and fishing grounds. Additionally, events that included income returns were sorted independently to see if a changing currency (i.e. kcal to cash unit) resulted in differences in time allocation.

Implications for the analysis of Pacific Island artisanal fishers

A question that remains to be answered is what does confirmation or refutation of optimal foraging theory hypotheses tell us about the foraging strategies of Pacific Island artisanal fishers? The first implication is a theoretical one. Confirmation of the foraging hypotheses suggests that fishers optimise their short-term self interests by harvesting resources as efficiently as possible. The models presented in this paper hypothesise that individuals chose habitat types and the foraging times allocated to them according to changes in habitat seasonal productivity. Such a strategy can result in the conservation or depletion of resources, depending on changing environmental conditions. Resource depletion may occur during periods of resource scarcity when fishers increase pressure on specific grounds (i.e. if there are no alternatives), whereas conservation may occur during periods of resource abundance when fishers' movement between fishing grounds, to increase short-term foraging efficiency, results in the abandonment of remaining prey. Foraging theory

shows that the consequences of human foraging behaviour are conditional and dynamic.

On the other hand, rejection of the foraging hypotheses can indicate inconsistencies with the models' assumptions (e.g. need for a new currency), or can show that fishers are indeed practising a resource management strategy. Fishers can mitigate resource scarcity by controlling their short-term intake rates (i.e. stop resource exploitation) to increase long-term sustainable harvests. In this scenario, fishers will actively restrain their efforts, whether aware or not, to reduce pressure from habitats and fishing grounds experiencing a perceived or absolute decline in productivity (Aswani, in press).⁴ Regardless of the results, the utilisation of foraging theory reveals foraging patterns that cannot be revealed by conventional qualitative ethnographic field methods alone.

A second implication is a methodological one. A major problem faced by some anthropologists in the field is the lack of an organised methodology and theoretical framework. In this respect, optimal foraging theory offers researchers a sound body of theory and a systematic set of field research methods. As foraging models focus on human daily actions, rather than exclusively on human beliefs and ideologies, they permit a detailed analysis of human foraging practices. Besides acquiring quantitative measures of time use and yields, the application of foraging models necessitate the investigation of indigenous foraging choices and the extrinsic environmental and social forces shaping them. This requires, among other data sets, the collection of indigenous ecological knowledge, the mapping of regional ecological characteristics, and the study of the local social-economy—data that can be useful for management purposes.

The final implication is a managerial one. Because foraging models are able to predict the types and abundance of fish that fishers prey on, the frequency of visits to marine habitat, and the changing intensification of fishing activities, they are useful in linking anthropological studies with coastal management plans. Foraging data together with local and western biological knowledge can be incorporated into management blueprints which mimic local seasonal resource exploitation patterns. For instance, during periods of declining exploitation, certain habitats could be temporarily closed. Access restrictions to habitats or grounds that are temporarily considered less desirable than other fishing grounds would likely be more acceptable to local fishers than closing prime areas

(Aswani, in press). Finally, data on the relative productivity of habitat types and specific fishing grounds, can assist fishery researchers in regional stock assessment.

Conclusion

For all its merits, optimal foraging theory is not a theoretical and methodological panacea, and much can be said about its shortcomings. However, a growing number of anthropological studies employing this approach are showing that it is robust enough to understand the foraging practice of subsistence and mixed economy societies. It is hoped that the integration of optimal foraging models to the study of Pacific Island artisanal fisheries will result in a clearer understanding of human foraging activities and their impact on the coastal ecosystem.

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4. An important distinction needs clarification. When fishers allocate less overall fishing time to habitats undergoing a seasonal decrease in yields, the behaviour suggests that they are either practicing a resource management strategy or an optimisation one. To distinguish the actual strategy, it is crucial to analyse time-use of fishers while foraging in specific grounds within the habitat experiencing a decrease in yields. An increase in per-bout time suggests a foraging strategy designed to maximise foraging efficiency (i.e. only if there are no alternative areas, or travel times elsewhere are too high), while a decrease in time suggests a strategy designed to manage resources. This is counterintuitive to the common notion that fishers decrease time during seasonal lows and increase per-bout foraging time during seasonal highs (Aswani, in press).

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Native title recognition of CMT and the implications for the GBRMPA and future management of marine areas

by Julie Lahn¹

Introduction

The Great Barrier Reef Marine Park (GBRMP) stretches along the Queensland coast of Australia. It has often been showcased both locally and internationally as the world's most successfully managed marine park. However, in its management of this park, the Great Barrier Reef Marine Park Authority (GBRMPA) has come under scrutiny by researchers and indigenous people alike. This paper presents an update on issues concerning indigenous rights, management strategies and GBRMPA.

Indigenous interests in the Great Barrier Reef Marine Park

The Great Barrier Reef Marine Park Authority has initiated research and workshops to examine Aboriginal and Torres Strait Islander interests in the marine park area. One workshop (Gray & Zann, 1985) concluded that traditional knowledge

and use of the marine environment could be a solid basis from which to build management strategies. Traditional knowledge is acknowledged as useful and the study suggested that further research and consultation should be carried out around Australia to 'take stock' of the information held by indigenous people and to listen to current concerns.

Other research funded by GBRMPA also stresses the importance of Aboriginal interests in marine areas (Smith, 1987). Ethnobiological research carried out by Andrew Smith (*ibid.*) in two Cape York communities, Lockhart River and Hopevale, documented Aboriginal interests in the Cairns and Far Northern Sections of the Marine Park. Smith carried out a comparative study of marine hunting and fishing practices of the Hopevale and Lockhart River communities and at the completion of his research, made suggestions for future directions GBRMPA should take with regard to Aboriginal and Torres Strait Islander peoples.

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