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Editor's note

Five contributions make up this edition of the *Traditional Marine Resource Management and Knowledge Information Bulletin*. I am happy that all these articles were unsolicited, and especially because four of them are by graduate students. I wish to encourage both of these trends!

In "A new synthesis in oceanic domestication: The symbiotic development of *loko i'a* aquaculture in pre-contact Oceania", Kekuewa Kikiloi, a graduate student in the Department of Anthropology at the University of Hawai'i at Mānoa, examines: 1) aquaculture as a dynamic food production system, and 2) the coevolutionary or symbiotic nature of marine procurement strategies in the oceanic world.

In "Canoes, subsistence and conservation in the Louisiade Archipelago of Papua New Guinea", Mark Smaalders and Jeff Kinch examine in detail the construction and use of traditional sailing canoes, together with the economic and social roles. The authors also discuss the replacement of canoes by motorised dinghies, and the potential implications this has for marine resource use and management.

In "The coexistence of whaling and whale watching in a traditional whaling region: The case of Taiji, Wakayama Prefecture, Japan", Shio Segi, a graduate student in the School of Policy Studies at Kwansei Gakuin University, examines efforts to develop a new industry in a declining rural region in western Japan. Mr Segi seeks to understand why a whale watching industry has not developed in traditional whaling communities in Japan, in an attempt to stimulate local economies devastated by the whaling ban. He examines the processes and factors regarding the coexistence of whale watching and whaling in the wider area of southern Wakayama Prefecture, and the application to other whaling communities.

Inside this issue

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We also have two articles on marine turtles by Regina Woodrom-Luna, who is also a graduate student in the Department of Anthropology at the University of Hawai‘i at Mānoa. In the first, “The merging of archaeological evidence and marine turtle ecology: A case study approach to the importance of including archaeological data in marine science”, she summarises the results of an initial examination of archaeological evidence on marine turtles from the Pacific Islands and looks specifically at prehistoric Pacific Islander use of and impact on marine turtle populations. In a second article, “Traditional food prohibitions (*tapu*) regarding marine turtles among Pacific Islanders”, Ms Woodrom-Luna examines traditional “laws”, many of which represent indigenous conservation measures that protected turtles.

Kenneth Ruddle

SPC *Traditional Marine Resource Management and Knowledge Information Bulletin* ON-LINE

Past issues of this bulletin, as well as many other publications from the SPC Coastal Fisheries Programme, are now available on SPC’s website at:

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Go to “Publications” to find the *Traditional* and other information bulletins, as well as other recent SPC Marine Resources Division publications

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

A new synthesis in oceanic domestication: The symbiotic development of *loko i'a* aquaculture in pre-contact Oceania

Kekuewa Kikiloi[1]

Introduction

Oceania comprises more than 30 per cent of the earth's surface, and is where some of the world's richest aquatic resources are found. The islands in this region provide an ideal setting for investigating questions of domestication as a biological process between fauna and humans. From an evolutionary framework, the operation of natural selection and evolution can be seen in many examples of cultural practices throughout Oceania. Within Oceania, a combination of food-production technologies and strategies of domestication arose owing to the limited amount of arable land and relatively impoverished terrestrial faunal resources.

In the research reported on here, I examine both aquaculture as a dynamic food production system and the coevolutionary or symbiotic nature of marine procurement strategies in the oceanic world. My objective in this research is to expand conventional views of domestication, by adopting a broader definition of this biological process and outlining the various components that comprise this relationship. During the development of this relationship, humans must acquire control and management of four different aspects of the production system: protection, growth, reproduction and harvesting. This requires a sophisticated understanding of species types and of coastal zone habitats, considering the amount of variation in oceanic ecosystems throughout the archipelagos in Oceania, and reflects the interrelationship these indigenous peoples had with biological species of the *'āina* (land) and the *kai* (sea). As this control increases, the relationship has the potential to become the equivalent to food production and domestication. Not all food production systems in Oceania necessarily controlled all four components, and various activities were done in relation to the marine environment.

Evolutionary Oceania

The study of complex historical interactions between human populations and the ecosystems they inhabited has been the focus of many recent archaeological studies. The historical ecological paradigm has come to dominate theories on human arrival in seemingly "pristine" island environments, relying heavily on the assumption that these natural island ecosystems were stable and unchanging before the advent of humans in the region. On entering previously unoccupied "pristine" island ecosystems, indigenous people initiated a series of changes that reshaped the physical landscape, drastically altered vegetation regimes, and transformed both the composition and distribution of island faunas. Environmental disturbances such as forest clearing and exploitation of wild food sources led to dramatic transformations of the *'āina* (Kirch 1983).

But in this article I focus on the surrounding *kai* associated with these islands, because the expansive seascape in remote Oceania comprises more than 65 per cent of the geographical area. The ocean itself has greater potential in addressing these issues because it is not restricted by size, form and diversity in resources. Thus the ocean provides a neutral testing ground for hypotheses that specify the relationship between humans and their environments.

The fundamental goal of evolutionary theory is to explain the common threads underlying life's diversity. Evolution seeks to explain the unity and diversity in life, and natural selection is the major "editing mechanism" that dictates this change. Natural selection occurs as heritable variations are exposed to environmental factors that favour the reproductive success of some individuals with certain variants over others. Each species develops its own set of adaptations, or features, that evolved by means of this selection process. This theme is the cornerstone of understanding life.

Coevolution is a type of evolution that involves two genetically unrelated species, and occurs whenever the interrelationship of the organisms positively effects the potential survival of each other. It recognises that even at the simplest

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level of inquiry, species coexist in the natural world. This coexistence allows for a richness of species types co-occurring in an area at a particular point in time. In biology, species represent the most basic phylogenetic unit in evolutionary understanding and under natural conditions all organisms are enmeshed in one way or another in a web of relationships with a variety of organisms. In evolutionary studies, species is the unit preferred over higher units such as genera, family, or order. The species level of analysis permits a detailed understanding of the relationship between organisms, thus leading to a better understanding of the principles that govern that interaction.

The approach advocated here adopts a similar framework that views human interaction with the environment as the outgrowth of evolutionary potentials that may develop whenever an animal species feeds consistently on a set of individuals from another species. In evolutionary theory domestication has been defined as a natural process by which animal and plant species are able to increase their fitness. In its basic definition, domestication represents a symbiosis between humans and plant species (Rindos 1980:212). Likewise, in Oceania, traditional aquaculture can be conceptualised similarly as an evolutionary process that incorporates the domestication of aquatic plants and animals to produce a system that increases the carrying capacity of the environment for the aquatic plants and animals selected, and which in turn can support humans (adapted from Rindos 1980).

In the research reported here, I demonstrate how through fishing methods and technological strategies, populations in Oceania were able to develop coevolutionary relationships with selected fish species based on a very sophisticated and multilayered understanding of ecological processes in the natural world. Also, through proper management practices, people were able to maintain the biological integrity of fish stocks for generations, and the biodiversity of each marine region. Within the fundamental biological concept of unity and diversity, it can be seen that people from many of the major archipelagos in Oceania had different methodologies and strategies for fish-related domestication, but all have in common the basic principles of mutualism and coexistence.

Biological advantages of water as a culturing medium

It is important to note that the ocean provides several advantages over land and terrestrial food production.

First, the ocean is relatively uniform and provides a stable supply of marine resources. As a consequence, migrating indigenous peoples of these regions found the sea to be one of the most reliable of all long-term food sources.

Second, in physical terms water bodies are three-dimensional growing spaces. Water occupies the major portion of space in the Pacific Island region compared with land.

Third, the body density of fish and swimming crustaceans is nearly the same as that of the water they inhabit. This means that since they do not have to support their own weight, compared with terrestrial animals they can devote more food energy to growth. Further, because fish are cold-blooded they do not need to divert energy for thermoregulation.

Finally, arable land and terrestrial resources decline from west to east in Oceania. This has led to a dependency on aquatic resources as reliable food sources. In turn, this relationship has led to a system of conservation directed toward the preservation of marine and natural resources, and has regulated the use of inshore and offshore fishing.

Elaboration of fishing strategies and relationships

Aquaculture is a dynamic food production system and the aquacultural ecology of any region is the product of numerous factors interacting over long periods of time. As we begin to understand the functioning and evolution of aquacultural ecology, control is likely to increase as coevolutionary relations intensify. These relations have the potential to become the equivalent to food production and domestication, but this does not always occur. This happens because in some cases during the development of this relationship, only some parts of the aquacultural ecology are completely under human control, while some forms may show relatively little coevolutionary linkage.

For those relations to intensify, humans must acquire control and management over four different components of the production system:

- protection of the selected species from predators;
- control of the reproduction of the selected species;
- regulation of the growth of the organisms; and
- control of the harvesting process.

Not all food production systems necessarily controlled all four components, however, and there was a variety of human activities within each that could be done in relation to the marine environment. These activities with respect to fish species will be identified.

Aquacultural domestication has its origins in fishing, as it was later developed into an integrated system of production. The historically documented fishing strategies of Pacific Islanders exhibited an intimate knowledge of fish, their characteristics, habits and domains. The broadening of the Oceanic subsistence base ultimately led to greater variation in food procuring techniques. Studying these strategies as outcomes of selection first requires an understanding of the biological organisation and distribution of communities in the marine ecosystem.

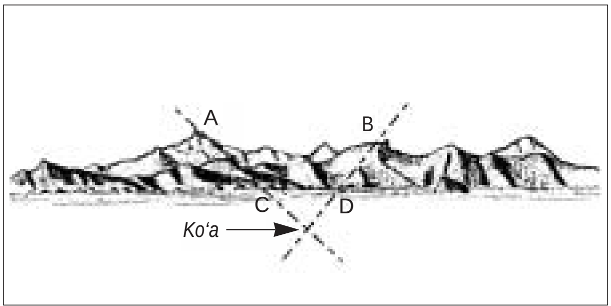

Figure 1. **Offshore fishing grounds (*ko'a* or *toka*).**
An example of the demarcation of the fishing grounds through alignments of shrines (C and D), or other permanent landmarks, both onshore and on ridges (A and B). (*Adapted from Best 1939*)

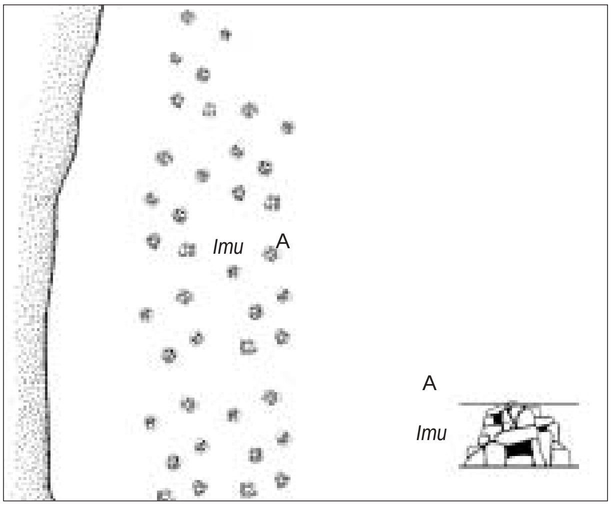

Figure 2. **Fish shelters (*imu* or *umu*)**
Fish shelters are artificially constructed reef along inshore or lagoon areas that would normally lack natural reefs. These piles of rock (A) or coral serve as habitat for numerous fish species, and seek to increase biodiversity in barren areas. (*Adapted from Hunter-Anderson 1981*)

The marine ecosystem is divided into three major zones: 1) the pelagic, or offshore zone; 2) the benthic, or subsurface habitat area; and 3) the inshore and coral reef zone. My objective here is to determine how human activities in these different zones display aspects of food production through coevolution, or symbiosis.

Ko'a, or fishing grounds, and offshore harvesting

In the pelagic zone, fishing grounds were important areas where a variety of fish species congregated. These fishing grounds were termed *ko'a* (in Hawaiian) or *toka* (in Maori, Best 1939:4–5) and were located in areas with depressions in the ocean floor or those with rocky prominences extending upward from the ocean floor. Those grounds where pelagic species were consistently found were identified by the intersection of lines extending out from two prominent terrestrial landmarks. In Hawai'i these two bearings were made with stone shrines, also known as *ko'a*, on the shores, mountain ridges, or other topographical features (Malo 1951). By aligning oneself between these markers, the fishing ground was found (Fig. 1). Some of the fish species found in these areas were barracudas (*Sphyraena* sp.; *kākū*), suckfish (*Remora remora; ono*), marlins (Istiophoridae; *pelu*, *a'u*), common dolphinfish (*Coryphena hippurus; mahimahi*), yellowfin tuna (*Thunnus albacares; 'ahi*) and flying fish (*Cypselurus simus; mālolo*). Often, fishers could spot fishing grounds by watching from the shore, noting schools of these fish going in a certain direction before disappearing. The preservation of the *ko'a* was vital for sustainable resource management, and fish were often fed edible excess waste food such as sweet potato, (*Ipomea batatas, 'uala)*, so that fish growth could be monitored. Assisting fish growth and monitoring fish populations ensured that the resources would not be reduced below a critical level and provided a very reliable and quick means of procurement. These fishing grounds often served as indicators of the biological health of the surrounding pelagic zone. If the ground was mismanaged and overfished, it would, in turn, affect the entire area, as it would take time for other fish to establish themselves in the habitat and replenish the resource.

Fish shelters as inshore protection

In certain areas of Polynesia such as Hawai'i, and in places in Micronesia, fish shelters, called *umu* or *imu*, were common features along shorelines that helped provide protection and regulated the growth and reproduction of inshore fish species (Fig. 2). These fish shelters were artificial reefs made of rock or coral piles with enough space between the rubble to allow for algal growth on the surfaces (Kikuchi 1973:78). These stones functioned in the same way that naturally occurring rock outcroppings and coral reef habitats do, by providing a hard substrate necessary for the basic formation of reef bottom communities. Besides providing stability and some protection from predators, these shelters also helped to regulate fish growth and potentially increase fish stocks by serving as artificial homes for fish to congregate and reproduce. Some of the prominent fish species that inhabited these shelters were squirrelfish (*Myripristis* spp.; *u'u*), unicornfish (*Naso unicornis; kala*), surgeonfish (*Acanthurus triostegus; manini*), goatfish (*Parupeneus multifasciatus; moano*), greater amberjack (*Seriola dumerili; kāhala*), parrotfish (*Scarus* spp.; *uhu*), and eels (Muraenidae; *puhi*). These types of fish shelters are also found in Yap, where there are fields of mound constructions called *ulug* that work in a similar way to *umu* (Hunter-Anderson 1981:86). It was the simplest of all aquacultural features, and its location was determined by a lack of naturally occurring coral and rock shelters.

In Samoa, these heaps of stone were called *taufatu*, and were similarly collected and piled in areas lacking reefs, and in areas that had reefs to attract fish. Once fish settled the habitat, Samoans would surround the pile with a net and take the stones away one-by-one. The fish were trapped as they gradually escaped the *taufatu*. This process of culling fish was relatively easy and required a relatively low investment of energy for food production.

Fish traps in inshore tides and currents

Methods of trapping fish were common throughout the Pacific as were strategies that regulated and controlled the harvesting component of food production. Trapping is very effective for catching large numbers of fish in the inshore zone. On a small scale, basket traps and net traps of various sizes and shapes have been important in capturing fish (Reinman 1967). This controlled method of harvesting eventually developed into large structural traps made of basalt and coral in the inshore area throughout Oceania. The more common type of trap was the *pā*. The *pā* was constructed in the inshore area or found in channels between the reefs or islets and is still common throughout the Cook Islands, Tuamotus, Society Islands, Mangareva, Samoa, and the Hawaiian Islands. A *pā* can range in shape from a simple V-shaped enclosure to a very complicated labyrinth, with a number of enclosures in a single trap. It functioned with the tides. The walls of these traps became wholly submerged at high tide (Reinman 1967:125; Hunter-Anderson 1981; Stokes 1909), allowing fish to swim freely into the structures, yet trapping them within the enclosure when the tide dropped. In other parts of Oceania, *pā* traps are found on both sea and lagoon reefs, or between islets in a single atoll (Reinman 1967:128). One of the commonest forms resembles a large stone arrow with the point facing the sea or lagoon. These types of traps are also common in the Marianas, Palau, Yap, Lukunor and Nanoluk, Ifaluk, Ponapae, the Gilberts, and Kapingamarangi. Some of the principal species of fish that were found in the *pa* were wrasse (*Thalassoma ballieui; hīnalea*), surgeonfish (Acanthuridae; *manini*, *pūalu*), and the daisy parrotfish (*Chlorurus sordidus; uhu*). Driving was the method used to frighten fish into nets, and was done by slapping the water and frightening the fish into weirs or capturing them with a net.

Perhaps one of the most interesting developments in this fish trapping method is the construction of what Hawaiians called a *loko 'umeiki*. These fish traps were much larger, and were constructed by building a wall in an arc from two points from the shoreline, providing protection from predators. Although many of these traps superficially resembled shoreline ponds with low semi-circular walls, their distinguishing characteristic was a series of breaks with lanes that led into and out of the pond area (Fig. 3). These open lanes were oriented to the longshore currents, taking advantage of the natural tides and flow of the ocean. The lanes connecting the traps with the ocean were used to catch fish migrating down the coastline. These fish were attracted to the surge of water at the lane entrances, and the possibility of finding herbivorous-stocked ponds. Fishers simply laid a net facing the sea across the opening of the lane to capture fish on the incoming tide. When the tide reversed, fishers faced their nets toward the traps capturing fish as they swam out toward the sea. The principal fish species found in these traps were usually highly mobile fish that travelled in schools, such as bonefish (*Albula vulpes; 'ō'io*), yellow surgeonfish (*Acanthurus xanthopterus; pūalu*), goatfish (*Mulloidichthys* spp. and *Pseudopeneus* spp.; *weke*), parrotfish (*Scarus* spp.; *uhu*), round herring (*Etrumeus teres; makiawa*), bigeye scad (*Selar crumenophthalmus; akule*), mackerel scad (*Decapterus macarellus; 'opelu*), skipjack (*Katsuwonus pelamis; aku and Euthynnus affinis; kawakawa*), and sharks.

Aquacultural *loko i'a* production systems

The general Hawaiian term for these aquacultural ponds is *loko*, or *loko i'a*, derived from the proto-Polynesian word *roko*, meaning pond or lake (with *i'a* or *ika*, meaning fish). Aquaculture technology

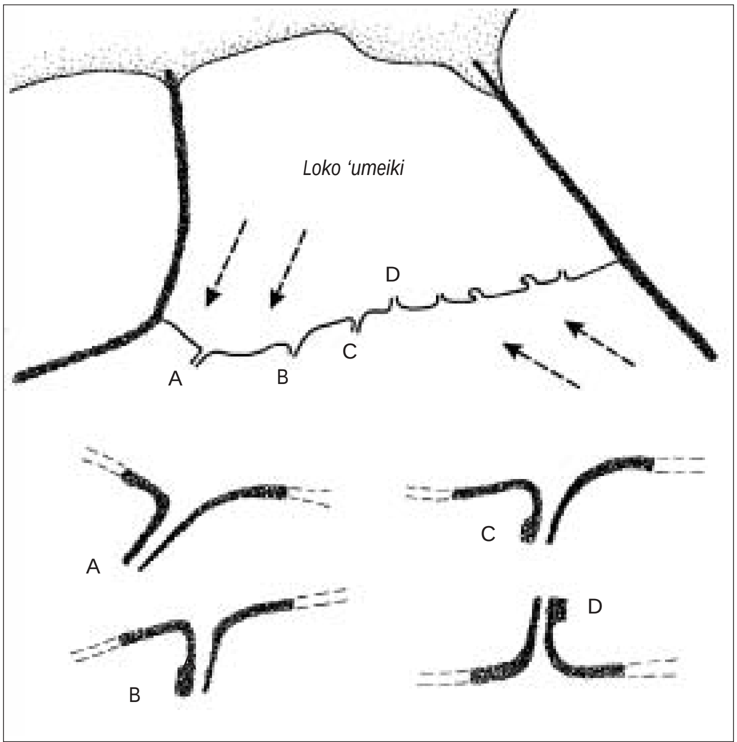

Figure 3. **Fish traps (*loko ʻumeiki*)**

Fish traps use the currents and tides to capture fish. The fish trap, *Paʻiliʻili*, shown here is wedged between two fishponds. Details of three outer canals (A, B, C), and one inlet canal (D) are shown. Note the large wall sections on canals B, C and D. These were features used to accommodate fishermen, as nets were used to capture fish migrating along the shoreline. (*Adapted from Stokes 1909 and Costa-Pierce 1987*)

was an innovation that developed in few places in Oceania, with the most intricate systems established in the Hawaiian Islands. Four basic types of fishponds were used in pre-contact Hawaiʻi. These were not regarded as a single entity, but as one link in a continuum of food production technologies (Kikuchi 1976). Aquacultural ponds were part of a continuous system that spanned the inland ponds to the sea and created a series of environments, each of which was structurally homogenous and temporally stable. The various fishponds ranged from four types within the *ahupuaʻa* (traditional land tenure system):

- *loko iʻa kalo*, or freshwater taro fishponds,
- *loko wai*, or freshwater ponds,
- *loko puʻuone*, or brackish water ponds, and
- *loko kuapā*, or ocean fishponds (Costa-Pierce 1987:325).

Humans were able to control these environments through a number of activities that managed reproduction of the species, their growth, and the harvesting process. This coevolutionary relationship allowed Hawaiians to provide an artificial selective advantage of certain fish species over others, by excluding predators and competing aquatic fauna in these environments. In turn, humans were able to procure a highly reliable food production source within a system that utilised a variety of strategies and management skills. For the purposes of this article however, I will focus only on the *loko kuapā*, or ocean fishponds.

In this process of domestication two species of herbivorous fish were targeted for obligatory coevolutionary relations in the Hawaiian Islands, flathead mullet (*Mugil cephalus; ʻamaʻama*) and milkfish (*Chanos chanos; awa*). Both are diadromous species, meaning they can migrate between fresh and salt water in a catadromous life cycle. This unique ability is a key aspect to their biological reproductive cycle, which requires them to go from freshwater and brackish-water habitats to the sea to spawn. After they hatch and mature they return upstream to the fresh and brackish-water areas. This ability to live within a fresh to salt-water continuum allowed for a specialised type of domestication that used a harvesting process that followed a schedule of seasons and the reproductive cycles of the selected fish species. Besides mullet and milkfish, a number of secondary domesticates were capable of establishing themselves, such as weeds, in the aquaculture in all phases of salinity. Although not targeted for domestication, they were able to adapt to such systems and provided humans with a secondary source of protein. These secondary domesticates evolved with the same selective pressures as the primary domesticates, as they both evolved in the same environment. They were able to enter the aquacultural system the same way mullet and milkfish did, and had similar feeding habits. The core group of species that made up this secondary domesticate assemblage included gobies (Eleotridae and Gobiidae; *ʻoʻopu*), Hawaiian flagtail (*Kuhlia sandvicensis*; *āholehole*), goatfish (Mullidae; *weke*), and ladyfish (*Elops hawaiensis*; *awaʻaua*).

An aquaculture example: walled seaponds

Seaponds (*loko kuapā*) represent the culmination of evolutionary potentials between humans and fish species. There were highly valuable for subsistence food production as well as for the political economy. These seawater ponds were characteristically built either by closing off the mouth of small bays or extending outward in an arch between two points along the shore. The walls were constructed with consideration for the flow of the ocean current along the reef and at times produced a linked effect along substantial distances of shoreline (Fig. 4). The main isolating feature of these ponds were seawalls (*kuapā*), constructed of coral and basalt rock. Most ponds were designed to have depths of only 0.6–1.0 m, so that light could penetrate the water and provide energy for the growth of algae for fish to feed on (Kelly 1989:3). Many times, the seaward face of the wall would slope outwards, whereas the inner face was more vertical, enabling the pond to efficiently withstand and absorb wave energy (Kikuchi 1973:54).

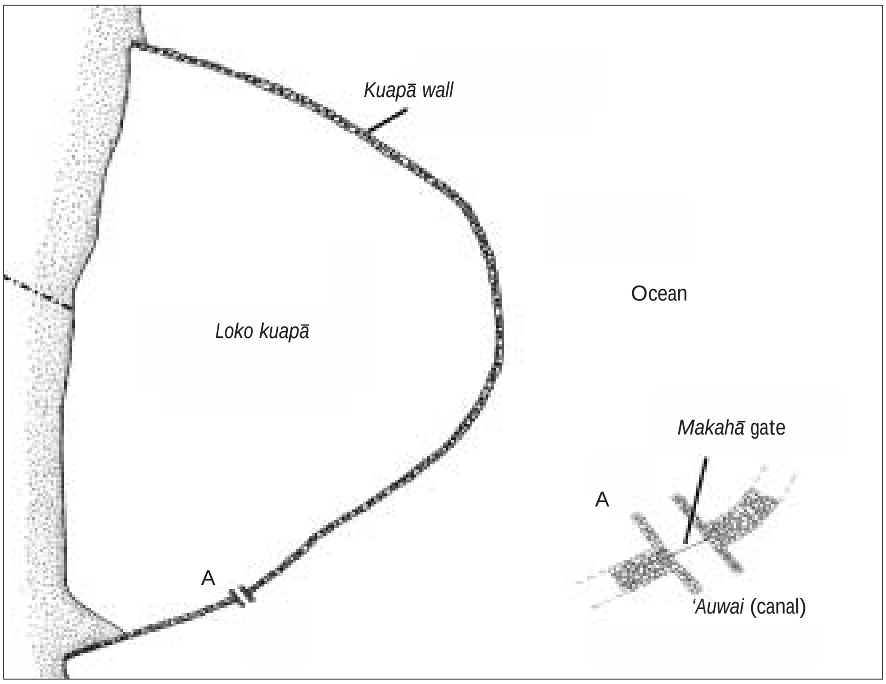

Figure 4.

Loko kuapā were ponds built along the shoreline usually on top of a reef flat with basalt rock and / or coral to form the *kuapā* wall. Controlled harvests were accomplished by using the canal ditch, a net, and gate system (*adapted from Kikuchi 1976; Summers 1964; and Costa-Pierce 1987*). The *makahā* (A), or sluice gate was permanently fixed in the *'auwai*, or canal connecting the pond to the open ocean.

Canals or *'auwai* were constructed into the walls of the ponds to stock, harvest, and clean the ponds with minimal effort. The canals connected the ponds directly to the sea and had a single fixed grate, called the *makahā*, made of dense native woods. This open gate allowed for the incoming tide to periodically flush the enclosed pond, and allowed very small fish to pass freely in and out of the pond, thereby creating a stock supply. Herbivorous fingerlings entered the pond through narrow openings in the sluice gates and fed on the algae within the walls of the pond. The openings in the sluice gate also allowed clean seawater with its nutrients and diluted oxygen into the pond. The ponds protected herbivorous fish from carnivorous predators outside the walls, and provided them with sustenance from the microbiota and algae that grew in its estuaries. There are seventy distinct algae species edible to both humans and herbivorous fish in Hawaiian waters. Propagation of selected algae in brackish and saltwater areas was accomplished by finding epiphytic algae attached to rocks and pebbles (Tilden 1905:142). These were collected and transported to the fishponds (Titcomb 1952:77). The reproduction of the selected algae species was facilitated by manually dispersing spores into the water column.

It is important to point out that the selected algae would not proliferate in the pond without the assistance of humans for propagation, cultivation and maintenance. As the fingerlings fed on the microbiota and diatoms, they grew in size and became too large to escape through the same narrow sluice gate openings they had used to enter the pond.

Secondary and tertiary walls were constructed within the pond to compartmentalise it into more workable, segregated areas, and to protect fingerlings in areas that were too shallow for smaller predatory fish (Kikuchi 1976:57). Fish harvesting was timed and scheduled on the reproductive cycles of the selected fish. During certain times, milkfish and mullet returned from their fresh and brackish-water habitats to spawn in coastal seawater. The *makahā* closed off the migratory return route of the fish and created a relatively easy process, increasing dramatically the success of harvesting (Costa-Pierce 1987:327). Proper management called for periodic cleaning of the pond by

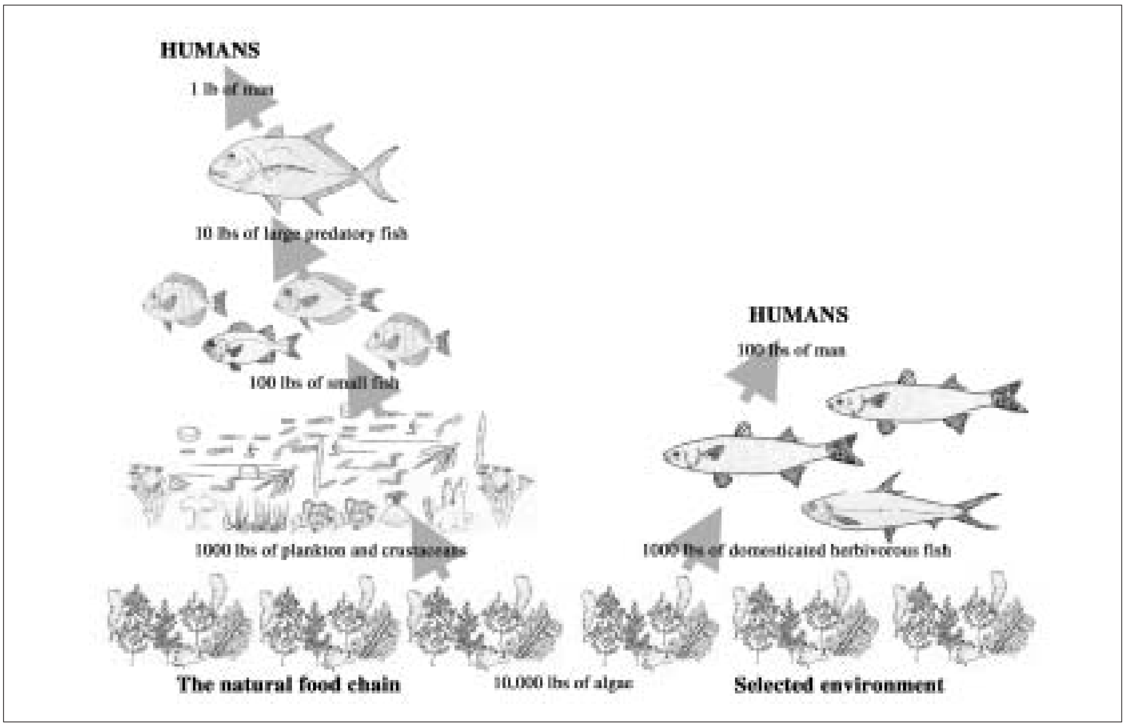

Figure 5. The selective development of the herbivore link in comparison to the natural food chain.
To the left is an illustration of the natural food chain with an energy conversion ratio of 10:1 from one link to another. To the right is an illustration of how the aquacultural ecology was a hundred times more efficient because of: (1) cultivating selected algae species, (2) domesticating herbivorous fish species, and (3) effectively reducing the number of predator species in the habitat.
(*Adapted from Hiatt 1947; Kelly 1989*)

breaking up the existing biota layer of algae to encourage new growth of benthic microbiota. This process of cleaning was accomplished by opening the sluice gate and flushing the system with the incoming tide. In some cases ponds became filled with silt after heavy rains. This silt could potentially harm algal growth, so weighted bamboo rakes, called *kope ʻohe*, were towed behind outrigger canoes to help facilitate movement of the accumulated sediment out of the ponds. This innovation of the *makahā*, or sluice gate, was very important because it allowed new seawater to enter the pond, bringing in fresh oxygen and nutrient flow of microplankton, and plankton in which other non-competing secondary domesticates feed (Hiatt 1947). The incoming water also brought opportunities to trap or catch larger predatory fish that flock into the sluices looking for prey. This was done simply by harvesting the larger fish in the sluice with small hand nets.

At least 22 species of edible marine life flourished in these ponds as secondary domesticates (Costa-Pierce 1987:326). In addition to the selected mullet and milkfish, and core assemblage of secondary species that could transverse with them through the different environments, there was a wide range of other inshore species that occupied this habitat. Some of these were threadfish (*Polydactylus sexfilis*; *moi*), anchovy (*Encrasicholina purpurea; nehu*), bonefish (*Albula vulpes; ʻōʻio*), big-eye scad (*Selar crumenophthalmus*; *akule*), Hawaiian ladyfish (*Elops hawaiensis*; *awaʻaua*), jacks (Carangidae; *pāpio* and *ulua*), as well as the crab (*Metopograpsus messor; ʻalamihi*), numerous reef fish and invertebrates.

Aquacultural protein yields

One of the most innovative aspects of the aquacultural food production system was its ability to use the herbivore link in the biological food chain. Whereas the average yield theoretically increased over time because of the elaboration of coevolutionary relations, the absolute yield at any given moment was a function of specific environmental conditions. A natural food chain can be expected to produce a ratio of 10:1 in terms of conversion of one link to another (MacGinitie 1935). The cultivation and domestication of herbivorous fish species makes it possible to skip two steps in the natural order of the food chain. Herbivorous fish directly feed on the minute algae, organic detritus and diatoms growing on the larger algae on the bottom of the pond (Fig. 5). Thus, the natural food chain efficiency and protein yield was enhanced and multiplied a hundred-fold (Hiatt 1947; Kelly 1989) as the grey mullet and milkfish acted as bottom feeders and were directly harvested by their only predator, humans.

Discussion

Domestication is a biological process between animals and humans that developed through reciprocating relationships between humans and their environment. By adopting an evolutionary framework we are able to have a better understanding of the components that make up this domestication process. By looking at the different strategies that target reproduction, protection, growth and harvesting, it is clear that the symbiotic nature of this relationship is employed in many cultural practices throughout Oceania. Without breaking down the components that make up this process, many of these cultural practices and marine procurement strategies would continue to be overlooked, as they would not fit traditional view of what constitutes "domestication".

In Oceania, the marine environment has always been a reliable food source and hopefully this study has shown how it can be a neutral testing ground for questions of human interaction with the environment. The goal is to understand the basic principles that governed the relationship humans had with other species and with the environment as a whole. The larger purpose of this research is to serve as a foundation for future dialogue and discussion of the subject in oceanic research.

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Canoes, subsistence and conservation in the Louisiade Archipelago of Papua New Guinea

Mark Smaalders[1] *and Jeff Kinch*[2]

"Voyaging by sailing and paddling canoes for subsistence, ritual, trade and pleasure remains central to the lives of most Louisiade peoples." Lepowsky 1995:52–53

Introduction

The Louisiade Archipelago is a group of volcanic and coral islands located in the southeast of Milne Bay Province, Papua New Guinea (Fig.1). Many islands are small (less than 10 km^2), and their inhabitants have traditionally relied on subsistence fishing and agriculture for food security. Incomes are very low, with average annual household income estimated at approximately USD 130. Cash is sought after (Kinch 2001), and is needed to pay school fees, buy foodstuffs, and pay for health care, and is also beginning to be used to meet traditional obligations. Sources of cash income vary, but in recent years beche-de-mer has become a primary income source for inhabitants of some of the smallest and most marine-dependant islands (Kinch 2001; 2002a).

Residents in the more remote islands of the archipelago (in particular the islands in Deboyne Lagoon and the Calvados Chain) rely heavily at present on sailing canoes (*sailau* in the local Misima language) as a basic means of transport (Fig. 2). Sailing canoes are used to move between islands[3], to transport goods and cargo, to access fishing grounds, and when engaging in trading, mortuary obligations and exchange[4]. The planked canoes vary in length from 4–12 m and carry a single outrigger. The larger canoes are substantial,

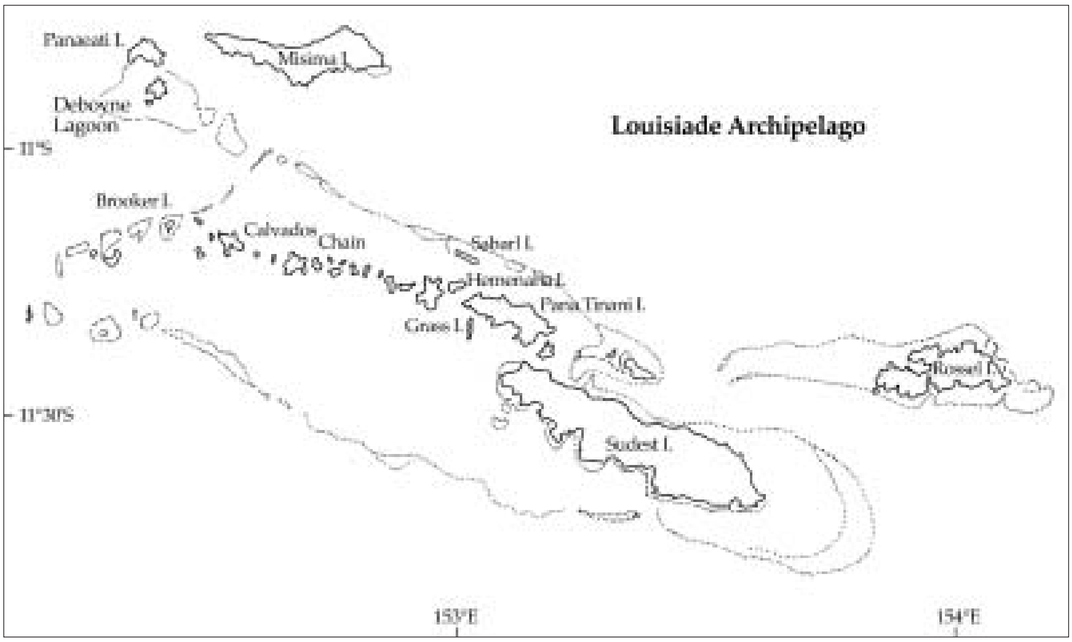

Figure 1. **Louisiade Archipelago. (*M. Smaalders*)**

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2. Jeff Kinch, Conservation International, PO Box 804, Alotau, Milne Bay Province, Papua New Guinea. Email: j.kinch@conservation.org
3. Owing to land and/or water shortages, some inhabitants of the small islands in the Calvados chain are forced to live on one island and garden on another; transport between garden and home is typically by sailing canoe. The most extreme example may be Sabarl (or Sabara) Island, which has virtually neither topsoil nor freshwater (Battaglia 1983); islanders maintain gardens on Hemenaha (3 km away) or Pana Tinani islands (some 6 km distant).
4. Both ceremonial and subsistence goods are commonly exchanged. A survey conducted in 1999–2000 in the western portion of Milne Bay found that 65% of households had gone trading in the preceding six months (Kinch 2001).

seaworthy craft, able to carry five or more crew plus freight, and are capable of long-distance voyages when handled by experienced sailors.

Although many islanders are able sailors, fewer are skilled canoe builders. Most islanders obtain their canoes from expert canoe builders through complex social exchanges, with the larger canoes in particular representing significant investments. Cash as well as subsistence and ceremonial goods are typically involved in an exchange.

Growing populations, reduced government expenditures and expanding individual expectations are increasing the pressure on islanders to accumulate cash. At the same time, market prices for selected marine resources (such as beche-de-mer) are rising; and as a result, islanders are increasingly turning to them to earn cash. Stocks of some beche-de-mer species and other marine invertebrates are becoming locally scarce (Kinch 2001). Local exporting companies have begun offering credit schemes to islanders to purchase motorised dinghies. These allow islanders to venture farther afield in search of high value resources, to make more frequent harvesting trips (including when winds are absent or very light), and to harvest in previously inaccessible areas (such as those with particularly swift currents). As a consequence, over the last two to three years there has been a rapid increase in the purchase of dinghies. The outcomes of this ongoing technological change are as yet uncertain, but if dinghies replace sailing canoes as the primary means of transport, results are likely to include an erosion of traditional knowledge relating to canoe building and sailing, significant social and cultural changes, and an increase in harvesting pressure on commercial marine resources.

Figure 2. ***Sailaus*** **in Deboyne Lagoon. (*M. Smaalders 1997*)**

Figure 3. Canoe builder and Normanby-based buyer. (*M. Smaalders 1997*)

Canoe design and construction

Most canoes built in the islands are constructed on Panaeati Island (within Deboyne Lagoon), a regional canoe building centre for at least 100 years (see Haddon and Hornell 1975). Gawa Island serves the same function in northern Milne Bay (Hide et al. 1994). Some canoes are built for use by Panaeati residents, but many are destined for other islands (primarily the small islands of the Calvados Chain and neighbouring Vanatinai, or Sudest Island). Canoe builders on Panaeati indicated that canoes were also traded with residents of Normanby (Duau) and adjacent islands

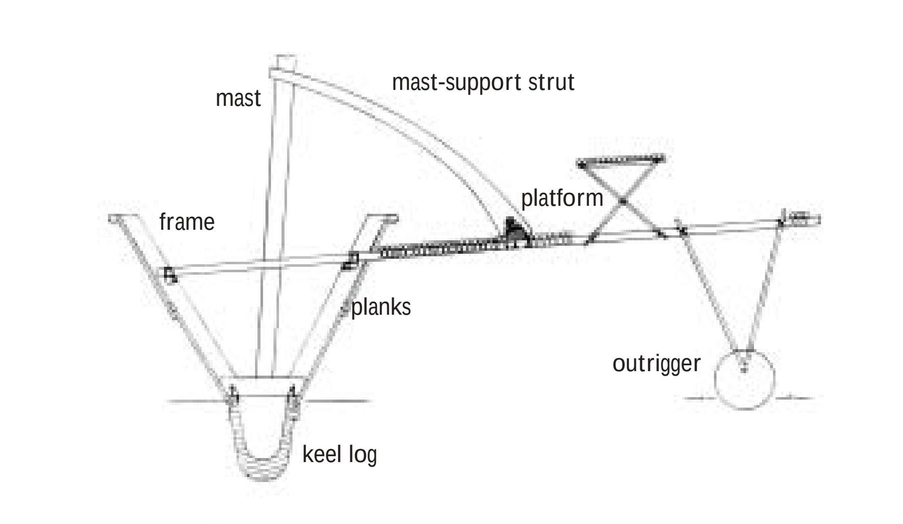

Figure 4. **Canoe cross section. (*M. Smaalders*)**

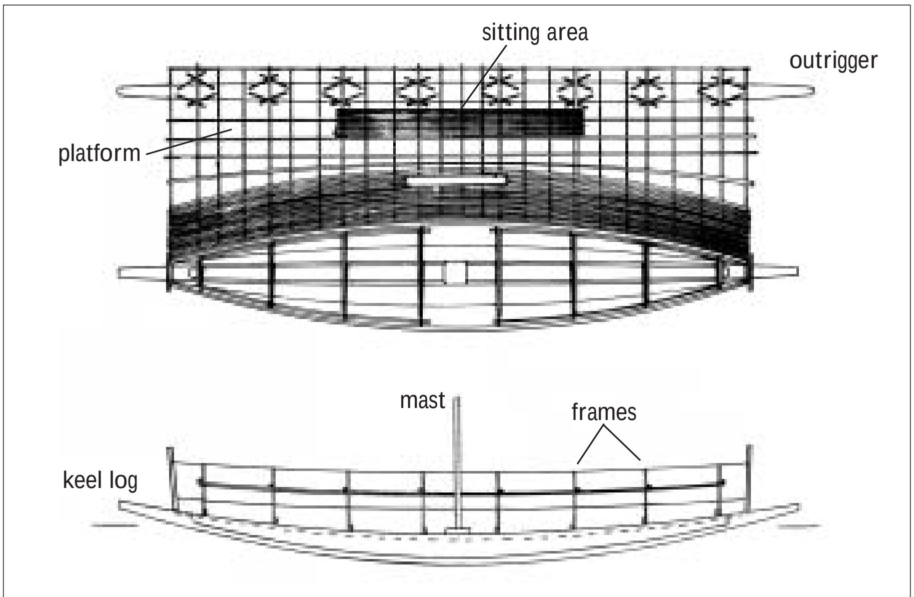

Figure 5. **Canoe plan and profile. (*M. Smaalders*)**

(Fig. 3). In 1997 there were some 20 expert canoe builders on Panaeati (Weda Gaunedi, Panaeati canoe builder, 1997, pers. comm.).

Louisiade Archipelago sailing canoes are all of a similar design, with a single, planked deep-V hull balanced by an outrigger (Figs. 4 and 5). They are rigged and sailed as proas, which reverse ends (bow becomes stern) when changing direction (called shunting rather than tacking). The outrigger is always kept to windward.

Canoes are typically measured by outstretched arm-length, with a "five-arm" canoe approximately 9-m long[5]. The width of the main hull on a 7-m canoe is about 1.2 m. The overall width of such a canoe is approximately 3 m.

The wood used for canoe construction on Panaeati is *Calophyllum inophyllum*, known in the Misima language (spoken on Panaeati) as *malauwi*. *C. inophyllum* grows in the interior of the island, and on Panaeati it is used exclusively for canoe building

5. The sailing canoes in use in the archipelago are classed by size as follows: *sailau dory* (length 5.3 m–6.4 m, hull width 0.85 m–1.0 m, overall beam 2.15 m–2.65 m); *sailau* (length 7.0 m–8.4 m, hull width 1.05 m–1.35 m, overall beam 2.7 m–3.35 m); and *sailau bwabwatana* (length 8.9 m–10.2 m, hull width 1.25 m–1.4 m, overall width 3.3 m–3. 6 m).

Canoes are typically constructed from two *malauwi* trees: one with a curved stem forms the main hull's keel log while a straight tree is selected to furnish the planks that are fastened atop the keel. The keel log portion of the canoe is a true dugout, being carved from one tree and hollowed inside (Fig. 6). In profile, the keel log is carved into a graceful, tapering arc. Frames are fashioned from *malauwi* (shaped in a modified V) and positioned atop the keel log. Once frames are shaped, holes are drilled in the lower legs, with corresponding holes in the inside of the keel log. Vine or, more typically, small diameter synthetic line is used to lash the frames to the keel log. An 8-m canoe would typically have eight frames (Fig. 7).

Four planks are cut from the second log (on larger canoes these may be 60 cm wide and 10.5 m long); they are tapered in thickness from about 32 mm in the centre to 12 mm at the ends (Figs. 8 and 9). Traditionally, planks are lashed to both frames and keel, but today most builders use copper nails in conjunction with the lashings.

Light, round beams about 35 mm in diameter join the hull and outrigger, with one beam adjacent to each frame. These are lashed to round longitudinal stringers fitted inside the hull. The outrigger, fashioned from a single debarked breadfruit log, is joined to the outboard end of the beams by crossed sticks inserted into holes in the outrigger and lashed to the beams. Slender sticks (of *aipapakena*) are lashed atop the beams to form a platform between the hull and outrigger. The final result is a strong but flexible construction that places no loads on the hull planks.

The canoes are rigged with a dipping-lug sail, using bamboo for the boom and yard (Fig. 10). The sails are made from a variety of materials: plastic sheeting, tarps and old Dacron yacht sails (obtained through exchange with visiting yachts) are all common (pers. obs.). The dipping-lug rig was apparently inspired by Australian pearl lug-

Figure 6. **Hollowed-out keel log.** **(*M. Smaalders 1997*)**

Figure 7. **Keel log with frames attached, and first plank being fitted. (*M. Smaalders 1997*)**

Figure 8. **Initial work on planks is done in the bush with an adze.** **(*M. Smaalders 1997*)**

Figure 9. **Final smoothing of hull planks with hand planes. (*M. Smaalders 1997*)**

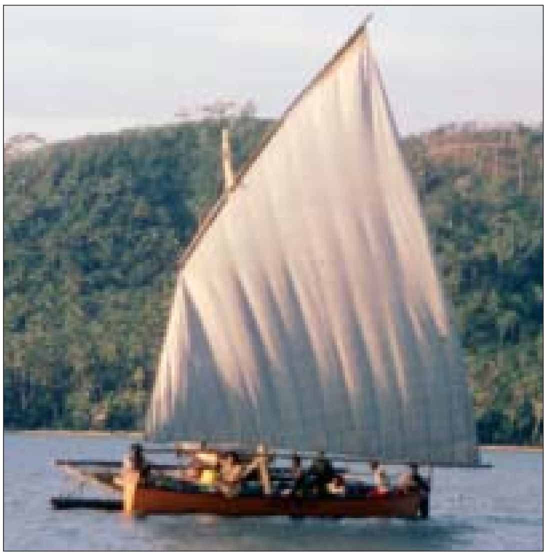

Figure 10. **All Louisiade canoes are fitted with dipping-lug rigs. (*M. Smaalders 1997*)**

gers[6]. The mast, shaped from a small tree, is canted toward the outrigger (i.e. to windward), with four shrouds led to the far edge of the platform. A curved strut, forked at both ends, is inserted between the mast and a sturdy longitudinal beam atop the platform. Wooden blocks can be inserted to adjust the mast: light winds call for the mast to be nearly upright, whereas in stronger winds the mast is angled increasingly into the wind. Increasing the rake has the effect of reducing the projected sail area, and generates lift in strong winds.

The helmsman sits on the platform at the stern of the canoe, with one foot on the end of the keel log, the top of which is flattened. A large paddle is used for steering; raising and lowering the paddle alters the course relative to the wind. To make small course adjustments the paddle is twisted, which brings the trailing edge away from the keel log. Under sail the canoes are well balanced and generally easily handled[7].

Trade and exchange in canoe building

The process of constructing a canoe is typically lengthy, in part to allow the logs and planks to slowly dry, but also as a result of the complex system of trade and exchange that operates in the islands. Work on a canoe often comes to a halt once the keel log and planks have been moved from the bush; many planks and keel logs can be seen stored beneath houses on Panaeati. The delay before construction recommences may last for months or even years. Builders constructing a canoe for their own use may lack either time or resources to proceed with construction, whereas those who have contracted with a builder may need to accumulate cash, trade goods or ceremonial valuables[8].

When builders trade canoes with other islanders the exchange often involves ceremonial valuables (e.g. shell-disk necklaces and greenstone axe blades), in addition to practical goods (plates and clay pots) and food items such as pigs, yams and sago (Lepowsky 1983; Kinch 2001). The terms of

6. A Panaeati canoe builder indicated that the *sailau* rig was copied from Australian pearl luggers, which were active in the Milne Bay area as late as the 1950s (Weda Gaunedi 1997, pers. comm.). Berde (1983) indicates a Brooker islander developed the sailau design while labouring in Queensland sugar fields early in the last century; it is likely that he would have likely seen pearl luggers and other similarly rigged coastal craft in use; the design spread from Brooker to Panaeati in the 1930s.
7. Small canoes are easily steered once the principles are understood; larger canoes require significantly more skill to handle, especially in rough weather.
8. Typically, very little cash is expended to obtain the materials for the canoe. Local residents pay five kina (about USD 1.30) to the local community for each tree felled, and a few kina are spent on a handful of copper nails. In addition, materials for the lugsail must often be purchased with cash. More importantly, a builder's workers and guests must be fed, which requires that either the builder himself or the buyer amass significant surpluses through family or clan relationships.

exchange for a canoe vary with the size, the prospective buyer's relationship to the canoe builder, and what the buyer has to trade. Canoes may also form the bride price that a groom must pay to the bride's family, or be payment to a traditional landowner for a house site in a village (Levi Arthur, Panaeati canoe builder, 1997 pers. comm.). In some instances exchanges are complex, with valuables being obtained from a number of third parties (Kinch 1999); some valuables are passed down through mortuary feasts (Lepowsky 1995).

Figure 11. **A *sailau* and motorised dinghies share the beach at Enivala (Punawan) Island. (*J. Kinch 2002*)**

Canoe construction itself also involves an exchange. When initially constructed, Panaeati canoes are fitted with temporary (albeit well-finished) outriggers, typically fashioned from a breadfruit tree. When the canoe is complete, the builder will set out on a maiden voyage, bound for Normanby, Suau or Basilaki Island. The builder carries with him yams or other goods, and these are traded for a tree (*vihowan*) that is lighter than the original breadfruit. Using tools carried in the canoe, the builder fashions a new outrigger, and the canoe is then sailed back to Panaeati, or on to another island, if it is to be traded. Thus, even before they are completed, the canoes enter the trade system.

The broader exchange network

The exchange network in the Louisiades involves both subsistence and prestige trade goods, and has been characterised as a very practical response to the resource shortages facing the inhabitants of these small islands (Lepowsky 1983; Kinch 2001). Edible trade items include fish, turtles and eggs, clams, Nicobar pigeons, shellfish, yams, sago, bananas, taro, betelnut and mustard; money and store goods (e.g. tobacco, rice and sugar) are often part of exchanges as well (Kinch 1999). European visitors to the islands (a number arrive every year on sailing yachts) are readily drawn in to exchanges, with used Dacron yacht sails, rope, needles (to repair sails), clothes, fabric, magazines and books all in demand (pers. obs.). Trading voyages are most frequent between the islands of the eastern Louisiades (especially the Calvados Chain, but also Sudest Island, the Deboyne Islands, and Misima Island); Ware, Tubetube, Normanby and Kwairawa are also visited.

As islanders' needs evolve, the specifics of the exchange networks and the goods traded have altered. Exchange continued and even expanded following pacification, despite disapproval by missionaries and the colonial government. Exchange networks have provided islanders with a higher standard of living than would otherwise be available, have promoted the development of regional specialisation, and encouraged the production of surplus (in the form of garden produce, practical goods such as pots and canoes, and ceremonial items). Exchange voyages have been very efficient means of distributing these surpluses among islands and clans, have expanded islanders' social networks and cultural contacts, and facilitated the distribution of ideas and customs (Lepowsky 1983). Canoes and the exchange networks that they make possible "weave remote communities into webs of social ties that facilitate a higher standard of living, a richer social life, chances at treasure and fame, and the means to honour religious obligations" (Lepowsky 1995:52).

Evolution in marine transport

Sailing canoes have been the primary means of transport for islanders for hundreds of years, but this situation may soon change due to a rapid increase in the number of motorised dinghies. The demand for sailing canoes has increased on at least some islands over the last 30 years, while the last few years have seen a dramatic increase in the acquisition of motorised dinghies (Fig. 11). In 1971 Berde found 11 sailing canoes on Brooker (see Kinch 1999), while in the late-1970s Lepowsky (1983) found 11 canoes in use on Grass Island (whose population then numbered 200). By 1999, Kinch (1999) counted 50 sailing canoes in use on Brooker, with many households owning or having access to one or more canoes; in late-2002 there were 38 sailing canoes at Brooker, and canoes were being actively exchanged to the east with residents of Sudest Island and various islands in the east Calvados).

The use of dinghies is a very recent phenomenon. In 1997, few islands had more than one motorised dinghy. In February 1999, Brooker Island still had just one motorised dinghy in use (Kinch 1999). The number increased to three later that year (Kinch 2001). By early 2001 the number had reached 12 (Kinch 2001), and by September 2002 there were 17 dinghies on Brooker Island (Jeff Kinch, pers. obs.).

The number of canoes under construction during the same 30-year period has decreased significantly. In 1971 Berde recorded over 40 sailing canoes under construction on Panaeati, and similar figures were reported in 1994 (Hall et al.1994). In 1997 there were about 20 canoes at some stage of construction (Mark Smaalders, pers. obs.). By 1999 that number had dropped to nine (Kinch 2001).

Brooker islanders have historically made greater use of sailing canoes than have residents of some of the larger islands, owing to their greater reliance on marine resources and trade, but the dramatic increase in canoe usage over the last two decades appears unprecedented. It may partly be the result of an increase in population, but it is likely that commercialisation of marine resources (with the attendant opportunity to earn cash, which is increasingly in demand) has also played a role. The latter is directly responsible for the recent and very rapid turn to motorised dinghies, which allow islanders to harvest greater quantities of beche-de-mer (or other marine resources), from a larger area, in a shorter amount of time (Kinch 2001). There are indications that the widespread adoption of motorised dinghies on Brooker may be in part a move by islanders to avoid being disadvantaged, in what might be likened to a transport "arms race". Islanders have indicated that motorised dinghies allowed some people to increase their harvest of marine resources and thus make more money; this was viewed as unfair, and led many more islanders to invest in dinghies (Jeff Kinch, pers. obs.).

The decrease in canoe construction observed during the late-1990s may be the result of an increased desire for motorised dinghies, though reduced availability of *C. inophyllum* may also have played a role (Kinch 2001). In 1997, canoe builders and sailors on Panaeati expressed concern over the sustainability of *malauwi* harvesting, and over the increasing practice of building canoes for cash, rather than traditional exchange (Weda Gaunedi 1997, pers. comm.). Efforts to control the trade relied on an additional levy for each *malauwi* tree felled, if canoes were built for non-residents of the Deboyne Islands. Non-residents paid 50 kina, as opposed to the five kina resident fee, but most purchasers evade the higher fee because they have a relative on Panaeati.

Marine resource use and conservation in Milne Bay

The marine ecosystem of Milne Bay (including the waters around the Louisiade Archipelago) has been identified by recent surveys as being among the world's most ecologically diverse and pristine, displaying high levels of endemism and supporting large populations of threatened species (Global Environment Facility 2002). This environment has also been identified as being at risk of degradation, a matter considered of global concern owing to the area's extremely high levels of marine biodiversity (Filer 2002). A number of islands (45) within Milne Bay have been identified as "small islands in peril" because of a combination of high population density and dependence on subsistence resources from a limited area[9].

As is true in much of the Pacific region, marine resource use in the Louisiade Islands is artisanal in nature, providing for subsistence needs as well as limited small-scale commercial production. Because of a lack of regularly scheduled cargo transport and the absence of refrigeration facilities, commercial harvesting primarily targets non-perishable, high-value invertebrate products. Residents of some of the smaller islands are especially dependent on income from harvesting resources such as beche-de-mer, with the cash thus generated used for basic necessities, feasts and other social obligations, education, and church contributions[10] (Kinch 1999; 2001). Residents of the larger islands within the eastern Louisiades (such as Rossel and Sudest) are generally less dependant on the commercial harvesting of marine resources, relying also on pigs, betel nut, copra, and traditional valuables such as shell necklaces (*bagi)* as income sources (Hide et al.

9. "Small islands in peril" are defined to include those with less than 100 km^2 of cultivable land and a population in excess of 100 persons per square kilometre of cultivable land, where the population depends primarily on subsistence activities for survival, and lacks rights of access to subsistence resources on or around other islands sufficient to moderate this level of population pressure. Fully 44 of Milne Bay's "small islands in peril" are "very small islands in peril", as their cultivable land area is between 1–10 km^2 (Filer 2002).
10. Beche-de-mer alone accounted for just under half of Brooker residents' earnings between July 1998 and June 1999; most of the remainder was acquired through harvesting trochus, crayfish, fish and giant clam (Kinch 1999).

1994). The approach taken by the inhabitants of the larger islands is perhaps more typical of Pacific Islanders generally, who tend to treat shallow water invertebrate fisheries as a source of "windfall" cash, rather than a dependable income source (Dalzell et al 1996).

The inhabitants of the smaller Louisiade islands differentiate between subsistence and commercial fishing activities. The two activities are kept distinct in the minds of islanders, who are more prone to restrict outsiders' access to fishing grounds if commercial species are being targeted than if the object is a subsistence catch. Kinch (1999; 2001) documents a number of instances of conflict over access to fishing grounds, primarily involving commercial species, but also in cases of invertebrates used in the manufacture of trade goods with ceremonial value (i.e. *bagi*).

Studies in Milne Bay Province indicate that there has been an impact on both the abundance and diversity of selected marine species through small-scale commercial harvesting, including more valuable beche-de-mer species (Kinch 2001; 2002a), and giant clams (densities in the province are estimated to have declined by over 80% from their pre-commercial harvesting levels [Kinch 2002b]). Declines in giant clam abundance have a direct impact on food security, as these are an important subsistence food source.

The pattern of rapid overexploitation of resources by artisanal fishers is not new. Historically the beche-de-mer fishery in the South Pacific has been cyclic, with periods of heavy exploitation followed by much reduced pressure; during the latter period the resource may recover. Small-scale commercial fisheries generally are of a "sporadic, boom and bust" nature (Adams and Dalzell 1994:1), and have been characterised as being particularly prone to overharvesting (Dalzell et al. 1996). The current beche-de-mer boom in the Pacific Islands began in the mid-1980s, and has continued, despite declining stocks, owing to high demand in Asia, which has been termed "apparently insatiable" (Dalzell et al. 1996:75).

To address the potential degradation of the marine environment, resulting from both subsistence and small-scale commercial harvesting, the Milne Bay Community-based Coastal and Marine Conservation Program (MBCP) is being implemented by a number of partner organisations[11]. The aim is to establish Locally Managed Marine Areas in selected areas; marine use policy changes covering all of Milne Bay Province and capacity-building at the local and community level are also planned. The goal of these efforts is recovery of currently overharvested species (such as giant clams), and prevent overexploitation of other marine species owing to population increase or development of new markets (Global Environment Facility 2002; Kinch 2002b).

Canoes and sustainable lifestyles

The subsistence lifestyle of the inhabitants of the smaller islands of the Louisiade Archipelago has depended directly on a marine transport system that is sustainable with minimal cash inputs. The sailing canoes described here are one aspect of a system that has been in use for generations. This system also incorporates and depends on other elements. These include the social and exchange networks that support canoe construction and assist in distributing canoes throughout the archipelago, the trade networks that help to bring benefits and status to canoe owners, and the maintenance of specialised knowledge by canoe builders and sailors. Cash inputs into this system have historically been relatively minor (though cash has become an increasingly important component of canoe purchases), but other commitments are significant. Canoes generally represent a significant investment of subsistence and / or ceremonial goods, and maintenance of the other elements of the system requires a considerable time commitment. The system is thus a costly one, but the cost has been borne in subsistence terms, on a generally sustainable basis: the use and construction of sailing canoes has not placed significant pressure on either subsistence or commercial marine resources[12].

The elements of the system are mutually interdependent, with the low cost (in cash terms) of maritime transport in the islands allowing Louisiade islanders to maintain their trade and exchange network. The exchange network, in turn, contributes to food security, and serves to distribute risk from natural events (such as droughts and cyclones) between or among islands, with residents of smaller islands able to obtain yams and other foods from trading partners on larger islands. Louisiade islanders have recognised the

11. Partners include the provincial government, national government, United Nations Development Program, Global Environment Facility, and Conservation International.
12. The canoes can be seen as a form of physical capital, which allow islanders to access natural capital (marine resources), and maintain their social capital (exchange networks) and cultural capital (values and belief systems); there is also human capital involved (building and sailing the canoes requires specialised knowledge, and exchange networks encourage other specialisation to be retained). In contrast motorised dinghies require primarily just financial capital. See Lal and Keen (2002).

value of their trade and exchange systems, and have continued to build canoes and maintained their inter-island exchange, feasting and visiting networks despite significant efforts by colonial and national governments, missionaries and traders to put an end to these activities. In fact, the act of continuing to practice these customs can be seen as an overt act of resistance by islanders to external control, and an affirmation of cultural autonomy and personal identity (Lepowsky 1995).

Replacement of sailing canoes with motorised craft has clearly begun, on both Brooker Island and in western Milne Bay[13]. If this trend continues[14] and spreads to additional islands, such a shift may have significant implications for both subsistence lifestyles and marine conservation. Although dinghies will not provide greater absolute range than the larger sailing canoes, they will enable fishermen to cover more area in a given amount of time. They may thus contribute to an increase in fishing pressure, and to increased exploitation of resources in remote locations. In addition, motorised craft require significant and continuing cash inputs (including payments for the boat and maintenance and fuel costs); the cost of an outboard in 2003 represented approximately 25 times the annual average household income[15].

Fishers using dinghies must harvest a greater quantity of resources than do those using canoes, owing to the higher ongoing cash needs. One of the common mistakes in fisheries, in the Pacific region and elsewhere, is that fishers and money lenders are prone to estimate economic returns of a fishery based on initial catch rates, rather sustainable yields (which are generally much lower). The provision of easy credit and soft loans encourages over-capitalisation of fisheries, in which an excessive number of vessels compete for an often rapidly shrinking resource. The end result is that fishers either default on their loans, or start exploiting other resources (Dalzell et al 1996)[16].

Conclusion

The increasing use of dinghies represents not simply a change from one type of boat to another, but a significant shift in the type of investment made by islanders. Sailing canoes depend on and support both social networks and specialised knowledge and skills; the canoes are an intrinsic part of a complex subsistence lifestyle. In contrast, the use of dinghies depends on the availability of credit and the ability to earn cash (for purchase payments, fuel, and maintenance). What appears to be a simple choice regarding transport — canoe vs dinghy — is actually a decision that is likely to have much broader significance. Islanders who choose to invest in dinghies will face a growing need for cash, and the dictates of the cash economy, rather than the requirements of social networks and trade relationships, are likely to have increasing influence over dinghy owners' decisions. While the use of sailing canoes has encouraged investment in other subsistence-oriented aspects of life, the use of dinghies is likely to hasten the movement toward a cash economy (by increasing both the ability to obtain and the need for cash), and to weaken islanders' social networks and specialisations[17].

Dinghy use is also likely to lead to greater pressure on commercially harvestable marine resources in the Louisiade Archipelago. The potential for commercial overexploitation of marine resources in Milne Bay is significant, and even the canoe-based fishery has exceeded sustainable limits, as indicated by the above mentioned overharvesting of giant clam and beche-demer. Pressure on these resources can only increase with the introduction of motorised craft. The combination of increased range and increased cash needs also suggests that fishers with dinghies may target additional resources.

The lack of reliable, low-cost marine transport (for both fishing and transport of catch) represents a constraint to coastal fisheries development in

13. Brooker is one of the more marine-dependant of the small islands in the eastern Louisiades, and has the largest sea territory in Milne Bay; Brooker islanders are also perceived by neighbouring islanders as wealthy. Because they can access a large marine environment, they may have more incentive to make a move toward motorised dinghies than do residents of other islands.
14. At present, sailing canoes are still heavily used on Brooker and other islands; a recent fuel shortage meant that sailing canoes were being used by Brooker islanders in preference to dinghies. This may lead to the development of a dual transport system — with islanders owning or having access to both dinghies and canoes, as several families already do — but the investments required are significant.
15. A Brooker islander indicated that in early 2003 a new 30 hp outboard motor cost 12,000 kina (approximately USD 3250); fuel cost in 2002 was approximately 4.60 kina/litre (USD 1.25/litre). Some families/clans have earned large quantities of cash from beche-de-mer harvesting over the last several years; a Brooker family/clan earned 17,000 kina and purchased two dinghies; another is estimated to have made K 24,000.
16. In contrast with the movement to motorised dinghies, past improvements in canoe technology (such as took place with the development of the sailau, and which would have resulted in improved handling and speed) did not materially affect the subsistence nature of the transport system that had been developed.
17. Dinghies and motors represent a very large investment, and this may force many islanders to rely on their families and clans to help pay for the purchase. The assistance they will be seeking will again be in the form of cash, however, and the net result may be to cause an even larger group of people to become more cash-dependant.

much of the Pacific Islands region, but in Milne Bay (and possibly elsewhere) may have also served an unintended conservation role by making it difficult for islanders to exploit many species commercially. When such transport does become available, subsistence fishing may be transformed into commercial fishing almost overnight, often with negative effects in terms of local resource management, nutrition and food security (Preston 1997). There is also a heightened risk that fishers may look to destructive fishing practices, which are typically resorted to because of population growth exceeding the sustainable carrying capacity of a subsistence fishery, or because of commercial pressure (i.e. the presence of a particularly high value resource, and access to a market). Across the region, improvements in the fishing power of gear and growth of human populations have in many locations been paralleled by declines in stocks, catch rates and, in some cases, landed volume of reef fish (Dalzell et al. 1996).

The agencies and researchers involved in efforts to establish conservation and fishery management programs in Milne Bay (including the MBCP) would do well to examine closely the factors fuelling the move to motorised dinghies, the resultant changes in patterns of resource exploitation, and the impact on social networks. Given that the shift to dinghies is still in its infancy, it may be possible to develop creative management policies that help mitigate or prevent some of the many problems that have arisen in other locations as a consequence of technological change.

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The coexistence of whaling and whale watching in a traditional whaling region: The case of Taiji, Wakayama Prefecture, Japan

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Introduction

The discussion about the relationship between whaling and whale watching is polarised. Anti-whaling groups believe these two activities cannot coexist, and continue to urge that whaling be ended, stressing the economic benefits to be obtained from the sustainable use of cetacean resources. Examples from the Dominican Republic, the Bahamas and other Caribbean locations (Hoyt 1999), and from Vava'u, Tonga (Orams 1999), attempt to demonstrate the superiority of whale watching.

In contrast, whaling groups, composed mainly of anthropologists, economists and sociologists, seek coexistence. They have sounded the alarm on socially and culturally negative impacts caused by converting from whaling to whale watching, and have demonstrated the arbitrariness and overestimation of anti-whaling groups' economic analysis and falsehood of their outcomes. However, both groups place value on economic effects to greater or lesser degree.

Whale watching has been conducted in 87 countries and territories worldwide, attracting over nine million boat- and land-based tourists annually. In 1988, the value of the global whale watching industry was an estimated USD 300 million and a further USD 1049 million was gained from indirect tourism expenditure (Hoyt 2000). Although these estimates are still disputed, it is clear that the direct and indirect economic impacts of whale watching are extremely important. Further, about 100,000 tourists annually participate in domestic whale watching tours, and many more participate in tours overseas (Hoyt 2000).

Owing to IWC's commercial whaling moratorium, the local economies of Japanese whaling centres have been devastated and their societies disrupted by the exodus of young people in search of employment and careers; and, there is little prospect of change. Although Japan has campaigned for a resumption of whaling at IWC, the prospect for an increase in the coastal whale quota is bleak, to say nothing of full resumption.

Under these circumstances it has been thought that whale watching could become a fast growing tourist industry with a large potential to resuscitate the economies and societies of the traditional whaling communities. But so far no whale watching businesses have developed in traditional Japanese whaling communities.

In this article I examine the traditional whaling community of Taiji, in Wakayama Prefecture, to clarify why a whale watching industry has not developed in traditional whaling communities. I also examine the processes and factors regarding the coexistence of whale watching and whaling in the wider area of southern Wakayama Prefecture, and its application to other whaling communities.

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Background information on Taiji

The traditional whaling town of Taiji (Fig. 1) is located in the southeast of the Kii Peninsula, close to the southernmost point of the mainland of Japan (Fig. 2). In 2000, the town had a registered resident population of 3892 persons. The population peaked at over 4800 in 1978, but has been declining since.

Figure 1. The traditional whaling town of Taiji

Figure 2. Kii Peninsula, Japan

The principal industries in Taiji are small-scale coastal whaling, other small-scale coastal fisheries and tourism. In the 1960s over 30 per cent of the town's budget derived from the Atlantic Ocean whalers, large- and small-scale whalers, as most residents were then engaged in whaling and related industries.

But as the IWC moratorium struck this small town, the former 200 whalers gradually started losing their jobs. Nowadays, there are only nine small-scale coastal whalers and 27 dolphin hunters. Together they provide only 3.2 per cent of the town's budget.

The main types of mostly small-scale fisheries practised at present are fixed netting, tuna fishing, pole-and-line fishing, and stick-held dip net (*bouke-ami*). Under these circumstances, the Taiji authorities now attach major importance to promoting tourism. But despite the town's best efforts, the number of both day-trippers and tourists staying overnight has been dropping steadily.

History as a whaling base

Taiji is known in Japan as the birthplace of "ancient whaling", where the first professional whaling organisation was formed. The town played an important role in the development of whaling methods during the ancient whaling era. In former times hand-held harpoons were used, but this was inefficient as fineback, humpback and sei whales sink when they die, so catches were often lost. As a result, net whaling was invented in Taiji in 1675. This technique involved luring whales into an area where a net was set. Once trapped, the whales were seized with other nets and harpooned (Komatsu 2001). The catch numbers increased sharply, and this technique was transferred to Shikoku, Kyushu and other parts of Japan (Freeman 1989). But net whaling ended in Taiji in 1878, when 111 members of a whaling team died in a storm. This incident prompted the introduction of modern whaling to Japan.

Whaling culture and identity

Taiji is well known for its unique whaling culture. This includes a whale ceremony, festivals with prayers for a good catch, distribution and usage of whale meat, and food customs such as cooking methods are those most widely described.

Among the people of Taiji who share this unique culture and historical background, there exists strong community consciousness based on clear identity as being a member of a traditional whaling community. The public slogan of Taiji, "Town of sun, the black tide and whales" precisely shows this. Public buildings, local stores and the like often use whale characters for decoration, signboards and other purposes.

The strong community consciousness and distinct identity of Taiji was well demonstrated when its citizens rejected administrative consolidation with neighbouring cities and towns. In the 1950s a local spontaneous residents' campaign led to the disregarding of prefectural advice on consolidation. During that period the number of local governments decreased from 27 to 8 in Higashimuro County, to which Taiji belongs. Today, Taiji preserves its identity as the smallest locally governed area in Wakayama Prefecture (WISE 1989).

Tourism resources

Almost without exception tourist resources in Taiji are related to whales and whaling. These resources can be classified by five types: ancient whaling, modern whaling, academic facilities, "touching" facilities, and whale culture. The representative resources are as follows:

- Ancient whaling: Cape Toumyo, Cape Kajitori, Takatsuka signal station, drifting cenotaph, Jyunshin temple, Toumyo temple, the nets shed and related items.
- Modern whaling: the processing plant, ships for large- and small-scale whaling and related items.
- Academic facilities: the Whale Museum and related institutions.
- Touching facilities: facilities for swimming with dolphins, dolphin show.
- Whale culture: festivals, distribution and use of whale meat and food customs, among others.

Although the local government and residents have endeavoured to use all available tourist resources, the number of tourists visiting Taiji continues to decline. Local government data on tourist arrivals show that the total annual visitors reached about 0.5 million in 1976, after which it declined to about 0.31 million for a decade. However, it increased remarkably in 1982, the year of IWC's adoption of a blanket moratorium on commercial whaling. The number of visitors peaked at 0.51 million in 1995 but thereafter continued to drop sharply to 0.3 million in 2001.

Given the severe economic conditions in Taiji, and the strong desire of the local government to develop tourism as a replacement industry for whaling, it could easily be imagined that the whale watching business would have developed. However, whale watching has never developed in the town, and Taiji citizens do not even consider the possibility.

Why has the whale watching business not developed?

There are three principal reasons why whale watching has not developed in Taiji.

The first is Taiji peoples' image of whale watchers, which overlaps with their image of excessive and aggressive environmentalists. The ultimate objective of most environmental groups is to put an end to "the primitive and barbarous practice of whaling". They believe whale watching is the one way to "use" cetaceans in a sustainable way. Thus, Taiji people believe that the symbolic meaning of whale watching is anti-whaling. It is not a surprise that the traditional whaling community of Taiji has a negative image of those who deprive them of whaling, and thus associates whale watching with a plot to make whale watchers repeatedly confront whalers, and eventually eradicate whaling. Further, people in Taiji have seen, through the media, aggressive environmental groups deliberately colliding with whaling ships from Japan, Iceland and Norway.

Small-scale coastal whaling nowadays operates under extremely severe business conditions, with tight restrictions on catch numbers, seasons and whaling grounds. Under such conditions, operations are barely profitable. The future of small-scale coastal whaling depends totally on how whalers operate to fulfil their quotas in the most efficient way. Taiji whalers are anxious that any impediment to the efficiency of their operations may be fatal to the industry.

Taiji people are also concerned that if animal-loving whale watchers should actually witness whales being harpooned and then processed it would convey a negative image of Taiji.

Even if the negative image Taiji people have of whale watchers and the negative image observers have of whaling activities change in Japan, people in Taiji find it very hard to handle the concept of whale watching as a local activity.

Rejection of the idea of converting from "hunting" to "watching"

People in Taiji believe they are the descendants of the legendary "ancient whalers", the very core of their shared community identity. "Hunting" whales is the tradition that they have inherited over generations. But nowadays, without even acknowledging their basic role in the cultural, economic and social life of Taiji, larger forces have turned cetaceans into "eco-political resources" (Ohmagari 2002). As a result, their identity as whalers was unilaterally suppressed. "Watching" whales is an integral part of this suppression and is, thus, totally unacceptable to them.

Social constraints from the tight community consciousness

A well-organised professional whaling group in the "ancient whaling" era required numerous human resources. In those days, most residents of Taiji were involved with whaling in various ways such as boat crew, boat captain, manufacturers and craftsmen of whaling gears, whale processors, and whale meat distributors, among many other jobs. In addition to the men, women and children played an important role in the business. Everyone in the community depended on whaling, since there was little cultivable land and the community had long been fully dependent on marine resources, especially whales. Whaling was so highly profitable that, as one of the historical food encyclopaedia written more than 300 years ago stated, "hunting one whale would enrich seven villages" and "hunting three whales a year would bring massive wealth" (Komatsu 2001). Since the entire community was involved with whaling, the occupation engendered an extremely tight community consciousness.

Formation of such social consciousness continues even today. But the focus has changed. It is not so much the whaling itself, but the Taiji people's shared wish to recover the basis of their identity. This long-continuing process has, at the same time, also given rise to social constraints. As a consequence, it is unexpectedly difficult for Taiji people to set up a whale watching business.

Coexistence between whaling and whale watching in and around Taiji

As shown above, although there are some incentives to introduce whale watching as a new tourism resource, several sociocultural factors prevent its introduction in the community. It can be assumed that whale hunting and whale watching cannot coexist in Taiji.

The same types of social constraints are not found in nearby communities. This has given rise to a different form of coexistence between whales and whale-watchers, with the latter operating in several communities near Taiji.

Whale watching companies around Taiji

Five companies operating a total of six boats conduct whale watching in the Taiji area. There are two in Katsura, another two in Kushimoto and one in Koza. Each company owns one boat except for one company in Kushimoto. The capacity at one time ranges from 4 to 156 watchers. The operating season runs from April to the end of September.

The interaction of pioneering whale watching company and the Taiji whaling community

This company (called here "Anon Co") was the first to introduce whale watching around Taiji. It was established in 1991 by several former dolphin hunters. By 2002, Anon Co had approximately 2500 customers, and has had over 30,000 since its establishment.

Three distinct stages can be distinguished in the interactions between Taiji and this company.

The early stage corresponds to the time when the dolphin hunters were planning to set up a whale watching business. Some, who were also the future founders of the company, consulted a person closely involved with whaling to seek his advice regarding potential operational problems from the whaling standpoint. This person advised them not to operate during the dolphin hunting season, which begins in October, since it would not be advisable for whale watchers to witness the slaughter of dolphins.

The middle stage corresponds to the period from the establishment of the company to a few years later. Since the company's establishment, no substantial talks between the whalers and the company have taken place. However, both parties have been extremely cautious about not letting tourists witness the actual hunting and killing of dolphins at sea by tourists — but, this has occurred, and the tourists reacted calmly, contrary to the company's fear. There has been no conflict between the whalers and the company, despite minor incidents.

While being conscious and having reached an understanding regarding each others' interests, the relationship proceeded to the next step, when the whalers and the whale watching company gradually started talking and cooperating. At this time, the whale watching business in the area became well recognised and financially stable, and other companies emerged in neighbouring areas.

The Anon Co played a central role in establishing the Wakayama Whale Watching Association to administer the companies founded later, maintain order, and help them avoid trouble with whalers. Further, the association attempted to promote a positive interaction and began to hold an annual social event with the whalers. As a result, for the last five years the whalers and the companies have been informing each other about the location, types, size and other useful data about whales they encounter.

Factors of coexistence

From the above information, several factors emerge regarding the coexistence between whales and whale watching companies.

1. *Coexistence in an area including neighbouring communities*
   If there is no basis to set up a whale watching business within a community and no social capacity to accept it from outside, then the pos-

sibility of coexistence within a single whaling community may be considered extremely low. But coexistence with neighbouring communities that lack their own whaling tradition, and would not cause confrontation and conflict with whalers, could facilitate the development of a whale watching business.

2. *Whale watching as a kind of "fishery"*
   Operators don't base their whale-watching business around Taiji and its neighbouring areas on their love of cetaceans. For these whale-watching companies, whale watching is nothing but a kind of fishery and a more economically productive business than dolphin hunting.

3. *Setting rules that consider the whalers*
   The local rules self-imposed on whale watchers recognise that traditional whalers are the primary users of cetaceans and whale watching companies are secondary users. The establishment of the adequate, self-monitoring rules that cover the relationship between both major stakeholder groups are essential for coexistence.

4. *Information sharing is important*
   In the case of Taiji, even though whalers cannot obtain a direct profit from the information they give to the whale watching businesses, the information they receive in return from those companies about whales seen is vital in that it enables more efficient hunting. So, information sharing is mutually profitable to both parties that share in and profit from the limited cetacean resources.

Applicability and problems

The type of coexistence described above between the whaling and the whale watching interests in the Taiji area can be applied to other traditional whaling regions that suffer similar constraints and problems. However, some prerequisites need to be fulfilled.

First, should the whale watching business be developed around traditional whaling bases? Different species of cetaceans pass through different areas, and some whale species are not suited for whale watching, especially those that surface only briefly and then dive for hours. A sea area in which these species of whales predominate would not provide a suitable base for a profitable whale watching business.

Second, even though a whale watching business might be successful in neighbouring areas, coexistence with whalers cannot be expected if the watching is based on a love of cetaceans. Whale watching based on this type of emotion cannot accept whaling, and the whalers would become cautious and estranged from the whale watching business. Under such circumstances cooperation based on establishment of appropriate rules and information sharing would never emerge.

Finally, the coexistence at Taiji is based on the mutual benefit of information sharing. Were more severe IWC restrictions imposed, such as outright bans on particular species, then it is likely that the quality of information the watchers could provide to the whalers would deteriorate. If there is no benefit for the whalers, it is likely that the interaction between the two groups would be crucially weakened.

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The merging of archaeological evidence and marine turtle ecology: A case study approach to the importance of including archaeological data in marine science

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Introduction

In "ecology through time" Jackson et al. (2001:561–748) highlight the importance of including paleoecological, archaeological and historical data in ecological research. The authors note that few modern ecological studies consider the former abundance of large marine vertebrates, and focus instead on local field studies, lasting only a few years, without including a long-term historical perspective. An historical perspective would help clarify both the underlying causes and rates of ecological change, but also the theory that ecological extinction caused by overfishing precedes all other anthropogenic disturbances to coastal ecosystems. Archaeological evidence is also required to encompass the full life histories of many important species and to document environmental disturbances such as tsunamis and cyclones, geologic events such as uplift and subsidence, and prehistoric overfishing (Jackson et al. 2001:561).

In this paper I present the results of an initial examination of archaeological evidence from the Pacific Islands regarding the marine turtle, a vertebrate with a very long history of high cultural — often spiritual — significance. I look specifically at prehistoric Pacific Islander use of and impact on marine turtle populations. I present information collected from marine turtle remains in archaeological faunal assemblages that indicate presence / absence, abundance, and decline in numbers of marine turtles. And in one case, possible evidence for the implementation of conservation measures regarding marine turtles is described. In the first section, archaeological evidence from the case studies is presented. In the second I discuss the significance of this evidence in demonstrating a trend of overfishing by the initial colonisers of several Pacific Islands that led to the rapid initial decimation of marine turtle populations. I conclude that:

- marine turtle populations were extremely vulnerable and easily depleted;
- the affected populations did not recover to pre-contact states;
- those effects may be related to the ratio of human population to marine resource base; and
- the inclusion of prehistoric evidence indeed reinforces the theory that ecological extinction caused by overfishing precedes all other anthropogenic disturbances to coastal ecosystems.

The archaeological evidence

In this section I present evidence from the archeological record of the relationship between marine turtles and prehistoric Pacific Islanders. The islands discussed are Niuatoputapu, Tikopia, Tongatapu, Tahuata, and Utrõk Atoll.

Niuatoputapu, a Tongan outlier

The evidence for the Polynesian island of Niuatoputapu, an outlier of the Tongan archipelago, has been well documented by Kirch (1988:1–287). Niuatoputapu is a high island with an extensive system of pristine reef flats, barrier reefs, and lagoons. It is located at the edge of the Tonga Trench and is being upthrust as the Pacific plate slides under the Fiji plate. This uplift has resulted in a 312 per cent increase in land area and a 50 per cent decrease in reef and lagoon habitat. The land area of the island at the time of settlement was 4.9 km^2 and is now 15.2 km^2.

The settlement sequence of Niuatoputapu has been delineated into four phases: Phase I, the Lolokoka Phase (1400 / 1200–500 B.C.); Phase II, the Pome'e Phase (500 B.C.–A.D. 800); Phase III, the Niutoua Phase (A.D. 800–1550); Phase IV, and the Houmafakalele Phase (A.D. 1550–1830). At the time of initial occupation, the island had high numbers of marine turtles and colonists relied for subsistence on the intensive exploitation of the rich marine resources. During this phase, the targeted marine species suffered significant population reductions owing to regular exploitation

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(Kirch 1988:241). Phase II showed a clear reduction in marine resources — although turtle was well represented in this phase, it was below that of the early phase. Kirch (1988:242) suggests that this reduction reflects a decline in marine resources owing to continual human predation.

By Phase III, tectonic uplift had resulted in the progradation of the leeward shoreline and the emergence of broad reef and lagoon flats in portions of the island. This uplift eliminated extensive areas of reef and lagoon habitat. The archeological record reflects both this elimination of inshore habitat and continued human predation, as remains of marine resources, including marine turtle, decline substantially in this phase (Kirch 1988:243). Phase IV marks the boundary between prehistory and history, A.D. 1550–1830.

Kirch (1988:221) documented osseous carapace and plastron fragments, limbs, and cranial fragments of marine turtle. He found a reduction over time in the distribution of turtle bone as follows: from the early site, NT-90, Kirch found a density of 1.39 bones m^{-2}; at the slightly later site, NT-100, 0.53 bones m^{-2} and at site NT-93, 0.27 bones m^{-2}. The sharp reduction in turtle from the initial colonisation NT-90 site suggested to Kirch (1988:221) a sizeable nesting colony of marine turtles and a corresponding initial situation of high resource abundance for the first settlers that was quickly depleted.

Tikopia, a Polynesian outlier

Kirch and Yen (1982:1–396) documented archeological evidence for the Polynesian outlier of Tikopia. Tikopia is a small, isolated, high island surrounded by a fringing reef. The island experiences shoreline progradation from tectonic uplift and especially from the transport of material across the reef flats during cyclones and storms. Kirch and Yen (1982:325) found stratigraphic evidence of prehistoric peoples adding to this shoreline aggradation by initiating and intensifying erosion through the use of fire in forest clearance. At the time of settlement, the land area of Tikopia was 38 per cent less than at present, and the area of exploitable reef habitat was 70 per cent greater.

The settlement sequence of Tikopia has been delineated into three phases: Phase I, the Kiki Phase (900–100 B.C); Phase II, the Sinapupu Phase (100 B.C.–A.D. 1200); and Phase III, the Tuakamali Phase (A.D. 1200–1800). During initial occupation there existed a deep bay, open to the sea across a broad reef flat, and there was a heavy reliance on the abundant marine resources (Kirch and Yen 1982:106, 325). The authors suggest that this occupation marks the initial colonisation of a previously uninhabited ecosystem, citing the great abundance of turtle bone and the abundance of and large size of mollusks as indicating that the marine resources had not previously experienced intensive predation. The impact of these initial settlers on the marine turtle resources of the area was the virtual decimation of the turtle populations (Kirch and Yen 1982:327).

Phase II is characterised by the complete absence of turtle remains as well as those of sharks and rays (Kirch and Yen 1982:329–330). Phase III is characterised by substantial aggradation of the island's shoreline, expansion of the north and north-western coasts and the transformation of the deep saltwater bay to a brackish lake (Kirch and Yen 1982:333).

Kirch and Yen (1982:284–285) document a reduction over time in the distribution of turtle bone. The initial colonisation TK-4 site had a dense concentration of turtle bones, at 59.2 m^{-3}. There followed a sharp reduction (to 14.5 and then to 10.0 m^{-3}) and the complete absence of turtle remains in the succeeding phase II deposits. Finally, there occured an increase from 0.0 to 1.1 to 5.3 bones m^{-3} in the later phase III deposits. The later concentrations of turtle remains corresponded to contemporary data at the time of the study. Kirch and Yen (1982:284–285) suggest that the sharp reduction in turtle remains from the initial colonisation TK-4 site is the result of intense exploitation of a large nesting population, but they further suggest that the abrupt total absence of turtle remains in the Phase II deposits was more likely related to *tapu* restrictions. Kirch and Yen (1982:356–358) suggest that the combined absence of sharks, rays, and turtles for 1000 years during phase II and their reappearance in phase III is unlikely to reflect simultaneous local extinction of such a wide range of species adapted to both shallow and deep waters. They suggest that food prohibitions (*tapu)* that class turtles, and especially sharks, as inedible for having spiritual or totemic value were likely responsible.

Tongatapu, Kingdom of Tonga

The third case study presents the archeological evidence documented by Spennemann (1987:81–96) in a study he conducted on mollusc shell samples excavated by Poulsen (1967, in Spennemann 1987) on the island of Tongatapu, as well as evidence documented by Burley et al. (2001) conducted a re-excavation and assessment of the Nukuleka and Ha'ateiho sites in Fanga 'Uta Lagoon on Tongatapu, and a survey of the Lapita-age paleoshoreline of the lagoon. The largest Tongan island, Tongatapu is a flat coral limestone island with a shallow lagoon with no passages, fringing coral reef on three sides, and a patch reef on the other. Like Niuatoputapu and Tikopia, the environment of Tongatapu has undergone natural changes since initial settlement. Owing to a fall in sea level, part of the lagoon became brackish, and it became smaller compared to its size at time of initial occupation (Spennemann 1987:82–83).

The settlement sequence of Tongatapu has been delineated into three phases: early, middle and late. Arriving at a large protected bay around 1500–1300 B.C., the initial colonists of Tongatapu spread outward to eventually establish a continuous distribution of sites around the Fanga ‘Uta Lagoon shoreline (Spennemann 1987:82–83; Burley et al. 2001:103).

According to Spennemann (1987:82–83), middens from the early phase sites demonstrate that the initial occupants relied heavily on lagoon and reef resources such as molluscs, marine turtles and fish. Based on a systematic collection of column samples (50 x 50 cm) from the northern and southern excavation units of Ha‘ateiho, Burley et al. (2001) found that early phase faunal collections contained a relative abundance of marine turtle that were “less abundant or absent in the upper strata” (Burley et al. 2001:100–102). The authors suggest that the initial colonisers at Ha‘ateiho were exploiting the natural resources “to their maximum capacity” with an intensity that had an immediate negative impact on the surrounding environment. They conclude that the short-term consequences of human settlement were numerous extinction events and probable depletions in “even the most abundant” resources (Burley et al. 2001:100–103).

Tahuata, Marquesas

Rolett (1998) presents the archaeological evidence of Hanamiai, a prehistoric settlement on the island of Tahuata, in the southern Marquesas. Tahuata is a high island with no coastal plain, no lagoons and virtually no coral reefs. This lack of reefs distinguishes Tahuata, and the rest of the Marquesas, from other Polynesian islands (Rolett 1998:20–21).

Rolett suggests that the initial inhabitants relied heavily on wild foods, as shown by the abundance of ground-nesting seabirds, flightless landbirds, and a greater frequency of turtle and porpoise-sized whale remains than either dogs or pigs. Rolett suggests that the marine turtle population at Hanamiai was depleted during initial colonisation. Deposits in the initial phase (3.1% of total NISP) were more than twice those in any other phase (Rolett 1998:103).

Utrõk Atoll, Northern Marshall Islands

Weisler (2001) conducted an archeological study at Utrõk Atoll, near the northern limit of permanently inhabited atolls in the Marshall Islands. Based on radiocarbon age determinations and physical characteristics of the islets, Weisler suggests that Utrõk islet was colonised first and the smaller islets only visited during the earliest period of colonisation. The less inhabitable islets, including Allok and Bikrak, have cultural stratigraphy that suggests only periodic, short-term visits.

A total of 13,545 bones were collected, including those identifiable only to vertebrate (0.9%) and bones of marine turtle (0.7%) (Weisler 2001:124). Using the identified bones that were spatially associated with the unidentified vertebrate bones as reference, Weisler (2001:126) believes that the unidentifiable specimens are most likely those of human, marine turtle and large fish. He also believes that many, if not all, of the 98 marine turtle remains (77 from site 1, 21 from site 5) are probably those of the green turtle (*Chelonia mydas*), which still nests on several of the islets of Utrõk Atoll. Approximately 79 per cent of all turtle remains were recovered from nine units at site 1. Several bones were associated with an 890 ± 50 age determination (Beta-103908), whereas others were recovered from the upper spits of TP 15 and 21 (Weisler 2001:126). This suggests to Weisler (2001:130) that turtle was consumed over a 1000-year period without decimating the stocks — “that is, there is not a declining frequency of turtle bones from throughout the cultural layers.”

Discussion

What is the significance of the evidence described above in demonstrating a trend in the use of and impact on marine turtle populations by prehistoric Pacific Islanders? In Table 1, I present a summary of the impact on marine turtles that the faunal remains contained in the archaeological record suggested to the archaeologists involved.

A clear trend is suggested. In each of the first four cases, the archeologists involved suggest that marine turtle populations were decimated during the initial occupation phase, owing to intense human predation. In the fifth case, Weisler (2001:130) suggests that turtle was consumed over a 1000-year period without decimating the stocks. However, Weisler (2001:129) also notes: “As marine resources were depleted near the main villages on Utrõk and Aon, the smaller islets would have provided campsites for staging forays along the adjacent reefs or conducting fishing sorties beyond the oceanside coast, progressively farther

Table 1. **Reduction of marine turtle remains by case.**

	Impact on marine turtles suggested by author(s)
Niuatoputapu	Initial decimation from heavy initial exploitation and continued reduction in numbers over time of a nesting colony.
Tikopia	Initial decimation from heavy initial exploitation, followed by absence of remains owing to *tapu* restrictions for 1000 years, followed by resumed exploitation of a nesting colony.
Tongatapu	Initial decimation from heavy initial exploitation and continued reduction in numbers over time.
Tahuata	Initial decimation from heavy initial exploitation and continued reduction in numbers over time.
Utrõk Atoll	Turtle consumed over a 1000-year period without decimating the stocks.

from the main settlements." This may indicate that the consistency he perceives in marine turtle consumption may be related to the relationship between a small human population and a large marine resource base. In contrast to the other high volcanic and raised limestone islands, atoll environments have a uniquely high ratio of reef to land area. Utrõk Atoll is no exception. Utrõk Atoll, with a land area of only 2.4 km^2, has a 57.7 km^2 lagoon, and 86.7 km^2 of ocean and lagoon side reefs. The extremely small estimated population density (Weisler 2001:131) coupled with that huge expanse of lagoon and oceanside reef habitat makes it likely that prehistoric inhabitants of the atolls never needed to overuse their marine resource base. In addition, fishing forays to other islets would have increased their resource base beyond what the land-limited population could affect. Weisler (2001:111) presents ethnographic evidence for these types of fishing expeditions for marine turtle when he discusses the two atolls farther north, Bokak (Toangi) and Pikaar, which "were not inhabited year-round in prehistory but, today, are visited occasionally to harvest sea birds and turtles."

In the second case study, Kirch and Yen (1982:356–358) suggest that food prohibitions (*tapu)* that class turtles as inedible for having spiritual or totemic value were likely responsible for the complete absence of turtle remains for a 1000 years during phase II. Might this be archaeological evidence for the implementation of indigenous conservation measures regarding marine turtle? According Firth study (1967) of Tikopia rituals, turtles were *tapu* to all but the people who claimed it as their totem, the Fangarere. The Fangarere could eat them, whereas others regarded the marine turtle as disgusting and believed that should they eat it, "they will vomit" (Firth 1967:256, 362).

The Tikopia case perhaps also provides a natural experiment on the vulnerability of marine turtle to even limited prehistoric overfishing. But there are problems with the authors' evaluation of the turtle faunal data as a ratio of the amount of sediment excavated: deposition clearly varies but does subsistence change in conjunction with it? If Kirch and Yen are correct that for a 1000-year period the take of marine turtle was severely limited by a *tapu*, there appears to have been no recovery of the population by the end of that period. The initial concentration of turtle bones (59.2 bones m^{-3}) was never approached in the later deposits. Even the level of exploitation shown at the end of the Phase I deposits (10.0 bones m^{-3}) was twice that found in later deposits. The highest concentration found, once exploitation resumed, was 5.3 bones m^{-3} in the late phase III deposits, which corresponded to contemporary data at the time of the study, 200 years later. This could possibly be confirmed from the archaeological record of Firth's ethnographic information, and therefore points to the period when turtle exploitation solely by the Fangarere began. Regardless of that, this is exactly the type of necessary information Jackson et al. (2001) were speaking of when they talk of the importance of including archaeological information to truly understand the life history of many marine vertebrates.

There is an interesting relationship between the Tikopia case and the contemporary impact of overfishing on particularly vulnerable marine species — those that take a long time to reach sexual maturity, like the marine turtle. Several studies conducted along the Great Barrier Reef demonstrated that all marine turtle populations heavily exploited during historic times rapidly collapsed, and all failed to regain more than a small fraction of their former abundance (Neil 1998; Jones 1980; Ganter 1994; in Jackson et al. 2001). But in those studies, the authors were discussing periods of only a few hundred years. The archaeological data presented by the studies cited in this article a much longer timeframe, and demonstrates the failure of some marine species to *ever* recover from even limited overfishing.

It would be remiss not to mention the limitations of the studies used here. In choosing survey methods the researchers cited here made several assumptions. First, they commonly limit their study to sample subsets of the site rather than attempting to study the entire area. So they assume that what they observed within these subsets is representative of the site as a whole (Hallacher 2002:1). To make suggestions regarding the state of the marine turtle population, the researchers targeted faunal remains of marine turtle found in the archaeological record. In focusing on these remains, they have assumed that the density of these target remains in their subsets represents their density in the greater community at that particular site. In addition, in quantifying and identifying the remains of marine turtle, the researchers relied on both the individuals on site (diggers, sifters, etc.) who gathered those remains and on the observers who were responsible for interpreting those remains. This assumes that every individual and observer had equal skills in terms of obtaining and identifying the data gathered — this may not be the case and should be considered when reviewing these findings. And what of the conclusion that the decimation of turtle stocks on both Niotaputopu and Tikopia represents extensive initial exploitation of a nesting beach? In delineating their methodology the authors do not state whether or not they conducted genetic testing on the turtle remains and determined a sex ratio biased toward females, or conducted analysis of the skeletal components to assess growth. If they did not, then the evidence for a nesting beach is not convincing.

Conclusion

The consistent initial decimation owing to heavy initial exploitation demonstrated by the above brief literature review suggests a trend rather than isolated incidences and provides a model of marine resources depletion at time of initial settlement. This model had long-term consequences for marine turtle populations and may be correlated with a ratio of human population to marine resource base; the lower the human population in relation to the resource base, the less its ability to deplete that base. The next task is a more thorough review of the relevant literature to verify these conclusions.

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Traditional food prohibitions (*tapu*) on marine turtles among Pacific Islanders

Regina Woodrom Luna[1]

Introduction

As ecotourism increases in Hawai'i, turtle watching has become an increasingly popular activity. A recent survey of tourists found overwhelming interest in information about marine turtles and how to go about seeing them. In fact, the Hawai'i Tourism Authority estimates that marine turtles are probably second only to humpback whales as the most popular marine life attraction in the Hawaiian Islands (Balazs 1995, 1996).

Owing to both the status and cultural popularity of these animals, laws have been enacted in Hawai'i making it illegal and unacceptable for people to disturb or harass them in any way (Balazs 1995, 1996; NOAA 2001).

In Hawai'i, as throughout Polynesia and other islands of the Pacific, sea turtles have always been a traditional part of the local culture and have historically been revered as special and sacred beings. And just like the laws that make certain behaviour toward marine turtles illegal in Hawaii today, Pacific Islanders have traditionally had their own sets of "laws" regarding these animals. Many of these "laws" represent indigenous conservation measures that acted as a measure of protection for this special species. For example, the eating or capture of certain species was forbidden (*taboo*, *tapu*, *kapu*) to particular clans, castes, age groups or genders (Johannes 1978). In this paper I present a brief overview of some *tapu* or traditional conservation measures traditionally placed on marine turtles by Pacific Islanders.

Tapu placed on the eggs of marine turtles

In a study of traditional marine conservation methods in Oceania, Johannes (1978) documented a number of ways in which sea turtles have been protected. The natives of Tobi and Sonsorol placed a *tapu* on the eating of turtle eggs and placed fences around the nests for their protection. When hatched, the young turtles were fed for several months and then taken out by canoe to the open sea to be released. *Tapu*s were also placed on taking marine turtle eggs in Vanuatu and Western Samoa. In Samoa, a local chief imposed a *tapu* on frequenting a favourite spot on the local turtle-nesting beach by declaring a certain rock outcrop on the nesting beach to be *tapu*. Since the digging of turtle eggs was a social activity in Samoa, and that particular rock provided the only shade where people could sit and talk, the activity lost its charm to the local people and they took less turtle eggs than before (Johannes 1978:1–24).

Tapu placed on the habitat of marine turtles

In Kiribati, it was the taking of turtles while on the beach that was forbidden. The Enewetak islanders made several uninhabited islands into turtle reserves by forbidding the taking of marine turtles from those locations and made it *tapu* to take all of the turtles found. Traditional *tapu*s were also imposed in the Caroline Islands of Micronesia regarding the green turtle (*Chelonia mydas*) (Lessa 1984).

Tapu placed on the consumption of marine turtles

In Kiribati and Tuvalu marine turtles were protected and their consumption was limited to village chiefs (Zann 1985). In his study of Tikopian rituals, Firth (1967) documents turtles as *tapu* to all but the people who claim it as their totem, the Fangarere. The Fangarere could eat them if they wished and could even be saved by a turtle if in danger at sea. Others regard marine turtles as disgusting and believed that if they should eat it, they will vomit (Firth 1967:256, 362).

In their study of the ethnology of PukaPuka, Cook Islands, Ernest and Pearl Beaglehole (1938) discuss the *tapu* on the belly fats and the major internal organs of turtles. It was *tapu* for all but old men to eat these parts — if any other person consumed them, sickness and grey hair would result. It was also *tapu* on PukaPuka to eat coconut with turtle.

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They tell of one man who did so and was caught by a male turtle and drowned the next time he went turtle fishing. Baby turtles were saved for periods when the chiefs wanted to divide out special foods. They were caught as they emerged from their shells, placed in wooden enclosures, and fed on squid and octopus until of appropriate size (Beaglehole and Beaglehole 1938:69, 105, 219, 351).

In the Lau group of Fiji, turtles were a very important feast food. In her study of that area, Thompson (1940) describes turtles as great delicacies, eaten only at important feasts and then only by high ranking persons. In Lau, turtle is considered the most chiefly of all foods and is protected by special *tapu*. Eating the head of the turtle was reserved for the chief of the highest rank, because it was felt to contain the *mana*. The rest of the turtle was apportioned depending on rank. Permission to fish for turtles could only be granted by the chiefs' master fisherman who decided the day and place of the hunt, which was a community event.

The people of Lau also maintained a brackish lake in the centre of the uninhabited island of Wangava, which was used for turtle breeding. As on PukaPuka, young turtle were caught and kept in an enclosure until large enough to survive on their own. At that time, they were released into the lake at Wangava and reserved for the chief's consumption (Thompson 1940:24, 72, 128, 137, 141, 154). Eating the head of the turtle was also reserved for the chief of the highest rank in Samoa. In addition, the juice from the abdominal cavity was reserved for the chiefs as were the front flippers (Hiroa 1930:123).

On Uvea, great seine nets were used to catch turtles at night, turtles were sacred to the king and it was *tapu* for any others to consume them (Burrows 1937:144). Similarly, in Tongareva, Hiroa (1932) documents "the turtle ceremony" where turtle was regarded as of great importance, was monopolised by the high chiefs and priests, and was *tapu* to women in particular. The turtle was cooked on an elevation of stones as a sacrifice to the gods and while the people formed a large circle around it, was consumed by the chiefs. Select lesser male chiefs in the circle would be offered shares but never the women (Hiroa 1932:91).

Conclusion

As this brief overview has demonstrated, the marine turtle has a history of high cultural, often spiritual, significance. These animals have long fascinated people and figure prominently in rituals and *tapu*s throughout the Pacific Islands. We have seen here that, like the current laws protecting marine turtles, Pacific Islanders acted in protecting this species by restricting both their take and consumption. What is missing from the cases described above is any discussion of the reasons for and methods of the protection. Why marine turtles? How did they become "elevated" above other food sources? What is it about the turtles that caused them to become worthy of protection? Nothing in this archival research presented any answers to these questions. These are fascinating and important topics that I hope will be form the subject of later research.

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Registration

Registration materials will be mailed or emailed in November. Fees will range USD 300–450 with special lower fees available to students. Registration fees cover attendance at all conference sessions from 26–29 July, four lunches, reception, morning and afternoon tea and coffee, the conference banquet, and conference proceedings (published after the conference). Optional events (such as pre-conference study tours, and symposium, pre- and post-optional conference tourism in Japan) will be available as a small extra charge to conference participants and companions.

Schedule of the conference in July 2004

20: Arrival in Tokyo; 21–23: Pre-conference tour A1 in Fukushima / Miyagi and Pre-conference tour A2 in Misaki / Kanagawa; 24: Pre-conference tour B in Tsukiji / Sea Food Show; 25 (Sunday): Free; 26: Opening (Plenary S.) and Registration / Reception; 27–29: sub-theme session, dinner party on 29; 30: Symposium (plenary session) on conference theme; 31: Departure.

Deadlines

13 / 12 / 03	Financial support requests*
16 / 01 / 04	Abstracts submissions
1 / 04 / 04	Acceptance decisions by Scientific Committee sent to authors
16 / 04 / 04	Submissions of complete papers for “Best Students Paper Awards”
26 / 07 / 04	Final Papers for inclusion in Proceedings (camera ready hard copy and diskette): Conference Registration Desk, 5:00 p.m.

* Limited funding support may be available for applicants from low income or developing countries only. Please send a request with your abstract.

Logistics

The conference will be held at Tokyo University of Fisheries, the biggest institution among 17 fisheries universities and colleges in Japan. It is located in Shinagawa Area of Tokyo, Japan’s capital city. Frequent connections are available between Narita, Tokyo and the whole world. From Narita to downtown Tokyo takes about 60 to 90 minutes by bus or train, according to traffic. Haneda Airport, 70 minutes from Narita Airport by limousine bus, is the domestic airport of Tokyo and 19 minutes by Keikyu train to Shinagawa where accommodations near the University are situated.

Shinagawa area is very convenient place for shopping and visiting any place in Tokyo. Accommodations are available from USD 50–200 per night at your choice.

The university has a student population of just under 2000, and is situated on the Tokyo waterfront. The university offers a wealth of fisheries-related fields of study, from oceanography, marine chemistry and biology, physics, to fishing, aquaculture and food science and technology. The university provides a venue for the formal opening session, and a range of fully equipped lecture rooms for all conference sessions, along with space for poster display and informal discussion, and lunch, morning and afternoon tea and coffee facilities. This will all be provided on one site.

Japan destination

Japan is one of the top fisheries nations, the top importer of fisheries products in the world, and a country heavily dependent on fish as an animal protein source. Japan also has a unique approach to fisheries management. Most management initiatives come from fishers themselves, under a system of organisations at various levels, responsible for the design, implementation, and enforcement of regulations. The combination of small-scale and commercial fishing activities present in Japan has provided many management challenges; yet unlike most other fishing nations, Japan has succeeded in reducing fishing capacity since the beginning of the 200-mile EEZ era. Pre-conference study tours will enable you to visit such sites.

As for tourism opportunities, Japan has everything from incredible, serene, natural beauty, to most modern technology and cities, tempered by a delicate aesthetic tradition, which permeates every aspect of both its physical and cultural environments. The pictures taken by Ann L. Shriver during her recent visit to Japan can be seen at http://oregonstate.edu/Dept/IIFET/Japan/Index.html. There are hundreds of websites that could help you to plan a family trip, but a good place to start is at the Japanese National Tourist Organization (http://www.jnto.go.jp).

This conference is organised by Japan International Fisheries Research Society (JIFRS) in collaboration with RAKUSUIKAI, fisheries-related scientific societies, universities and colleges, fisheries-related industries and organisations, and the Fishery Agency of Japan.

Please visit the website at http://www.iifet2004Japan.com (currently under construction) for more details as the conference themes develop. This URL will also link to sites that will introduce you to the tourism possibilities in Japan.

Please contact:

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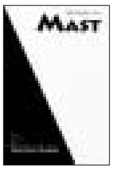

Maritime Studies (MAST)

Editors: Rob van Ginkel, Jojada Verrips and Marloes Kraan (University of Amsterdam)

Maritime Studies (MAST) is an international journal on maritime issues with a social scientific focus. It is a revitalised version of Maritime Anthropological Studies, which appeared between 1988 and 1993. The new name, Maritime Studies (while maintaining the acronym MAST), is intended to signal that the journal is a platform not only for anthropologists, but also for scholars from a broad range of disciplines who are engaged in research on maritime peoples, cultures and adaptations, from an academic or applied point of view. MAST will be published twice a year. It welcomes articles, commentaries, research reports of work in progress, review essays, and book reviews on any aspect relevant to social scientific approaches to maritime studies.

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