THE SUSTAINABLE, THE EXPENDABLE, AND THE OBSOLETE

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This is a preliminary exploration of the concept of sustainability and its potential usefulness to anthropologists. "Sustainable" is distinguished from "stable" and "viable" in terms of its implications of directionality of time, pointing both backward and forward. Given the time implications, the contexts of "sustainable Xs" (technology, activity, development, etc.) are crucial to explaining what happened to X in the past and prognosticating its future. The argument is illustrated by analyzing data on obsolete fishing practices on Kapingamarangi Atoll (Federated States of Micronesia), focusing on the contexts of change in political/religious organization in the twentieth century. Changing access to both new and old technology render many traditional fishing practices obsolete through replacement by new techniques and by neglect. The relationship between the obsolescence and the sustainability of fishing techniques changes over time, the change constrained by the Kapingamarangi concept of "knowing" and by fishermen's dependence on technology requiring cash outlay. Sustainability in this analysis is a concept most appropriate to the emerging field of political ecology.

This is an exploration of the construct of sustainability to answer the question of how useful it might be to anthropologists. "Sustainability" has become a buzzword in the social sciences and in fields such as urban planning, economic and commercial development, public-health programs, and among public and private funders. Foundations considering proposals for interventions in these areas demand to know how a proposed intervention will be "sustainable" after the funding period. There is already a rapidly growing literature on this subject, and there is variability in the ways that scholars in different fields understand and use the concept. I do not question their judgments or research agendas but merely pose a set of questions

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that anthropologists would ask given our own sorts of research agendas. My naïveté on this subject may be evident, yet I have found that there is a lot to be learned from naïve questions. So if my approach seems elementary, it is because the utility of a new research construct is always measured both by the new sorts of questions to which it leads and by how it fits with constructs and logic that researchers know to work in the field situations in which we find ourselves.

"Sustainable X" (technology, policy, community, and so forth) is a very appealing term. Like other fortuitous concepts, its core meaning initially serves to connote more than to denote. What sustainability connotes is an arena of inquiry. If sustainability starts out as vague and contentless, then its usefulness depends on how one fills in its denotata. "Filling in" is common in scientific discourse, as the histories of "atom," "gene," "intelligence," and "culture" amply demonstrate.

Sustainability is neither a thing nor a process. Sustainability (or sustainable X) refers to an outcome of one or more processes such that some X is observed to be continuously present over some period of time. Practically, X is sustainable if some observer's description of it at $time_2$, $time_3$ . . . $time_z$ is more or less the same as the description of it at $time_1$. In normal usage, it is the size of the population in its environment that is continuous. A sustainable technology (or development, policy, and so on) is commonly understood to denote one that allows for maintenance of a population at a constant, if not expanding, size.

If this construal is acceptable, then is describing X as sustainable saying anything more than that X is stable? Are "stable" and "sustainable" synonyms? Kind of. Both refer to temporal continuity of some state for long enough to dismiss "temporary" as a reasonable description. While their denotations overlap, their connotations do not. Stability has a "present time" synchrony about it in the way it is used: "Is this a stable system? His condition is stable. They are trying to destabilize X." These sorts of usages—and usages count—imply something on the order of stability as the expected outcome of the nature of X, as somehow built into X and, therefore, timeless or at least asynchronous in its manifestation.

Sustainability, in contrast, connotes diachrony. Used in prognosticating an outcome of some planned program of change, it points forward in time. Used to describe the current state of some X, it points backward in time. Either way sustainability seems to imply some temporal sequence of events that begins with an innovation resulting in a new order of stability or, conversely, a relatively permanent instability. In the former case, we describe X as sustainable, in the latter case as unsustainable.

The sustainability of X might imply that X is somehow self-sustaining.

That is, X is either preadapted to its environmental and social contexts or it is adaptable to those contexts with appropriate modifications. In either case, the implication is that X somehow *fits* with a community's customary activities or that the changes in activities necessitated by adopting X are coordinated well enough to preclude disrupting the internal functioning of the community or causing environmental damage that threatens the population's existence. "Fit," like sustainability, is appealing and tricky—it is shorthand for "compatible with," a descriptive summary of ethnographic evidence. Like sustainability, "fit" also points in two directions: (1) to a community's ordering of social relationships and to an ordering between the community and higher-level authoritative relations that contextualize X and (2) to the ordering of human relations with the nonhuman environment. Both the political-economic relations of the community with other communities and with higher-level authority (if any) and the environmental conditions to which people ordinarily respond contextualize the community and, thus, contextualize X.

So, for example, a new item of technology might be compatible with some or all other items in the community's technological assemblage. Or it may make some items in the assemblage obsolete. Or it might be incompatible with some or all of a community's technology. It might fit with a community's technology but disrupt relations of group organization and authority, as, for example, Sharpe's description of missionaries introducing steel axes to Australian aboriginal populations through women (Sharp 1952). Or it may be a useful, adaptable technology for 10 percent of the population but not for the other 90 percent. If this ratio replicates the way items are normally distributed in a population, for example, with one class of people getting the new item to the exclusion of others, then fit is assured (unless those introducing X intended it to be distributed equally, in which case the introducers have not done their homework). X may be so efficient that its use by more than 10 percent of the population leads to resource overexploitation and environmental degradation, making it incompatible with the environmental context. A technological change might be sustainable in one community while disrupting its relationships with another community with which it practiced regular exchanges. Pomponio (1993) describes this sort of situation in the Siassi Islands, where the livelihood of Mandok Islanders, traditional middlemen in exchanges throughout the island group, was threatened when their partners began cash cropping and importing Western goods.

These examples indicate that the sustainability of any X is an outcome of systemic processes that link people to one another within a community, to their natural environment, and to other communities. Sustainability is a systems construct or it is nothing. Common to different versions of system theory is the idea of a system as the coordinated relationships among interacting components inside a boundary, these relations serving to process inputs from an environment and to transform them into outputs to the environment —all in relation to some observer (Hall and Fagen 1968:81–92). A system's internal states change over time according to the kind and intensity of its inputs corresponding to changes in the states of the environment (see Ashby 1956:202–218). To the extent that the interactions among components serve to regulate the interaction between the system and its environment, we can describe the system as both adaptive and self-regulating. So, say that some X, whether introduced from the environment as a new input or generated from within the system by an internal change (see Barnett 1983 for examples), serves to change one or more of the system's components or their relations so that the system achieves new states. The sustainability of X depends on the extent to which the changed system can regulate its internal relations to achieve a new steady state in relation to its environment. The X initiating the change is sustainable if and only if the system continues to be adapted to its environment.

Taking X as technology, what does "sustainable technology" mean? What is it that is sustained: the technology? the population? the environment? From a systems perspective, what is sustainable or unsustainable is a particular kind of relationship between a population and its environment. This relationship is shaped by the hardware; by its techniques of fabrication, acquisition, and use; by the social organization regulating access to the hardware and techniques; and by the features of the environment to which they are applied. One can examine the components of this relationship and see how they cohere. One can ask, for example, whether a particular social organization can support a particular technology. Or, one can ask what the minimal social organizational requirements for a particular technology are or which environmental relationships change with the adoption of a particular technology. For example, the adoption of metal fishhooks on Kapingamarangi Atoll in Micronesia resulted in reduced pressure on several species of mollusks and fish (e.g., filefish) formerly used for hooks, cutting tools, and abrasives.

Focusing on the kind of relationships between the population and its environment that result from a particular technology, one can say that a sustainable technology is an outcome of the persistence of that relationship. This view of the matter casts doubt on the reliability of population size as an indicator of a sustainable technology. Population size may be an outcome of any number of factors having little to do with technology. As demonstrated below, population size can vary dramatically with no change in the population-environment relationship.

With these systemic considerations in mind, I turn to a specific case to examine the utility of this approach to sustainability. The ethnography of fishing practices on Kapingamarangi Atoll, a Polynesian community in Micronesia, affords a useful test of the systems view of sustainability for five reasons.

1. It is a longitudinal ethnographic study beginning with the Thilenius expedition in 1910 (Eilers 1934), followed by research in 1947 by Kenneth Emory (1965), Peter Buck (1950), and Samuel Elbert. A team of environmental scientists worked on Kapingamarangi in 1954 (McKee 1957; Niering 1956; Wiens 1956, 1962). My own field research began in 1965 and has continued through five field stays to 1990 (Lieber 1994). Ethnohistorical work extends our data back to about 1780.
2. The acquisition of materials for and fabrication of traditional fishing hardware are documented in superb detail by Peter Buck (1950), supplemented by the organization of the techniques of its use and the social organization of its application to specific locales in the atoll environment (Lieber 1994).
3. Changes in fishing technology have been documented from precolonial to colonial through the most recent times—all in the context of how fishing is organized.
4. A systems framework guided the design of the data collection on fishing activity on the atoll (Lieber 1994:19–39). By using the activity as the unit of analysis, data collection focused on the processing aspect of the population-environment relationship so that features of each activity (e.g., goals, procedures, personnel, social organization, equipment, and occasions for an expedition to net spinefish on the reef) are immediately generalizable as constraints shaping the activity. This generalization enables comparison of constraints and the organization of constraints across different fishing activities, making their systematic nature transparent (ibid.:113–127).[1]
5. Data on fishing activities and their organization are without exception Kapingamarangi fishermen's own accounts of their work. Thus, empirical generalizations about its systemic organization follow from the ways that Kapinga fishermen represent what they do, how they do it, and why they do it that way.

Kapingamarangi Fishing Activity: The Lesson of Obsolescence

Kapingamarangi Atoll is fifty miles north of the equator, lying northeast of New Guinea and 485 miles southwest of Pohnpei Island, the capital of the

Federated States of Micronesia, of which the atoll is part. Before colonial contact in 1877, Kapingamarangi was one of the more isolated atolls in Oceania. The atoll's half a square mile of land area supports a population of 450 people, who make a living cultivating taro, breadfruit, coconuts, and pandanus, the only food plants native to the island. Protein comes from the reef, lagoon, and deep sea. By 1900 Kapingamarangi (hereafter Kapinga) fishermen had a repertoire of eighty-five different, named catch techniques. These techniques were variations of seven major methods—netting, angling, pole and line, trapping, use of weirs, collecting on the reef, and diving (for clams).

The Organizational Context of Traditional Fishing Activity

Before conversion to Christianity, Kapinga fishing activity was organized to respond to two sorts of environmental conditions: (1) predictable variations in winds and associated water surface conditions and tides, and (2) the much less predictable activity of spirits, six of whom inhabited the deep sea, while others moved between the island and the horizon.

Several constraints shaped the choice of netting methods. Most important are seasonal wind and tide patterns and variations in tide patterns through a lunar month. During the windy season, from October through early April, the lagoon is choppy, making canoe travel impossible, and there is one low tide per day, usually in the evening or at night. Fishermen had to rely on angling in the lee of the wind beyond the reef, on pole and line fishing between the channels and on the seaward shores of the islets, and on group netting on reef flats. During the calm season, the lagoon is navigable, and there are two high tides and two low tides per day. Every technique in the Kapinga repertoire was available. During a lunar month in any season, the rapidity of fill and ebb, how long the tide stays low or high, and how high or low the tide gets varies regularly through three-day periods from the new moon to two days before and two days after the full moon, followed by another set of three-day periods until the next new moon. Different tide patterns bring different fish together in the varied reef ecosystem, and netting activity is planned around these regularities. Other constraints on netting included manpower, canoes for transporting people and fish, the presence or absence of spirits in the lagoon (forcing a possible taboo on fishing activity), alternative methods being made available by the arrival of pelagic fish (e.g., tuna), and variability in the fish and bait supply. Which techniques were available to which fishermen on any day, however, depended first on the expected activities and dispositions of powerful, whimsical, and often malicious spirits.

Six spirits inhabited the sea, each controlling a sector of ocean surrounding the atoll in roughly six concentric circles beginning at the seaward reef margin and extending out to the horizon. Fishermen on canoes had to know where each boundary was, which god controlled the sector, and which chant of appeasement was appropriate for it. Because each god had to be familiar with the man doing the chanting, the farther from the reef the canoe traveled, the older the fisherman had to be. This requirement resulted in an age stratification of anglers. This stratification was embodied in the personnel on a canoe and replicated in the seating arrangements in the men's house, where the oldest men were seated farthest lagoonward and younger men seated progressively inland.

Other spirits (or gods) came to the island each evening to sleep in the cult house, leaving each morning to travel southward through the islets and then out to the horizon. These spirits killed anyone encountered on their route, so people stayed indoors until the spirits had left. The gods being unpredictable, avoiding them was sometimes impossible. Occasionally, one or more of them would break off the daily routine and return to the island early. Refusing to be visible, they took the form of sharks, whales, or rays. Fishermen had to be familiar enough with these animals to recognize atypical behavior signaling a god in animal form. The response to a sighting was first a ritual chant of appeasement, then a signal to other canoes to vacate the ocean, and then a race shoreward to notify the high priest. The high priest organized the proper ritual to determine why the god or gods had returned and what they wanted. Ocean and lagoon were ordinarily tabooed until the high priest determined that the gods had resumed their normal routine.

Because of the dangers of deep-sea angling, the high priest had to ensure that the men who worked on the deep sea were trustworthy. If a fisherman erred by misidentifying a shark as a god, for example, the result was the loss of a day or two of fishing. If he misidentified a god as a shark, the result was far worse—death through encounters with the god as well as many other deaths through the gods' vengeance, expressed in droughts, fierce winds, lack of fish, and so on. One way of forfending possibly costly mistakes on the water was limiting access to canoes. The high priest controlled all of the breadfruit trees and drift logs from which canoes were made. His permission was necessary to select a log and to begin construction. His information about a fisherman was supplemented by the secular leader, whose permission was also necessary to begin construction. This leader, the *tomono,* was the sponsor of the men's house connected to the cult house. He worked with the men's house headman to enforce group decisions, helped to organize labor on men's house and cult house repair, and provisioned men's house feasts. His contact with fishermen was instrumental in deciding who was fit for dangerous work. Less than a third of active fishermen owned canoes before 1917 (Emory 1965; Lieber 1994). The other two-thirds did their fishing in groups organized through the men's house. Canoe ownership, however, did not make a fisherman free to do as he pleased.

All fishing on any given day was coordinated through the men's houses. Each evening, men's house members would meet with the headman, discuss the day's fishing, and plan for the next day. Reports of conditions on the reef, lagoon, and deep sea—what fish were available, what schools of fish were sighted on the reef (particularly by anglers on their way to or from the channels), and the like—were discussed. What netting expeditions would go out the next day, who would go with which group, how the men's house canoes and gear would be distributed, who would lead each group, and where groups would go and when were all decided in the meeting. If fishing groups needed more than the two canoes owned by the men's house, anglers would be conscripted to provide both canoes and personnel for netting groups. For example, the first three days of the new moon during the calm season were full of activity—netting flying fish in the evening, blocking the channels at several islets to catch fish caught by the rapid ebb tides during the early morning, going out to net spinefish on way to the main channel in the late morning, mounting surrounds of rock piles on the reef flat during the afternoon, and angling close to the reef margin both at night and during the day. Late morning and afternoon fishing all required canoes and nets, so personnel and gear transfer had to be tightly coordinated to get all the work done. As tide patterns changed during the lunar month, different netting methods had to be similarly coordinated with bait fishing and angling.

The constraints on fishing activity were, thus, hierarchically ordered. At the top were ritual constraints that determined whether fishing could be done and where permissible and impermissible areas were. If fishing was permitted, then seasonal conditions determined which fish habitats were available. Information about available fish habitats from fishermen at men's house meetings fed into decisions about which specific expeditions would be mounted on a given day and how personnel would be distributed to each. Once these decisions were made, the men doing angling had to cope with availability of bait, tide and wave conditions allowing passage to the deep sea, and current conditions determining how chum and bait would be used. The men doing group netting had to cope with tide patterns, timing of travel to the area to be fished, and transport of gear and fish.

Was this hierarchically organized relationship between the Kapinga and their environment sustainable? The answer must be a qualified yes, because that relationship remained unchanged until the 1920s. Adding the qualification of a population's being sustained at a continuous or expanding size, however, renders the answer less clear. Kapingamarangi is typical of what Alkire (1978) calls a "low island isolate." Without regular contacts with other islands (until after 1877), natural disasters such as extended droughts precipitated boom-and-bust cycles. A drought and famine between 1916 and 1918, for example, killed about 30 percent of a population recovering from a slaughter of about half its people by Marshallese castaways in 1870 (Emory 1965:53–55). Wiens (1956) estimates the population as about six hundred before 1870, yielding a variation between six hundred and three hundred persons. In contrast, atolls that are parts of interisland networks (either as interacting "clusters," such as the Tokelaus, or as "complexes," parts of political hegemonies of high islands, such as the so-called Yapese Empire) show a narrower range of population fluctuation (Alkire 1978). In times of stress on islands that are parts of clusters or complexes, people rely on aid from friends and kin on other islands. The resident population on such stressed atolls can vary as dramatically as that on an isolate, but migration, not death, accounts for most of the variation.

How should the observer specify the population size for which a particular technology is sustainable? Is the number of people left after the drought the appropriate figure? Does the figure depend on the frequency of such disasters, so that it is necessary also to specify the average or mean number of years between disasters? Should one adjust population size for conditions of isolation or island networks? If so, should researchers isolate populations with de jure or with de facto populations of clusters and complexes? Or are the isolation of Kapingamarangi and the networks of atolls of, say, Arno in the Marshalls (see Hess in this volume) or Pulap in the Westerns (Flinn 1992) taken as conditions that facilitate and constrain people's adaptations? Perhaps the difference between Kapingamarangi and Arno before colonial contact was the navigation technology that Arno had and Kapingamarangi lacked. Does that difference make for a more sustainable population on Arno than on Kapingamarangi? Or does it simply imply a smaller fluctuation of population size on Arno than on Kapingamarangi? For those who survive the brunt of the typhoon (which Kapingamarangi also lacks), perhaps.

Clearly, the complexities inherent in the variables that determine population size render determination of an atoll's "carrying capacity" highly speculative. Sustainability as a function of population size may make theoretical sense, but any specification beyond a documented range of fluctuation becomes an exercise in arbitrary decision making of the observer. The difference between an atoll isolate and an atoll in a regional network is that they are part of qualitatively and quantitatively different environments. The technologies that mediate the population-environment relationship are different but comparable as analogues:

Kapinga : Arno :: Gods : neighboring atolls :: ritual techniques : navigation.

If one concludes that traditional Kapinga fishing technology was sustainable, then what happens when innovations are introduced into that technology? Is the technology still sustainable? I address this question first with innovation in precolonial fishing activity and then with data on innovation during the colonial and postcolonial periods.

Innovation in Precolonial Kapingamarangi Fishing Activity

Although isolated until colonial contact, Kapingamarangi occasionally received castaways introducing new knowledge. Castaways from Woleai (about 1780) introduced a new variant of a surround used on the outer reef. This method, called "coconut leaf netting," is similar to an indigenous technique called "pushing up the lagoon beach." Both require about thirty to forty men. A purse net is placed either on the outer reef flat (with a four-foot-high tide) or on the inner reef flat (with a lower high tide), with long coir nets attached to each end of the purse net, forming a wide V shape with men holding up each end of the coir net. The rest of the men form a wide arc about one-half mile in diameter, surrounding an area and slowly moving toward the nets. In the older method the men surround the fish, gently sweeping poles along the surface of the water to slowly push the fish toward the reef. In the newer method they use a long rope with coconut leaves tied to the rope every five feet or so to surround the fish. The men slowly pull the rope in toward the nets. Once the fish are inside the range of the coir nets, several men take each end of the coir net and close it behind the fish, preventing their escape. Once the coir net is closed, the fishermen continue to push the fish into the purse net, whose ends are then closed, trapping the fish. The major difference between these two methods is that the older method nets only larger fish, such as parrotfish and larger surgeonfish, that cannot hide in the crevices of rocks and coral heads. The smaller fish left untouched attract other larger fish to the area within a few days. The coconut leaf method, however, nets all of the fish, as the smaller fish flee their hiding places at the approach of the coconut leaf. It takes weeks until the area is ready to be fished again.

The older method was used mainly for supplying small feasts, family affairs where the prestige of supplying larger fish to guests is important in making a splash. The newer method was used to supply larger groupings with lots of food. Because of its relative efficiency, it was the method of choice during the windy season, when none of the methods requiring canoe travel in the lagoon was available. Its popularity prompted much scouting of the reef for additional places where a net could be set. Fishermen alternated the use of this method with other netting techniques available for the windy season, such as netting goatfish and soldierfish on the outer reef during the day and at islet channels during the evening low tide. Pole and line fishing and angling in the lee of the wind supplemented netting. During the calm season, neither of these surrounds was used often.

These two netting techniques differed in only two features—the use of poles as opposed to the use of a rope with attached leaves and the necessity of changing catch sites more often because of the larger and more varied catches of coconut leaf netting. There was a significant overlap of important features such as their identical personnel and organizational requirements. Their different catch profiles allowed for segregating their uses into different, complementary contexts. Their potential for overexploiting reef fish was constrained by diminishing returns in catch size, making other techniques more attractive. The conclusion that coconut leaf netting was sustainable is warranted by its compatibility with other catch techniques and the fact that this technique is one of the very few that has survived twentieth-century technological and social change, remaining part of the current repertoire (although it, too, faces obsolescence).

All of the other examples of technological innovation in fishing activity on Kapingamarangi are part of the larger context of colonial contact and domination of the atoll by three successive colonial administrations, resulting in a sequence of profound social organizational changes. The relatively simple case below illustrates problems of innovation and obsolescence in a context in which technological change results from diffusion rather than planned development. The data on change in the next two sections focus on whether a particular population-to-environment relationship can sustain particular items of technology.

Innovation in the Colonial Context

Regular colonial contact resulted in Kapinga traveling to other islands for periods of days, months, and years, with some young men learning new fishing techniques and introducing them on their return to the atoll. One such technique was the use of the throwing net, learned from Japanese fishermen on Pohnpei Island in the early 1900s. The throwing net was introduced in 1920 after the atoll's conversion to Christianity, which replaced the ancient religion that constituted the major constraint on fishing activity. The throwing net rapidly replaced four group netting techniques that required twelve to twenty men. The throwing net could cover the same area of the reef (or deep water just seaward of the breakers) as a surround group. Since the net's areal coverage eliminated the necessity of surround, it took less time to conduct. One person with a throwing net could net about the same number of fish as a surround group. The use of a throwing net also replaced two pole and line methods used on the inner reef. Both of these pole and line techniques required several men fishing together to be efficient.

Of these four obsolete netting methods, one was conducted on the outer reef and the others at surge channels at the outer reef margins. Two of the four were young men's sport. The method practiced on the outer reef flat, for example, was called "netting while glancing up." It was used at tide pools on portions of the outer reef flat when afternoon high tides stayed steady at about ten to twelve inches. Two or three older men holding a purse net at the lagoonward edge of the tide pool directed groups of six young men, who, at a hand signal, would run screaming through the tide pool, chasing the fish feeding there to the purse net.

The other sport method was called "netting while strolling seaward," conducted during the calm season, when late afternoon tides reached twelve inches, and sea bass, trevally, surgeonfish, and triggerfish came to the reef margin to feed. One or two older men directed a group of twelve to fourteen young men, who surrounded the fish at the seaward edge of the outer reef margin and, at a hand signal, swam and ran screaming through the surf toward the reef, chasing the fish before them into a hand-held net set at the base of the surge channel.

The other two netting methods took advantage of weak wave action during the late afternoons of the first and third quarters of the lunar month, when surgeonfish and squirrelfish feed in the breakers. Spotted surgeonfish are easily frightened, so surrounding them took time as men swam out to deep water and, using poles with a slow, sweeping motion, slowly herded the fish toward a surge channel at the reef margin, where two men waited with a hand-held net. The men kept a low profile in the water and timed their push so that the fish went in waves to the net. Striped surgeonfish and squirrelfish are less easily frightened, so the push method used for them took less time.

The hardware for conducting these four types of expedition was relatively simple and accessible—a purse net for one and poles and a hand-held net for the others. The organization of these expeditions was simple—one or two men led and held nets, and the others conducted the surround. All (with the partial exception of netting striped surgeonfish) were organized through the men's house. Kapinga fishermen retained the capability for mounting these four types of expedition well into the 1950s, and the fact that each of these methods was conducted for two or three days per lunar month during the calm season obviated overfishing. From a technological perspective, these usable techniques became expendable after the introduction of the throwing net. But there is a good deal more to expendability than technology in these cases.

The introduction of the throwing net coincided with a reorganization of the atoll social order following a disastrous drought and famine from 1916 to 1918 that claimed the lives of ninety people and the ancient religious order among its victims. The secular chief, the *tomono,* had emerged as a political power on the atoll owing to his position (which colonials called "king") as liaison with the colonial agents visiting or living on the atoll. Conversion to Christianity left this man and the men's houses as the surviving political institutions. The "king" was also the native pastor of the (Congregationalist) church, and he used both the pulpit and monthly community meetings to communicate atoll policy.

By 1920 Kapinga landowners found themselves in control of their own breadfruit trees with no one to prohibit either their building canoes or their using them whenever they wished. The introduction of a new style of canoe from Nukuoro Atoll, 164 miles to the north, helped to spark a frenzy of canoe construction after 1922. The Nukuoro canoe was faster, more maneuverable, and required far less wood and time to construct than the indigenous one. By 1947, 243 of these canoes had been built (Emory 1965; Lieber 1994), rendering the traditional canoe obsolete.

Deep-sea and lagoon angling had always been the most prestigious fishing methods, and with equalized access to canoes (by owners and their crew members), the number of men angling tripled in the thirty years following the collapse of the ancient religion. As the frequency of angling increased, that of group netting decreased. While men's house membership remained steady, their organizational capability weakened, particularly since the headmen had no way of enforcing men's house decisions, even when there was a consensus. The men's houses continued to be places where young, unmarried men slept and where men of all ages met to talk, repair gear, and plan expeditions for feasts or alternatives for bad luck in angling expeditions. What helped maintain men's houses as viable institutions was their emerging political functions as places where the "king" and his assistant could build consensus on policy issues. Work schedules, however, had changed, and netting became one alternative to angling or, particularly during the windy season, a supplement to angling.

The organization of fishing activity had changed as its higher-level constraints changed. Almost anyone who wanted to participate in angling expeditions could, and besides the throwing net, spear fishing with diving goggles and a hand-held spear had become popular among younger men, who were the first to explore underwater fish habitats. The throwing net made it possible to continue to catch the same fish that had been targets of the four obsolete methods. But the fact was that the personnel requirements for these methods could no longer be consistently met. The organizational infrastructure that made these netting methods possible no longer existed. Thus, from a social institutional perspective, these four netting techniques were not only expendable, but also, and more important, unsustainable—organizationally unsustainable.

Technology, Authority, and Sustainability

The precolonial organization of fishing activity was a nested hierarchy with the high priest at the top. The Kapinga conception of community was an organized response to danger from the outside—from the gods, ultimately—so that the community was identical to the congregation, which was headed by the high priest (who could communicate with the gods). He was assisted by the *tomono,* whose position as the sponsor and enforcer of the men's house connected with the cult house gave him control over a considerable labor force. The men's house headmen were the ones to whom the high priest communicated information about the nature of spirit activity on the water and which areas were open or prohibited to fishing. The headmen used this information in nightly men's house discussions to plan the next day's activities. The result of this structure of authority was a regulation of fishing activity that spread catch pressure over some two hundred species of fish over the course of a year. The men's house was ideally suited for the communication of authoritative information and the exercise of authority over coordination of activities for several reasons: (1) the activities that the men's house coordinated shared considerable overlap of critical features, most requiring an organized group of men and several types of gear (nets, traps, and ropes), making a standing group the most efficient way of organizing the activities; (2) it was a central place where information could be disseminated; and (3) it was a multipurpose institution, coordinating fishing, distributing labor for cult house projects, housing unmarried men, serving as the forum for nominating a new high priest, and providing storage for canoes, nets, and other gear.

The community organization that followed the collapse of the cult house was no longer hierarchical, but it had important continuities with the traditional order. The order that developed in the 1920s consisted of four separate but connected institutions—the chief, the church, the men's house, and the community meeting (committee of the whole). The chief (or king) was also a pastor of the church, and he used that latter position to legitimate his chiefly decisions. The chief used the men's houses to help formulate public policy and to create consensus for them prior to the community meeting, where decisions were discussed and ratified. This organization of distinct institutions connected together by the person of the chief gave the image of autocracy while having the substance of carefully managed consensus. Like the high priest, however, the chief was the liaison between the community and powerful outsiders—the Japanese colonial administration and Jehovah. While his policies were sometimes questioned, his authority was not.

The men's houses maintained their membership under the new order. Even as more members opted for deep-sea and lagoon angling, the men's houses continued coordinating netting expeditions requiring large groups. The efficiency of men's house organization for these activities was obvious, as was its role in communicating information about fishing conditions and organizing large groups for labor, as for community feasts or work on the church house. Part of the reason for the continued role of men's house fishing expeditions was a radical change in work scheduling owing to the introduction of a church calendar that divided time into weeks, months, and years. The week was the most important, since Sabbath meant no fishing or other work, making Friday the day for getting vegetable foods from land on the outer islets and Saturday the day for getting enough fish for two days' worth of meals. When tuna were not in season, Saturday netting expeditions were required. Fishermen's work weeks were five-day weeks, weather and other projects permitting.

With the establishment of the American administration (the U.S. Trust Territory of the Pacific Islands) after World War II, the Kapinga social order underwent yet another transformation. The last chief abdicated his position in favor of a chief magistrate, to which position he was immediately elected. Using the American model learned in high school, he set up and trained an elected legislative council of ten men. Two local-court judges were later added, and the atoll was chartered as a municipality of Ponape District in 1960. The elected officials quickly learned that their supposed powers of self-determination were limited by a whimsical administration and an increasing number of bureaucratic agencies of the administration that controlled school, dispensary, cooperative, and other policies affecting local affairs. Authority on the atoll became fragmented in a way that reflected the bureaucratic organization of departments and agencies of the colonial administration. Characteristic of these new institutions was their separation from the church and the irrelevance of the men's house to deliberations on public policy. Such deliberations were now the prerogative of the legislative council and its committees. From the late 1960s onward, the location of authority became increasingly uncertain.

The results of the gradual ambiguation of authority are clearly seen with regard to the coconut leaf netting method that began this account. This catch technique, a mainstay in the Kapinga repertoire for two hundred years, had ceased to be used by 1982. The reason, according to fishermen, was that the headman could no longer control "young men" during the final phase of the surround. Once the coir net is closed behind the fish, they are packed together and looking for escape routes. It takes several men holding the net to continue to push them toward the purse net that traps them. Younger men brought spear guns, and instead of holding their parts of the coir net, they speared the fish inside, allowing most of them to escape through the openings they created. When younger men ignored the headman's subsequent ban on spear guns at coconut leaf netting, the headman refused to conduct any more expeditions.

Unlike the four netting techniques made obsolete by the throwing net and the organizational changes of the 1920s, the organizational infrastructure to mount a coconut leaf netting expedition existed. Missing was the authority of the headman to compel all participants to follow instructions to complete the catch. Coconut leaf netting is now an unsustainable activity—an outcome of change at two levels of social context. The organization for the implementation of the technology remained but community organization from which the men's house derived its authoritative constraints on its members had changed. The men's house headman's lack of authority was an outcome of changes in the organization of the community, whose fragmented authority structure left the men's house as one more institution, like the church, the school, the court, the cooperative, the dispensary, and the council, with no central integration from which authority could be derived. This catch method was technologically and organizationally sustainable, but politically unsustainable.

Obsolescence and Sustainability

It is clear that innovation can augment the technological repertoire, but it can also render parts of that repertoire obsolete. The four cases presented above exemplify processes involving fit, obsolescence, and categories of sustainability. Table 1 summarizes the outcomes of these processes. The table lists all of the catch techniques that were verifiably obsolete as of 1990.

Of the thirty-eight techniques listed in Table 1, all but four are technologically sustainable. That is to say, for the remaining thirty-four techniques, the hardware and the knowledge of how to use it were still available as of

1990. By examining the four technologically unsustainable techniques, the temporal property of sustainability becomes apparent.

Two of these techniques, NC4 and NC5, are described as organizationally unsustainable by the 1920s. By 1982 they were also technologically unsustainable, because the men who knew how to organize them had died. None of the old men who described these techniques to me had actually participated in them. Similarly, netting at the rock piles (NC) had not been practiced since 1920, and no one was considered capable of leading such an expedition. The rainbow runner surround had not been practiced for about twenty years, and not only was the men's house headman without the power to control the younger men on this very dangerous expedition, but he had never led one during his tenure and did not consider himself knowledgeable enough to lead one. Technological sustainability turns on what it means to know something, not only in these cases, but in all cases.

To "know" *(iloo)* something is to have had repetitive experience with it to the point of being "comfortable" with or "accustomed" to it *(wouwou).* It is this repetitive experience that gives one the right to know something (see Lieber 1994:116–118, 178–180). One's age, sex, family status, and the like confer eligibility to learn particular things. Men have the right to know how to fish, but they do not have the right to know how to plant and care for taro. Men's house headmen have the right to know how to lead rainbow runner netting expeditions, while those who are still apprentices do not have the right to know (but are acquiring it). Knowing how to do something, moreover, is not the same as knowing how to organize and direct others in doing it. Because experience and the right to know are acquired by persons, all that is glossed as "knowledge" is personal knowledge rather than the Western concept of a body of accumulated information that is (at least potentially) available to everyone. As for rights over knowledge, when those with the right to know (from experience) disappear, the technique disappears. The techniques listed as technologically sustainable are only temporarily so. By the year 2010, all techniques listed in Table 1 will be technologically unsustainable, and the number of obsolete techniques will have nearly doubled.

The catch methods in Table 1 give a slightly distorted picture of the relative vulnerability of traditional catch methods to obsolescence. By measuring the percentage of obsolete to nonobsolete methods in each category of catch technique listed in Table 2, the profile of relative vulnerability of catch methods (in Table 1) to obsolescence becomes quite clear.

The processes of obsolescence vary by category. Weir fishing is the most vulnerable. Minnow weirs, set up on the reef flats adjoining the central islets to trap minnows as they crossed the reef, became obsolete after red tides wiped out the minnow population in the 1950s. Goatfish weirs were

TABLE 1. **Obsolete Fishing Techniques**

Technique	Replaced By	Dropped Entirely	Technologically Unsustainable	Organizationally Unsustainable	Politically Unsustainable
Netting					
NC—netting at rock piles	–	associated with 1916–1918 famine	+	+	+
NC3—spreading out to lagoon beach	–	–	–	+	+
NC4—strolling seaward	throwing net	–	+	+	–
NC5—glancing up	throwing net	–	+	+	–
NC11—net rainbow runners	night angling	–	–	+	–
NC12—spotted surgeonfish	throwing net, spear	–	–	+	–
NC14—Waigeu drummers	throwing net, angling	–	–	+	+
NC15—flying fish (surround)	throwing net	–	+	+	–
NC16—striped surgeonfish	throwing net, spear	–	–	+	–
NC17—triggerfish	angling	–	–	–	–
NY1—soldierfish	spear	–	–	–	–
NY2—squirrelfish	trap, spear	–	–	+	–
NW1—coconut leaf netting	–	–	–	–	+
NW2—diving	spear, angling	–	–	+	–
Pole and line					
PC1—coral heads	spear	–	–	–	–
PC2—handfish	throwing net, spear	–	–	–	–
PC3—triggerfish	angling	–	–	–	–
PC4—bonito	trolling	–	–	+	–
PC5—Waigeu drummers	throwing net, angling	–	–	–	–
PC6—snapper	–	+	–	–	–

PC7—mullet	throwing net	–	–	–	–
PC8—crimson squirrelfish	throwing net (bait fish)	–	–	–	–
PC9—goatfish *(madu)*	–	men refuse to chum for 4 days		–	–
PC9—garfish	throwing net	–	–	–	–
PC10—goatfish *(gala)*	–	men no longer chum 4 days		–	–
PC11—bluespot mullet	–	men no longer chum 5 days		–	–
Weirs on reef					
WR1—minnow	–	+	minnow population gone	–	–
WR2—goatfish	–	+	–	+	–
WR3—garfish	–	+	–	+	+
Traps					
T2—stinky trap	angling	–	–	–	–
T4—flat trap (reef eels)	–	+	–	–	–
Lagoon angling					
LD4—Vlaming's unicornfish	–	men will not chum for 5 days		–	–
LD5—Waigeu drummers	spear	–	–	–	–
LD6—gold-banded fusilier	–	men will not chum for 5 days		–	–
Deep-sea angling					
DC3—buried line	canoe angling	–	–	–	–
DC4—chumming the hole	baited hook tied on rocks	–	–	–	–
DY3—sharks at drift logs	–	+	–	–	–
DC10—crimson squirrelfish	–	+	–	+	ritually no longer required

Source: Coded from Lieber 1994:215–218.

TABLE 2. **Percentage of Obsolete Catch Methods by Category**

Category of Catch Method	Total Methods in Category	Number Obsolete	Percentage Obsolete
Weirs	3	3	100
Netting	27	14	52
Pole and line	15	7	47
Trap	5	2	40
Angling	29	7	24

simply abandoned when the men's houses no longer organized their maintenance. With an increase in angling and with at least four other techniques for capturing goatfish, there was neither the interest nor the organization to use or maintain these weirs. Garfish weirs were the property of two priestly families, whose ownership was recognized by token gifts of part of a catch. These fell into disuse after conversion to Christianity. This change can be seen as part of the decline in the frequency of group-organized expeditions, but garfish weirs also had the taint of the heathen "time of darkness."

Netting depends on organizing a group, which depends on institutionalized differences of leadership and followership and institutionalized contexts of organization. The decay of men's house organization leaves netting expeditions as ad hoc procedures, dependent on men recognized as capable of leading expeditions. As these older men retire, there are increasingly fewer younger men with the knowledge and authority to replace them. This process of diminishing opportunities for leadership experience began with the collapse of the ancient religion and was accelerated by political reorganization of the atoll after 1958 (Lieber 1994:131–188). By the 1960s the men's house organized only the large, coconut leaf netting surround and the capture of three species of spawning fish—coral trout, rabbit-faced spinefoot, and vermiculated spinefoot—(as described above) on the outer reef. Other netting expeditions were organized on the spot. Of fourteen obsolete netting methods, all but one required a minimum of eight men to perform. These techniques are the most vulnerable to changes in political and institutional organization, as the decreasing frequency of netting expeditions resulted in decreasing frequency of opportunities to learn the catch methods' organization, procedures, and skills. Thus, it is political changes that have resulted in (and continue to drive) the obsolescence of netting techniques.

Pole and line techniques, unlike netting, are highly individualized. While they are effective catch methods, they lack the prestige of angling. As canoe ownership increased, the frequency of pole and line fishing decreased rapidly, particularly those techniques that required several days of chumming before using a hook and line. Men no longer see the need to spend three to five days chumming when they can go into the deep sea with less chum and bring home fish the same day. The pole and line techniques that survive are, like surviving netting techniques, ad hoc procedures that can yield a catch in a single day.

Of the two obsolete trapping techniques, the white eel trap was simply abandoned with the rush to acquire canoes and go angling. The stinky trap, a very large trap for fish like the giant snapper, jewfish, and other large fish, was replaced by angling, which required only one trip to the pass as opposed to the two to three trips necessary to place, check, and empty the trap.

The processes of obsolescence listed here all derive from organizational change in the atoll sociopolitical order. That is, obsolescence is an outcome of systemic social and political change. Only two technological innovations have in fact qualitatively changed Kapinga fishing methods—the spear gun and the throwing net. Metal fishhooks, manufactured lines and nets, cloth and polyester sails, the Nukuoro canoe, and outboard engines have replaced their local equivalents, but these items are not responsible for the obsolescence of the thirty-eight techniques listed in Table 1. The throwing net replaced only six techniques, and spear fishing has replaced two netting techniques already replaced by the throwing net. These six techniques were already organizationally unsustainable with or without the throwing net.

Innovations in Kapinga ritual and political organization (that equalize access to canoes) account for the accelerating obsolescence of traditional fishing technology. While catch techniques in use have not changed very much, their deployment has changed, and with this change has come a change in the population-environment relationship. Nothing illustrates this change better than the atoll landscape.

Change, Differentiation, and Obsolescence within the Atoll Landscape

Colonial contact brought to the atoll a wide variety of Western goods that Kapinga desired. These demanded cash, mainly from the sale of copra. By 1954, 80 percent of pandanus trees had been replaced by coconut trees (Wiens 1956). The introduction of *Xanthosoma* taro, which quickly became a dietary staple, not only largely replaced the native *Colocasia,* but also resulted in the tripling of central islet areas given over to taro pits, replacing breadfruit, pandanus, coconut, and other plants formerly grown in these areas. After 1914 access to cash was augmented by emigration to Pohnpei for contract labor, wage work, and commercial fishing. The founding of a Kapinga colony in Porakied (in Kolonia town) on land leased from the Japanese colonial administration enabled a steady flow of people between Pohnpei and the atoll (Lieber 1977). These opportunities were further augmented after World War II by U.S. Trust Territory of the Pacific Islands development programs, which brought wage work (including positions as teachers, nurses, and radio operators, legislative stipends, and jobs in public works programs) to the atoll and provided educational opportunities for Kapinga to qualify for positions on the atoll and on Pohnpei. The incorporation of the Federated States of Micronesia has brought yet other opportunities for acquiring cash.

All of these activities procure cash for what has become a subsistence fishing technology that requires money to implement, for hooks, lines, leaders, weights, spear guns, outboard engines and parts, and gas and oil. Acquiring cash has focused people's attention outward to sources of cash and the education, training, and institutions that make cash accessible. Pohnpei, its associated atolls, other islands making up the former U.S. Trust Territory of the Pacific Islands, Guam, Saipan, Hawai'i, and the U.S. mainland are all places familiar to Kapinga people through personal experience and the stories of kin and friends. Kapinga working as fishermen and sailors have become familiar with Rabaul, Port Moresby, Honiara, Pago Pago, Fiji, Japan, Taiwan, Hong Kong, and Manila. Eight Kapinga families now live on the U.S. mainland. The world outside the atoll has become ever more differentiated since 1877, that differentiation corresponding to the growth of opportunities for financial gain.

The atoll landscape, at the same time, has become ever less differentiated. Figures 1 and 2 show the place names of every sector of the outer reef, the inner reef, and the coral heads in the lagoon. These place names were pieced together in 1982 from the knowledge of the oldest fishermen on the atoll, men in their seventies and eighties, and cross-checked both among them and with slightly younger men who knew names and locations of many but not all sectors. Younger men in their forties and fifties knew correspondingly fewer of the sectors. Knowledge loss formed a pattern by age category, with 90 percent retention among the oldest men (who had participated in all but two of the eighty-five catch types and disagreed only on sector boundaries). Men in their sixties knew most but not all of the outer reef names, between 50 and 60 percent of the inner reef names, and 80 percent of the coral heads. Men in their forties and fifties knew 60 to 65 percent of the outer reef names, 40 to 50 percent of the inner reef names, and 65 percent of the coral heads. Among the latter group, there were some names of inner and outer reef sectors that these men had never heard, some that they had heard but located incorrectly, and some that they had heard but could not locate.

These patterns of loss and retention correspond to the sorts of fishing experience that each age category has had with the shift from group netting, much of which was done on the inner reef, to angling, which is done in the

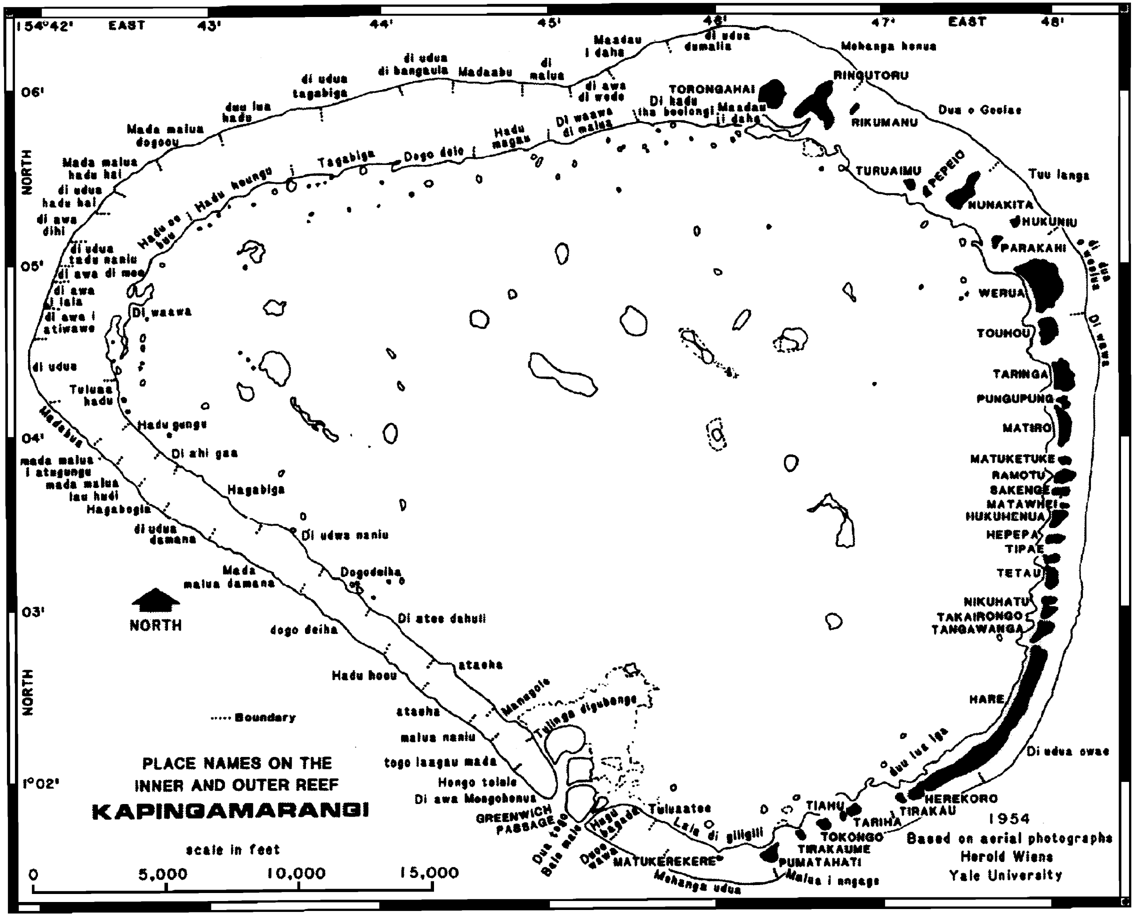

FIGURE 1. **Place names on the Kapingamarangi Reef.** (After Lieber 1994)

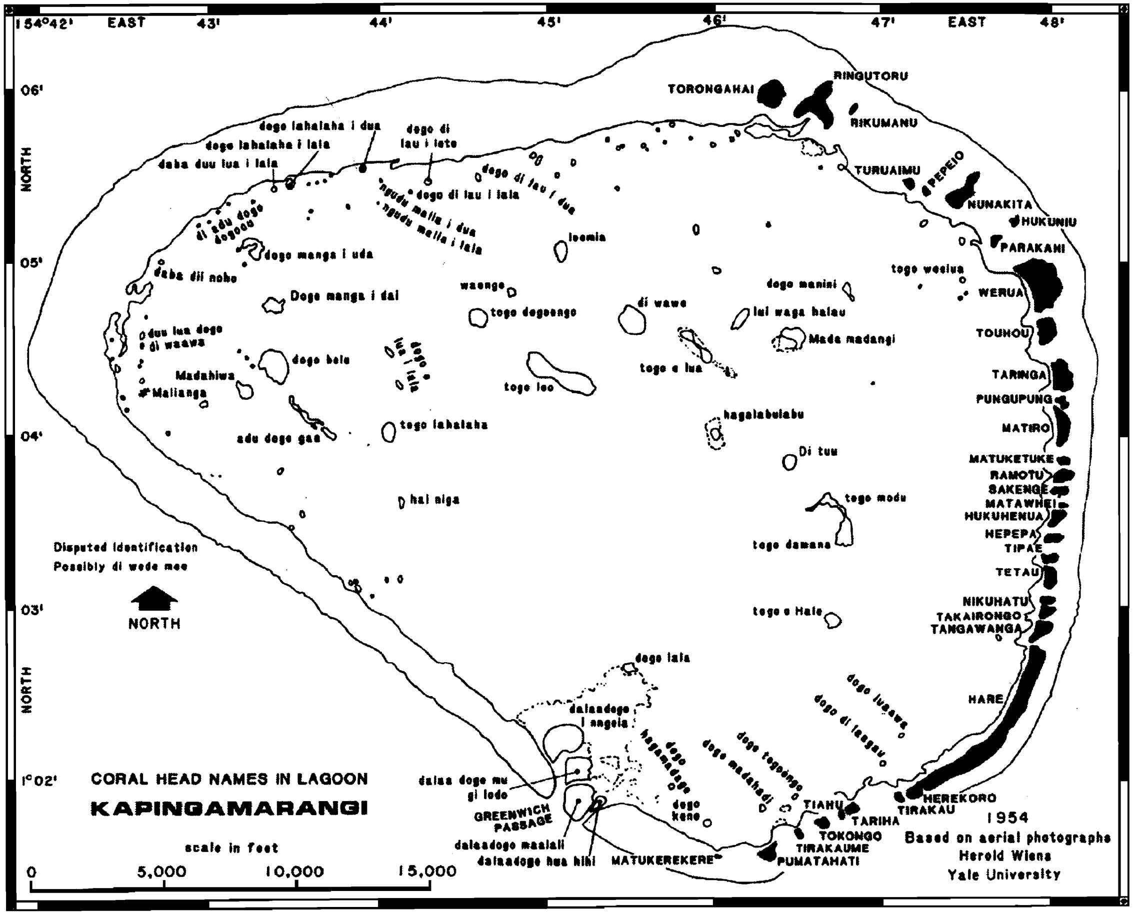

FIGURE 2. **Coral head names in the Kapingamarangi Lagoon.** (After Lieber 1994)

lagoon and by the larger coral heads and on the deep sea. Place names on the outer reef were and still are used to mark a fishing spot in deep water by triangulating with a feature of an islet across the lagoon or with a second named place. More of the outer reef place names have been retained, because these are still in use. Inner reef names are becoming obsolete at roughly the same rate as netting methods. Names of coral heads used for angling, bait fishing, and spear fishing have been retained, while those not so used (mainly in the northeast quadrant) are not remembered or learned.

In an inverse ratio, as Kapinga people's map of the world outside the atoll has become more differentiated, the map of their own island has become more homogeneous. Like the New Zealanders described by Dominy (this volume), those with differing interests map the landscape differently. In the New Zealand case, communities of interest differ in terms of economic, political, and ideological position, and the features of the landscape they contend over vary accordingly. In the Kapinga case, interest in and investment in the landscape vary within the same community by each generation's different experience of that landscape. For each of the competing interests in New Zealand, the high country constitutes a different sort of environment. For each Kapinga generation since 1920, the same atoll has constituted a different environment. Relationships between people and different parts of the environment—both with places and with the fish species that inhabit them—have been severed.

Change and Sustainability

Traditional fishing activity incorporated a sustainable technology until 1920 in the two senses in which the term is used here. The repertoire of eighty-five catch techniques with its associated hardware and organizational modes maintained a relationship between the atoll population and a wide variety of fish habitats in the lagoon, its coral heads and inner reef, the outer reef, and the deep sea, encompassing over two hundred species of marine animals. The population sustained the entire repertoire for several centuries. Is this technology sustainable today? The question is moot, since the technology, population, environment, and relationships among them have all changed.

The atoll population is only one part of the total Kapinga population. More Kapinga people live in Porakied village on Pohnpei than on the atoll, and Kapinga have two blocks of homestead land in Madolenimhw in the southern part of Pohnpei. Other Kapinga live in Guam, Hawai'i, and the United States. The off-atoll population is more than double that of the atoll population, which has remained steady at about 450 people since the 1950s (Wiens 1956; Lieber 1977, 1994). Between 1947 and 1950, there were almost

600 people living on the atoll (Emory 1965), with about 150 people repatriated from Pohnpei by the U.S. Navy. Once regular shipping between the atoll and Pohnpei resumed, people began returning to Pohnpei. The atoll population reached 450 by 1954 and has remained at that level since, with Pohnpei drawing off natural population growth on the atoll. It has been during this period, from 1956 onward, that fishing techniques have become obsolete at an accelerating rate while the political organization, with its redistribution of authority, has been transformed.

Fishing technology during this period has changed in a patterned way: the technology used today concentrates on angling, spear fishing, and netting techniques that can be organized on an ad hoc basis. That is, out of the total range of traditional techniques, a limited range has been selected—those that can be organized on an individual or small-crew basis. This selection has left Kapinga fishing technology specialized for deep-water and lagoon angling, supplemented by spear fishing, moray eel trapping, diving for clams, and occasional netting expeditions. The range of exploited fish habitats has narrowed accordingly. This is an evolutionary pattern of change. It is irreversible—even if fishermen could remember how to conduct obsolete catch methods, they no longer know where to conduct them, nor does the current social order provide the personnel, authority, and organization to support them. This pattern of change is analogous to the evolution of the horse from a browser to a grazer, relying on part of its previously exploited environment.

Although Kapinga fishing technology is part of an evolutionary change in the organization of the population-environment relationship, the level of systemic change is that of the organization of fishing activity and its instrumental linkages with other activities that produce cash. At a higher level of systemic organization, that of Kapinga assumptions about the context of these activities, there has been no detectable change whatever. That is, Kapinga people continue to assume that control over conditions of their environment and over marine resources lies outside the atoll social order. In the precolonial period, control was vested in the gods. Since 1920 control resides in Jehovah and in successive colonial administrations. While the agents of control have changed, the locus of control has not. Given this cultural premise, Kapinga people's access to resources and to influence over local conditions has always depended on their knowing what the powerful outside agents want and on complying with their demands and desires. Ritual activity, education, wage labor, copra production, and craft production are all forms of compliance that Kapinga use to maintain their relationships with powerful outside agents. Put another way, they are all strategies for implementing the cultural premise that defines the relationship between Kapinga people and the world outside the atoll.

The question remains, is current fishing technology sustainable for the atoll population? The short answer is that as long as current implementation strategies for linking Kapinga people with outside agents and agencies work, then the technology is sustainable. Sustainability depends, in other words, on the maintenance of a steady if not growing cash flow to the atoll through government salaries and stipends, copra production, public-works projects, handicraft production, and the success of planned commercial fishing that involves the sale of fish to the supercargo of the field trip ship for resale on Pohnpei. These sales involve government subsidies of a walk-in freezer for the atoll and retrofitting and maintenance of a freezer compartment on the field trip ship.

The maintenance of this cash flow to the atoll depends on levels of funding for the Federated States of Micronesia, which depend on the relationship between the Federated States and the United States, between the Federated States and a consortium of countries sponsoring fishing fleets in Micronesia, between the Federated States and the Asian Development Bank, and so forth. The decisions affecting these relationships are made in Washington, Suva, and Tokyo and, lastly, on Pohnpei, where the national government determines disbursements to the states. The portion of funding going to the atoll depends on the negotiating skills of its representative to the Pohnpei State Legislature, where Kapingamarangi is one of eleven municipalities competing for a shrinking pool of dollars.

Perhaps ironically, population size may be a better indicator of the degree of sustainability of current fishing technology than it was in the precolonial context. Given that gas supply is a major constraint on fishing activity, any serious decrease in cash flow to the atoll would be reflected first in the frequency of fishing and, thus, in catches. A decreasing supply of fish would support a smaller population than the current one, resulting in increased emigration to Pohnpei. That is, without change in the technology and the population-environment relationship that it constrains, change in amounts of available cash (for whatever reason at whatever systemic level) would be reflected in changes in population size.

Conclusion: Levels of Sustainability

The contribution of cultural anthropology to understanding what makes technology, development, or any other planned change sustainable is the same as its contribution to understanding any other outcome of complex processes in human communities. It is an understanding of the ordering of complex relationships between people and between people and things, and of how those relationships are informed by shared patterns in how people perceive and implement those relationships.

Anthropologists infer the organization of human action and interaction (with the human and nonhuman environments) from repeated observation, calling these inferences patterns. We then seek to explain the principles that structure these patterns, some of which can be articulated by people and some of which cannot and must be inferred. Anthropologists refer to this latter sort of inference as "covert" or "implicit" culture. I use the term "cultural premises" to refer to the unconscious axioms that order people's perceptions and representations of the ways that they organize their relationships. How our observations and inferences proceed depends on two kinds of theories—a theory of organization and a theory of culture (and the relationships between these theories).

In this article, I have taken advantage of cybernetic theory about how systems are typically organized and how they change over time. In the version of cybernetics used here, heavily influenced by Gregory Bateson, culture is integrated with social systems as a theory of how humans come to share common ways of perceiving the things, people, and relations among them that make up common experience (Lieber 1994:27–34). This integration of theories of organization is the perspective from which thinking about sustainability makes sense in the observer's universe.

The concept of sustainability, whether the specific focus of observation is technology, economic or other development, or social or ecological policy, is about temporal maintenance of human activity in relation to the environment of the activity and of the human community that contextualizes both. It is the activity that directly affects people and the environments for which that activity is designed, not the hardware that implements the goals and strategies of the activity. The use of hardware has its own requirements, and these requirements are part of the constraints that shape the activity. As soon as researchers focus on human activity as our unit of analysis, we are immediately enmeshed in the organization of the constraints that give that activity (and others related to it) its shape. The systematic organization of constraints on an activity is the key empirical generalization for understanding what is and is not sustainable, for it is this organization of constraints that one tracks over time. Even in this relatively simple example of technological innovations in Kapinga subsistence fishing, it is apparent just how complex and how layered the organization of constraints (and changes in that organization) can be. It is because this complexity is systemic that we can attempt to make the kind of prognostication that sustainability represents. That is, we are in a position to predict a range of outcomes of the population-environment relationship when we understand the levels of constraint and the ordering of those constraints on that relationship. What we infer are levels of change and of stability (Lieber 1977).

The constraints that shaped precolonial fishing activity were hierarchically ordered, following from the hierarchical order of local institutions. The cult house constrained men's houses, which constrained the activities of fishermen (taking into account the conditions of fish habitats). Religious constraints were satisfied first, men's house decisions next, resulting in individual fishermen either being assigned to fishing groups or left free to go angling. The sustainability of new fishing techniques in this context depended on the fit between the features of the technique and this hierarchy of constraints. The coconut leaf netting technique, introduced in the 1780s, shared important features with indigenous techniques. It was sustainable both in the sense of being doable and in its contribution to sustaining the population.

Organizational change following conversion to Christianity offers an example of what Herbert Simon (1996) calls the "near decomposability" of hierarchical systems. Under radical change, hierarchies rarely collapse entirely. Instead, they usually break down into their most stable components. In the Kapinga case, the men's houses and the secular chief remained stable institutions, enabling the transition from a theocratic hierarchy to a chieftainship whose legitimacy was based on the chief's leadership of the church and his ability to use men's houses to form political consensus. Without the ability to enforce decisions about daily fishing activities and because anyone with access to a breadfruit tree could now own his own canoe, the frequency of angling increased at the expense of group netting. The traditional hierarchy was gradually breaking down to the individual fisherman or the canoe crew as the most stable organizational unit.

In this context of organizational change, the study of obsolescence affords an avenue to understanding the kinds and combinations of processes whose outcomes are sustainable or unsustainable activities. First, we must be clear that we observe change and stability at different levels of organization. While angling gear has changed—manufactured lines, hooks, outboard engines—angling techniques have changed little since 1900. The organization of fishing activity has changed radically over the same period. Not only have group netting, use of weirs and traps, and pole and line fishing decreased in frequency, but the institutions that coordinated their deployment either disappeared or lost their ability to require participation by the 1920s. But change at the institutional level was also an outcome of fishermen's newfound opportunity to act on the unchanging value that people placed on the personal autonomy that canoe ownership represented. Given a choice, any Kapinga man would rather be angling on a canoe than netting in a group. The collapse of the cult house presented fishermen with that choice. It is in this context that a researcher observes the obsolescence of fishing techniques.

The four examples of obsolete techniques above illustrate the levels of processes that have rendered the catch techniques both obsolete and unsustainable. These processes include *technological unsustainability:* fishermen no longer know how to conduct particular expeditions; *organizational unsustainability:* fishermen no longer have the organizational capacity to conduct particular expeditions; and *political unsustainability:* leaders of fishing expeditions no longer have the authority to enforce their commands. The four examples are keys to understanding the array of obsolete techniques presented in Table 1. Ultimately, their obsolescence represents various outcomes of decentralized control over the distribution of canoes and the coordination of fishing.

The rapidly increasing technological unsustainability of the techniques in this list and the obsolescence of named fish habitats on the reef and in the lagoon exemplify change at one level—the loss of the knowledge and capacity to conduct expeditions—and stability at another. Given the Kapinga concept of knowledge as an outcome of personal experience based on one's right to have that experience, knowledge disappeared when those with rights to train others to conduct expeditions failed to do so. Without the opportunity to master a technique, the right to know disappears. Thus, change at the level of activity is constrained by continuity at the level of cultural premise (defining what "knowing" means). This stable premise ensures that all of the techniques listed in Table 1 will become technologically unsustainable and that the list will continue to grow.

The technology that has replaced these obsolete techniques includes most traditional angling methods, some new ones, spear-gun fishing, a few older netting techniques, and the use of outboard engines that considerably reduce travel time. This technology represents an evolutionary shift in its selection of part of the traditional repertoire for elaboration, and it requires activities that generate cash for much of its performance. Cash generation focuses people's attention on relationships with agents and institutions outside the atoll. Although these activities represent change at the social organizational level, they implement an unchanged cultural premise about the locus of control over resources and environmental conditions.

The sustainability of this new technology depends on cash flow for gasoline, engines and parts, and gear. Cash flow is constrained by opportunities for earning cash and by the political leverage the atoll representative to the state legislature has to get funding for atoll projects. Available funding is constrained by the (decreasing) levels of income under the Compact of Free Association between the Federated States of Micronesia and the United States and by other agreements that the Federated States can make, for example, deriving cash from fishing licenses for Japanese vessels. The amounts of money available in the future will depend on the next agreement between the Federated States and the United States, which continues to depend on the U.S. perception of the political and military importance of the Federated States. Nero, in her article later in this volume, sees this relationship as more stable than a precarious dependency. Indeed, dependency is probably a misnomer—at least for the Marshall Islands—since the United States is as dependent on the maintenance of that relationship as the islanders are. A sustainable fishing technology for Kapingamarangi is, thus, an outcome of sustaining the relationship between the United States and the Federated States of Micronesia.

To the question of whether any X is sustainable, there are two sorts of answers: (1) no, because . . . and (2) yes, if. . . . What follows "because" or "if" are the minimal conditions of systemic variables at relevant systemic levels that must remain constant for the population-environment relation to remain constant. Data on the activities that constitute the relationship either satisfy these conditions or they do not. It is clear, however, that "population" in the population-environment relationship is more than a matter of population size and age-sex categories, which, like sustainability, are but one class of outcome of the population-environment relationship. It is the population as a human community organizing activities that has the capacity for relationship with the environment. In this sense, the Kapinga case is comparable to the examples of the Tongan farmers described by Stevens, the Arno case described by Hess, and the case of the high-country ranchers described by Dominy, elsewhere in this volume. Sustainability in these cases is useful as a prognostication of the outcome of an intervention to the extent that it focuses the observer's attention on its systemic implications in relation to the activities that constitute the population-environment relationship. The arena of this sort of inquiry is what Stevens and Evans, in their articles, call political ecology.

NOTE

1. See Goodenough 1963:330–347 for a detailed account of the features that shape any activity, how activities constrain one another, and how activities can be used to forecast change. Goodenough illustrates activities analysis with fishing on Onotoa Atoll in Kiribati, making his illustration comparable with data presented here (see also Lieber 1994:154–163). For both theoretical and practical reasons, Goodenough's method of data collection and analysis is designed for the kind of prognostication that a determination of sustainability demands.

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