Only once did we have some bad weather, and that fell on a weekend. Familiarity with the fishing methods, how they are usually conducted, and what minor alterations were needed to satisfy the scientific objectives was also essential to the project's success. This was achieved because of the familiarity with the island's culture and fishing methods acquired by Smith during the traditional fisheries project. The fact that Smith is married to a woman from Woleai probably also contributed to some degree to the co-operation we received.

Payment of the fishermen, hiring of the necessary boats, and provision of outboard motor fuel for the time spent fishing ensured the men's continued interest. Payments were made after the completion of work at each of the four fishing sites. Prior to the field work, considerable time and effort was put into ensuring that the fishermen would be paid in cash, rather than the usual government cheques which can take months to be issued.

After the project was competed and the report prepared, copies were sent back to the council of chiefs and to Woleai Atoll. On subsequent visits to the atoll Smith has continued to answer questions concerning fisheries management posed by the chiefs and fishermen.

Reference

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Traditional fishing on a Polynesian atoll

by Michael D. Lieber*

Abstract

Field research on the organisation of traditional fishing activities on Kapingamarangi, a Polynesian atoll, shows that homeostasis in this marine ecosystem is an outcome of how the constraints on fishing activity are mutually ordered. Even a very simple technology that uses only local resources can generate hardware and techniques that are capable of wiping out whole species of fish. It is how fishing methods are sequenced that prevents potential devastation, and this depends on the human institutions that control the sequencing. These institutions are designed to cope with environmental conditions as they are perceived by the local human population. Change either the local perceptions or the local institutions, and the ordering of constraints on fishing activity change. This is what makes the difference between homeostasis and ecological (and social) chaos. The idea of sustainable technologies is useless if it includes only hardware. It must also include the organisation of deployment, the institutions that implement that organisation, and the cultural patterns of perception that shape the institutions.

An atoll is one of the most marginal human habitats on earth. Pacific atolls support only 50 to 100 plant varieties, and of these less than a dozen are edible. Coconut and pandanus trees are almost everywhere, and maybe also arrowroot and edible creeper. Breadfruit and taro grow only on those islets—strips of land perched on the lagoon side of the reef—wide enough to support a ground-water lens, since the only source of fresh water is rain. The only native mammal is the rat. From this skimpy resource base, people have to make their living.

When disaster—typhoons, red tides, droughts—strikes, there isn't much to fall back on unless there are other islands nearby that people can flee to for refuge. Most Pacific atolls are fortunate enough to have been parts of regional interdependent clusters from time immemorial. The Polynesians of Kapingamarangi Atoll in Micronesia weren't so lucky. This tiny atoll with less than half a square mile of land area was one of the most isolated islands in Oceania until colonial contact in 1877. Kapinga people were left alone to survive as they could for most of their 800-year history.

The land supported taro, breadfruit trees (for food, canoe hulls, cordage, and clothing), coconut trees (food, drink, baskets, thatch, and house posts), pandanus (food, thatch, mats, canoe sails), hibiscus (cordage, loin-cloths), a few varieties of hardwood for construction, and coconut shells for bowls, fuel and small fish hooks. The lagoon and deep sea

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provided shell for fish hooks, knives, adzes, scrapers, drills, abrasives and food—the only source of protein. That was all there was before Europeans arrrived: but it was enough. What made it enough for Kapinga people was their knowledge: 'knowing what they could do with what they had.'

My job in research on traditional fishing was to find out how Kapinga organised knowledge (about fish and their habits, about the reef, lagoon, deep sea, tide patterns, wind patterns, and the ubiquitous spirits that comprised the fishermen's environment), and how they put that knowledge into practice in their catch techniques. I was seeking to understand the indigenous organisation of a human ecosystem as seen from the inside.

Kapinga's 85 traditional catch methods were variations of just seven kinds of techniques: netting, hook-and-line attached to a pole, hand-held hook-and-line done from a canoe (angling), trapping, use of weirs, reef collecting and diving for clams. Netting, done mainly in groups of men organised through a communal men's house under a headman, was the mainstay for feeding the population. Netting groups provided not only food, but also the context in which young boys learned and tested their skills and came to understand the meaning of teamwork, discipline, quick response and masculinity.

Angling was the most prestigious kind of fishing, but canoe ownership was limited to a minority of adult men by the high priest, who owned all of the breadfruit trees and who had to initiate canoe-building with the proper ritual. All other techniques had much less prestige than these two (except for bonito fishing with a pole and line) and were used seasonally.

Which technique a fisherman used on a given day ultimately depended on two major environmental variables: winds (with their associated tide patterns) and the activity of powerful spirits in the deep sea and the lagoon. During the October to May windy season, strong northeasterly trade winds made the lagoon and most of the deep sea too choppy for Kapinga single-outrigger canoes, leaving only small lee areas of calm waters to anglers.

The fish available in these places were limited by what kinds of bait fishermen could obtain. So, for example, if hermit crabs were the only available bait, fishermen could angle for triggerfish and varieties of sea bass that would take crab. Once some of these were caught, they could be cut up for bait, allowing fishermen to move to deeper waters for jack fish, but all this only if the currents were not too swift.

The trade winds also brought higher tides (up to 4–5 feet) during the day and only one low tide in the evening or at night. This limited netting methods to those that could be done on the outer reef by day, and in the channels between islets from the lagoon shore in the evenings. Netting in groups involves surrounding an area with from 15 to 40 men and driving the fish toward a waiting net or trap. Depending on the fish and the area, the fishermen could use either a 'sledge hammer' or a 'finesse approach'.

For example, with a four-foot high tide on the outer reef, fishermen could fan out from the purse net (attached at each end to big coir nets) up to a half mile and slowly ease the fish toward the nets by gently sweeping the water in front of them with punting poles. This method gets only larger fish, since the smaller ones hide in coral heads and rubble as the fishermen pass by.

Once the fish are at the purse net, the ends of the coir nets are closed behind them to prevent escape. Then the noose is tightened to push fish with the purse net,whose draw strings are pulled to close them in. A variation of this method is called 'coconut leaf netting', because instead of punting poles, fishermen surround the area with long lengths of connected rope with coconut leaves tied to them every five feet or so. Because all of the fish run from the leaves, this method clears the reef of fish, and it is a windy season mainstay.

The sledge-hammer approach takes time to set up, mostly to carefully position the fishermen and the net or trap. Once it starts, it is inter-islet channel, and dirty, scaring the fish out of their wits and giving them no time to look for escape routes. A reliable windy season example is catching small reef fish as they feed around the channel between islets in the evening low tide.

One group of men surrounds the fish in the lagoon around the fan-shaped area of sand created by water that flows from the ocean to the lagoon. They beat the water with paddles, driving the fish toward the sand spit on one of the islets, where another group of men (forming an arc across the channel to the opposite sand pit) beat the water to keep fish moving across the channel.

Inside the arc is an area of swift-flowing deep water. Fish will not go there for fear of predators, so the fishermen form a gauntlet forcing the fish to the opposite beach, where a trap with two attached nets awaits them. As the fish pass, fishermen follow them, beating the water behind them to prevent their turning back. The men push the fish into the trap.

Calm season from May until September opens up the lagoon, reef and deep sea to every technique in the repertoire, and a single fisherman often finds himself going on two or three different fishing expeditions in a single day.

For example, at the new moon, a young man might find himself conscripted to paddle the canoe out beyond the reef at night while his elders are torch-fishing for flying fish. He will probably get his turn with the torch in one hand and the flying-fish net in the other. With plenty of fish, the men may decide to test for rainbow runners, so the young man will be busy cutting and chewing flying fish to bait hooks for eight-fathom lines.

If the test is successful, the men will stay on the water until the canoe is loaded. It will reach shore just in time for the young man to be conscripted by yet other men preparing lengths of coir net to stretch across an inter-islet channel to block the return of goatfish and rabbitfish from the reef to the lagoon.

After they collect the fish in the trap set on one of the sand spits, the young man might manage to slip away for some sleep, unless he is unlucky enough to be spotted by another group going to the outer reef to net schooling spinefoot by blocking their path to the big reef channel (to breed). Even if he manages to avoid these men, there will be work waiting for him by mid-afternoon, when a 14- to 18-inch high tide on the reef is perfect for 'netting at the rock piles'. Fishermen surround large piles of rock placed on the inner and outer reef flat and, beating poles or paddles on the water, drive the parrotfish, trevally, and other reef feeders into these rock piles.

Then the fishermen surround the rock pile with a coir net while one or two men working inside the net pull the pile apart, putting the rocks on top of another coir net laid beside the pile. Fish escape to this pile, and when the first pile is gone, the ends of the net are lifted up, the rocks inside discarded, and the fish inside put into a canoe. Fishermen work three to four of these rock piles in an afternoon, unless someone spots a school of rainbow runners beyond the reef.

Then the men's house group will abandon the rock piles and gather at the men's house to organise a rainbow runner surround. Up to 40 men surround the fish in deep water off the reef with connected coir nets, slowly easing them to a place on the reef that is clear enough to get them to swim over the reef margin and onto the reef flat, where the net can be closed around them. The entire operation is directed by the men's house headman from the reef using hand signals. If rainbow runners spook, they'll fly out of the water at terrific speeds, and their hard beaks can maim or kill a fisherman.

Our young get little sleep for about three days, after which the tide patterns change and the two high and two ebb tides occur later in the day with a different ebb and flow, opening up yet other netting techniques.

But this can all change suddenly and radically if yellowfin tuna appear. Once this happens, the only canoes allowed on the water are those used by tuna fishing crews—and these are limited by the number of old men who know and can use the proper chants to the gods of the deep water.

If the young man has not been selected to work on a tuna crew, then the only fishing he will do is netting and pole and line that can be done without canoes, such as walking the reef at low tide, turning up rocks and catching hiding fish in a hand net; helping in a surround of a coral head at a lagoon beach or walking to the outer reef with a group, surrounding fish feeding in a tide pool and frightening them into a waiting net. The lagoon and deep sea belong to the tuna crews for bait and tuna.

Tuna season is critical to this community, because the tuna caught during these four to six weeks will be processed into jerky to tide people over during the relatively poor catches of the windy season, which Kapinga call 'the hungry time'.

Tuna season also presents fishermen and the community with palpable danger—not only do fishermen have to be careful with the six gods of the deep water, but they also have to cope with the possibil-

ity that another set of gods that sleep in the cult house by night, leave the atoll in the morning, and return to sleep in the early evening, might suddenly decide to change their routine and return early in the day.

Whereas the deep-sea gods can be mollified if dealt with properly with ritual chants and careful circumlocutions by the canoe crew, the other gods are unpredictable, whimsical and gratuitously nasty. They refuse to be seen, so they change shape by taking the forms of rays, whales, or sharks when they make unscheduled returns. It's up to the most knowledgeable fishermen to determine when a shark is really a shark or really a god and to be prepared with the proper ritual of appeasement.

This is why tuna crews must have old men to lead them. If the shark is really a spirit, then the crew has to signal other canoes to return to shore, notify the high priest, and wait for him to use ritual means to determine when it is safe to go out again. That may take several days. These dangers were always present in the old days, but they were intensified during tuna season because so many canoes were continually out on the deep sea and a lost day of tuna fishing meant hunger during the windy season.

Tuna canoes are named and kept in a special enclosure on the beach during the tuna season. Crew members abstain from sex and frivolity, and crews work together out on the water.

Fishing begins with chumming—chewed and chopped pieces of bait in a breadfruit leaf package weighted by a rock and wrapped with fishing line are lowered to a 60- to 90-fathom depth and opened by jerking the line so that it unravels and lets the rock drop out and the package open. After several packages have been dropped, fishermen bait their hooks and angle at a uniform depth, usually starting at 60 fathoms and moving deeper as needed.

On the first days of fishing, canoes form a line, catching the tuna as they swim by the line. This procedure accustoms the tuna to finding food in a single place. When they return to that spot, the canoes circle to drop their chum, trying to get the tuna to swim in a circle where more of them can be caught. Fishermen continue this daily until the catches are small. At this point, the season is declared over by the high priest, and other anglers are allowed to take canoes out for a few days of tuna fishing, but each canoe is allowed only two tuna.

Tuna (and other deep-sea) fishermen's favorite bait was a kind of sardine that was caught at weirs constructed between islets seaward of the inter-islet channels. Long-sided, V-shaped weirs with their open ends facing the lagoon and their opposite ends almost touching at the ocean side, caught the sardines at a rising tide as they swam from the lagoon to the reef.

All it took was a net placed over the small opening at the seaward end of the weir and hand nets to scoop up the trapped sardines. These weirs were laid end to end in a zig-zag pattern and a smaller, diamond-shaped weir built at the lagoon ends of the big weirs for catching sardines as they returned to the lagoon at ebb tide. Kapinga also used goatfish weirs on the inner reef and two other kinds of weirs on the outer reef flat, all for calm season fishing.

Traps are the lazy man's way of getting lots of fish, and Kapinga use several different kinds. One of them, a rectangular box with an opening and a trap door, baited inside with hermit crab or even coconut, is simply placed in two or three feet of water close to the lagoon beach and covered with rocks, leaving only the mouth of the trap uncovered and the trap looking like a small coral head. Fish enter the mouth looking for the bait and get trapped.

Other fish go in after the fish that are already there, and, after two or three days, the fisherman retrieves a trap loaded with small reef fish, empties, re-baits and replaces the trap, and comes back in another three days (or until bad weather, when the lagoon is murky and fish won't enter the trap).

Another trap identical to this one, only four times larger, is baited with starfish and left weighted down in the rocks of the main channel that cuts through the reef. This one, called 'the stinky trap' because of its bait, fills up with large fish such as the giant grouper, the giant snapper and jack fish. Kapinga use a small, flat trap set near the currents in the inter-islet channels for white reef eels and another, oval-shaped trap for moray eels.

The moray eel trap is set on the outer-reef slope in the rocks where these eels make their homes, baited with crab or octopus, weighted with clam shells, and left for two or three days. An abalone shell is tied to the top of the trap so the fisherman can spot the trap from the water surface. Traditionally, the only men who could use the eel trap were those who knew the ritual that initiated it, and this ritual was a closely guarded secret. Moray eel was and still is the quintessential feast food.

Trapping and lagoon angling can be combined, for example, in fishing for sea perch. Fishermen rarely catch a lot of sea perch at one time, and the few who

do get a lot are the lucky ones who know a secret spot on or near a deep-water coral head where these fish congregate. A fisherman will test his spot with a baited trap weighted with rocks and lowered to the right depth. A line with a small stick for a float locates the trap, and the fisherman takes off so as not to let others know what he is doing.

Meanwhile, any fishermen nearby will watch him like hawks trying to locate his spot. It's a tricky game. When the fisherman thinks no one is watching, he'll go back and check his trap. If it has enough sea perch inside, he baits his hook on a hand line and angles, going back each day over a five-day period as catches get larger, until the fish run out. He can do this once a season for each spot.

Collecting on the reef and diving for clams are calm-season activities. Women do most of the collecting on the reef, mainly looking for sea urchins. This is a chance for them to get away from their houses and socialise with their friends as well as providing food and spines (which men use for smoothing wood). Diving for clams is a fall-back catch method when nothing else is productive or when people have a yen for clam meat. The diver carries a knife to cut the muscle that holds the clam shell shut, cuts out the meat, and retrieves the giant clam shell, which fishermen use for adze blades and hooks.

Wind and tide patterns determine what kinds of fish are available on a given day, but it was the spirits that determined whether or not a fisherman had access to them. Jealous of their turf and their perks, spirits would punish even the most unintentional of slights by with-holding fish, by killing the fisherman, or by bringing drought or gale winds.

Fishing was always risky, but spirits made it downright dangerous. A mistake on the water could mean mass starvation on land. Fishermen coped with these dangers using ritual chants of appeasement and metaphorical speech to keep a predictable but low profile. Only older, experienced men could be trusted to assess dangerous situations and to deal with the spirits on the water. Only the high priest could communicate directly with the spirits to ascertain their wishers.

This is why the high priest controlled access to canoe ownership and showed preference to men trained as priests in granting new canoes. This is why access to the reef and designated areas of deep sea was restricted by age grading. This is why the high priest controlled access to the lagoon and the deep sea and why he had to be in constant contact with men's house leaders. This is why the temple and the men's house—the two institutions that organised the community—organised traditional fishing activiity.

Wind and tide patterns combined with the activity of spirits continually transform the lagoon and deep sea, the reef and the beaches, the coral heads and the channels from one sort of fishing spot into another sort. These constant transformations of the ecosystem meant that fishermen continually shifted attention from one variety of fish to another.

Over a year, catch activity was spread evenly over 200 indigenous varieties of fish, with none of them being exploited to the point of threatening their numbers. Traditional fishing activity, in other words, was a self-sustaining system, despite the fact that conservation was never a goal of fishermen. Indeed, Kapinga fishermen were and still are maximisers who will take every available fish on any expedition, limited only by how many they can transport home.

If I have given the impression that Kapinga fishermen did not have technology to wipe out fish populations in their traditional repertoire, I have to tell you that this is only partially true. They did have at least one method, mentioned above, that was capable of wiping out the breeding stock of one sea bass and two spinefoot species.

Three days before the new moon, during the four months of calm season, a particular variety of sea bass schools on the outer-reef flat in the early morning and moves clockwise around the reef toward the main channel in the southeast quadrant of the reef, where it breeds.

For three days following, rabbitfaced spinefoot do the same, and for the following three days another spinefoot variety migrates over the reef. Using the method of blocking the path of these fish with a net, fishermen get every one of them.

Assiduous practice of this method every day of this nine-day period throughout the calm season could have eliminated these species within two or three years. The reason that it did not has nothing to do with the technology. It has to do with how the constraints on the use of the technology occurred.

A day of heavy rain prevented the use of this method because a rain-soaked sail was too heavy to manoeuvre, eliminating the possibility of getting to and transporting the fish. An early spotting of rainbow runners would prevent this sort of netting as the men went after the rainbow runners.

Because of other options (e.g., angling and other netting expeditions,) it was rare that any men's house could assemble the requisite men and canoes for more than one or two days out of three. If tuna were in season, this method would not be practised at all. Since the tuna season occurs in the middle of the calm season, that means that there are at least two lunar months in which these fish proceed unmolested to the channel.

It was precisely these three species of fish that were being threatened with extinction in 1980, not by netting, but by the use of a light, hand-held spear gun deployed in the channel as they entered (ironic, since the net is far more efficient than a single fisherman with a tool). What makes this technological change so devastating is not its efficiency, but the organisation of its deployment. A single fisherman can get 75–100 fish, and several fishermen together multiply the catch.

Without other constraints, they can continue working till the fish run out. By 1982, the constraints on fishing activity had changed radically. The traditional hierarchical ordering of constraints (with wind and spirits at the top, followed by a nested set of ritual constraints exercised in turn by the high priest, the men's house leaders, and their lieutenants, with specific environmental constraints such as bait, tide pattern, etc., at the very bottom) was long gone with conversion to Christianity.

Changes in the relationship between the atoll and its colonial masters and the organisation of authority in the atoll social order had robbed the men's houses of their organisational power. The organisation of fishing activity had shifted from control by institutions to control by individual fishermen over their own decisions and resources. The adoption of outboard engines affixed to outrigger booms made access to any part of the lagoon or deep sea quick and easy (and expensive). There are no longer any constraints on fishermen's activities other than bait, the weather, and the gas supply. This is why these species are threatened.

I have condensed a much larger argument and its substantiation into a very small space and have glossed over cultural ordering of this human ecosystem and its processes of change. You will find a complete account in my book *More than a living: fishing and social order on a Polynesian atoll*, Boulder, Colorado: Westview Press. (1994).