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HANDBOOK of REGENERATIVE LANDSCAPE DESIGN

Edited by
Robert L. France

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7 Bottom-Up Community-Based Coral Reef and Fisheries Restoration in Indonesia, Panama, and Palau

Tom Goreau and Wolf Hilbertz

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ABSTRACT

The Global Coral Reef Alliance (GCRA) works with community-based management efforts to restore severely damaged coral reefs and fisheries using its Biorock® technology. In Bali, Indonesia, the village of Pemuteran used traditional village law to organize patrols to stop reef blast and cyanide fishing in their waters, establish marine protected areas for ecotourism and fish sanctuaries, and built more than 40 Biorock coral reef nurseries with a total length of over 500 meters. Their bottom-up efforts have won many national and international awards for community-based coastal zone management and underwater ecotourism.

The visibly obvious buildup of fish populations has made fishing villages across Indonesia realize that they can grow corals and harvest fish and shellfish, farming reef ecosystems instead of hunting fish and destroying corals. Our workshops are training fishermen, dive shops, university students, and government fisheries agencies in the new methods of reef restoration. In Ukupseni, Panama, the Kuna Indian community has established solar powered Biorock coral nurseries, lobster habitats, and breakwaters to increase habitat for lobster (the economic basis of the region), and to protect their low lying islands from eroding. The Kunas are preparing their own coastal zone management plan to establish lobster hatcheries and create habitats to increase shelter and food for lobsters at all stages of their life cycle. In Palau, GCRA works with the Hatohobei State Government in the most isolated atolls. These islands suffered catastrophic mortality of corals and fish after record high temperatures in 1998 and are undergoing severe erosion. Projects are being planned to grow solar-powered Biorock breakwaters to save the islands and their culture, coral and fisheries habitat, and revive ancient techniques for fish habitat that have not been practiced for generations. The tools for large-scale community-based restoration of coastal marine habitats and fisheries now exist, but their implementation is being blocked by the lack of government policies backing community-based restoration and lack of funding for them from international agencies.

INTRODUCTION

The Dilemmas of Coastal Zone Management: By Whom and for What?

Coastal resources are in severe or catastrophic decline almost everywhere. Discussions with the oldest fishermen invariably reveal a former wealth of living resources, which have declined so severely that young fishermen find it hard to believe their elders and assume that they are senile or making it up. Scientific studies of coastal resources almost everywhere postdate the worst of the decline, and so shed little light except for documenting the disappearance of the last vestiges. Modern coastal zone management has largely been a top-down imposition by outside agencies (whether from the national capital or foreign "experts"), rather than a genuine outgrowth of community needs, and tends to override or ignore local long-term management concerns (Walley, 2004).

Furthermore coastal zone management is generally based on ideologies that value nature not for its own sake but only insofar as it is exploited to yield immediate returns. The dogma that nature exists only for humans to exploit it is common to "modern," "universal" ideologies, including globalism, capitalism, communism, Christianity, Islam, and the "monetary value is the only measure of worth" theorizing of economists. These "missionary" ideologies often believe they possess the only universal values, and feel compelled to force all to follow their own view of the world. In contrast, a multitude of ancient traditional cultures view humans as an integral part of nature, with a reciprocal responsibility for humans to maintain nature's overall balance and responsibly nurture it to the most healthy possible state (Ereira, 1990). These "native" or "aboriginal" traditions are largely viewed by outsiders as "backward," and are being actively exterminated, forcibly displaced, marginalized, or at best undermined, by the "universal" forces of modernist ideologies that value resources only insofar as they can be converted into money.

Any economist can "prove" that the "optimal" use of any natural resource is to "realize its monetary value" (i.e., extract it and sell it), invest the money, and live off the interests and profits, and that this strategy inevitably maximizes monetary return and hence all possible "utility" and "satisfaction." Because the purpose of such "management" is simply more efficient exploitation, it reinforces top-down relationships of external power and economic control over indigenous communities as well as nature. For example, until one generation ago Australian aboriginal people were legally classified under the Wildlife Act, with all the legal protection from hunters it entailed!

These ideological frameworks primarily benefit outside groups at the expense of both local ecosystems and local human communities, and almost never really empowers locals to manage their own resources for their own long term benefit, much less that of the entire ecosystem, despite often-made claims that this will result. Top down projects often act to destroy local community-based management practices and potential (Colchester, 2003; Chapin, 2004; Walley, 2004). Management based on contempt for local cultures and ecosystems alike is hardly likely to improve the lot of either.

Conservation Versus Restoration

The major current tool of conventional biodiversity and fisheries management is conservation based on the Marine Protected Area (MPA), which is widely claimed to increase both (Gubbay, 1995; National Research Council, 2001). By sealing off an area and barring its traditional users, it is claimed that naturally "resilient" ecosystems will automatically bounce back by themselves. Nevertheless, even though many MPA proponents say that this will happen anywhere, it is obvious that such policies can only work where ecosystem health, water quality, and carrying capacity are excellent. Yet every coral reef ecosystem is now degraded, and every coral reef MPA is also undergoing drastic decreases in live coral cover (and fish populations) due to global scale stresses (global warming, new diseases, land-based sources of pollution, etc.) that are beyond the control of any MPA. Because MPAs cannot control the real root causes of coral death, or of decreasing habitat quality and declining carrying capacity for fishes and shellfish, they cannot protect coral reefs and fisheries in the long run (Goreau and Hilbertz, 2005). There are some remarkable cases of short-term MPA success on a small scale at locations where environmental conditions are excellent, such as Apo Island in the Philippines, but it is clear that the same successes will not take place in the vast majority of reefs, which are already badly degraded.

The most lavishly funded MPAs in the world are in the richest countries, yet long-term monitoring programs of the Great Barrier Reef Marine Park Authority and the Florida Keys National Marine Sanctuary show that live coral cover is now down to only about 20% (AIMS, 2004) and 7% (CREMP, 2003), respectively, and steadily falling. Yet these two MPAs are the focus of publicity claiming that these are "well managed," "resilient ecosystems," and that poor countries can achieve the same results by following their example! If the rich can't protect their reefs now, and will be even less able to do so as global warming, pollution, and new diseases intensify, it is clear that imposing such policies on those without vast financial resources is even less likely to work. Yet this failed strategy remains the primary management objective of governments and international funding agencies. Because so little reef now remains in pristine condition, and none can be protected from globally-intensifying stresses, conservation efforts focus on finding the last good patches and, in effect, trying to build walls around them, ignoring the vast degraded areas around them on which local communities must rely. No funding is allocated to effective restoration, only towards methods like gluing and cementing broken corals, but these will die whenever the water gets too hot, dirty, polluted, or when diseases break out and pests infestations occur.

We take the antithetical approach that active, large-scale, community-based habitat restoration is the *sine qua non* of effective biodiversity and fisheries management in a world that is changing so fast that the conventional top-down conservation strategies can no longer work. We take the view that the proper management of natural resources is simply to maximize its quantity and quality, not to isolate the last examples in preserves, and that the best results for ecosystem health and maintenance of natural services will result from local optimization, writ large. Local communities are the best placed to value and protect their habitat, but they only can if they are allowed to hold responsibility for managing their own surroundings, obtain the knowledge and tools to do so effectively in the context of their own traditions, and convince their neighbors of the benefits by example. Unfortunately, local communities are losing or have lost control of their resources almost everywhere, often to allow them to be exploited by outsiders. Thus, it is essential to re-empower communities to control the resources providing their livelihood for long-term management to be possible.

In this paper, we describe collaborative coral reef and fisheries restoration projects with traditional communities in Indonesia, Panama, and Palau who have maintained control of their coastal zone from national and outside forces despite increasing economic pressures on their resources.

Top Down Versus Bottom-Up Management

The Global Coral Reef Alliance (GCRA) works closely with a wide range of local partners around the world, including community groups, local governments, divers, environmental organizations, and hotels. Their common feature is that they have recognized that their local reefs are vanishing, and realized that if they wait until they can get funding from top-down programs it will be too late. They further understand that conservation alone has become inadequate, and that immediate efforts to grow corals and restore fisheries habitat are urgently needed to make a meaningful difference, and must be started whether or not outside funding can be found (Goreau and Hilbertz, 2005).

GCRA works closely with local partners to assess current and historical health of sites, and trains them to design, construct, install, monitor, maintain, and repair restoration projects. Because to date no government or large funding agency has supported meaningful coral reef restoration efforts, all projects have been supported purely by small donations, mostly in-kind donations of materials, food, and lodging by local groups. This local support has increased local participation and control of projects, but of course the very small amounts of funding available have greatly limited the size and number of projects. We have been unable to respond to urgent requests for help from many communities around the world due to lack of funds. This situation will remain until governments and funding agencies change their policies and choose to support bottom-up community-based ecosystem restoration programs instead of the top-down efforts that have consumed so much money with so little results.

Similar efforts at community-based management of whole watersheds and coastal zones and reef and fisheries restoration were first developed in Jamaica (Goreau et al., 1997). However, these failed because outside funding agencies, which came in only after local community management plans had been developed, paid for, and controlled the management implementation agendas and did not see community-based management of entire ecosystems as their goal. Instead they focused on making tourism "parks" to repay foreign exchange debts. Instead of supporting detailed pre-existing community-based management plans, developed over years of meetings in every community in the watershed, they funded MPAs in the tourism areas as separate units administratively isolated from the human populations in the up-stream watersheds that affected them. As a result, the community's role in management was marginalized. The reefs could not be protected from the land-based sources of pollution that were killing them, and proceeded to deteriorate even more rapidly after money was spent to "manage" them (Lapointe and Thacker, 2002). After 10 years, the failure of these "conservation" efforts to protect corals and fish are obvious, and once the foreign funds and consultants that dictated their mismanagement were exhausted and left, local communities are again requesting help from GCRA to restore their crippled reefs and fisheries. Ironically, only after bottom-up community-based efforts to integrally manage whole watershed and coastal zones had been effectively prevented by top-down funding impositions, these pioneering efforts in Jamaica became the direct inspiration for top-down "ridge to reef," "hill top to ocean," and "white water to blue water" programs by large international funding agencies.

Methods

We use GCRA's Biorock® Ecosystem Restoration Technology (Hilbertz and Goreau, 1996). Biorock uses safe, low-voltage, direct current, which can be provided by solar panels, windmills, and tidal current turbines to grow solid limestone structures of any size and shape in the sea. Biorock is the only coral reef restoration method that increases coral growth rates (typically 3–5 times), coral healing from breakage (more than 20 times), coral survival from lethal conditions of high temperature, sediments, and nutrients (16–50 times increase in survival over adjacent reefs after the 1998

bleaching in the Maldives), coral settlement (by 2–3 orders of magnitude), and coral reproduction, while greatly increasing fish and shellfish populations, especially juveniles (Goreau & Hilbertz, 2005). Using these methods, coral reef organisms can be kept alive where they would die, and coral reefs restored in record time where they cannot recover naturally. The Maldives, one of the countries most threatened by global sea level rise and global warming (Gayoom, 1998) has been a major focus in the development of Biorock technology to save coral reefs from global warming (Goreau et al., 2000). Biorock reefs in front of severely eroding beaches in the Maldives produced an ecotourism attraction full of corals and fish in a barren area in front of the beach, and the reduction of wave energy caused the beach to grow by 50 feet (15 meters) in a few years (Goreau et al., 2004). These projects were awarded the Sperry Award (top prize for Innovators and Pioneers from the Society for Ecological Restoration), and the Maldives Environment Award. Although energy and materials were needed for the Biorock reef breakwater, the energy consumption was less than the beach lights, and total costs per meter of protected shoreline were a few percent of the concrete breakwaters that surround the nearby capital island, Male. Those massive concrete walls have increased scouring of the shoreline while producing no ecological benefits.

PEMUTERAN, BALI, INDONESIA

History and Social Context of Fisheries

Indonesia has the largest area of coral reef and the highest marine biodiversity of any country in the world (UNEP, 2001). The village of Pemuteran lies in one of the few areas of Bali that are too dry to grow rice, the staple food, and its people were forced to rely on the sea, feared as the home of the evil spirits in Balinese culture. The shallow offshore banks nearby have the largest area of coral reef in Bali that are free of ferocious tidal currents, giving it the richest reef fisheries on the island. Most fish catch was used for subsistence or traded for rice, and the population was among the poorest in Bali, sharing mud-floored huts with their animals. Because Pemuteran is in the most remote corner of Bali from the tourist entry points in the South, it was the last coastal area to develop tourism. The large, lush, and current-free reefs made it an exceptional location for diving, and a small diving industry developed followed by small hotels. These deliberately avoided the large-scale mass tourism of the South, giving it a tranquil setting and attracting Indonesian and foreign residents of Bali and Java eager to escape the congestion of the south as well as tourists straying off the beaten track to find more peaceful surroundings. The development of tourism created jobs other than subsistence fishing for the first time, creating new alternatives for educated local young people. The result has been a great increase in village standards of living, without loss of tradition.

Traditional village law, Adat, remains very strong in Bali and many outlying parts of Indonesia. It has been weakened in areas of the country where Muslim or Christian influences have displaced traditional culture and law, but is institutionalized in Bali because the ancient village laws have been incorporated into the island's Hindu-Buddhist culture, which focuses on maintaining harmony between natural forces. The founders of the Pemuteran tourism industry were careful to work closely with the village council, led by the Kepala Adat, the interpreter of village traditional law, and the Kepala Desa, the elected village leader. In order to protect the fish habitat in the fringing reef in front of the fishing beach and the snorkeling reefs for hotels, the village declared the area in front of the beach to be protected from all forms of fishing. A ban was also placed on use of bombs and cyanide for fishing in the entire reef area offshore from the village. It is important to note that this was done using village law alone: no permission was sought from national authorities, nor was any needed.

Impacts of Destructive Harvesting

During the Indonesian economic crisis of 1998, when millions of displaced workers and farmers took to fishing as a means of survival, maintenance of the ban on offshore reefs was no longer

enforced and bomb and cyanide fishing went out of control. One would hear 5 or 10 bomb blasts a day in Pemuteran Bay, and since diving was no longer safe, the local diving business collapsed. The bombers destroyed almost all of the shallow reefs on the offshore banks, leaving only deep waters and the area in front of the beach untouched. Most of this destruction was blamed on fishermen from the islands of Java and Madura, and on nearby villages in Bali inhabited by fishermen from Madura who emigrated because the fisheries on their own island had collapsed.

As the vibrant reef was reduced to dead rubble, the fisheries collapsed due to lack of habitat. Shocked by rapidly declining food and tourism income, the village decided to once again enforce their ban on destructive fishing methods on their offshore reefs, but the damage was already done. However, this time the hotels and dive shops arranged with the village to donate 5% of their profits to the village in order to organize boats, engines, and personnel for the village Pecalang Laut (Sea Guardians) to monitor fishing activity and enforce village laws. If fishermen are found to persist in using banned methods, their boat and all their gear are seized and they are thrown in jail. Although this is done by village law, Indonesian legal authorities recognize the arrests and prosecute the cases. As a result of this ban the devastated areas offshore are steadily recovering.

Community Response

GCRA began working with dive operators in Pemuteran to start Biorock coral reef restoration projects in 1998. From the first small start, these have exploded in size and popularity, now stretching over about half a kilometer of Biorock reef in 40 separate structures of different shapes. Studies by Putra Nyoman Dwija have shown that corals grow 4 times faster and heal from damage more than 20 times faster on Biorock than nearby controls (Dwija, 2002). Naturally broken coral fragments on nearby reefs that would roll around and die in the mud and rubble have been transplanted onto the Biorock reefs.

Not only have hard corals and other attached marine organisms like soft corals, sponges, and clams grown at phenomenal rates, they have attracted huge numbers of reef fish into an area that had been fairly barren. The types of fish attracted to structures depend on the size and shape of spaces created, and the structures can easily be built to have much more space for habitat than a natural reef, as it has many more layers. As a result fish populations have bounced back in the bay, and the reefs have attracted tourists from all over the world. The village has won Indonesia's most prestigious environmental award, the Kalpataru/Adiputra Prize, the KONAS Award for best community-based coastal zone management project in Indonesia, the SKAL Award for best Underwater Ecotourism Project in the World, the Association of South East Asian Nations Tourism Agencies Award for Excellence, and the Pacific Asia Travel Association Gold Award.

Three international training workshops in coral reef restoration have been held in Pemuteran in which students learned the theory and hands-on practice of design, construction, installation, monitoring, maintenance, and repair (Goreau and Hilbertz, 2004, 2005) (Figures 7.1–7.4). The first Pemuteran Workshop attracted around a dozen participants, the second attracted two dozen, and third had around 60. Only one Indonesian attended the first workshop, but the Indonesians made up the majority of the rest, with the remainder coming from all over the world. Biorock students have started their own projects in Java, Sulawesi, Lombok, Flores, and other parts of Indonesia, as well as in many other parts of the world. The fourth workshop was held in November, 2006, on the island of Gili Trawangan, Lombok, where around 70 participants built some 20 new structures.

Because of the dramatic buildup of fish populations in the Biorock reefs, including large swarms of juveniles, fishermen all around Bali have requested similar projects as a means of restoring their coastal fisheries and reef habitat. Besides fishermen, divers, hotels, and tourists, the projects have been visited by top officials of the Bali Island government and succeeding Indonesian government ministers of Environment, of Marine Affairs and Fisheries, and of Tourism, as well as by the executive director of the United Nations Environment Program. However, until very recently the project has received no funds from any government or large funding agency. It has been entirely supported

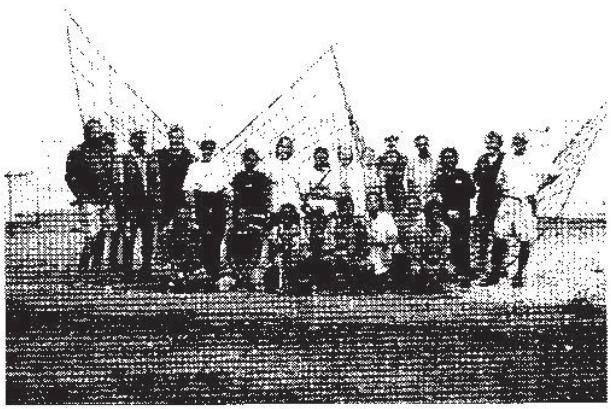

FIGURE 7.1 Second Pemuteran Reef Restoration Workshop participants and the newly built Big Manta Reef, Bali.

by small private donations, many of them local in-kind donations of materials, and food and lodging for participants, along with donations by impressed tourists. The project's success has attracted press and television coverage around the world.

The first funding to the village came at the very end of 2005, when the Bali Recovery Fund, a group funded by the Australian Aid Agency to aid economic recovery of areas economically depressed by the collapse of tourism following terrorist bombings of tourist targets in South Bali, supported the new Reef Gardeners of Pemuteran Program. This program, whose motto is "Protecting and Preserving the Reefs Now ... for the Future," has trained 10 young people from the village to be full-time paid reef restorers, focusing on the offshore bank reefs. The Reef Gardeners, who are young fishermen without the education and language skills needed to get a job in the tourism sector, have been trained as divers, are learning English, and taking courses in business management. A barge was built to house a mobile power supply used to start Biorock reef restoration projects to speed up recovery of the outer reef. They have sunken several old boats on the edge of one of the banks, and are turning them into Biorock reefs. They have constructed an underwater snorkeling trail, with sculptures in the design of a traditional Balinese temple garden. As the funding is a short

FIGURE 7.2 Getting ready to float the Little Manta Reef to its site, Bali.

FIGURE 7.3 Attaching naturally broken coral fragments to Big Manta Reef, Bali.

term startup, and will not be continued, the village has introduced a $2 fee for divers and snorkelers using the area, and local dive shops and hotels encourage guests to participate. It is hoped that these fees will pay for maintenance of the project and the salaries of the Reef Gardeners. To our knowledge these are the first professional paid reef restorers anywhere in the world.

Recently, for the first time, the Government of Indonesia has officially decided to seek large-scale funds from the German Government Debt Relief for Nature Swap to implement community-based Biorock coral reef and fisheries restoration projects in four different regions of Indonesia, and to train fishermen and students in the new techniques. If this funding materializes, Indonesian fishermen will begin to switch from being hunters of the last wild fish to coral reef farmers who increase their productivity by actively restoring reef habitat and improving its habitat quality and carrying capacity. It is hoped that Indonesia's lead in developing policies in support of active restoration will result in a transformation of Indonesia's fisheries and will be followed by other governments and funding agencies.

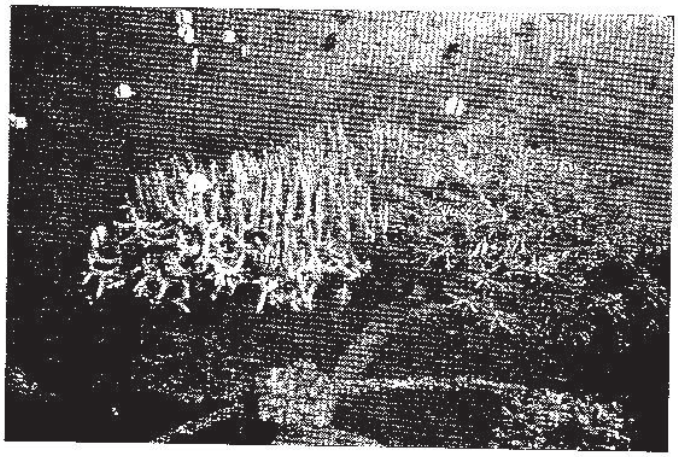

FIGURE 7.4 Biorock reefs have prolific coral growth and dense fish populations: Ibu Karang Reef, Bali.

KUNA YALA, PANAMA

History and Social Context of Fisheries

The Kuna Indians of Panama are unique among native peoples of the Americas in having never lost their land, culture, and laws (Howe, 1998). There are no roads to their land, Kuna Yala, and they do not allow outsiders to own land, settle, or deforest the jungles for the cattle ranching that has destroyed forests and soil fertility throughout the Americas (Ventrocilla, Herrera, & Nunez, 1995). The Kuna live on an archipelago of 365 islands in the Caribbean, 50 of them inhabited, but also own the entire watershed of northeastern Panama from the coral reefs right up to the top of the mountain ridges separating the Atlantic from the Pacific. Despite their poverty, Kuna culture is vibrant and confident; they have a unique appreciation for knowledge of all kinds, and produce an exceptional number of university students. Their leaders are elected based on intelligence and knowledge through an elaborate participatory democracy. Books written about their love of freedom and equality in the 1600s by Lionel Wafer and William Dampier, English pirates who were stranded there following failed raids on the Spanish gold fleets passing through Panama to Spain from Peru, were the direct inspiration for French theorists of "*Liberte, Egalite, et Fraternite,*" not the rigid class structure of Athenian "democracy."

Due to their isolation and traditional way of life, the Kunas have few products they can sell besides coconuts (which are of practically no economic value) and *molas*, the unique embroidery art of Kuna women using a reverse appliqué technique with multiple layers of cut cloth of different colors. Because they have the largest area of coral reef in Panama and because their coastal mangroves are intact, they had exceptionally high populations of spiny lobster and several species of edible crabs. Their entire economy is based on the export of lobsters and crabs, and the Kuna shellfisheries make up 70% of Panama's marine exports by value. However only a very small fraction of this goes to the Kunas, most being made by the retailers and middlemen who fly them from Kuna Yala to Panama City and then on to Miami. Because lobster and crab are the only available source of money for almost all Kunas, virtually the entire male population dives for lobster. SCUBA diving is strictly banned by Kuna law, even by tourists, because it would lead to too rapid depletion of lobsters. Kuna fishermen specialize in free diving, and are so good at this that they have migrated all over Panama, working in diving fisheries.

Impacts of Overharvesting and Eutrophication

Although the lobster and crab fisheries are the driving economic force in Kuna Yala, they are in an advanced state of decline. Fishermen admit that the populations are vanishing, but have no other way to earn money. The chief of one village told us "I am very worried for the future of the children because when I was young we would jump in the water right in front of our house in the village, pick up 10 or 15 lobster, and have them for dinner. Now we must paddle our canoes very far out at sea, dive very deep, and the lobsters are few and small." The head of the lobster fishermen in this village said that "Every day there are more fishermen and less lobster. If we don't restore the lobster populations our way of life will be finished."

Besides over-fishing, the entire reef habitat is undergoing serious eutrophication. Inhabited islands are very densely populated, and are ringed with outhouses over the water. The corals and fish are gone around inhabited islands, whose shores are covered with massive growths of algae species that are indicative of severe pollution and garbage. In contrast, uninhabited islands have dense coral populations, but even these are being steadily smothered by algae where affected by water flows from populated areas (Goreau et al., 1997). The health of the reef, and its ability to maintain large populations of fish, lobster, and crabs is steadily declining. All the islands are only slightly above sea level, and suffer strong erosion on their northward sides during high waves for 4 months early each year. Traditionally, the Kunas mined live corals to build up the eroded sides of their

islands, to expand their area, and even to build new islands. When there were few people and many corals, the reefs were not noticeably depleted, but this is no longer the case.

Community Response

GCRA has worked with the people of Ukupseni, Kuna Yala, since 1994. Due to lack of electricity, our projects there largely use solar panels to power a variety of coral nurseries, lobster nurseries, and breakwaters. The panels used were part of the world's largest solar power plant, built in Michigan in the 1970s as part of President Carter's Solar Energy Research Initiative, which was sold to a large oil company by the Reagan administration and dismantled for scrap. GCRA bought the last crate of the old panels for a fraction of their value and recycled them. Despite their age, their output still exceeds the original specifications. We have made breakwaters that are slowing down the waves next to one of the village eco-resorts, and a breakwater for the village hospital so that patient's lives can be saved by bringing them directly to the hospital by canoe, which had been impossible during the rough weather season. Coral nurseries are growing around 15 species of hard corals, plus soft corals and sponges, on a 20 ft (7 m) diameter dome over a muddy area where no corals were growing before (Figures 7.5–7.7), and the reef has attracted a large resident barracuda (Goreau et al., 2005).

GCRA has also brought educational books and videos, and given lectures to all the schoolchildren on the importance of protecting and restoring coral reefs. GCRA's Children's Program donated masks, fins, and snorkels to the school so that the students, who swim like fish but are too poor to own snorkel gear, can go on field trips to learn the differences between healthy and sick reefs, and participate in reef restoration projects (Figure 7.8) (Goreau, Goreau, & Solis, 2003).

The small private donations used for these projects have dried up completely, so we are unable to maintain or expand them, and no support for reef restoration has yet been provided from Panamanian funding sources. If funding can be found, programs in Kuna Yala will increasingly focus on creating habitat to increase populations of lobsters. Biorock structures can be built in any shape and size, and we noticed in Jamaica, Mexico, and Panama that structures built to provide spaces of the right size and shape are densely packed by lobsters. Lobsters suffer severe mortality due to lack of hiding places, especially the juveniles which live in sea grass beds, so their populations can be greatly increased by building shelters of the right sizes in mangrove, seagrass, and coral reef habitat used by lobsters at different stages of their life cycle. This technique has been widely developed in Cuba, where it has greatly increased production. Cuban "casitas," made from marine plywood, ferro-cement, or roofing material, provides shelter alone. Use of Biorock shelters is likely to be even

FIGURE 7.5 Assembling solar panels for lobster nurseries, Panama.

FIGURE 7.6 Transporting the Akabiski Galu Reef, Panama.

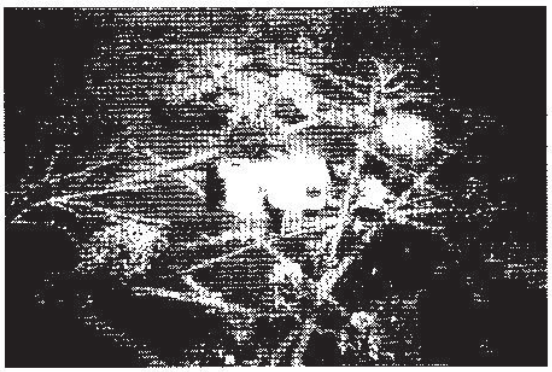

FIGURE 7.7 Akabiski Galu Reef, Panama.

FIGURE 7.8 Kuna children getting ready to snorkel on Akabiski Galu, Panama.

more effective as it provides a substrate for growth of barnacles, clams, and other food for lobsters. Future work will build solar powered lobster shelters of suitable sizes in different habitat in order to increase lobster populations and allow sustainable harvesting at higher production levels.

Successful efforts have been obtained in Kuna Yala despite the remoteness and poverty of the inhabitants, and very little funding. Now we are working to set up fisheries, mariculture, and reef restoration projects in other parts of Panama, such as restoring damaged reefs in Marine Protected Areas, building habitat for the release of juvenile snapper released from hatcheries, and oyster culture. These projects will be done with fishermen's cooperatives, mariculture operations, research hatcheries, the Autoridad Maritima de Panama, the Autoridad de Medio Ambiente, and in programs planned for the newly formed Universidad Maritima Internacional de Panama, if funding can be found. During 2005 there were record high sea surface temperatures in Panama, and severe coral mortality is likely to have taken place, making the need for such projects more urgent than ever.

HATOHOBEI, PALAU

History and Social Context of Fisheries

The Southwest Islands of Palau consist of six very low islands stretching from Palau almost to Indonesia, the Philippines, and New Guinea. All are small islands completely surrounded by fringing reef with no lagoon or passages, except for one, which consists of a large atoll with a single small sand cay. They are inhabited by people speaking a different language from Palauan, called Tobian or Sonsorolese, which is related to the languages of Yap (Friends of Tobi Island, 2005). In his book on traditional fishing cultures in Palau, *Words of the Lagoon*, Robert Johannes described them as the master fisher folk of the Pacific, having a wide variety of handmade hooks designed for specific fish species that were unknown elsewhere (Johannes, 1981). Johannes was never able to reach the Southwest Islands, and based his comments on the notes of P. W. Black, an anthropologist who had lived there. The Southwest Islanders lived in isolation until forced to labor in coconut plantations on Tobi by German colonial authorities, and later as mine and construction workers on other islands by Japanese colonial authorities during the Second World War. Following independence of Palau almost the entire population migrated to the capital, Koror, where they have established their own village. This was done because there were limited jobs, educational opportunities, and medical services on their islands, but small communities of subsistence fishermen and their families remain on the southwest islands. Migration between the southwest islands and Koror is an active, dynamic, vibrant, and ongoing population mobility resulting in cultural, political, economic, and social exchanges in both directions. Southwest islanders' residences in Koror village are not considered permanent homes but habitual ones due to the long period of wait between trips—due to the islands' distance from the main island of Koror. Although the Southwest Islands are surrounded by some of the richest tuna fishing grounds in the Pacific, the islanders do not have the boats to exploit it, and access to these resources is leased by the Palau Government to foreign fleets.

The coral reefs of the single atoll, Hotsarihie (meaning Reef of the Giant Clam, but usually called Helen Reef by outsiders), have the greatest diversity of corals, fish, and mollusks recorded on any Pacific oceanic island (that is, excluding Indonesia, the Philippines, and New Guinea) (Maragos, 1993). The island has been used by the people of Hatohobei Island (also known as Tobi) from ancient times, but was not permanently inhabited due to lack of drinkable groundwater on the small sand spit that is emergent at high tide. The lack of permanent inhabitants made it a mecca for poachers from Indonesia, the Philippines, and even Taiwan, who plundered the richest giant clam and valuable trochus shell populations in the Pacific until little remained. The unique marine diversity of the atoll, and its huge bird and turtle nesting populations, make it potentially valuable for diving and nature ecotourism, if it can be protected.

FIGURE 7.9 Helen Reef is a sandbar full of turtle nests and birds overhead, Palau.

Impacts of Global Climate Change

In 1998 the waters around Palau and the southwest Islands were extremely hot, and the vast majority of the corals died (Goreau et al., 2000). Following the death of most of the corals the Tobi fishermen noticed a dramatic decline in fish populations. The single small sand spit on Helen Reef is extremely vulnerable to global sea level rise (Figure 7.9). It is only about 10–20 centimeters above the normal high tide mark, and one can clearly see that sand waves have repeatedly passed right over it in storms. The island is unstable, and is moving southeast at about 15 m a year. The remains of a concrete floored structure built on the island by Japanese troops now sits in shallow water about 200 m from the shore. Coconut trees planted on the eastern shore of the island collapse into the sea on the opposite side of the island before they can bear, because the island has completely shifted its position eastwards in this time (Figure 7.10). Now that most of the surrounding coral is dead, the rate of erosion is likely to increase as global warming and sea level rise accelerate, placing control of all the natural resources of Helen Reef at risk, as well as the surrounding tuna fisheries.

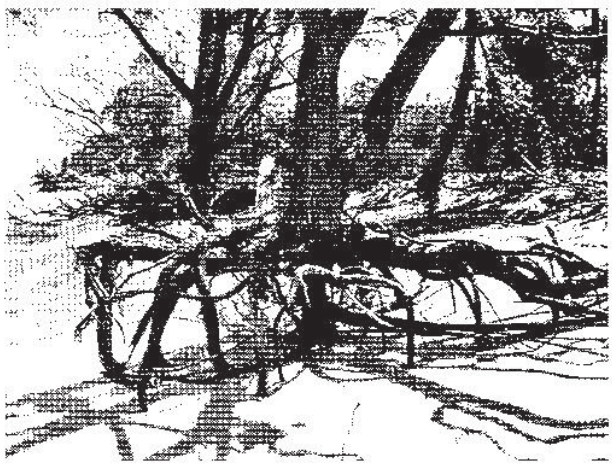

FIGURE 7.10 Trees collapse into the sea on one side of Helen Reef, Palau.

Community Response

The Hatohobei people feel that their top environmental priorities are to restore their coral reefs and fisheries and to stabilize the island on Helen Reef so that it can be developed as a base to protect the atoll's resources and for ecotourism. The Hatohobei State Government succeeded in getting a grant from a very large U.S. private foundation to station rangers on Helen Reef. However, instead of being allowed to control the funding to use to solve their own pressing problems, they found that the control of the money was entirely handed over to a U.S. organization. This is using it for their own consultant's salaries, travel from the U.S., and to tag turtles, instead of restoring habitat and protecting their islands from erosion, as the Tobi people wish. The attitude of the agency funding this project appears to be that local people don't know what their own problems are, and should not be able to control any funding, i.e., that indigenous people are not to be trusted to act on their own behalf.

The Hatohobei State Governor Sabino Sackarias learned about GCRA restoration and shore protection technology by chance in 2000 and immediately invited a collaborative project. Several large funding agencies with community-based management programs of the top-down kind all refused to help. It took 4 years to find a small amount of funding from a private donor to start these efforts. Funds were obtained for solar panels and materials to build a breakwater to stabilize Helen Reef Island, the top priority expressed by the governor. Due to the extreme remoteness of Helen Reef, there are only a few trips a year to it by the single supply ship that serves all the Southwest Islands. So there was no chance to assess the site beforehand, and all work had to be done during a single scheduled supply trip. However, the ship broke down, and had to be sent for repair to Manila, which took far longer than expected. By the time the ship was fixed, the good weather season was over, but as the funding had a time limit, there was no choice but to go ahead. Although Helen Reef is almost on the equator, and well outside of the hurricane belt, a typhoon formed in the area, unusually early in the season and far to the south of the area normally affected, delaying departure.

When the island was reached, extremely strong wind, waves, and rain indicated an exceptionally early start to the monsoon season. Despite very hard working conditions and inadequate materials and tools, the team of Hatohobei and GCRA volunteers succeeded in building a 450-ft-long breakwater along the most erosion prone coast, and powering it by 32 solar panels (Figures 7.11–7.12). At this point a Super-Typhoon developed, and the team was unable to leave the island until after exhausting all supplies except for one bag of rice. Due to inadequate funding, there was no money for a generator or a welding machine, so the entire structure had to be wired together by hand. Although the structure worked as planned (Goreau et al., 2004), the fact that it was finally built only at the start of the rough season, not at the start of the calm season as originally planned, meant that it was not

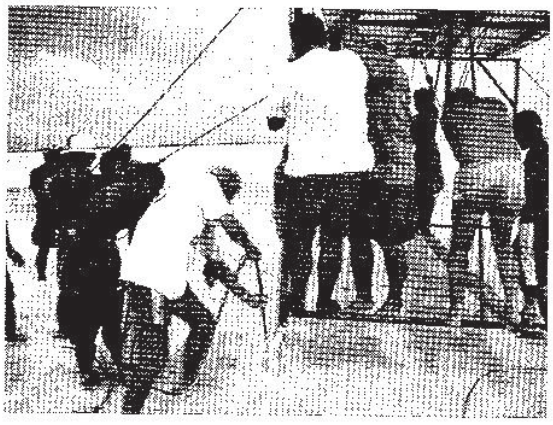

FIGURE 7.11 Jetting solar panel into the sand with a SCUBA tank on Helen Reef, Palau.

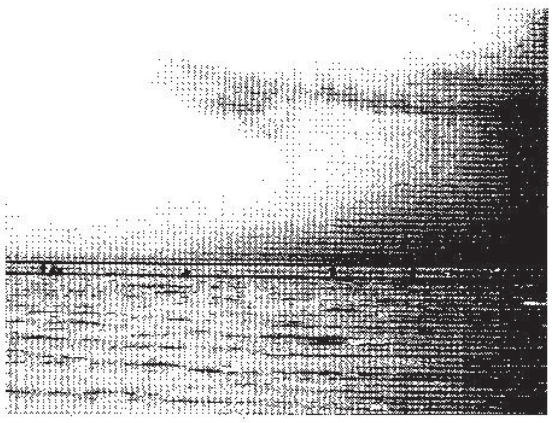

FIGURE 7.12 Building the breakwater in fierce winds and rain, Palau.

strong enough to withstand damage from huge tree trunks from Indonesia, the Philippines, or New Guinea that were smashed over the reef by monsoon and typhoon waves. As a result the structure was damaged before it was strong enough to withstand the logs. The solar panels were rescued, to be reused when we can find more funding to rebuild it using stronger materials and tools. There is no conceptual difficulty to saving the island, only a funding issue. The donor that supported the initial effort is not interested in follow-through, and so far no new funding has been found, despite efforts by the former governor, Sackarias, and the new governor, Crispin Emilio.

If more funding can be found we plan to rebuild the breakwater, and grow coral, fish, and giant clam habitat to restore the reef and fisheries. The Tobi people also want to reinvigorate an ancient artificial reef method they have not used now for several generations, which was unknown to Johannes. In the old days they would construct reefs from coral rubble with a lot of hiding spaces for fish, dismantle it after several years, catch the fish in the new habitat they had created, and rebuild the reef nearby. The intention is to compare these revived methods with the new ones. If suitable funding can be obtained to use tidal energy turbines, we plan to build a large island on the barren reef flat right next to the tidal pass into Helen Reef, which has extremely strong currents. The tools now exist for the Tobi people to save their islands, restore their reefs and fisheries, and create a new, much larger island to live on using purely renewable energy. The will and skills are there if the international funding community responds to their appeal to save their unique islands and culture from disappearing beneath the waves.

SUMMARY: CURRENT PROGRESS AND FUTURE STEPS

New tools now exist to allow fishing communities to restore their coral reef habitat and fisheries and protect their coastlines from erosion habitat even under conditions where it cannot recover naturally, and to greatly increase carrying capacity of fish and shellfish using structures specifically designed for certain species. Most Biorock restoration projects have been done with minimal funding, and in remote places that cause extreme logistic difficulties, but they show that even very isolated and poor fishing communities can easily learn and apply new skills. These will allow them to make the transition from being hunters wiping out the last big game to reef farmers who grow reefs to greatly increase populations of desired fish and shellfish species. This will finally bring the Neolithic revolution to the oceans, 10,000 year after big game hunters on land were forced to become farmers to survive. For this transformation to happen worldwide is not a matter of lack of knowledge or suitable methods, it is simply a result of the fact that governments do not invest in reef fishermen in the way that they invest in subsistence farmers to allow them to become cash crop farmers. Fishermen in tropical countries are usually the poorest element of society, and unless coral reef countries choose

to invest in them to allow them to apply new skills to restore their environment and sustenance, the deterioration will simply continue apace, no matter how much is spent on MPAs.

Unfortunately all funding being spent by governments and international funding agencies now goes towards implementing methods that have failed to protect reefs on a large scale, and will do even worse in the future as global warming and pollution increase. This strategy is based on "expert" opinion that if nature is left to take its course, "resilient" reefs will grow right back no matter what we do. This advice suits the interests of the rich countries while preventing developing countries from saving their vanishing reefs, fisheries, beaches, tourism, and shorelines. Indonesia has made a pioneering move in supporting community-based restoration, and it is to be hoped that other governments and international funding agencies follow its lead on a large scale before it is too late.

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N.B.: Color versions of all of these black and white figures can be seen at the Global Coral Reef Alliance Website: www.globalcoral.org.

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