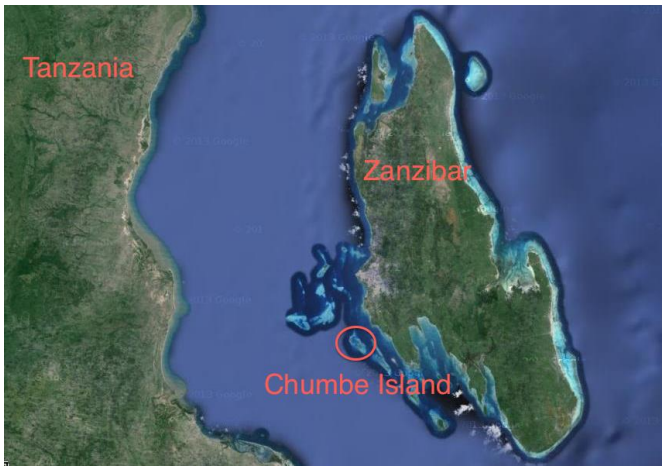
Reef Resilience **CASE STUDY**

The Establishment of a Marine Eco-Park to Conserve Reefs and Support Environmental Education in Tanzania

The Challenge

Chumbe Island is a small coral island in East Africa just west of the island of Zanzibar, Tanzania. Chumbe Reef has been well recognized as one of the most diverse in all of Africa, and is believed to host 90% of East Africa's hard coral species, as well as 425 reef fish species, the critically endangered Hawksbill Turtle (*Eretmochelys imbricata*) and the endangered Green Turtle (*Chelonia mydas*). The island's coral-rag forest also possesses numerous rare, threatened and endangered species, such as the Aders' duiker antelope (*Cephalophus adersi*), Coconut crab (*Birgus latro*), and various species of birds, trees and reptiles.



Location of Chumbe Island, Zanzibar, Tanzania

The western reef of Chumbe Island has been traditionally closed to fishing due to its proximity to the shipping channel between Zanzibar and mainland Tanzania. However, overfishing and destructive fishing practices such as dynamite fishing, smashing corals to encircle fish in nets, and beach seining are common in the region. With rapid population growth and the advent of mass tourism in Zanzibar, coral reefs are under pressure from overfishing, poaching and the use of illegal fishing methods. The situation at Chumbe Island is not uncommon for developing countries in the tropics: insufficient capacity for effective marine governance and enforcement, poverty, and lack of alternative livelihoods make it difficult to balance a sustainable environment and a sustainable community.

Chumbe Reef, live-coral dominated area
©Chumbe Island Coral Park

Actions Taken

Recognizing the high level of biodiversity in both reef and forest habitats, Sibylle Riedmiller, a conservationist and former aid worker, spearheaded the establishment of the uninhabited island and surrounding marine habitat as the Chumbe Island Coral Park (CHICOP) in 1992. The focus was to create a marine park where profits from tourism would help support conservation and environmental education. Ms. Riedmiller further realized that in order to take fishing pressure off of the reef ecosystem, she could offer local fishermen employment as park rangers, who would also be trained to educate fellow fishers about the spillover effect of a no-take zone that would benefit them by restocking over-fished adjacent fishing areas and thus increase catches.

Today CHICOP includes the fully-protected, 30-hectare Chumbe Reef Sanctuary (including coral reef, pelagic, coastal shallows and intertidal habitats), a 22-hectare coral-rag forest reserve (Closed Forest Habitat), a visitor's center, a small eco-lodge, nature trails, and historic ruins. Any extractive uses such as

fishing, anchoring, and the collecting of specimens (even for research) are prohibited. Recreational and educational activities such as swimming, snorkeling and underwater photography are permitted. The mission statement for Chumbe Island Coral Park is:

> *"To manage, for conservation and educational purposes, the Chumbe Island Reef Sanctuary and the Forest Reserve. This is also supported by eco-tourism activities which are directly related to the non-consumptive uses of the natural resources."*

How Successful Has it Been?

CHICOP has become a successful ecotourism destination and an internationally recognized conservation success. As of 2013, the Park employs and trains 41 local people from Zanzibar (93% of total staff) for positions such as park rangers, guides, and hospitality workers. The rangers and guides, eight of whom are former fishers, educate fishermen about the importance of coral reefs and of a small no-take zone as a breeding sanctuary for fisheries. As a result, CHICOP has been able to demonstrate that protection of the Chumbe reef helps restock overfished reefs beyond the waters of the sanctuary (1 km) within 3-5 years.

Chumbe Island has won many prestigious international awards and become a center of exceptional biodiversity and a breeding sanctuary for endangered and rare species. The Forest Reserve is the last undisturbed semi-arid 'coral rag' forest in Zanzibar, particularly after successful rat (*Rattus rattus*) eradication in 1997. With support from the Zoo Munich-Hellabrunn, Flora and Fauna International, and the Chicago Zoological Society, a translocation program in 1999 made Chumbe Island a sanctuary for highly endangered endemic Aders' duikers (*Cephalophus adersi*), which are threatened by poaching and habitat destruction elsewhere in Zanzibar. Chumbe also harbors the world's largest known population of rare Coconut crabs (*Birgus latro*). Attracted by abundant fish in the reef sanctuary, rare Roseate terns (*Sterna dougallii*) bred on Chumbe in 1994 and 2006.

Another outstanding feature of the Chumbe project is the application of state-of-the-art eco-architecture and eco-technology in all developments and operations. Rainwater catchment provides shower water that is heated by solar power. Photovoltaic energy is used for lighting, refrigeration of food and drinks, and communication. Composting toilets eliminate sewage and save precious water, while vegetative greywater filtration cleans shower and kitchen water before it is released. Water pollution is also minimized through biodegradable soaps and cleaners. Organic waste is composted and reused in the composting toilets, while other waste is removed from the island, and laundry is washed off the island. Guests are given solar torches for walking to the restaurant at night to avoid light pollution and protect feeding and breeding patterns of nocturnal animals.

The eco-lodge on Chumbe Island
©Chumbe Island Coral Park

According to the Chumbe Island Coral Park's Conservation and Education Status Report 2013, numerous biological, socio-economic and educational successes have been observed by Park staff and management, and acknowledged by the conservation community, the Government and people of Zanzibar:

Biological and Habitat Monitoring

CHICOP has hosted and conducted extensive research, some in cooperation with the University of Dar es Salaam's Institute of Marine Sciences and the Zanzibar Departments of Environment, Forestry, and Fisheries. CHICOP, in collaboration with its partners, have been conducting on-going monitoring in the following areas: sea water temperature monitoring since 1997; coral reef monitoring since 2006; seagrass monitoring since 2006; and humpback whale monitoring since 2008. The following are some of the key monitoring results in the Chumbe Reef Sanctuary (CRS) reported in the CHICOP's 2013 Status Report:

- In April 1998, due to El Niño sea surface temperatures were 2°C higher than average (over 30°C) causing severe bleaching and coral mortality events throughout the Indo-Pacific. The CRS was also affected, but its coral health, diversity and absence of anthropogenic stress are believed to have helped the reef recover more quickly and with more coral diversity compared to surrounding reefs in Zanzibar.
- Comparing the abundance of large commercial fish (more than 30 cm in length) between Chumbe and the fished control reef reveals that larger fish are found in the CRS.
- Compared to the fished control reef, Chumbe shows a much higher abundance of corallivore (coral polyp eating) butterfly fish. This abundance is linked to a high abundance of live hard corals in the sanctuary that provide a diverse reef habitat and food source for indicator species like the butterfly fish.
- When increased densities of crown-of-thorns (COT) starfish were noticed inside the CRS in 2004, CHICOP management initiated a manual COT removal program which involved park rangers who collect, count and measure all COTs detected during random swims inside the CRS. This removal program has proven to be a very effective management tool as a total number of 3898 COT starfish have been removed since 2004, which had a very positive effect on the health status of the CRS. The COTs are buried on island once they have been counted and measured.

Education

CHICOP has become a pioneer in the field of environmental education on coral reef ecology and nature conservation for teachers and school students in Zanzibar and mainland Tanzania. Though Zanzibar is a coral island and Tanzania has extensive coral reefs, school syllabi do not cover coral reef ecology and the general public has little awareness of their importance as a valuable natural resource.

CHICOP has offered one-day school excursions to Chumbe Island to more than 5600 students, 980 teachers and 346 community members and government officials since the establishment of the Environmental Education (EE) Program in 2000. Field excursions to the island provide hands-on experiences for students and teachers in marine biology, forest ecology, and conservation.

Educator explaining coral bleaching to local students
©Chumbe Island Coral Park

The following educational outcomes have been reported in the CHICOP's 2013 Status Report:

- The number of different schools applying each year to participate in the program has increased significantly, reflecting the program's popularity.

- The number of total education trips per year has constantly been increasing since its initiation in the year 2000.
- Increased interest from national and international universities to participate in the education trips has been reported.
- Teacher evaluation seminars, held after each EE season, confirmed in early 2013 that awareness about environmental issues has increased among students after their participation in the Chumbe Field Excursions.
- Inspired by the Chumbe Field Excursions, many secondary schools have started environmental clubs, aiming to increase environmental knowledge and awareness in their communities.
- CHICOP is often used as an example of good practice for other projects wishing to initiate and develop environmental education, e.g. Misali Island (Pemba, Tanzania) or Lamu Island (Kenya).

Socio-economics
Long-term staff have noticed an increased awareness after years of educating fishermen about the benefits of protecting coral reefs. Park rangers have also reported a decrease in poaching and trespassing, with less than 50 incidents per year since 2008, as opposed to as many as 170 per year in 1994.

Within the Chumbe Education Program, CHICOP strongly supports Education for Sustainable Development (ESD), which is a lifelong learning process. Through ESD, CHICOP helps students and community members to develop the knowledge, skills, and action competence needed to create and sustain a viable future for human and other living things in Zanzibar and on the planet. Thus the Chumbe Education Program contributes to the Millennium Development Goals, especially on resource management and strategies for addressing poverty.

Lessons Learned and Recommendations

- Private management of a marine protected area can be effective and economically viable, even in a challenging political climate.
- The park has benefited local communities by generating income, employment, market for local produce, developing new work skills, demonstrating sustainable resource management, and restocking commercial fish species in adjacent areas (spillover).
- Extensive work with government agencies in establishing the park has enhanced the understanding of environmental issues among local and national authorities.
- Private management has strong incentives to achieve tangible conservation goals on the ground, co-operate with local resource users, generate income, be cost-effective, and keep overhead costs down.
- Long-term secure tenure, together with a favorable political, legal and institutional environment, is needed to attract private conservation investment in the developing world.
- Ambiguous regulations and wide discretionary powers of civil servants in the area of land leases, building permits, business licenses, immigration and labor laws encourage corruption, and are hurdles to doing business by drastically delaying development and increasing costs.
- Investment in conservation and in environmentally sound technologies, as well as the employment of additional staff for park management and environmental education programs, raises costs considerably, making it more difficult to compete with other tourist destinations. Favorable tax treatment could encourage such investments, but is not granted in Tanzania.
- To avoid user conflicts, it is easier to preserve a resource that is not being used to a major extent for subsistence or other economic endeavors by local communities.

Funding Summary

The pre-operational phase (1991-1998) of CHICOP cost a total of $1.2 million (US). Of this, approximately 50% of the start-up and development costs were funded by the project initiator and main investor, Sibylle Riedmiller; 25% by a variety of small donors for non-commercial components (i.e. baseline surveys, visitor center, ranger training, nature trails, education program); and 25% from volunteers, including individuals and agencies.

Commercial operations opened in 1998. The minimum management costs for running CHICOP are approximately $250,000 (US) annually, which have been fully funded from the proceeds of ecotourism since 2001 (a minimum occupancy rate of 30% is required for this to occur, which has been met and exceeded every year thus far).

Volunteers have helped with a wide range of tasks, such as: conducting baseline surveys and developing monitoring systems, rat eradication, training local fishermen as park rangers in marine science and teaching English language, training hospitality staff, designing nature trails and educational materials, designing the eco-lodge, and installing and repairing photovoltaic and other technical equipment.

Several donor agencies have supported specific projects:
Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ): including GTZ German Appropriate Technology Exchange, GTZ Centrum für Internationale Migration und Entwicklung, and German Tropical Forest Stamp Program
The Netherlands Embassies in Kenya and Tanzania
World Wildlife Fund Tanzania
Flora and Fauna International
Chicago Zoological Society
Schloss Buchhof International School, Munich, Germany
Seacology

Educational program funders include:
World Wildlife Fund—Marine Education, Awareness and Biodiversity Program
Wildlife and Environmental Society of South Africa
National Fish and Wildlife Foundation
International Coral Reef Action Network
Southern African Development Community / Regional Environmental Education Program

Lead Organizations

Chumbe Island Coral Park
http://www.chumbeisland.com

Partners

Institute of Marine Sciences, University of Dar es Salaam
http://www.ims.udsm.ac.tz/

Zanzibar Revolutionary Government
Departments of Environment, Forestry, and Fisheries
http://zanzibar.go.tz

Resources

Chumbe Island Coral Park Conservation and Education, Status Report 2013

Chumbe Island Coral Park—Governance Analysis

Sustainable Marine Park Financing Through Ecotourism

A Private Sector Approach – Conservation Agreements in Support of Marine Protection

The Effect of Fully and Partially Protected Marine Reserves on Coral Reef Fish Populations in Zanzibar, Tanzania

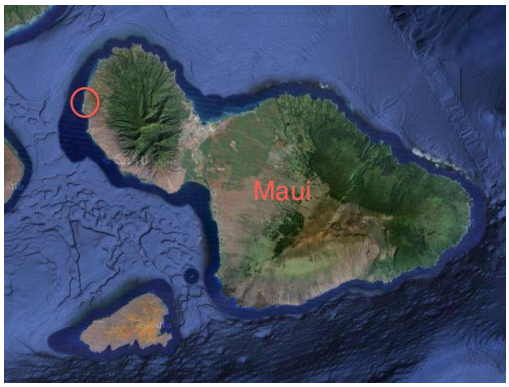
UNESCO, Biodiversity Conservation and Eco-Tourism: Chumbe Island, Tanzania
http://www.unesco.org/csi/wise/chumbe.htm

UN Secretary General, Report to the General Assembly on Protection of coral reefs for sustainable livelihoods and development

Managing Fisheries for Reef Resilience: Kahekili Herbivore Fisheries Management Area
North Kāʻanapali, West Maui, Hawaiʻi

The Challenge

Long term monitoring of coral reefs along the leeward coast of the Island of Maui began in 1999 by the State of Hawaiʻi's Division of Aquatic Resources (DAR) and the University of Hawaiʻi's (UH) Institute of Marine Biology's Coral Reef Monitoring Assessment Program. Many of these coral reef survey locations were established at previous study sites, providing managers with a longer term picture of the changes on these reef systems. Assessments have shown that of the nine reefs monitored, many sites experienced a significant decrease in live coral cover as reefs became overrun by invasive algae. At Kahekili in north Kāʻanapali, reef monitoring sites indicated a decrease in coral cover from 55% to 33% between 1994 and 2006.



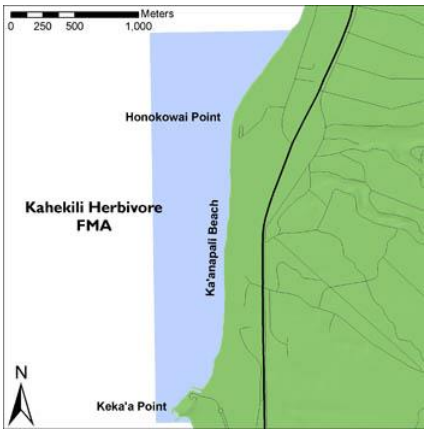
Location of North Kāʻanapali, West Maui, Hawaiʻi

The significant increases of invasive algae were seen as a major threat to West Maui's coral reefs. At Kāʻanapali, specifically, red algal blooms of *Acanthophora spicifera* had become much more abundant, which was suggested by UH research to be a result of elevated nutrients from wastewater and fertilizers. Despite the sources of land-based pollution, the increasing abundance of algae was exacerbated by the fact that there was a decrease in abundance of reef grazing herbivores, which fish surveys at the same sites confirmed.

Actions Taken

A cooperative "Fish Habitat Utilization Study" by DAR and the National Oceanic and Atmospheric Administration (NOAA) revealed clear evidence of the relationship between grazing fish and the abundance of invasive algae; the more herbivorous fishes present, the less algae on the reefs.

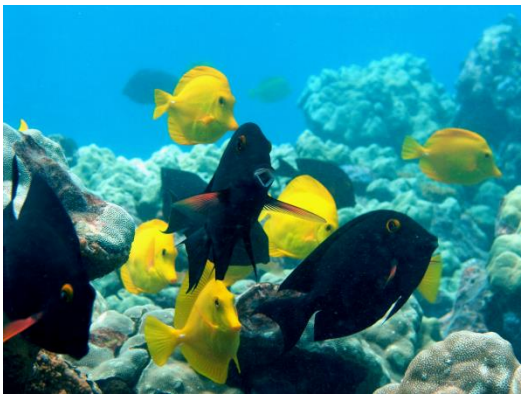
Therefore, in July of 2009, the State of Hawaiʻi designated the Kahekili Herbivore Fisheries Management Area (KHFMA) in order to control the overabundance of marine algae on coral reefs and restore the marine ecosystem back to a healthy balance. The killing, injuring, or harming of sea urchins and certain herbivorous fishes, including sea chubs, parrotfish, and surgeonfish is prohibited in order to increase the local abundance of these beneficial fishes and sea urchins in the area. Feeding of these fishes is also prohibited in order to promote grazing. The onshore boundaries extend from Honokōwai Beach Park (and offshore for a distance of 1,292 yards) south approximately 2 miles to Hanakaʻōʻō Beach (and offshore for a distance of 335 yards) (Hawaiʻi Revised Statues, Chapter 13-60.7).



Boundaries of the KHFMA along the Kāʻanapali Coast, West Maui © Hawaiʻi DLNR

How Successful Has it Been?

Although some fishermen and cultural practitioners opposed fishing rules, the majority of the community was in strong support of the KHFMA. Many of the local fishermen understood the poor conditions of the reef, and realized the benefits of fisheries management. The overwhelming support for the KHFMA has led to more education within the area as well as compliance with the rules.



Beneficial herbivorous fishes now fully protected within the KHFMA © Hawai'i DLNR

Since the establishment of the KHFMA in 2009, DAR, in partnership with UH and NOAA's Pacific Islands Fisheries Science Center (PIFSC), has continued monitoring the reefs at Kahekili. According to the PIFSC Interim Monitoring Report from February 2013, results thus far indicate the following:

- Consistent upward trend in biomass of parrotfishes, which more than doubled between 2009 and 2012
- Increases in parrotfish biomass have not been distributed evenly across the KHFMA, and, in particular, there has been little or no recovery of parrotfish biomass in the shallow, nearshore reef areas adjacent to Kahekili Beach Park;
- Strong positive relationship between total parrotfish biomass and total crustose coralline algae (CCA) cover. CCA is a benign algae that is important for coral settlement, and studies show that increases in parrotfish biomass leads to increased CCA cover
- No clear overall trend in biomass of surgeonfishes

A possible reason for the lack of change in biomass of surgeonfish could be linked to their lifespan; they can live up to 40+ years, so with three years of data, it is not surprising that biomass has not changed.

The steady increase in biomass of parrotfishes since the establishment of the FMA has potentially significant indications for reef resilience. The larger the fish, the deeper the excavating bites, which is important because this removes algae from the substrate, exposes bare rock and opens up new sites for coral recruitment.

Lessons Learned and Recommendations

- In addition to increasing stocks of herbivorous fishes on the reefs to control invasive algae, management must also include reducing sources of land-based pollution that is resulting in high levels of nutrients (nitrogen and phosphorus) found in nearshore waters, which is likely driving the algal blooms.
- Poor habitat quality resulting from invasive algae and subsequent degradation of reefs will also have lower economic (commercial and recreational) and cultural value.
- Studies have shown that reef deterioration in the monitored sites occurred rapidly; therefore, resource managers must take steps to not only restore reefs back to their healthy conditions, but also prevent any further threats from degrading Maui's reefs.
- Public awareness about coral reef health and the negative impacts of land-based pollution on reef ecosystems has increased since the designation of the KFHMA. With the community's support, West Maui reefs have since been designated as a priority site under the Hawai'i Coral Reef Strategy, have been chosen for a Ridge to Reef cooperative watershed management

project by the state and the U.S. Army Corps of Engineers, and have been designated as a priority site in the Pacific by the U.S. Coral Reef Task Force.

- Reef recovery takes time – although three years of data indicates an increase in biomass of parrotfishes, slow-growing corals will need long-term protection to fully recover.
- Making a genuine effort to provide data and have a dialogue with the local community at the beginning of the planning process is essential to the success of the project. Community members will gain more trust, offer input, and be part of the problem solving process.
- Data that is specific, real time, and applicable is vital to having a supportive, knowledgeable community.
- Identifying and engaging key stakeholders and fishers from the area can provide a wealth of local knowledge, as well as buy-in and compliance later on.

Funding Summary

The process to establish the KHFMA was funded and staffed by the State of Hawai'i's Department of Land and Natural Resources (DLNR) as part of the agency's mission and core responsibilities. Monitoring efforts have been funded primarily through a Sports Fish Restoration Program grant administered by the U.S. Fish and Wildlife Service. The islands of Maui and O'ahu receive roughly $300,000/year (US) from the program, of which Maui spends about $200,000 (US) for monitoring staff and other associated costs. Other funding partners include:

NOAA Coral Reef Ecosystem Division, Pacific Islands Fisheries Science Center
NOAA Coral Reef Conservation Program
University of Hawai'i
Graduate students with funding

Lead Organization

Hawai'i Division of Aquatic Resources, Department of Land and Natural Resources
http://state.hi.us/dlnr/dar/

Partners

Hawai'i Coral Reef Initiative Research Program
http://www.hcri.ssri.Hawai'i.edu/

NOAA Coral Reef Conservation Program
http://coralreef.noaa.gov/

NOAA Pacific Islands Fisheries Science Center, Coral Reef Ecosystem Division
http://www.pifsc.noaa.gov/cred/

The Nature Conservancy
http://www.tnc.org

UH, Hawai'i Institute of Marine Biology
http://www.Hawai'i.edu/himb/

UH Manoa, Department of Botany
http://www.botany.Hawai'i.edu/directory.htm

Resources

Hawai‘i Coral Reef Strategy: Priorities for Management in the Main Hawai‘ian Islands 2010-2020, State of Hawai‘i

Kahekili Herbivore Fishery Management Area – Interim Monitoring Results, National Oceanic and Atmospheric Administration, Pacific Islands Fisheries Science Center

Kahekili Herbivore Fisheries Management Area Rules
http://state.hi.us/dlnr/dar/regulated_areas_maui.html#kahekili

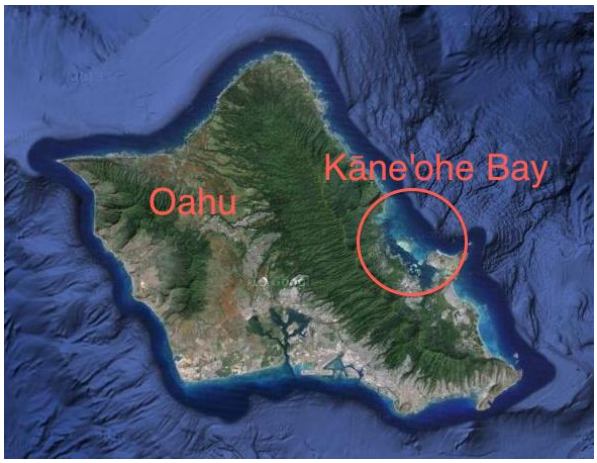
Regulated Fishing Areas in Maui County, Hawai‘i Division of Aquatic Resources
http://Hawai‘i.gov/dlnr/dar/regulated_areas_maui.html

Status and Trends of Maui’s Coral Reefs, Hawai‘i Division of Aquatic Resources

Building Reef Resilience Through Invasive Algae Removal and Urchin Biocontrol in Kāneʻohe Bay
Kāneʻohe Bay, Island of Oʻahu, Hawaiʻi

The Challenge

Kāneʻohe Bay lies below the dramatic Koʻolau mountain range on the windward side of Oʻahu. It is the largest sheltered body of water in the main Hawaiʻian Islands, and is surrounded by numerous freshwater streams and wetlands. It is the only bay in Hawaiʻi that includes fringing reefs, patch reefs, and barrier reefs. It has significant cultural and ecological value, and has long been a rich resource for commercial, recreational and subsistence uses. The bay has more than 40,000 people living near its shores or in the mountains above it, as well as a U.S. Marine Corps Base, the University of Hawaiʻi Institute of Marine Biology on Moku o Loʻe (Coconut Island), and a public pier that provides daily access to hundreds of tourists and fishermen.



Location of Kāneʻohe Bay, Oʻahu, Hawaiʻi

Invasive alien algae are a significant threat to Hawaiʻi's nearshore coral reef ecosystems. In ocean ecosystems that are already threatened by land-based pollution and overfishing, they can easily take over and smother reefs to death. Unfortunately, the reefs in Kāneʻohe Bay are suffering from an overgrowth of invasive algae that forms thick, tangled mats. *Gracilaria salicornia* (gorilla ogo) and *Kappaphycus/Eucheuma* spp. (smothering seaweed) were introduced to the bay for aquaculture purposes in the early 1970s. These fast growing algae have now spread throughout the entire bay where they outcompete native seaweeds, smothering and killing coral reefs, covering up native fish habitat, preventing new corals from attaching to the reef, and reducing the overall health and biodiversity of the entire bay. Fortunately, native sea urchins (*Tripneustes gratilla*) like to eat it, but their populations are depleted in the bay.

If nothing is done to stop the spread of invasive algae, it will continue to move northward, spreading from the bay to reefs along the rest of Oʻahu's shoreline.

Actions Taken

To restore Kāneʻohe Bay coral reefs and prevent the further spread of invasive algae, the State of Hawaiʻi's Division of Aquatic Resources (DAR), in partnership with The Nature Conservancy (TNC) and the University of Hawaiʻi (UH), embarked on a dual-phased restoration project to control the invasive algae by:

- Removing invasive algae to allow coral reefs and native fish habitat to thrive
- Restocking the reefs with native sea urchins that eat the invasive algae and keep it from growing back

Invasive Algae Removal
DAR, TNC, and UH developed the first Super Sucker barge in 2005 to "suck up" invasive algae. The Super Sucker is a suction pump on a barge with hoses that are used by divers to vacuum the invasive algae off the reefs. The invasive algae are then delivered to local farmers who use it for compost.

The Super Sucker is capable of removing anywhere from 600-1,000 pounds (270-450 kg) of algae per hour depending on location and conditions. Last year, TNC built a second Super Sucker and a mini Sucker to be used in shallower water, to help speed up the operation.

Divers using the Super Sucker to remove invasive seaweed © Hawai'i DLNR

Native Sea Urchin Biocontrol
Although the Super Sucker is effective at removing the bulk of the invasive algae, the algae can return within six months if nothing is done to stop it. In order to prevent the algae from growing back, DAR operates a sea urchin hatchery at their Anuenue Fisheries Research Center. These native "collector urchins" were once plentiful in Kāne'ohe Bay, but their populations have declined over the last few decades.

The state has successfully reared *T. gratilla* from the larval stage all the way through to adulthood. The hatchery has been producing approximately 5,000 urchins each month, and they are working to dramatically increase that number to keep pace with the rate of invasive algae removal. The urchins are transplanted directly onto the reefs to graze after the Super Sucker has removed the majority of invasive algae. Because the urchins will not cross the sandy areas between reefs, they are likely to stay put; they can also be re-collected and moved to other patch reefs if necessary.

Keeping the reefs clear of invasive algae opens up new space for coral recruits and native seaweeds, and helps restore natural habitat for fish and other sea creatures, making Kāne'ohe Bay more resilient to future threats.

Juvenile collector urchin being outplanted to the reef © Hawai'i DLNR

How Successful Has it Been?
Since October 2012, the coordinated TNC/DAR crews have removed 250,000 pounds (114,000 kg) of invasive algae from 20 acres (8 ha) of reef. The algae are given to local farmers for compost.

As of August 2013, the team marked a huge milestone: a total of 100,000 urchins from the Anuenue hatchery have been transplanted onto the reefs. Research is being done to determine the optimal density of urchins needed per acre to keep the algae in check. And field monitoring continues on urchin density, coral cover, coral recruitment, and algal density and diversity.

Lessons Learned and Recommendations

- Recommend cleaning all boating, fishing and dive gear to prevent the spread of invasive species to new areas.
- Encourage local fishermen to take only what they need. Leave herbivorous fish and native sea urchins to eat the invasive algae, and other sea life to reproduce and replenish the bay.
- Work with the local community to keep the watershed clean – educate residents about proper land clearing and maintenance and other ways to reduce runoff of sediment and nutrients into the bay.
- Encourage the public to volunteer with local community organizations who are working to restore the streams, wetlands, fishponds, and native agricultural lands in this watershed.

Funding Summary

State of Hawaiʻi
For the past three years, the Super Sucker barge and urchin hatchery have been funded through the state's Hawaiʻi Invasive Species Council, in addition to federal grants from the National Oceanic and Atmospheric Administration. Mitigation funds are also a source of current and future support.

The Nature Conservancy
The Nature Conservancy has committed to raise $2.5 million (US) to pay for the construction of the new Super Sucker and three years of operation.

Lead State Organization

Hawaiʻi Department of Land and Natural Resources, Division of Aquatic Resources
http://state.hi.us/dlnr/dar/

Partners

Hawaiʻi Department of Agriculture
Harold K.L. Castle Foundation
Hawaiʻi Invasive Species Council
Kākoʻo ʻŌiwi
Kamaʻaina Kids
Kāneʻohe Canoe Club
National Oceanic and Atmospheric Administration
The Nature Conservancy
University of Hawaiʻi Institute of Marine Biology

Resources

Hawaiʻi Invasive Species Council
http://www.Hawaiʻiinvasivespecies.org/

Protecting Hawaiʻi's Reefs from Invasive Seaweed, Hawaiʻi Department of Land and Natural Resources
http://youtu.be/wxFZ2cDyW9Y

Hawaiʻi Coral Reef Strategy: Priorities for Management in the Main Hawaiʻian Islands 2010-2020

Hawaiʻi Coral Reef Strategy: The culture of native collector sea urchins as a biocontrol option for alien algae control

http://www.Hawaiʻicoralreefstrategy.com/index.php/on-going

Hawaiʻi Aquatic Invasive Species Management Plan, Hawaiʻi Division of Aquatic Resources

Invasive Algae of Hawaiʻi poster, Hawaiʻi Division of Aquatic Resources

Reef Revival, The Nature Conservancy
http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/Hawaiʻi/explore/hi-reef-revival.xml

Reef Revival: A Campaign to Restore Kāneʻohe Bay, The Nature Conservancy
http://www.youtube.com/watch?v=gh9Gmhk1jAM

Comprehensive Watershed Improvements in Laolao Bay, Saipan
Commonwealth of the Northern Mariana Islands

The Challenge

The island of Saipan is the most populated island in the Commonwealth of the Northern Mariana Islands (CNMI) with just over 48,000 people. On the eastern side of Saipan, Laolao Bay is a popular fishing and diving site among residents and tourists alike. Unfortunately, the coral reefs and the rest of the marine ecosystems in the bay, including sea turtle habitat, are suffering from extremely degraded water quality due to a variety of point source and non-point source pollution. Ecological monitoring studies from the development of a golf course in 1991 provided baseline data for the bay, and in combination with more current monitoring, results show negative changes to the coral reef assemblages and fisheries over the last 20 years.

Location of Laolao Bay, Saipan, CNMI

The upland area of the watershed is a mix of residential lots (many of which have septic systems), a golf course, and agricultural and other private land uses. As a result, the bay is subject to erosion and runoff pollution from unpaved roads, unpermitted development, land clearing, and agricultural practices. Heavy rain events exacerbate the problem as stormwater carries soil and pollutants into the bay. Land-based pollution from upland watersheds has resulted in excess nutrients and macroalgae in Laolao Bay.

Actions Taken

In order to improve water quality and coral reef health, which in turn can enhance tourism and the local economy, the CNMI Division of Environmental Quality (DEQ) embarked on a multi-year, multi-million dollar engineering, road construction, re-vegetation and outreach project at Laolao Bay. A National Oceanic and Atmospheric Administration (NOAA) grant was awarded to DEQ through the American Recovery and Reinvestment Act (ARRA) for road and drainage improvements and revegetation. The following actions were taken to reduce erosion and sediment transfer into Laolao Bay:


Sedimentation stream outfalls prior to restoration project (2004) © Tim Lang

Road Improvements

The two access roads to Laolao Bay are Laolao Bay Drive and Gapgap Road. About a half a mile of Laolao Bay Drive was paved and storm water runoff controls were installed to redirect water into a series of sediment chambers at the bottom of the road. The unpaved portions of Laolao Bay Drive and Gapgap Road (which leads to a popular dive site from the village of Kagman) have been regraded to improve drainage. Plans were created to realign Gapgap Road to follow the natural curve of the land, decreasing erosion and sedimentation into the bay, although they have not yet been implemented.

Hardening Stream Crossings
The unpaved portion of the road was hardened at six stream crossings to prevent chronic erosion.

Revegetation
1600 seedlings of 12 native or naturalized species have been planted over a 14 acre area in the upper badlands of the watershed that had been damaged by land clearing and fires.

Community Outreach
Signs have been posted at beach access points to educate people about littering and sea turtles. Brochures were distributed to schools to teach children about revegetation efforts, and project slides were shown at the local movie theatres. Volunteers have been involved with raising awareness about the project and the threats to the natural resources in the bay. A social marketing campaign was launched in 2012 called "OurLaolao", encouraging visitors to take pride in the resources of the bay and clean up litter along the beaches.

Biological and Water Quality Monitoring
The DEQ and Coastal Resource Management Office (CRM) Marine Monitoring Team partnered with the Pacific Marine Resources Institute to conduct ecological monitoring of benthic substrate, coral communities, algal diversity, invertebrate densities and fish communities. Data from this assessment were compared to a similar study done in the fall of 1991 and the spring of 1992, before the construction of the Laolao Bay Golf Resort. The Division of Fish and Wildlife (DFW) Sea Turtle monitoring program surveys the beaches for turtle nesting sites. Fishing pressure and catch-per-unit effort are also monitored by DFW.

For the duration of the ARRA funded project, water quality was monitored at the reef flat on a monthly basis for temperature, pH, salinity, total suspended sediments, turbidity, and nutrients. During rain events, stormwater at ten locations where stormwater crosses the access road, some of which have been improved with ARRA funds, was sampled.

How Successful Has it Been?
The paving of 0.4 miles of Laolao Bay Drive was completed in April 2012. The new drainage system includes a curb and catch basin system, subgrade drain pipe, concrete sediment chamber, and a gabion sediment chamber. A total of 1.9 miles of unpaved parts of Laolao Bay Drive and Gapgap Road were regraded utilizing techniques learned from workshop training. Six stream crossings were constructed of reinforced concrete fords and included rip-rap slope protection.

Section of road grading work completed by DPW © Tim Lang

DEQ partnered with the Department of Land and Natural Resources, DFW, CRM and the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) on the reforestation of the watershed. More than 1,600 plants representing 12 native species and 5,000+ linear feet of Vetiver grass were planted in 2010 and 2011 across the 14-acre deforested upland site above Laolao Bay. Monitoring is ongoing, but within the first year, a 67% survival rate had been observed.

Several stakeholder workshops were held in order to educate the community about the project and get feedback. Fifty-five community volunteers attended training on revegetation. Along with the two beach signs for turtles and anti-littering, theatre slide Public Service Announcements (PSAs) were shown at the local movie theatre for six months, and radio PSAs were broadcasted on three stations for six months. Informational materials such as posters and brochures were distributed to 32 schools.

Workshop participants discuss stream crossing © Tim Lang

The Laolao Bay Coral Reef & Water Quality Monitoring Plan was completed in 2010. The DEQ-CRM Marine Monitoring Team completed a baseline ecological survey of the reef flat and slope in 2011. Compared to 1991 data, results indicated a significant increase in macroalgae, mainly consisting of red algae, but also seasonal brown algae. It is anticipated that the completion of road improvements will result in improved water quality and a decrease in algal cover, thus having a positive influence on reefs in the future.

Water quality monitoring of streams, reef flats, and the outer reef have been conducted regularly for 12 months to measure nutrient levels. During rain events, turbidity measurements are taken at ten stream locations to measure the effects of the road improvements and revegetation in the area.

Lessons Learned and Recommendations

- It is expected that with the completion of the road improvements and upland restoration activities that algae biomass will be reduced. However, ecological responses may take several years to realize. The biomass of herbivorous fish will play a large part in the control of algae on the reef.
- There are many societal components in Laolao Bay, such as historic sites, fishermen, and divers. A social diagram should be made to compliment the natural resource management work to make sure those social considerations are included in long-term planning.
- Private landowner conservation practices should be encouraged.
- In addition to existing natural resource targets, causes of forest habitat loss, overharvesting of Tangantangan (castor oil plant) for charcoal, soil, and birds should be considered as potential conservation targets for Laolao Bay.
- Through this project, agencies and the public have learned a great deal about how sensitive the watershed is, and the value of preventing land-based pollution. This will hopefully lead to better protected lands in the future and especially in the case when lands are being developed.
- Not every problem in the Laolao Bay watershed has been fixed. Poorly developed roads and aging individual wastewater treatment systems are continuous problems. Despite increases in the resilience of Laolao Bay in the past few years, the watershed and the coral reef continue to face threats.

Funding Summary

Original Grant - $641,273 (US) (awarded 6/26/09)

- Revegetate 14-acre upland area
- Marine Monitoring - Ecological & Water Quality

- Public Awareness Campaign - Beach Signs - Public Service Announcements - Informational Brochures & Posters

Supplemental Funding - $492,118 (US) (awarded 8/10/10)

- Enhanced Water Quality Monitoring - Additional sampling of streams - Sampling of reef flat - Profiling beyond reef
- Low-volume Roads Engineering Training Workshops
- Design and Construction of Stream Crossings
- Regrading of Laolao Bay Drive
- Laolao Bay Drive Minor Improvements

NOAA-Funded/Managed Works - $1,470,773 (US)

- 0.4 mile Road Paving and Drainage Laolao Bay Dr.
- Construction Management
- A/E Design for Gapgap Rd. Paving and Drainage

Total ARRA Funding: $2,604,164 (US)
Additional Funding: $65,926 (US) EPA grant (for stream crossings construction)

Lead Organizations
CNMI Coastal Resources Management Office
http://www.crm.gov.mp
CNMI Division of Environmental Quality
http://www.deq.gov.mp
CNMI Department of Land and Natural Resources, Division of Fish & Wildlife
http://www.cnmi-dfw.org

Partners
CNMI Department of Finance
CNMI Procurement & Supply
CNMI Department of Public Lands
CNMI Department of Public Works
CNMI Forestry
CNMI Historic Preservation Office
U.S. National Oceanic and Atmospheric Administration
U.S. Natural Resources Conservation Service
U.S. Office of Personnel Management
U.S. Office of the Attorney General
U.S. Office of the Governor
U.S. Office of the Lt. Governor
U.S. Office of the Public Auditor
U.S. Department of the Treasury
U.S. Army Corps of Engineers
U.S. Environmental Protection Agency US Fish & Wildlife Service
Northern Marianas College
Pacific Marine Resources Institute
The Nature Conservancy

Resources

Laolao Watershed Restoration Project, Coastal Resources Management Office, CNMI
http://www.crm.gov.mp/projects/laulau.asp

Coral Reef Initiative, Northern Mariana Islands
http://cnmicoralreef.com/

Marine Monitoring and Coral Reef Program, Division of Environmental Quality, CNMI
http://www.deq.gov.mp/sec.asp?secID=12

Turning Problems into Advantages – The Marianas Islands Responds to Nonpoint Sources in the Lau Lau Bay Watershed
http://water.epa.gov/polwaste/nps/success319/marianas.cfm

Laolao Bay Road and Coastal Management Improvement Project: Ecological and Water Quality Assessment

Laolao Bay Conservation Action Plan

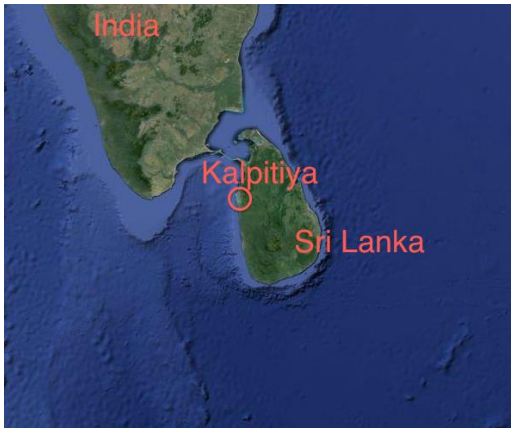
LaoLao Bay Road & Coastal Management Improvement Plan

Our Laolao
http://www.ourlaolao.com/

Sustainable Livelihoods Enhancement and Diversification to Reduce Pressure on the Bar Reef Ecosystem
Villages in the vicinity of Bar Reef, Kalpitiya, Sri Lanka

The Challenge

Kalpitya Peninsula is located along the northwest coast of Sri Lanka, and includes a range of rich and dynamic marine habitats that have provided food and income for generations of local fishermen and community members. The marine environment includes the second largest lagoon in the country, mangroves, sand dunes, seagrass beds, salt marshes, and Bar Reef - the most extensive coral reef complex in Sri Lanka. The natural marine resources of Bar Reef and the surrounding area play a significant role in the lives of the local coastal communities. Fishing is the most important commercial activity, even though the average income of coastal fishermen is well below the poverty line.



Location of Bar Reef, Kalpitiya, Sri Lanka

Prior to a massive bleaching event in 1998, Bar Reef possessed a high level of biodiversity. Stock assessment studies conducted by the National Aquatic Research and Resources Agency (NARA) in 2010 on selected species (sea cucumber, lobster, shrimp, and ornamental fish) revealed that these resources have been drastically reduced due to overexploitation and environmental repercussions. NARA research on coral reefs in the Bar Reef area also demonstrate that biodiversity has been reduced. With climate change already posing a serious threat to the reef, human activities have exacerbated the amount of pressure on the reef ecosystem. Despite the fact that Bar Reef was declared a marine sanctuary in 1992 under the Department of Wildlife Conservation, it is extremely vulnerable to degradation and resource exploitation due to overfishing, destructive fishing practices, and lack of enforcement. Furthermore, a 30-year fishing ban in the area was lifted in January 2013, which has resulted in a dramatic increase in fishing and subsequent reduction in per capita catch. As reef resources continue to be depleted, poverty levels have been increasing within the adjacent communities given there are no supplementary or alternative livelihoods.

Actions Taken

Considering the multifaceted social and economic situation in Bar Reef communities, the Marine & Coastal Resources Conservation Foundation of Sri Lanka (MCRCF) embarked upon a project to implement the IUCN's Sustainable Livelihoods Enhancement and Diversification (SLED) approach among the villages dependent on Bar Reef in 2010. The project was designed with three objectives in mind:

1.) Expand and strengthen sustainable livelihoods programs (home gardening, ornamental fish farming, and commercial seaweed cultivation) to take pressure off Bar Reef resources and diversify the socioeconomic status of local people
2.) Ensure sustainable livelihoods and use of marine resources in the Bar Reef area through education and awareness training
3.) Empower local fisher women in the Bar Reef area

As part of the sustainable livelihood programs introduced to Bar Reef community members, families were given seeds and taught how to grow their own food. Some were taught how to cultivate commercial seaweed instead of harvesting it from the ocean. An ornamental fish culture program designed to take pressure off reef fish taught villagers how to cut costs and maximize their profits with different husbandry techniques.

How Successful Has it Been?

By introducing alternative livelihoods to local families along Bar Reef, this project was able to achieve numerous successes. One of the home gardening projects under the SLED program introduced fisher women to the cultivation of vegetables. MCRCF appointed a coordinator and an agricultural specialist to conduct field inspections and provide guidance to eleven families such as how to prepare the land for cultivation, how to select suitable fruits and vegetables to be planted, how to prepare plant nurseries and propagate seeds for future use, how to water, and the value of using organic manures. Seeds, compost, fertilizer and other necessities were provided. Families were taught how to farm long-term perennial crops, such as coconut and mango, midterm crops, such as banana and papaya, and short-term seasonal crops, such as chilies, tomatoes and pumpkins. Families successfully grew their crops and were able to harvest continuously.

With the assistance of other donors, the home gardening project eventually led to an aloe vera cultivation program, which changed the attitudes and behavior of the fisher women as it enhanced their social status and self-confidence by training them in business skills. With the help of private sector partners who purchase the aloe vera, which is used in soaps, skin care products, and for medicinal purposes, this project has successfully continued for the past three years. About fifty families that are dependent on Bar Reef are earning substantial alternative income from this initiative. There have been social and environmental benefits as well from the aloe vera project including:

Home gardening program ©MCRCF

- Families have gotten involved in cultivation and enjoy working together
- More income is now being used for child education
- Less fishing pressure on Bar Reef as a result of more time spent tending the gardens

Mangroves for the Future, a partnership-based initiative promoting investment in coastal ecosystems for sustainable development, produced a documentary on the aloe vera project called, *The Beauty of Aloe Vera* at http://www.youtube.com/watch?v=bFxGZ-VSGXU.

With the assistance of an aquaculture consultant, five local fishermen were provided with tanks, shading nets, fish brood stock and feeding packets to start an experimental ornamental fish culture program. With no previous experience, the fishermen learned different techniques to cut costs and time in order to farm fish for the demanding market.

The commercial seaweed cultivation project provided start up equipment and seaweed to five local fishermen; however it was not as successful as the other programs. Some samples were eaten by rabbit fish, so efforts were made to cover the cages with small mesh as to prevent the fish from feeding on the seaweed. However, due to a variety of unfortunate weather conditions and associated salinity levels, initial samples were decayed or not grown despite efforts to save them. Although the initial sample period failed, the project was reactivated once the climate was more favorable.

Seaweed culture program ©MCRCF

Before this project, there was little knowledge within the local communities about the reef ecosystem and the benefits of protecting their natural resources. Three awareness-raising workshops were held as a result, where participants were educated on things like the negative impacts of overfishing and destructive fishing practices. In addition, three signs written in both English and the local language, depending on the location, were installed to inform people about the SLED initiative and the different livelihood programs available. The workshops and boards led to an increased awareness and discussion of alternative livelihoods among local villagers.

Awareness workshop at Kandakuliya School ©MCRCF

As a result of the commitment and assiduous work done by the MCRCF in the field of sustainable livelihoods and environmental conservation, they won the International SEED Award in 2011.

Lessons Learned and Recommendations

Lessons learned from the SLED program in Bar Reef are:

- Effective Stakeholder engagement is critical.
    - Conduct an in-depth analysis of the local community's resource uses and needs, and engage in direct communication with stakeholders about the goals and objectives of the project from the beginning.
- Partner with organizations and leverage local leaders to support the project.
    - Relevant community leaders should be fully informed and onboard with the project from the beginning.
- Every project should start with a common level of understanding within the community, and any project beneficiaries should be selected through a process supported by the community.
    - Example: Because almost all of the beneficiaries were selected through the SLED process with knowledge and agreement from existing fishing societies, there was a lot of support throughout the project. Furthermore, the local fishing community automatically took responsibility and ownership to run the project successfully.
- Consult specific topic experts in the planning and implementation stages to ensure appropriate project design and materials.

    - Example: During the home gardening project, the original seeds used were not able to propagate new seeds, thus after the initial harvest, new seeds had to be purchased and distributed.
- When working with natural resources and a community, a risk analysis should be prepared with precautions and alternative steps should a delay or problem occur.
    - If a problem does arise, the situation needs to be addressed as soon as possible and decisions and actions need to be communicated to all key stakeholders.
- Ensure project activities and timelines are aligned with optimal seasons and weather conditions.
- Consider the long-term costs of alternatives provided in the risk analysis to ensure the project is sustainable.
    - Example: When water was short due to a drought or unusual change in the weather, water supply became short and expensive.
- Build sustainable funding into your project.
    - The greatest challenge moving forward in the Bar Reef community has been the lack of funding to keep the project going. New concepts such as community driven surveillance to minimize destructive fishing practices on the reef are being developed, but unfortunately, MCRCF has not had the funds required to implement new or ongoing community initiatives. Although some community members ceased home gardening after the funding ended, they converted their gardens into plots for aloe vera cultivation.

Funding Summary

The Sustainable Livelihood Enhancement and Development (SLED) approach was first developed in 2008 under the International Coral Reef Action Network's (ICRAN) EU South Asia Project, in collaboration with the International Union for the Conservation of Nature (IUCN) and the Integrated Marine Management Ltd (IMM). Several pilot projects were initiated in select communities through small grant projects.

Due to the MCRCF's success in this community-level approach, ICRAN provided financial and technical support to them through the Center for Rural Empowerment and Environment (CREE) to initiate the SLED approach within the Bar Reef community. The program was implemented through the collaboration and partnerships between MCRCF, CREE, and ICRAN.

MCRCF has completed three small grant projects with support from the IUCN under Mangroves for the Future (MFF) (SEED awarded projects), and one through the UNDP under the Global Environment Facility (GEF) Small Grant Program. MCRCF is currently in the process of completing two small grant projects under the MFF program and are proposing additional projects for funding as well.

Lead Organizations

Marine & Coastal Resources Conservation Foundation
www.mcrcflk.org/

Partners

Center for Rural Empowerment and the Environment (CREE)
International Coral Reef Action Network (ICRAN)
International Union for the Conservation of Nature (IUCN)
Mangroves for the Future (MMF)
United Nations Development Program (UNDP)

Resources

Continuation and Strengthening Sustainable Livelihoods Enhancement and Development Process being Implemented in the Villages in the Vicinity of Bar Reef, Kalpitiya Sri Lanka

Coral Reefs and alternative income generation: diversifying livelihoods options for climate change resiliency
http://www.conservationforpeople.org/coral-reefs-sri-lanka/

ICRAN Small Grant Continuation and Strengthening of the Sustainable Livelihood Enhancement and Development Process within the Communities of Bar Reef
http://www.icran.org/action-sustain.html

Mangroves for the Future
http://www.mangrovesforthefuture.org/

Mangroves for the Future: The Beauty of Aloe Vera
http://www.youtube.com/watch?v=bFxGZ-VSGXU

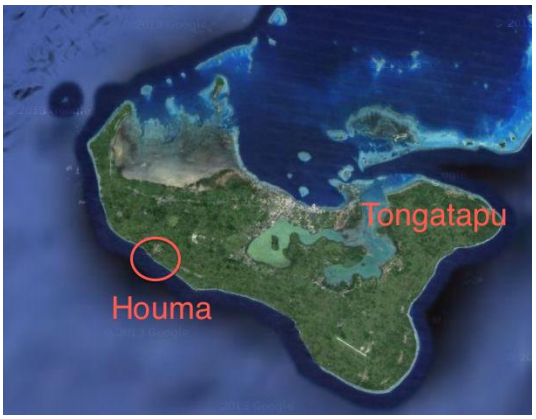
Marine & Coastal Resource Conservation Foundation, Sri Lanka
http://www.mcrcflk.org/

Sustainable Livelihood Enhancement and Diversification (SLED): A Manual for Practitioners

Coastal Reforestation in Tonga to Protect Agricultural Areas and Coastlines
Houma, southwest Tongatapu Island, Kingdom of Tonga

The Challenge

In large areas of Tonga, most of the original forest cover has been removed for timber, firewood or agricultural expansion. Tongan farmers traditionally protected coastal forests as a buffer between their farms and the sea to reduce salt spray, saltwater intrusion, and wind damage from storms and cyclones. However, during the past 25 to 50 years, these forests have been cleared to extend farms seaward and take valuable timber. The deforestation has exposed shorelines, accelerated coastal erosion, reduced suitable timber for construction and firewood, and resulted in the loss of medicinal, handicraft, and other useful plants.



Location of Houma, southwest Tongatapu, Tonga

This was particularly serious around Houma on the southwest coast of Tongatapu, the largest and most populated island in Tonga, where farms and grasslands expanded towards the coast, and traditional agroforestry trees were removed. Cattle, horses and especially pigs, and the indiscriminate use of fire to prepare gardens have also damaged these forests. These losses have resulted in drastic declines in agricultural productivity and associated biodiversity; some farms have been abandoned due to the increased wind and salt spray.

The coastal lands of many other small island states are seriously threatened by coastal erosion and increasing salination, which are exacerbated by rising sea levels. The erosion can be particularly serious if the natural coastal vegetation has been removed, which leads to seawater contamination and increasing wind damage to coconut plantations, food gardens and particularly, to freshwater wells. Accelerated erosion also damages nearby coral reefs.


The project site, a rocky, uplifted limestone area with a fringing coral reef © Randy Thaman

Actions Taken

The Tonga Coastal Protection and Reforestation Project was implemented by the Ministry of Agriculture and Forestry (MAF) and partners in the mid-1990s to address these problems. The primary objectives were to: develop and implement an effective model for coastal reforestation near the Blow Holes at Houma, and develop effective community-based programs to promote coastal reforestation and protection at community and landowner levels.

As a first step, the MAF assessed many indigenous coastal species to find the best local trees and shrubs to plant along the coastal zone. They examined previous propagation projects looking for salt- and wind-tolerant plants, particularly important food and timber trees, or other trees with cultural significance

such as those that are used medicinally or for woodcarving. Some of the species selected and used include: *Casuarina equisetifolia* which is successful as a windbreak, coconut palms, *Pandanus tectorius, Hibiscus tiliaceus, Excoecaria agallocha, Calophyllum inophyllum, Hernandia nymphaeifolia, Terminalia catappa, Tournefortia argentea, Barringtonia asiatica*, and *Neisosperma oppositifolium*. Other indigenous species that show promise for enrichment include the high-value carving wood and multi-purpose trees, *Thespesia populnea, Cordia subcordata, Guettarda speciosa, Xylocarpus moluccensis*, and sandalwood (*Santalum yasi*), which have all been historically selectively removed from Tonga's coastal forests.

The project site was then marked out and manually cleared to remove Guinea grass (*Panicum maximum*) and other shrubby vegetation in order to reduce wild fires, which damaged previous re-vegetation projects in Tonga. A 5 m wide firebreak was cleared along the land side and planted with cassava (manioke) and other crops to keep out the Guinea grasses and prevent people from trampling or driving over the young trees.

A three-phase approach was used for reforestation: First, fast-growing pioneer species were planted to provide shade and shelter from the wind, with Casuarinas planted in two staggered rows five meters apart on the land adjacent to farms. Large numbers of Casuarinas can be grown easily from seed; they fix nitrogen, are useful as firewood and grow rapidly to form effective wind breaks. Thirty different native coastal tree species were also planted on the seaward side of the Casuarinas. Secondly, after about 6 months, less-tolerant, but preferred species were planted in the shelter of the pioneers. Finally, they focused on hard-to-propagate species to increase diversity matching that of the original forest.

Double row Casuarina windbreak on inner margin of the reforestation area forest © Randy Thaman

A concerted awareness-raising program on coastal reforestation was also implemented with the local community. The program focused on the need for maintenance of the newly planted trees. This included: frequent weeding to prevent overgrowth by grasses, shrubs and vines and to reduce the fuel for wildfires and the maintenance of firebreaks; the protection of pre-existing mature trees within the planted area; and control of free-ranging livestock, particularly pigs, cattle and horses.

How Successful Has it Been?

The coastal reforestation project in Houma was very successful in re-establishing a viable forest and windbreak. By 2011, the forest was fully grown with the double row of Casuarinas forming a wall along the coast and protecting the farms and many other coastal trees in this multi-species forest.

- About 25,000 seedlings and saplings from 30 indigenous species were planted along 2 km of coastline in 2.4 hectares, mostly in a narrow band 12 m wide.
- Approximately 80% had survived after 2 years, which was more than had been expected and a credit to community-based management of the project.
- Cyclone Hina in March 1997 caused no damage to trees, except snapping off the upper crown of some Casuarinas.

- The community played a very positive and critical role in the project through preparing, planting, and maintaining the site.

A limiting factor for reforestation on Tonga is the legal definition of the coastal area, "the area between high tide and 50 feet (15.4 m) inland," but local boundary markers can vary considerably. This is virtually the only land owned and controlled by the Government; thus part of the Houma site was within the coastal zone, and the rest within the estate of village chiefs. No reforestation land was in farmers' allotments, but the coastal forests were considered to be common property for firewood, medicinal plants, wood for carving and building. Thus the agreement from the community and chiefs to the tree planting project and allowing the forest to grow was and remains a critical factor to project success.

This project has shown that coastal reforestation is a very feasible and practical activity for communities to protect their land from sea-level rise, climate variability, and extreme events (such as tsunamis and cyclones).

Lessons Learned and Recommendations

- Coastal forest protection should be a high priority for small island communities, particularly with the threat of sea level rise and increasing extreme events. Protecting original coastal forests is easier and more cost-effective than re-establishing a degraded forest
- Using local salt-tolerant species is a cost-effective, low-tech method for coastal reforestation to protect coastal lands and communities from natural disasters and sea-level rise, and to increase food production and promote livelihood security
- Involving traditional leadership and identifying a 'champion' to raise awareness in communities for a project can enhance success. The project was proposed by the traditional chief from Houma (who was also the Prime Minister) which greatly increased stakeholder buy-in to the effort from the beginning
- National legislation is needed to support community projects in the coastal commons to reduce coastal forest degradation, shoreline erosion, reduce sedimentation on reefs and to protect threatened marine and land animals, such as sea turtles, sea birds and land crabs, for which coastal littoral forests are their main habitat
- Before starting, it is essential to understand traditional ownership rights and customary ('usufruct') rights to resources on common land
- Planting cassava and other food crops in the fire break was successful because people were able to use their labor to reduce the fire threat through weeding while at the same time growing valuable crops
- Selecting the most appropriate multipurpose trees is important to gain community support, this project used over 30 indigenous species all of which are culturally valuable in Tonga
- Coastal reforestation is a long-term effort. It is critical when designing a coastal reforestation project to provide enough time to allow a three-phase coastal reforestation (pioneer species, non-pioneer species, and high forest biodiversity enrichment planting). Short-term projects often fail, which results in a lack of confidence and support from local communities
- Regular maintenance is essential to prevent grasses, weeds and smothering vines, and to reduce the amount of fuel for fires. This was done by the Forestry staff who were assisted by the Houma community
- Protection from free-ranging livestock is essential and may require fencing

- Coastal reforestation is a very practical activity for communities to protect their land from sea-level rise, climate variability and extreme events (such as tsunamis, cyclones and excessively high tides and waves
- Protecting original multi-species coastal forests is easier and more cost-effective than re-establishing or enriching a degraded forest

Funding Summary
Secretariat of the Pacific Regional Environmental Program - $10,000 (US)

Lead Organizations
Tonga Ministry of Agriculture and Forestry
http://www.tongafish.gov.to/

Partners
Australia Aid (AusAid)
www.ausaid.gov.au
Secretariat of the Pacific Regional Environmental Program (SPREP)
www.sprep.org
The University of the South Pacific
www.usp.ac.fj
The Nature Conservancy (TNC)
www.nature.org
The Houma local community

Resources
This case study was written by Randy Thaman, Andrew Smith, and Tevita Faka'osi, Case Study #22 from the following publication: Wilkinson, C., Brodie, J. (2011). Catchment Management and Coral Reef Conservation: A Practical Guide for coastal Resource Managers to Reduce Damage from Catchment Areas Based on Best Practice Case Studies. Global Coral Reef Monitoring Network and Reef and Rainforest Research Centre Townsville, Australia, 120 P.