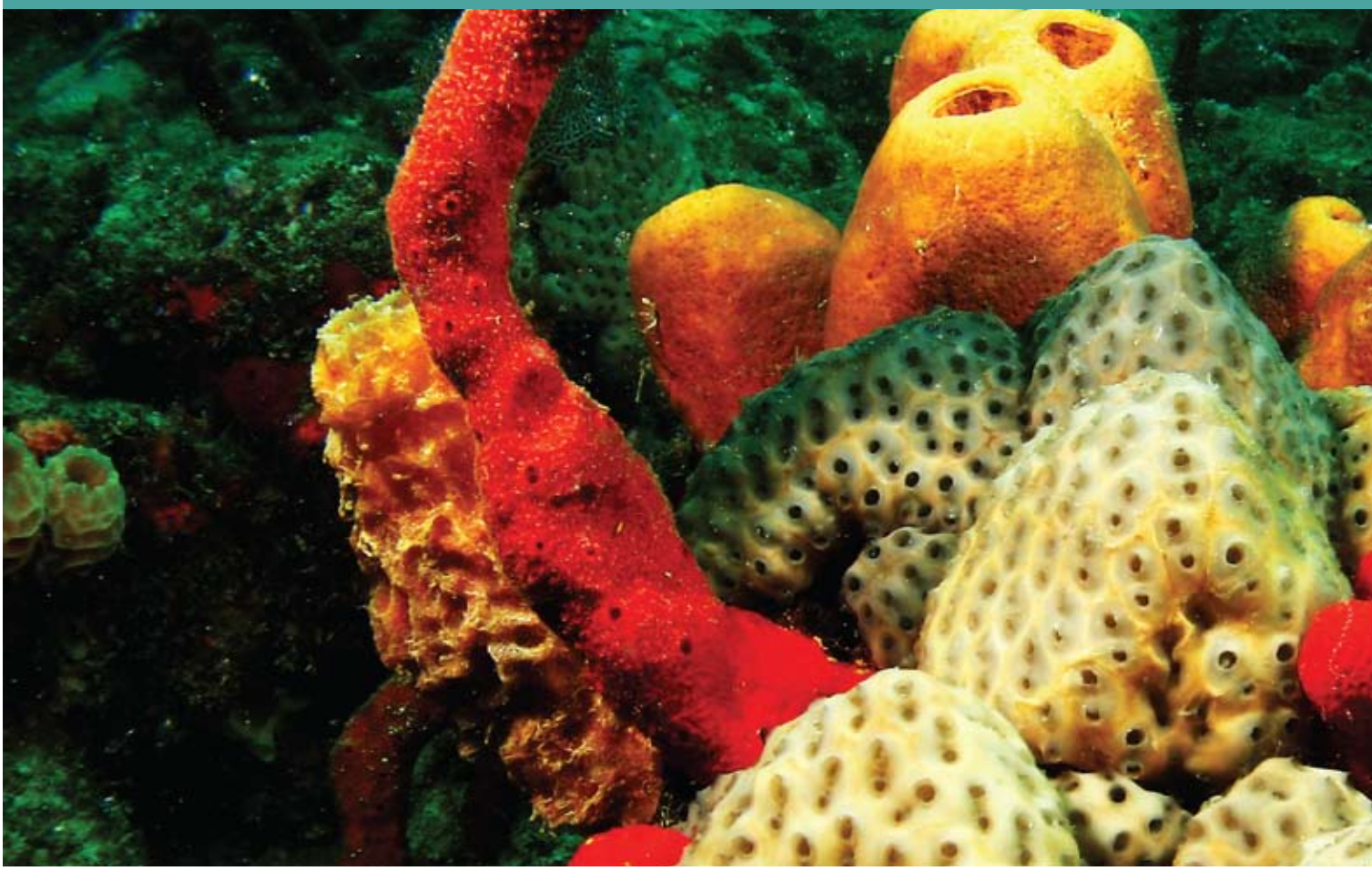
CHAPTER 9:
Restoring Damaged Reefs



Goal:

Increase the capability of federal and non-federal managers to efficiently and effectively restore injured or degraded coral reefs.

A well-developed coral reef can represent thousands of years of slow, incremental growth in resident stony corals. Many corals living today are centuries old. In spite of the longevity and apparent natural resilience of corals and the reefs they construct, they are extremely vulnerable to destruction by human activities–either through gradual degradation of habitat quality, or through sudden catastrophic damage from vessel groundings, toxic spills, coral bleaching, or other habitat destruction events. The natural recovery of coral reef communities and fish populations is jeopardized in areas of degraded habitat and in the presence of other stressors such as pollutants, climate change, or high abundance of pest, exotic, or competing species. Natural recovery may never occur, especially if the underlying habitat structure is destroyed or prevailing environmental conditions are degraded over time. However, reducing other stressors and ensuring sources of recruits to repopulate

damaged reefs can help coral reefs resist and more rapidly recover from injury events.

The National Action Plan recognizes that preventing the loss of coral reef habitat through proactive conservation measures is preferable to restoring coral reefs after they have already been damaged. However, when reefs have been damaged by human use or misuse, removing or mitigating the stressors responsible for the reefs' decline may enhance natural recovery. In specific situations, USCRTF members have facilitated recovery through active restoration efforts.

The practice of reef restoration is in its infancy. The USCRTF seeks to strengthen restoration science through the development, testing, and assessment of methods and tools used to repair human-caused damage and to assist in the natural recovery of coral reef ecosystem structure and function.

Accomplishments by Objective

Objective 1: *Review and evaluate existing reef restoration projects to quantify the benefits gained by the restoration effort and expenditure of the restoration compared to scenarios in which no restoration efforts were undertaken and make recommendations for improvements.*

Objective 2: *Develop and test innovative methods and techniques to expedite reef restoration for all major categories of coral reef injury using a hypothesis-driven approach that involves rigorous, quantitative evaluation.*

In 2005, NOAA revisited Aua, on the island of Tutuila, American Samoa, as part of restoration monitoring following the 1999-2000 removal of nine derelict vessels in Pago Pago Harbor. The team investigated the grounding sites, searched for residual debris, and revisited the area where over 350 corals

Coral restoration efforts following the Magara grounding off Puerto Rico (image taken in May 2007).

Student helps relocate 18 corals from an offshore coral nursery near Molasses Reef off Key Largo. Three different genotypes transplanted were marked with colored zip ties to more easily track their location and growth. All 18 corals are still alive and thriving, and most have more than doubled in size in the last 6 months. Original photo taken July 2007.

had been removed and then retransplanted during the wreck removal operation. These corals had been removed to avoid burial by temporary causeway construction and were reattached in their general area of origin. Sixty-two reference colonies were measured but not transplanted. The team also surveyed the footprints of all the wrecks to determine the extent of recovery and whether any further removal of debris or residual causeway material was warranted. The team also surveyed other known and reported wrecks and abandoned vessels on Tutuila and Aunu'u Islands. The study found high (91 to 92 percent) transplant survival rates approximately one year following reattachment in 2001; however, by 2005, survival showed a significant decline (60 to 78 percent). This decline may have been associated with a hurricane in 2004, which appeared to have toppled and overturned large pieces of reef platform at Aua. Transplant colonies fared no worse than the reference colonies in terms of survival, growth, and change in live tissue cover. The author concluded that coral transplantation was effective in preserving individual colonies from impending impacts, but the broader question of how and whether transplants contribute to broader system recovery still needs to be investigated.

DoD (Navy) and Guam are evaluating the feasibility of transplanting selected species of corals and other benthic invertebrates from the inner Apra Harbor entrance channel to other locations within Apra Harbor. The study includes preparation of a detailed report monitoring success rates.

In 2006, the *M/V Cape Flattery* grounded on the coral reef south of the entrance channel to Kalaeloa (Barbers Point) Deep Draft Harbor on O'ahu, Hawai'i. In the emergency response and natural damage assessment phases of the vessel removal process, NOAA and the USFWS implemented a multi-agency trustee

field assessment and coral reef restoration effort. The area with injury was estimated to exceed 15 acres (60,702 square meters). One-year monitoring of corals and substrate reattached with cement in the initial emergency restoration was completed. Measurements from control colonies were used to help model natural recovery projections for the area. Trustee agencies requested and provided oversight for Responsible Party removal of tons of incident-related, unattached reef debris, with some reattachment in flattened hull-impact areas as additional emergency restoration. In addition, Trustee agencies worked towards finalizing a list of proposed compensatory restoration projects to provide feasible offset to incident-related losses of natural resource services.

When the *M/V Fortuna Reefer* grounded in 1997 on Mona Island, Puerto Rico, a multi-agency restoration action reattached approximately 1,800 *Acropora* fragments. By following the success of these colonies over time, researchers have learned which methods yield the best results. In particular, the type of substrate, the size of the attached fragments, and the method of attachment all affect coral reef restoration success. Almost a decade after these activities began, the site is still not fully recovered. But compared to comparable grounding sites not restored, the restoration sites are a vast improvement, with increasing numbers of growing coral fragments and fish abundance and diversity. Long-term, frequent monitoring of restoration activities is important in determining how restored areas respond in the face of ongoing threats and impacts to coral reefs.

NOAA worked with local partners in the FKNMS to move juvenile long-spined black urchins *(Diadema antillarum)* from unstable coral rubble to deeper reefs in the FKNMS, before the height of the 2006 hurricane season. *Diadema* are important to the health of coral reefs because they graze on algae, which competes with corals for space on the reef. In the early 1980s, these urchins died off almost completely throughout the reefs of the Caribbean and southeast Atlantic. Although the *Diadema* have been returning slowly to the reefs of the Florida Keys, they have not approached their former abundance. To increase their survival rate, small urchins (three to five centimeters) were transplanted out of the high-energy rubble zone onto more protected reef areas, where it is hoped their population will increase more rapidly.

A USCRTF and university partnership project is researching settlement success of coral species and testing various methods to improve this process. Most reef-building corals reproduce by broadcasting their tiny gametes into the water column. Researchers can collect these eggs and sperm as they are released from parent colonies, and enhance fertilization and settlement success by caring for the larvae in a laboratory setting. An agency—university partnership is raising tens of thousands of coral larvae each year for various experiments and for restoration activities including direct settlement on reef surfaces or other substrates for transplantation onto reefs as they mature. Experiments are designed to determine which treatments encourage coral survivorship and growth. Researchers determined that cyanobacteria, which are locally abundant on restoration sites in the Florida Keys, appear to inhibit coral larvae settlement. A pilot study is evaluating new ceramic artificial structures to determine whether their unique design may improve survivorship of coral settlers.

Objective 3: *Develop regional restoration plans that identify significant restoration alternatives and weigh the costs and benefits of natural recovery compared with restoration alternatives.*

M/V Casitas aground on Pearl and Hermes Reef in the NWHI.

Bow of M/V Casitas.

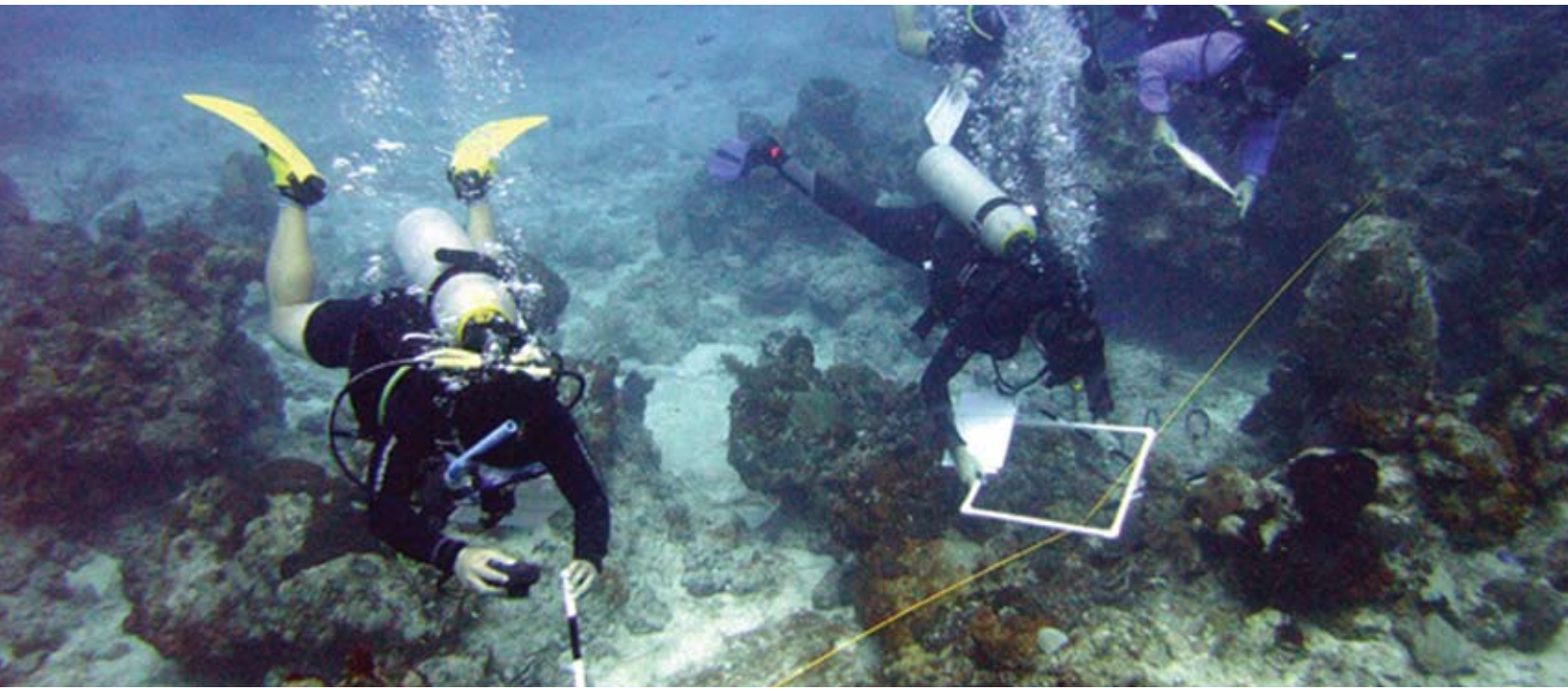
Puerto Rico DNER is initiating NRDA activities for two commercial vessel groundings—the *M/V Kent Reliant* and *M/V Sperchios*—and one recreational vessel grounding on seagrasses in a Natural Reserve, and has received funding from the National Pollution Fund Center for the Vista Bella oil spill to perform a damage assessment and create a Restoration Plan for the coastal areas of Puerto Rico and USVI impacted by this oil spill in 1991.

Objective 4: *Promote cost-effective pilot restoration of selected degraded U.S. reefs, focusing on habitats of high ecological, economic, and social conservation value.*

By November 2006, Monroe County, in conjunction with the Federal Emergency Management Agency, removed over 355 vessels and 45,000 lobster and crab traps that impacted habitats throughout the FKNMS in the aftermath of Hurricane Wilma in October 2005. Two large vessels remain—the 24-meter *Lady Luck* and the 48-meter *S/Y Legacy*—and negotiations to remove both vessels are ongoing.

Between October 2005 and February 2007, 399 vessel groundings were reported in the FKNMS. Of those cases, 60 required injury assessments and 42 were forwarded for enforcement action.

The USFWS, NOAA, USCG, and Hawai‘i continue to assess the impact of the 2005 grounding of the *M/V Casitas* at Pearl and Hermes Reef in what is now the Papahānaumokuākea Marine National Monument. The vessel remained on the reef for almost a month before salvage crews could remove fuel and prepare the vessel for refloating. Removal of the vessel was successful, but because of substantial hull damage, the USCG decided it was not safe to tow the vessel to Honolulu, and the decision was made to scuttle the vessel in deep waters at a predetermined scuttling site in the Monument. A field team composed



Students practice crime scene investigation techniques during the "CSI for Coral Reefs" workshop conducted in conjunction with the October 2006 International Tropical Marine Ecosystems Management Symposium in Cozumel, Mexico.

of representatives of the State and federal trustees, and a representative of the vessel's owner conducted a cooperative site survey at the grounding site after the vessel was extracted. The trustee agencies are scaling a set of restoration projects to compensate for the injuries caused by the incident.

The USFWS, NOAA, USCG, and other local partners continue to conduct follow-up action from a 1993 longline fishing vessel grounding and oil spill on Rose Atoll National Wildlife Refuge. Restoration activities have involved removing a chronic source of iron associated with vessel debris, thereby promoting recovery of natural resources damaged by the oil. Monitoring of the site, including 20 permanent transects, shows partial recovery of coralline algae, corals, and giant clams, with full recovery anticipated when the restoration project is completed. In 2006, all but two tons of the ship was removed, with the remaining wreckage debris removal planned for 2007. The assessment and restoration of natural resources injured due to the oil discharge at Rose Atoll were paid for through the Oil Spill Liability Trust Fund.

In Puerto Rico waters, the 228-meter *T/V Margara* grounded on April 27, 2006. The commercial vessel was carrying 13 million gallons of number six fuel oil from Venezuela to Puerto Rico. The Margara ran aground at approximately 10.5 meter depth on the reefs off of Guayanilla, Puerto Rico. Damage to the reef was significant and estimated to have impacted up to 8,500 square meter of bank type coral reef with significant cover of hard corals as well as gorgonians and sponges. As a result of the impact and ship recovery efforts, unstable reef rubble, sand and bare hard bottom areas were created. Patches of threatened *Acropora cervicornis* were also impacted and antifouling paint was transferred from the ship bottom to the sea floor.

A first phase of Emergency Restoration (ER) activities was initiated from July to October

2006, and ER was completed in a second phase in May 2007. The ER intended to facilitate the recovery of the impacted reef by reattaching the remaining viable corals, stabilizing rubble berms, and removing antifouling paint from the sea floor. Unattached viable corals were place upright and cached to avoid additional injury and to prepare for later restoration. Approximately 10,000 scleractinian corals and gorgonians were reattached to available substrate with hydraulic cement. The ER was a cooperative effort between Continental Shelf Associates, Inc. (representing the Responsible Party) and the co-Trustees, the Puerto Rico DNER, and NOAA. Damage assessment activities involved mapping the impacted reef areas and conducting a preliminary characterization of the surrounding unimpacted reef community. Monitoring of the ER was initiated in May 2007, with the goal of determining the relative success of coral/substrate reattachment and to detect and respond to significant changes in overall habitat characteristics and relative coral health.

The USFWS launched the Mangrove Recovery Initiative as a cooperative venture between the Federation of Fly Fishers, the USFWS J.N. "Ding" Darling National Wildlife Refuge, and local partners to recover and restore Florida's rich and diverse mangrove forests to support strong populations of fish and wildlife. Project examples include restoration of approximately 116 acres (469,435 square meters) of mangrove habitat in Clam Bayou on Sanibel Island to support productive marine fisheries and estuarine habitat and to prevent fish kills, mangrove forest losses, and seagrass and oyster bar die-offs. The USFWS Pelican Island National Wildlife Refuge established a cooperative partnership with the Florida Department of Environmental Protection and Indian River County to restore approximately 65 acres (263,046 square meters) of coastal habitat.

Objective 5: *Rehabilitate degraded fish habitat through the deployment of artificial structures and rapid, inexpensive transplant methods.*

On May 17, 2006, DoD sank the retired aircraft carrier ex-ORISKANY off the coast of Pensacola to provide an artificial reef for the State of Florida. The 268-meter carrier was sunk in 64 meters of water, 24 miles (38,624 meters) off the coast. The Navy worked with partners from the State of Florida, EPA, USACE, and NOAA to ensure the reef will be safe and not cause environmental damage. The final orientation of the carrier was carefully planned by the Florida Fish and Wildlife Conservation Commission. It is expected to benefit marine life and recreational fishing and diving. Upon sinking, ownership of the carrier/artificial reef was conveyed to the Florida Fish and Wildlife Conservation Commission.

Objective 6: *Transfer proven restoration tools, techniques, and lessons learned to domestic and international partners.*

The USFWS National Fish and Wildlife Forensics Laboratory has been working with NOAA and other private and academia partners to identify and test crime scene investigation procedures for use in investigating damage to coral reefs. In 2006, partners hosted a five-day "CSI for Coral Reefs" training workshop for resource managers, environmental assessment specialists, criminal investigators, and litigators at the International Tropical Marine Ecosystem Management Symposium, in Cozumel, Mexico.