

Benefits, Threats, and Solutions

Benefits

THE VALUE OF CORAL REEFS

Coral reefs enrich the life of our oceans. They provide food and shelter to countless thousands of species of plants and animals, and they exchange energy and nutrients with other marine ecosystems, such as the open ocean.

But people also directly benefit from reefs in many ways. Coral reefs break waves, protecting shorelines from erosion and keeping beaches and coastal communities intact.

Healthy coral reefs supply finfish and shellfish upon which many national economies depend. Reef-dependent fisheries include subsistence (providing a protein source in coastal people's diets),

commercial (providing jobs through supplying the world market demand for fish), recreational (providing jobs through fishing and tourism), and ornamental (providing jobs and income for tropical fish gatherers). The world consumption of seafood exceeds that of either pork or beef.

Tourism is also an economic mainstay for many countries with coral reefs, as people come to dive, snorkel, boat and fish. There are an estimated four million divers around the world, many of whom make more than one dive trip each year (Figure 3-1). The Florida Keys and many other coral reef areas are economically dependent upon their reefs for tourism and fishing. In the Caribbean, coastal tourism generates about US \$7 billion each year.

Treatments for cancer, AIDS, infection, arthritis,



Figure 3-1. Scuba diver on Cuban reef. (Photo: Larry Benvenuti)

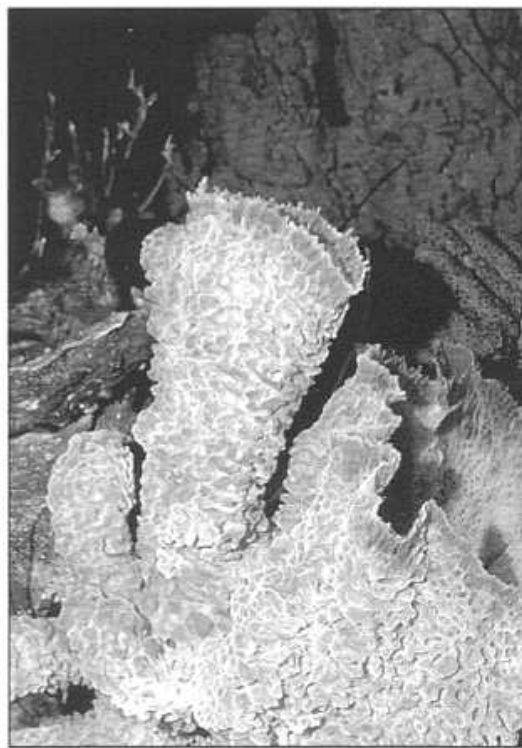


Figure 3-2. Caribbean sponges are used in the treatment of cancer and herpes simplex. (Photo: Milton Beral)

asthma, herpes, and even broken bones are being discovered in coral reef ecosystems around the world. For example, compounds derived from Caribbean sponges are being used in the treatment of cancer and herpes simplex (Figure 3-2). Compounds from sea squirts have been useful in treating tumors, viruses, and immune-related illnesses. Hard corals are being used to replace shattered bones as the human body more readily accepts coral than artificial replacements.

Many commercial products are also derived from coral reefs. Calcium carbonate from the skeletons of coral animals is used to produce lime which when added to mortar and cement helps it set more quickly. The internal shell of the cuttlefish, called cuttlebone, is sold in pet stores to cut calcium deficiency in the diet of pet birds. Chitin, derived from the shells of shellfish, crabs, lobster, and shrimp, is a component of chitosan, which is used in violin varnish to make it dry hard to provide good tone.

Much can be learned from reefs about historical conditions in the marine environment. Annual growth bands, elemental ratios, and isotopic signatures can be used to infer past sea levels, growing conditions, the effects of environmental management and other important phenomena.

The beautiful sand that makes up the beaches of tropical

islands is another benefit from coral reefs, formed by the breakdown of dead corals and algae by reef life.

Like rainforests, wetlands and savannas, coral reef ecosystems are integral parts of a healthy environment for all of the Earth's living creatures, including people.

Threats

Corals are highly sensitive to environmental conditions. They grow best in shallow, clear water between 68°F and 84°F (20°C and 29°C) with normal oceanic salinity. Both natural and human-caused (**anthropogenic**) disasters threaten coral reefs worldwide.

In 1997, the International Year of the Reef, it was recognized that corals around the world are threatened:

- In the Philippines, about 70% of the coral reefs have been degraded seriously and only about 5% are thought to be in good condition;
- In Jakarta Bay, Indonesia, human activities have caused the average coral coverage to diminish from 30% to 5% between 1985 and 1995;
- In Jamaica, where the coral coverage was 50% to 70%, overfishing has accounted for a decline of coral coverage to just 5%;
- In the Florida Keys, coral diseases, massive algal blooms, and a precipitous drop in water visibility on the world's 3rd largest barrier reef reflects the damage from agricultural runoff from Florida Bay and inadequate sewage treatment throughout the Keys.
- Conservative estimates indicate that up to 10% of the Earth's coral reefs are already seriously degraded and a much larger percentage is threatened by the impact of human activities;
- At the current rate of destruction, estimates indicate that 40% of the world's reefs could be destroyed by the year 2020.

While natural impacts such as hurricanes and population

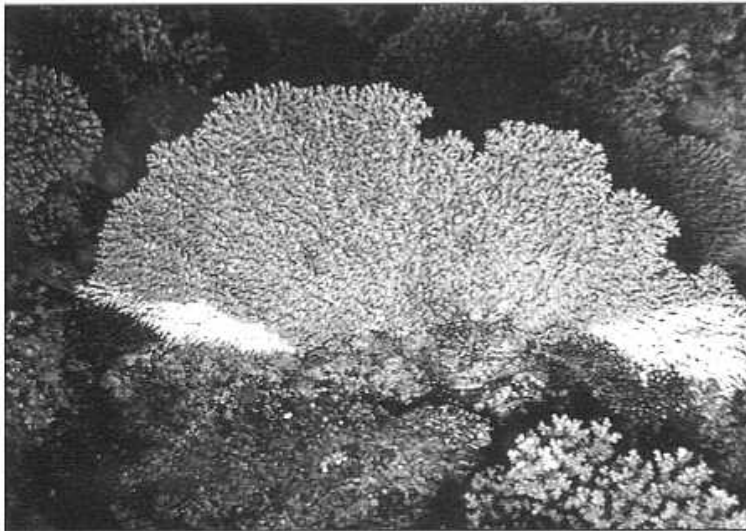


Figure 3-3. White band disease at the bottom of a plate coral. (Photo: Jim Thompson)



Figure 3-4. California sea lion entangled in fishing net, Sea of Cortez, Mexico. (Photo: Hal Beral)

fluctuations of predators play a role in the degradation of coral reefs. It is becoming increasingly clear that human activities are having the most catastrophic effects on these fragile marine ecosystems. We all know that human population growth is the single greatest threat to global environmental health, but the problem has pointed significance for coastal regions. In 2025 three quarters of the world's population will be living within 50 miles of the world's oceans, seas and lakes.

Natural Threats

Natural threats to coral reefs include **sea level changes, hurricanes, cyclones, abnormal weather patterns, fluctuations in seawater temperatures, heavy rains** that dilute salinity, **extreme low tides** that expose coral, **disease**, and **predator population explosions**, such as crown-of-thorns sea stars. Reefs

can sometimes recover from these seemingly disastrous attacks if human-caused stresses do not impede their recuperation process.

Human-Caused Threats

The human impact on the world's coral reefs are widespread and reaching catastrophic proportions. Some scientists believe that the effect of coral reef destruction on global biodiversity is of the same magnitude as that of the destruction of rainforests. Indeed, coral reefs are often referred to as the "rainforests of the sea" because they are the most biologically diverse marine ecosystem.

The most destructive human impacts on coral reefs include overharvesting of fish; destructive fishing practices (cyanide and dynamite fishing); nutrients and pesticides draining onto the reefs from agricultural areas upstream; tourists who unwittingly damage reefs, boat anchors dropped onto fragile corals; raw sewage from coastal areas with insufficient treatment capacity; coral mining for construction materials; sedimentation from deforestation, road construction and dams; and oil pollution from shipping.

• Global Warming and the Greenhouse Effect

Greenhouse gases (carbon dioxide, methane, nitrous oxide and chlorofluoro-carbons) are accumulating in the atmosphere, trapping the heat from the sun and causing the Earth's atmosphere to become abnormally warm. These gases are increasing as people burn more fossil fuels for energy and cut down carbon-dioxide absorbing forests. The resulting increase in sea temperatures, sea levels, and violent storms negatively affect corals. The weakened coral then becomes more susceptible to disease (Figure 3-3). One of these effects, **coral bleaching**, results when the coral is stressed, as when the water temperature becomes too warm for the coral polyps to survive. When the polyps die, the coral loses its color and becomes white.

• Harmful Fishing Practices

Coral reefs provide habitat for marine life, such as fish, turtles, octopus, bivalves (mussels, clams), gastropods (snails, conchs), spiny lobster, shrimp, echinoderms (sea cucumbers, urchins). These are sources of food and income for many coastal people, as well as large commercial fishing operators. Around the world, more

and more fisheries are collapsing (species of fish are disappearing from many areas) due to damaging fishing techniques and over-fishing (more fish being harvested than the area can reproduce).

In many places, traditional fishing methods have been replaced with super-efficient modern technologies, often with damaging long-term effects. The introduction of motorized boats and SCUBA gear, such as masks and fins, has increased the catch, often to unsustainable levels. Biodegradable traps and nets woven from vegetable fiber or coconut fronds have been replaced with non-biodegradable nylon, metal and wire.

When lost they often become dangerous: entangling and injuring or killing marine life (Figure 3-4), breaking corals, or continuing to catch fish that will never be collected.

Cyanide poison is used by fishers in Indonesia, the Philippines, and other island nations to stun fish, making them easier to catch. **Chlorine bleach** and **quinidine** are used in the United States. Hunting for food or aquarium fish, the fishers shoot the chemical solutions at reef fish or into coral enclaves where they live. The poisonous residue kills coral, invertebrates, and other fish.

Fishers in the Pacific and southeast Asia often blast reefs with **dynamite** or other explosives that rupture fishes' air bladders so they can scoop them up as they float to the surface. The explosions destroy reef formations, kill non-target fish (by-catch), and often kill or maim the fishers themselves.

Some fishers also use '**Muro-Ami**', which is the name of the net that fish are driven into when hundreds of boys pound on the coral and wave white plastic streamers. Again, this technique damages the coral and results in huge quantities of by-catch.

• Mariculture

Mariculture, the farming of marine plants and animals, is becoming more popular in the tropics, often in

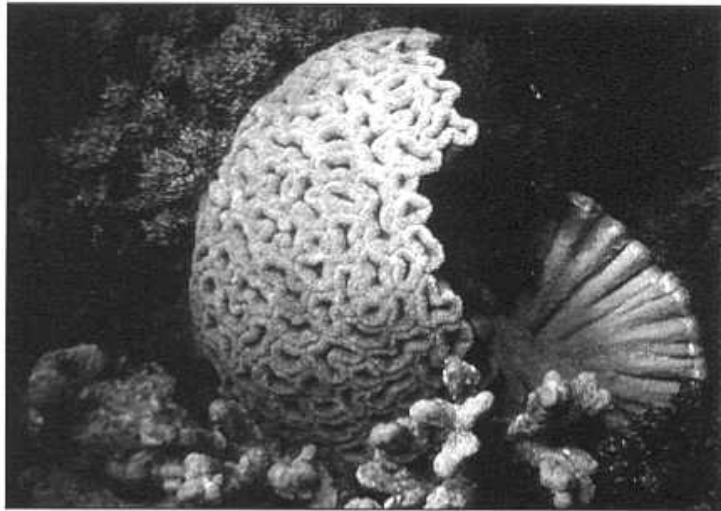


Figure 3-5. Massive coral broken in half by boat anchor. (Photo: Jim Thompson)

response to the loss of wild stocks. Giant clams, fish, conch, seaweed and shrimp are among the many farmed species. Unfortunately, while mariculture provides a means of employment and reduces pressure on overexploited stocks, it can have a negative impact on the reef. In many areas, entire mangrove forests have been bulldozed to make shallow ponds for these farms, eliminating juvenile fish nurseries and habitat for marine birds and animals. In addition, these farms siphon already short fresh water supplies, poison the water with chemicals and antibiotics, and cause a decrease in wild fish populations. Ultimately, the coastal people are left with little protein source since they are unable to afford the mariculture product.

• Damage from Boats

In areas that are popular with recreational, diving or fishing boats, the reef is subject to damage from accidents and carelessness. Anchors tossed on coral break the fragile animals (Figure 3-5), and the chains drag a swath of destruction around them. Boats and ships that run aground on the reef can destroy hundreds of corals in an instant. Propellers churn up sediments that smother the reef. Boat bilges and toilets are discharged, dumping an overload of algae-causing nutrients into the water. Some cruise ships and recreational boats have been documented dumping their trash overboard, despite laws against ocean dumping.



Figure 3-6. Abandoned oil drums and tractor tires from coastal construction project leach poisons.
(Photo: Christopher McLeod)

• Damage from Divers

Although recreational divers are often the greatest advocates for protection of coral reefs, careless diving can present a hazard to the ecosystem. Popular dive spots often attract more visitors than is healthy for the area. Lack of mooring buoys can result in damage from anchors. Unscrupulous dive charters may use food to lure fish toward their customers, disrupting their normal feeding and behavior patterns. Divers and snorkelers who take souvenirs, touch coral, let their fins and other equipment bash into it, or even kick up excess sediments contribute to the demise of the very reef they came to enjoy.

• Coral Mining

Coral mining is a problem in countries with few resources for construction. Iron bars are used to dismantle entire sections of reef to build roads, walls, homes and office buildings.

• Pollution

After it rains, storm water runoff carries trash, oils, chemicals, and other undesirables from the land into the sea. Fertilizer, pesticides, and herbicides from agriculture also wash out of fields into streams and into the ocean. **Chemicals**, such as chlorine-based cleaning solutions, PCB's and DDT, heavy metals, and minerals from mining and other industrial pollution are known to be poisonous to marine animals (Figure 3-6).

Deforestation and development can damage coral reefs offshore, smothered by loosened soils washed by rain into rivers and out to sea. Insufficiently treated or raw sewage introduces excess nutrients on the reef, covering corals with algae.

Warm water discharges from power plants cause corals to bleach. Large sections of reef off Guam and Taiwan have been destroyed by this **thermal pollution**.

Corals are vulnerable to **oil pollution** caused by spills, leaks in tanks or pipelines, ships flushing their tanks

and bilges, offshore oil exploration and land-based sources, such as refineries and gas stations.

Trash from fishing vessels, cruise ships, recreational boaters, ocean dumping and beach visitors inflicts damage on beaches, reefs, and marine animals. Some turtles and seabirds often make the deadly mistake of eating plastic bags and debris because it resembles one of their favorite foods, jellyfish. Every year many marine animals and fish are entangled in nylon fishing nets, six-pack rings and other garbage.

Radioactive pollution, including nuclear bombs, accidents and leaks at nuclear power plants, and nuclear testing, whether atmospheric, underground or underwater, all are known to kill a wide range of reef life.

Dredging to clear channels for shipping, marinas, and ports, or to mine coral rock or sand causes excess silt

to contaminate the water. Corals can be damaged by artificially created channels, as they trigger changes in water circulation, tidal flow, and water levels.

• Coral Harvesting

Coral is also harvested to make jewelry, gift store curios (Figure 3-7), coffee table knick-knacks, and aquarium habitat. Under optimum conditions, many corals take 37 years to regenerate.

THREATS TO CORAL REEFS IN THE UNITED STATES

In the United States, coral reefs in Florida, Texas, Hawaii, and the U.S. territories of Guam, Puerto Rico, and the U.S. Virgin Islands are threatened by development, sewage, and other problems resulting from too many people too close to a living coral reef.

Florida

In 2003, over 4 million visitors came to the Florida Keys, home to the world's 3rd longest coral barrier reef, which is now protected through creation of the Florida Keys National Marine Sanctuary. This is the most visited coral reef in the world and home to the largest charterboat fleet. It is said, *We are literally loving our reefs to death.*

Visitors can have a negative impact on the coral reef ecosystem in many ways. Careless snorkelers and divers touch, stand or drag equipment over fragile living coral formations, opening them up to infection or nuisance algae that can lead to the loss of an entire coralhead. Any physical contact with coral can crush the fragile coral polyp that lives encased within the calcareous exoskeleton that provides the foundation for coral growth. Divers who feed the fish upset their natural feeding habits, and harvesting marine life and corals depletes the reef.

Overfishing has led to the creation of restricted species laws governing conch, jewfish, and lobster. Most commercially-harvested fish and marine life are subject to bag-and-take limits. No fishing zones have been established at sixteen heavily-visited reefs in the Florida Keys. Spearfishing is still allowed elsewhere in the sanctuary, although it has led to the depletion of certain species such as the slow-moving jewfish.

Massive development of the Florida Keys is having measurable impacts on the coral reef, the third longest



Figure 3-7. Coral curios in a gift store. (Photo: Jim Thompson)

barrier reef in the world (Figure 3-8). Inadequate sewage treatment from illegal cesspits, shallow injection wells, leaky septic systems and municipal sewage treatment plants that lack nutrient removal release tons of harmful nutrients into the porous limestone substrata of the Keys. Studies have documented that this effluent quickly migrates into nearshore waters.

Petroleum products from boats cause water pollution. Boaters sometimes ground on the reefs, tear up seagrasses in shallow areas with boat propellers, kick up sediment, break corals with anchors (Figure 3-9), and litter the reef with plastic, aluminum cans, fishing gear and other debris that tears, abrades, and smothers the reef.

Agricultural run-off from Florida Bay and the Everglades is even more damaging, since a campaign to increase water flowing into Florida Bay has resulted in tons of nutrients, pesticides and mercury reaching the downstream coral reefs of the Florida Keys. In 1996, over 900 tons of nutrients reached Keys reefs from direct discharges into Florida Bay compared to 35 - 40 tons from domestic wastewater. Agricultural runoff from sugarcane and other agricultural products in South Florida, along with the need to drain former wetlands for urban sprawl, have polluted Florida Bay creating a "dead zone". Litigation has produced a court order that "the polluter must pay."

The traditionally crystal-clear waters of the Florida Keys have become murky and green. Visibility has dropped from over 100 feet to an average of 30 - 40 feet at the reef. Coral diseases, many of them first observed as part of the Reef Relief Photo Monitoring Survey, have increased dramatically along with macroalgal blooms and coral bleaching. Corals require clear, clean, nutrient-free waters to thrive. Only swift action to clean up the pollution will save these coral reefs. Hopefully, the Water Quality Protection Program of the Florida Keys National Marine Sanctuary; in concert with local, state, and other federal agencies, will heed the call issued by Reef Relief that these coral reefs are truly endangered.

Nearby is Biscayne National Park, just north of the Florida Keys and 24 kilometers south of Miami, containing the waters of Southern Biscayne Bay. It is home to numerous patch and bank reefs which are managed with some success by the National Park System, largely because of their undiscovered nature and limits to commercial access imposed by the park system.



Figure 3-8. Marathon Airport in the Florida Keys. (Photo: Larry Benvenuti)

Texas

The Texas Flower Garden Banks National Marine Sanctuary was established in an area of the Northwestern Gulf of Mexico where the clear, warm oceanic water makes possible coral reef development. The sanctuary is located over 200 kilometers southwest of Galveston and features reefs 100-200 meters deep, cresting at 20 meters deep. The bank reefs are the most complete and complex coral communities in the Gulf, although coral diversity is low compared to other reefs in Florida and the Caribbean. Oil and gas drilling operations in the area have modified their operations to eliminate any discharge into the marine environment and abandoned rigs are now the site for healthy artificial reefs.

Hawaii

Like elsewhere, coral reefs in Hawaii face problems resulting from human pollution. In Kaneohe Bay, Oahu, macro algal blooms from inadequate sewage

treatment have produced large mats of nuisance algae that has smothered many corals. Fast growing algal blooms out-compete slow growing corals for habitat. Extending the sewer line beyond the harbor has improved the situation, however our oceans should not be used as dumping grounds for storm drainage, sewage, or garbage.

For many years, beaches in Hawaii have been developed as resorts. This development, along with historical pineapple agriculture, has altered many of the shorelines. Airports have been built adjacent to the reefs. The construction of hotels, golf courses, ports, and marinas has resulted in the dredging and destruction of seagrass beds, mangrove forests, and coral reefs. Golf courses require tremendous amounts of irrigation water, herbicides, pesticides and fertilizers which often leach into the seawater damaging the coral reef ecosystem. The creation of the Hawaii Islands Humpback Whale National Marine Sanctuary in Hawaii has resulted in a management plan to help address these impacts.

Guam

In Guam, military defense activities both during World War I and II and military testing thereafter have damaged many of the coral reefs. Development of the island has added to this damage and now a growing tourism economy is creating additional coastal development that is negatively impacting all of Guam's marine ecosystems even further. The extent of living coral reefs in Guam are now very limited.

Puerto Rico

Puerto Rico is working to address the many human impacts to its coral reefs with efforts to create marine protected areas, increase educational efforts, and restrict further development. Relatively healthy coral reefs can be found at Culebra, Culebrita, Mona Island and Parguera. Many other areas of the coast that have been developed have lost the benefits of mangroves resulting in massive siltation and erosion. In addition, industrial development, particularly of pharmaceuticals, has resulted in severe pollution discharges

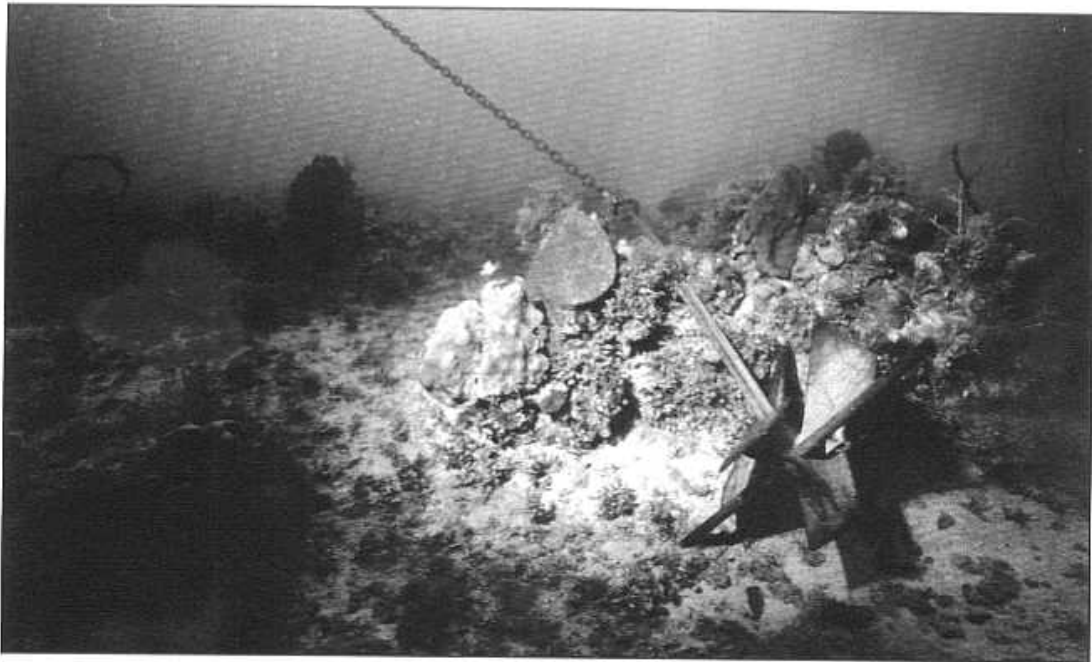


Figure 3-9. Before the widespread application of reef mooring buoy technology, first designed by John Halas and Harold Hudson of the Florida Keys National Marine Sanctuary, anchors were the accepted way of securing a boat above a coral reef. Unfortunately, anchors can tear, crush, and drag fragile corals. (Photo: Craig Quirolo)

from industrialized ports around the island.

U.S. Virgin Islands

The U.S. Virgin Islands has long attracted numerous visitors to the Virgin Island National Park who enjoy the diving and fishing of protected areas. However, these coral reefs, too, are showing the stress of high use, despite management strategies that include installation of reef mooring buoys, education, and no-take zones.

Solutions

EDUCATION AND ACTION

People have lived along the coast in tropical areas since prehistoric times, and they have been dependent upon the coral reefs as a vital part of their existence.

Initially, they used the reefs as a source of food, tools, ornament, and building materials. These activities had little impact on the reef ecosystem or the adjacent land because they lived in balance with their surroundings. Only recently have people begun to over-exploit the reef and coastal areas, severely threatening the health and survival of this ecosystem.

In order to preserve coral reefs around the world, it is important that we understand the incredible part that they play in the balance of our Earth's ecosystem and in the diversity of life that they contribute to our existence and evolution. With understanding comes respect, with respect comes a desire to protect, with a desire to protect comes action.

Education and action are integral components of REEF RELIEF's efforts to preserve and protect living coral

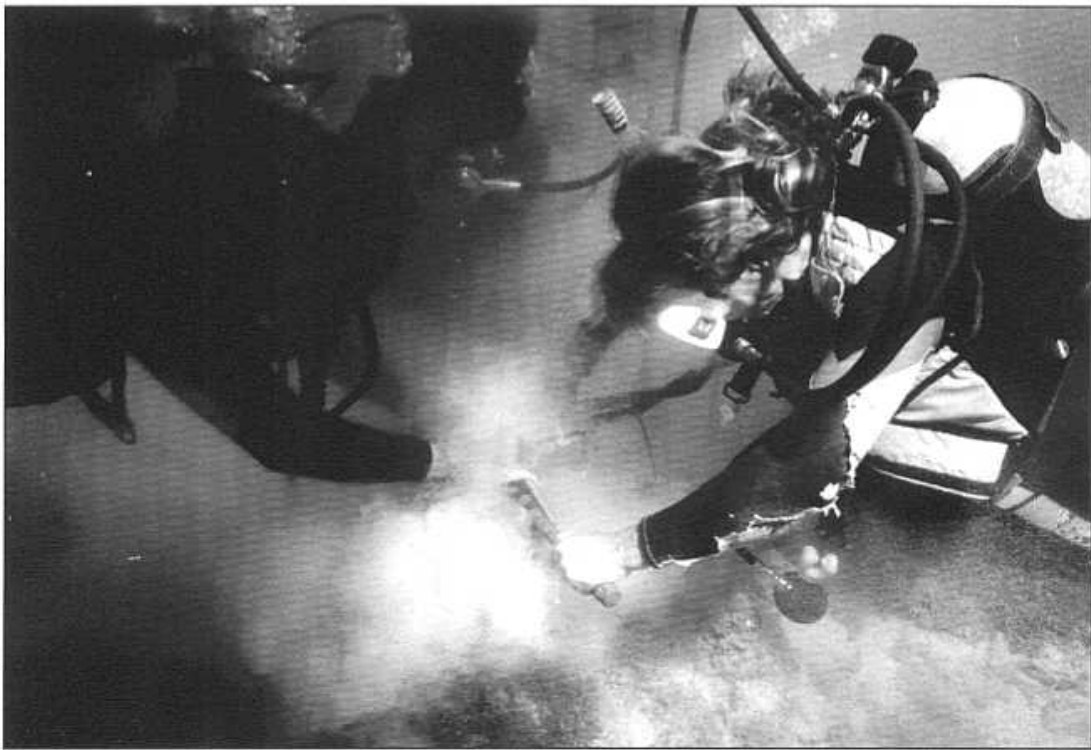


Figure 3-10. Reef mooring buoy installation involves the use of a hydraulic drill to remove a core from the fossilized coral bottom. A stainless steel eyebolt or u-bolt is inserted into the hollow core that is then filled with hydraulic cement to secure it to the ocean bottom. Next, a down line, round buoy float and pick-up line assembly are attached to the eyebolt. Pictured are divers drilling out the cores on the ocean bottom. Reef mooring buoys eliminate anchor damage to coral reefs. Buoys were first installed at Key West-area reefs by Reef Relief. (Photo: Craig Quirolo)

reef ecosystems. This is done with activities and programs both at home and abroad.

REEF RELIEF: PROTECTING NORTH AMERICA'S ONLY CORAL BARRIER REEF

Florida is home to the world's 3rd longest coral barrier reef. It begins south of Miami, parallels the landbase of the Florida Keys, and extends 67 miles southwest to the Dry Tortugas. Patch reefs extend north of Miami to the Palm Beaches. Together with mangroves and seagrasses, this coral reef ecosystem provides habitat for one-third of Florida's threatened and endangered species. Residents and visitors depend upon the reefs for tourism, fishing, recreational activities, an intrinsic wilderness experience and protection from storm surge.

As a result of the natural beauty of the area and convenient location, the Florida Keys is also the most heavily-visited coral reef in the world, the biggest dive destination, and as a result, the coral reefs are amongst the most endangered in the world.

Reef Relief is a nonprofit membership organization dedicated to *Preserve and Protect Living Coral Reef Ecosystems through local, regional and international efforts*. Reef Relief is focused exclusively on saving coral reefs through direct action marine projects, environmental education and policy guidance. It was founded by charterboat captain Craig Quirolo in 1987 and incorporated as a Florida not for profit corporation in Key West, Florida.

The first effort was installation of reef mooring buoys to prevent anchor damage to the heavily-visited coral reefs near Key West. Buoys eliminate anchor damage by providing an easy method of securing a boat at the reef without damaging the fragile coral below. Reef Relief protected Key West's coral reefs from the world's largest fleet of charterboats by installing and maintaining 116 mooring buoys at six Key West-area coral reefs for a period of 10 years. They are now part of the Florida Keys National Marine Sanctuary Reef Mooring Buoy Action Plan.

Next came the Coral Reef Awareness Campaign, an effort to educate boaters, divers, fishermen, and then residents, businesses, students and policymakers on how to protect coral reefs. Even casual contact with the reef from fins, hands or equipment can damage fragile coral polyps, providing a foothold for disease or nuisance algae that could result in the loss of an entire coralhead. Reef Relief maintains *ReefWorld*, an environmental education center in Key West that introduces residents and visitors and

others around the world of the benefits and methods of protecting coral reef ecosystems. A multi-media campaign includes an extensive website at www.reefrelief.org, brochures, special events such as Reef Awareness Week, the *Discover Coral Reefs* School Program, signage, documentary films, radio and television public service announcements, and a small gift shop featuring educational products for teachers and books.

Water pollution is a great threat; corals need clear, clean, nutrient free waters to thrive. The group works with policymakers, media, educators and citizens to increase support for improving water quality and it is a watchdog for policies affecting the coral reef. Reef Relief rallied the community and helped stop plans for offshore oil exploration and development. In 1991, its founders were presented with a Point of Light Award by George Bush who soon declared the area off-limits to offshore oil. Reef Relief was a major supporter of the effort to create the Florida Keys National Marine Sanctuary including the first Water Quality Protection Program of any sanctuary. Reef Relief has worked to upgrade Florida Keys sewage and stormwater treatment systems to nutrient removal tertiary treatment, led the effort to designate Florida Keys waters as a No Discharge Zone for boater sewage, introduced a county-wide ban on phosphate detergents, and promotes the removal of harmful nitrogen from agricultural runoff from the Everglades.

Reef Relief established a Coral Nursery at Western Sambo Reef in the Lower Keys that has salvaged storm damaged corals, secured them to the ocean bottom and elevated so that they may survive. Sanctuary restoration staff used the fragments to restore a boat grounding site.

Since 1993, Reef Relief's founder Craig Quirolo has monitored reef health of many coral reefs near Key West on a slide and video format that has led to the discovery of several new diseases. He collaborates with Reef Relief's Scientific Advisory Board comprised of leading coral reef scientists. The survey provides continuous reef health data invaluable in their studies of coral disease and is incorporated into Reef Relief educational programs to keep the public informed. The images are available on an online database at www.reefrelief.org that is currently being posted. The survey includes coral reefs in Jamaica, Puerto Rico, Cuba, Mexico, and the Bahamas.

In partnership with the City of Key West, Reef Relief created the Key West Marine Park in 2003. Located along the oceanside shore of Key West, it features several non-motor swim areas and access lanes for motorized vessels.

How to use Mooring Buoys

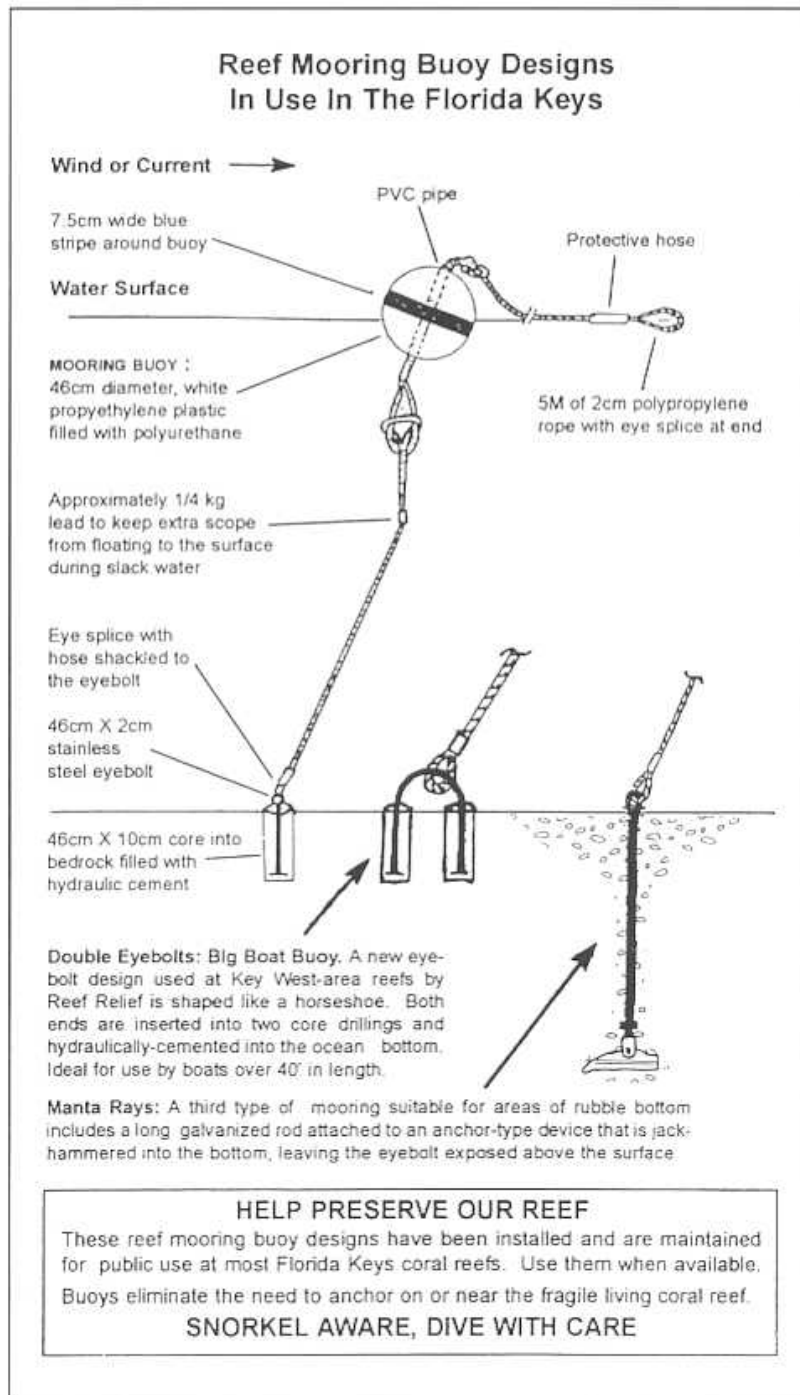


Figure 3-11