The Importance and Status of Florida Coral Reefs: Questions and Answers

Cory J. Krediet, Kim Ritchie, and Max Teplitski

Introduction

Coral reefs are some of the most productive and diverse ecosystems in the world; however, they are also some of the most threatened. Here we address a number of the most common questions regarding coral reef biology, coral reef health, and the ecological and economic benefits coral reefs provide.

Q: What exactly is a coral?

A: Corals are invertebrate animals that live in marine environments. Most corals are colonial animals, with each colony consisting of myriads of individual polyps, all of the same origin (Figure 1). Like some of their relatives (jellyfish and sea anemones), most corals form mutually beneficial relationships (symbioses) with single-celled dinoflagellates and bacteria. The symbiotic dinoflagellates are commonly referred to as “zooxanthellae.” In this relationship, the polyp (an animal) provides a protective environment and nitrogen-containing nutrients to the zooxanthellae that live within the animal cells. In turn, the zooxanthellae fix dissolved CO$_2$ through photosynthesis to produce carbohydrates that the coral animal can use. Corals assimilate carbohydrates for their own nutritional needs and then excrete the excess onto the coral surface in the form of mucus. Coral mucus mostly consists of carbohydrates and proteins. Mucus can protect the coral from damage caused by ultraviolet (UV) irradiation, drying at low tides, and harmful bacterial colonization. Corals also use mucus to help remove sediment from their upper surfaces. In addition to carbohydrates that can be transferred to the coral by the zooxanthellae, coral
polyps are capable of capturing food using their tentacles (suspension feeding).

The roles of bacteria in this symbiosis are much less clear. They are hypothesized to fix atmospheric nitrogen for their polyp and zooxanthellae partners, but they may also produce various antibiotic compounds that function to protect against infection.

**Q: What are coral reefs?**

A: Corals are found in many parts of the planet, but their distribution is limited by environmental conditions (especially light and temperature). Coral reefs are typically found in shallow waters between 30° north and 30° south latitudes. However, there are some non-reef-forming coral species that live in deep water, and some, like those belonging to the genus *Lophelia*, thrive in the deep ocean as far north as Norway.

Corals can be divided into those that produce calcium carbonate skeletons ("hard corals") and those that build a protein-based skeleton ("soft corals"). The former group includes the reef-building corals and is the type discussed in this publication. The latter group contains sea fans, sea rods and sea whips.

Coral reefs are calcium carbonate structures that are built by some species of hard corals and grow over time. The coral polyps remove dissolved carbon dioxide and calcium from the ocean water and combine the substances to form limestone (calcium carbonate) that is laid under each polyp to form a solid structure. A living, hard coral consists of a thin layer of connected polyps on top of a limestone coral skeleton. Typically the growth rate of this skeleton is rather slow (0.5–2 cm per year), but favorable conditions can lead to more rapid growth (Edmunds 2007).

**Q: Why are coral reefs important to economies?**

A: According to the *United Nations Atlas of the Oceans*, reefs support the economies of at least 100 countries by helping to provide food for more than one billion people (UN 2010). While corals are not edible themselves, coral reefs provide habitat for many commercially important species, including many types of fish and lobsters. Mucous slime secreted by corals is high in polysaccharides and proteins. The slime is an important food source for some plankton consumed by commercially harvested fish species. Florida coral reefs provide habitat for more than 6,000 species of marine life and support commercial and recreational fishing industries that generate approximately $60 million annually (NOAA 1995; Bhat 2003).

In addition to providing food and habitat for other species, corals—especially soft corals—are being explored for their medicinal properties. Chemicals purified from corals have promising anticancer and antibacterial properties. The estimated value of the planet’s coral reef resources is $375 billion a year (Costanza et al. 1997).

Florida reefs are a major tourist attraction. Visitors spend an estimated $460–$1,087 on each individual trip to a reef (Park et al. 2002). In southeast Florida, coral reefs contribute at least $4.4 billion annually to local economies (based on expenditures by residents and visitors of Palm Beach, Broward, Miami-Dade and Monroe counties) and directly provide employment for 98,000 people (Johns et al. 2001).

The “use value,” or maximum amount of money that reef users are willing to pay to maintain the reefs in their existing condition and to add more artificial reefs to the system in the aforementioned Florida counties (from June 2000 to May 2001), was estimated to be $8.5 billion (Johns et al. 2001).

**Q: What factors have led to coral reef decline worldwide?**

A: Extensive coral mortality can be caused by catastrophic natural events (storms, hurricanes, volcanic eruptions). Ship groundings, boat anchor damage, poaching, and damage to corals from recreational diving can have a significant, negative impact on coral reef ecosystems, especially in densely populated coastal areas like Florida (Bellwood et al. 2004). Loss of seaweed-eating fish and sea urchins from overharvest and/or disease has resulted in overgrowth of some reefs by macroalgae (seaweeds). The macroalgae can cause coral death by overgrowing, shading out or increasing sediment load...
on corals. In many developing nations, sediment runoff from land-clearing activities has negatively impacted coral reef health (Mumby and Steneck 2008).

Ocean acidification tends to lead to the dissolution of the calcium carbonate skeleton (which is not unlike the effects of carbonated beverages on our teeth). Since the Industrial Revolution, ocean acidification has increased as evidence by the decreasing pH of the oceans (Fung et al. 2005). This is a concern for reef scientists as coral skeletons are made from limestone that dissolves when pH is lowered. Studies are underway to investigate the effect of changes in pH on corals and coral reefs.

Coral bleaching and coral diseases (discussed further below) can have devastating impacts on corals.

**Q: What is Coral Bleaching?**

A: Coral bleaching is the loss of color resulting from the loss or expulsion of symbiotic zooxanthellae or the degradation of the single-celled organisms’ photosynthetic pigments (Hoegh-Guldberg 1999; Dunn et al. 2007). Left without their symbiotic dinoflagellates, bleached corals appear white (the color of the calcium carbonate skeleton). Corals will feed more with their tentacles when bleached to compensate for the loss of the photosynthetically driven carbon food source. Coral bleaching generally occurs in times of stress, often caused by warm sea surface temperature or UV radiation from the sun. When environmental conditions become favorable later, the corals may reacquire zooxanthellae and may recover. However, many bleached coral colonies will not recover and will die. Coral bleaching also can be caused by pathogens that produce toxins that can either stress or poison photosynthetic pigments in zooxanthellae. First reports of massive coral bleaching associated with elevated sea surface temperatures in the Florida Keys were in the 1980s, although earlier marine perturbations (cold water stress, brief periods of warming, reduced light penetration) have been recorded for the region (Causey 2008).

**Q: What are coral diseases and where do they come from?**

A: Beginning in the early 1980s, the proportion of corals within the Florida Keys National Marine Sanctuary affected by coral diseases increased dramatically (Causey 2008). In 1996, 11 species of corals were affected; by 1998, 35 species (85% of all species) were affected by some type of disease.

Many organisms that cause coral diseases are not dedicated pathogens but are opportunistic. Opportunistic pathogens normally are found in the environment and are generally benign (Rosenberg et al. 2007). Opportunistic pathogens invade their hosts only when the host defense system is compromised. Coral diseases caused by opportunistic pathogens are now widespread.

Coral diseases—such as black band disease, white band disease, and white plague—have resulted in mass mortalities of some coral species, especially in the western Atlantic Ocean. Black band disease was first reported on brain corals in Bermuda in the early 1970s but became rampant in other species in the Florida Keys, and elsewhere, in 1985. A group of microbial species, including cyanobacteria, causes black band disease. It affects many massive corals and sea fans; however, it does not seem to affect the branching elkhorn and staghorn corals. The cause of white band disease is unknown, but it seems to only affect elkhorn and staghorn corals. White plague is a bacterial disease that affects massive and plating corals and now affects about half of the reef-building corals in the Caribbean. White plague can kill corals within days or weeks. White pox, a disease that killed many elkhorn corals in the Florida Keys in the 1990s, is caused by a bacterium, *Serratia marcescens*, which is a common, opportunistic pathogen of animals and humans.

The discovery of *Serratia marcescens*, which is sometimes found in human waste, prompted research on the role of human activities in coral reef health. While this observation is important, conclusive evidence that wastewater is reaching and adversely affecting coral reef environments along the Florida Keys is limited. However, a recent study demonstrated that *S. marcescens* isolates from
diseased coral colonies were identical to isolates from human sewage effluent (Sutherland et al. 2010).

**Q: How do human influences affect the health of Florida’s coral reefs?**

A: Human activities and their direct and indirect outcomes can impact coral reef ecosystems. Although these ecosystems may recover from natural disasters, their ability to recover from human impacts is less certain. Unlike natural disturbances, such as hurricanes, the effects of human activities are often sustained, cumulative (Szmant 2002; Lapointe et al. 2004), or occur so frequently (e.g. overfishing) that there is little time for reefs to recover. Frequent and constant removal of important herbivorous and predatory fish from the reef ecosystem alters the dynamics of the reef. For example, herbivorous fish are required to control the growth of macroalgae (which can outcompete corals for space), and predatory fish keep populations of coral-feeding fish at sustainable levels.

Global climate change is regarded as one of the major threats to the future of coral reefs because temperature increases of only a few degrees induce global-scale coral bleaching episodes and mortality. Warming water is the leading cause of coral reef decline, and it may increase outbreaks of marine disease. If trends continue, atmospheric carbon dioxide concentration will continue to increase, and the pH of ocean waters will continue to decrease. These changes will increase stress to corals and increase their susceptibility to bleaching and disease.

Through human activities, corals are exposed to increasing nutrient, sediment, and pollutant loads discharged from the land that alter the dynamics of the reef ecosystem. Seaweed and cyanobacterial blooms result from nutrient enrichment of otherwise nutrient-poor waters. These blooms outgrow seagrasses and adult corals and inhibit recruitment of juvenile corals. Corals may also be outcompeted by other filter feeders (e.g., sponges, bivalves, ascidians, bryozoans, and barnacles) that are more efficient at utilizing particulate organic matter. Nutrient enrichment (for example, from the runoff of fertilizers used in agriculture, sport turfs, or on private lawns) also directly influences the dynamics of the coral–zooxanthellae symbiosis. Zooxanthellae density increases in response to high concentrations of dissolved inorganic nutrients (e.g., nitrogen and phosphorus). Under these conditions, coral skeleton growth often decreases, but the mechanism causing this decrease has yet to be identified. Increased particulate organic matter (e.g., clay and organic particles suspended in the water) also indirectly influences corals by reducing light penetration to the zooxanthellae. If prolonged, this may lead to lower carbon gain by the coral from zooxanthellae photosynthesis, slower calcification rates, and thinner coral tissue. Also, as particles settle on the coral surface, the coral must put more energy into mucus production to slough off the sediment.

**Q: What can Floridians do to help maintain health of coral reef ecosystems?**

- When diving, snorkeling, and boating around coral reefs, it is important not to damage the corals by touching them, standing on them, or using them for anchoring.
- Do not participate in illegal trade or harvest of corals.
- Help reduce nutrient runoff: Contact your local Extension office (locations at www.solutionsforyourlife.com) to learn Florida-Friendly Landscaping principles.
- These simple steps can help us contribute to the preservation of our unique coral reef ecosystems.
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References and Suggested Further Reading


