Environmental Case Study

Living Jewels in a Coral Reef

Often referred to as undersea gardens, coral reefs are among the most species-rich and productive ecosystems in the world. Ornate and visually stunning, vast reef ecosystems are built on colonies of minute animals called polyps (fig. 5.1), whose calcium carbonate exoskeletons provide the rocklike structure of the reef. Like all living systems, the reef depends on primary producers that capture energy and nutrients in organic compounds (chapter 2). Single-celled plants, specialized algae called zooxanthellae, are embedded in the clear tissue of the polyps. These algae photosynthesize energy and nutrients, using sunlight that reaches through the clear, shallow water of the reef. The algae provide nutrients and oxygen to the polyps, and the polyps provide shelter and carbon dioxide to the algae. Without this mutualistic relationship, most reefs would not exist.

Why do reefs occur only on shallow, tropical coastlines? The algae survive best in warm water, so reefs are restricted to latitudes where water temperatures are about 20°C or warmer. Shallow, clear water allows sunlight to reach the photosynthetic algae. Where floating organisms (plankton), debris, or sediment are abundant, as near the mouths of tropical rivers, water becomes too turbid for photosynthesis. In addition, polyps deposit calcium carbonate, the basis of the reef structure, more readily in warm water than in cold water. Below about 30 m, water is too cold (and too dark) for reef growth.

Despite these environmental requirements, reefs are widespread, highly productive, and incredibly diverse. The complex structure of the reef provides shelter, nutrients, and physical support for countless species of fish, crustaceans, worms, sponges, sea fans, and other organisms. Marine biologists have identified some 4,000 species of fish and 800 species of reef-building coral, but the total number of species associated with reefs is probably more than 1 million.

Reefs are essential to human well-being, as well as to marine ecosystems. They protect shorelines from waves, storms, and coastal erosion. They shelter marinas and tourist beaches. They provide nurseries for many of the fish on which human populations depend. Many of the world’s fisheries, and almost all the tropical aquarium fish trade, depend on healthy reefs.

A study of global coral reef health conducted by the World Resources Institute recently concluded that nearly 60 percent of the world’s reefs are at risk from human activities. The reefs of Southeast Asia, which are the most species-rich in the world, are the most threatened, with 86 percent at medium or high risk. The Pacific Ocean, on the other hand, which contains more reef area than any other region, is in much better shape, with just 10 percent of its reefs at risk. Built from the skeletons of tiny coral
polyps, reefs grow slowly, often 1–2 cm per year. Recovery from disturbance can be very slow.

Reefs suffer from a number of human activities:

- Farming: increases sediment and nutrients washing offshore onto reef systems.
- Urbanization and industry: produce concentrated pollution and human waste.
- Fishing: causes physical damage to reefs when heavy equipment is used.
- The tropical fish trade: devastates reefs when fish collectors use dynamite or cyanide to stun fish.
- Tourism: causes pollution from large hotel complexes and physical damage from boats and anchors.

In addition to these risks, global climate change is emerging as one of the greatest long-term threats to coral reefs. When coral polyps are stressed by unusually low or high temperatures, they often expel their symbiotic algae. With the colored algae gone, the transparent coral polyps appear white. Patches of bone-white “bleached” reef result. Some corals can acquire new algal partners, but prolonged stress can kill large patches of reef. Bleaching appears to result from a variety of stresses—ultraviolet sunlight, pollution, and diseases—but it occurs most often with sudden or unusual warming: Just 1–2 degrees warmer-than-usual water for a month or two can produce bleaching.

Once rare, bleaching has now become common and widespread. In 1998, reefs from the Caribbean to Australia were hit by the worst coral bleaching episode in recorded history. On the 350,000 km² Great Barrier Reef, bleaching killed 60 percent of all corals. Some of these reefs were more than 700 years old. If worst-case scenarios for global warming come true, some marine biologists predict that all the remaining coral reefs in the world may be dead or dying in 50 years—by the time your grandchildren are your age.

Coral reefs are one example of a widespread, general category of living system. Understanding the patterns and processes of life on earth involves knowing the names, characteristics, and distributions of these living systems. Understanding these systems also involves understanding the disturbances and threats posed by human activities.