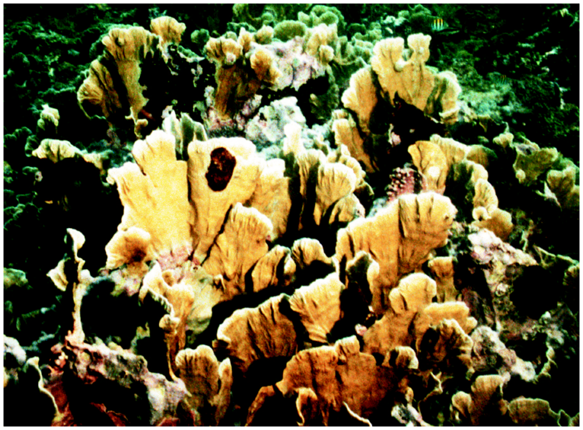

Close-up of bleached fire coral after oiling during the Bahía las Minas spill in Panama (Arcadio Rodaniche)

CHAPTER 2. GLOBAL AND LOCAL IMPACTS

Key points

- Coral reefs worldwide are under stress from a variety of global and local impacts.
- High sea surface temperatures bleach coral.
- Bleaching may cause little to nearly 100% mortality, depending on its severity.
- Overfishing is pervasive on many coral reefs and may contribute to ecosystem shifts.
- Increased sedimentation may slow coral growth and affect reproduction.
- Coral reefs recover from damage caused by tropical storms in varying time frames.

The effects of spill response operations in coral reef environments must be viewed as one of many anthropogenic and natural impacts that affect corals worldwide. These include both global impacts, such as sea surface warming and increasing levels of carbon dioxide, and local impacts such as land-based pollutants, sedimentation, overfishing, and physical disturbances.

Alarming trends in reef degradation have been noted since the late 1970s: live coral cover has significantly decreased and there have been major changes in coral species composition. Researchers have identified specific causes for many of these phenomena, such as the link between rising sea surface temperatures and coral bleaching. Since multiple impacts have a compounding effect on coral reef habitats, we need to understand the background health of reefs when assessing another impact, like an oil spill and its associated response activities.

Global warming impacts and bleaching

Global warming detrimentally impacts coral in several ways. Levels of atmospheric carbon dioxide are increasing, causing rises in sea surface temperature (SST), and this, in turn, increases the frequency and severity of coral bleaching. Levels of carbon dioxide are also increasing in seawater, resulting in weaker coral skeletons, reduced coral extension (growth) rates, and an increased susceptibility to erosion on reefs. Global warming is also linked to greater frequencies of severe storms, which are a major cause of physical damage to reefs.

Coral bleaching is defined as the loss of the zooxanthellae that live symbiotically in the coral polyps. Bleaching occurs naturally and is related to various stressors, including increased or decreased light, reduced salinity, and temperature changes. Recent widespread "mass bleaching" events are thought to be a relatively new phenomenon. There have been six major bleaching events worldwide since 1979; the most severe to date destroyed an estimated 16% of the world's coral reefs in 1998. Hardest hit were reefs in the Indian Ocean, Southeast Asia, and the far western Pacific.

Elevated SST is the major cause of mass bleaching in coral. In 1998, NOAA's "HotSpot" program accurately predicted bleaching based on recorded SST for most geographic regions. The NOAA NESDIS website provides current readings of SST worldwide (Appendix 2).

Bleaching can kill or otherwise damage coral, depending on the severity and duration of the temperature increase, and the sensitivity of the individual coral species. Corals can survive mild bleaching, as zooxanthellae have some ability to recover, but severe bleaching may kill nearly all the corals affected. Corals that withstand bleaching still suffer reproductive impairment, slowed growth, and decreased ability to calcify and repair themselves. These impacts persist even when coral recover their zooxanthellae after bleaching.

Overfishing and other ecosystem disturbances

Heavy fishing has both decreased biodiversity and shifted the ecosystem structure of fish and reef communities. Overfishing has been implicated in ecosystem-wide disturbances on coral reefs, often with other effects such as disease or pollution. In Jamaica, a combination of overfishing and disease removed fish and urchin herbivores from the reef habitat, resulting in proliferation of fleshy algae and up to 90% decreases in coral cover. Destructive fishing practices, such as the use of dynamite and poisons, common in some areas of the Pacific, directly damage and kill coral.

Overfishing is widespread on coral reefs, even in areas previously considered undisturbed, according to 1997 worldwide reef surveys. This study found a widespread lack of top predators (often the target species for fishing) in most areas surveyed. Few reefs were without anthropogenic impacts, even though most reefs surveyed were far from population centers or known pollution sources.

Outbreaks of the coral-eating Crown of Thorns starfish have damaged many reefs in the Indo-Pacific region, including the Australian Great Barrier Reef. We don't know why these outbreaks occur, but theories include possible connections to nutrient runoff and to the removal of starfish predators.

Sedimentation and nutrient enrichment

Increased sedimentation is stressful to corals because it reduces the ambient light available for photosynthesis, clogs coral polyps and, in large quantities, can smother or bury entire coral colonies. Sedimentation can result from poor land use practices, such as logging, coastal development, dredging, and from tropical storms. Ship groundings, which destroy reef structures, also create coral rubble and subsequent increases in sedimentary material.

Chronic input of nutrients to coral reef ecosystems can increase plankton and algal growth, especially in enclosed lagoons. Kaneohe Bay, Hawai'i was one of the first documented cases of domestic sewage pollution contributing to an overgrowth of corals by algae. Increased plankton growth increases turbidity and lowers light levels, impeding coral growth and reproduction. Chronic inputs of sewage and agricultural runoff can also reduce biodiversity on impacted reefs, and may favor the growth of fleshy algae. When combined with reduced grazing (which may be caused by fishing or disease), fleshy algal growth takes over areas previously covered by coral.

Corals vary widely in their tolerances to nutrients, salinity, and sedimentation. Nearshore reefs on shallow continental shelves are more likely to experience fluctuations in these parameters, and corals habituated to these environments tend to tolerate such fluctuations better than do oceanic species. However, when salinity or sedimentation changes faster or more frequently than usual (from increased frequency of storms or freshwater runoff, for example), even tolerant species may not be able to adapt.

Invasive species

In isolated coral reef environments, the introduction of an alien species (fish, invertebrate, or algae) can devastate the reef ecosystem. Introductions can occur through marine debris, ship groundings, ballast water, scientific research, and poor management strategies. On the island of O'ahu, some 19 species of algae have been introduced since 1950. At least four of these species successfully over-grow living coral. Alien sponges have also been observed overgrowing coral. Moreover, introduced fish may completely shift feeding guild assemblages on reefs. Areas with endemic species populations, such as Hawai'i and the Galapagos Islands, are at high risk from alien species introductions.

Physical disturbances

Tropical storms periodically hammer coral reefs. Whether hurricanes, cyclones, or typhoons, these storms can cause varying degrees of physical damage to reef structures and associated organisms, especially those in shallow waters. Storms exacerbate other injuries, such as bleaching, impacts from coastal construction, anchoring, or grounding. With no compounding impacts (bleaching, disease outbreaks), reef environments rely on natural recruitment mechanisms to recover, though this may take decades.

Physical disturbances to nearshore reefs from coastal construction (shading from piers, filling, etc.) also cause permanent reef destruction. Structural damages from anchors and ship groundings will be discussed in Chapter 5.

Cumulative impacts

Coral reefs, like most ecosystems, are inherently resilient to naturally occurring impacts and can recover over varying time frames. For example, some coral fragments broken off during hurricanes regrow vegetatively and recolonize adjacent areas. However, repeated impacts in rapid sequence or too many major impacts over a short period of time can reduce an ecosystem's ability to recover. Severe impacts may set in motion species shifts that cause long-term ecosystem changes. A recent case study in Belize showed that the combined impacts from severe bleaching followed by physical damage from Hurricane Mitch reduced coral recruitment substantially compared with areas that sustained only hurricane damage. Reefs recovering from bleaching may be more susceptible to disease, or more sensitive to toxic impacts from oil or other pollutants. Current evidence shows that nearly all coral reefs are under stress. An additional stress, like an oil spill and associated response operations, would thus tend to have a greater impact than if it had occurred in a healthy, more pristine system.

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