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Biology Standard
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Student Edition

California Education and the Environment Initiative

Differential Survival of Organisms

California Education and the Environment Initiative

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California Natural Resources Agency

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A Second Chance for Sea Otters

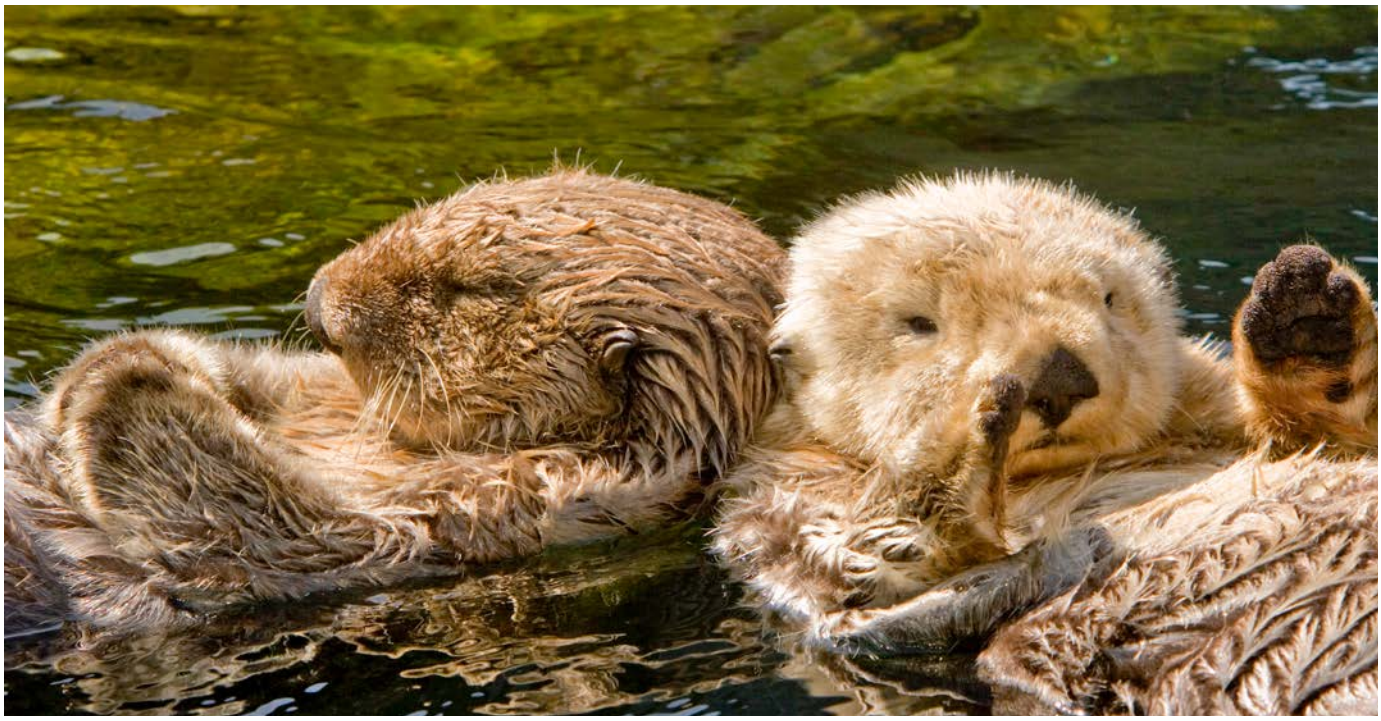
One spring morning in 1938, Howard Granville Sharpe gazed at the ocean through his telescope. Sharpe lived 13 miles south of Carmel, California, at the edge of a rocky cliff overlooking the sea. On this particular morning he glanced over the plentiful kelp beds close to shore. Something caught Sharpe's eye: It floated lazily on its back, covered with long strands of kelp. Was it a small seal or sea lion? Sharpe did not think it was either.

Sharpe called the California Department of Fish and Game. Commissioners there insisted the animal he saw was a seal or sea lion, but Sharpe protested; he knew what a sea lion looked like, and this creature did not match up with the animals in his pictures. For one thing, the animal was smaller and had beautiful, thick fur. Soon Sharpe located more of these creatures with his telescope; when he looked closer, he saw that they had white furry faces. They look "like muskrats," Sharpe said. As it turned out, Sharpe had "rediscovered" the lost member of the Mustelidae family, the southern sea otter (*Enhydra lutris nereis*), that until that point was thought to be extinct.

Sea otter with urchin

Range of the Otter

There are 13 species of otters in the world; only one of these species lives in a marine environment. *Enhydra lutris* consists of three subspecies. Sea otters only live in regions of the Pacific Ocean along North America and north Asia. The playful *E. l. lutris* lives near the Kuril Islands stretching from Japan to Russia; *E. l. kenyoni* lives throughout the Aleutian chain, the Alaska Peninsula, British Columbia, and



Sea otters

Washington; and *E. l. nereis* lives along the western coast of North America, from Monterey Bay National Marine Sanctuary to a point just below Point Conception near Santa Barbara. One population persists on San Nicolas Island off the coast of Los Angeles, and is currently the southern-most geographic extent. At times, a few southern sea otters have been spotted as far south as Baja California.

Changing Population

Historians estimate that 150,000 to 300,000 sea otters occupied the world's oceans before hunters started killing these animals for their beautiful pelts in 1741. By the early 1900s, 1,000 to 2,000 otters remained, only 50 of which lived off the coast of Central California. Land managers passed the International Fur Seal Treaty of 1911 to protect fur seals, but it ended up protecting several other fur-bearing species, including sea otters. The treaty was the first international law enacted for wildlife conservation, and it effectively stopped the slaughter of certain marine mammals for their valuable fur.

Since 1911, otter populations have increased, though not without setbacks. When disease and environmental factors affected otters and other marine mammals in the early 1970s, lawmakers passed the Marine Mammal Protection Act to protect and replenish otter, seal, and sea lion populations. Today more than 100,000 sea otters occupy 75% of their original habitat. In the northern Pacific Ocean, sea ice limits the otters' distribution. In California, where winters are warm, the location and condition of the kelp beds where otters forage for food determine the otter's distribution and rates of survival.

Adaptations for a Cold Ocean

Sea otters can grow up to five feet long, and weigh up to 100 pounds. They have wide,

cream-colored heads with small eyes and thick, glossy coats that range in color from dark brown to black. Otters use their webbed hind feet to propel themselves through water at a slow pace on their backs. When threatened, otters flip onto their stomachs and swim away.

Otters dive for food, foraging for sea urchins, sea stars, crabs, abalone, and mussels. They roll on their backs, place a small rock on their stomachs, and use their five-fingered paws to smash sea urchins against the rock. Otters are the only marine mammals to use such tools. If you concentrate while walking along the shore or sitting quietly in a boat, you can sometimes hear the clicking of shells on rock above the sound of the waves.

In addition to eating and sleeping, sea otters spend large amounts of time grooming their luxurious fur. The pelts, valued by hunters since the 1700s, allow the otters to survive in cold water. One square inch of an otter's coat contains approximately 1 million hairs. That is 10 times the number of hairs on a human head! Because otters have no extra fat on their bodies, they rely heavily on having healthy coats to keep them warm.

The Kelp Forest

When resting, otters often wrap themselves in long strands of kelp, which keep them from drifting away. Scientists identify sea otters as a "keystone" species, because the presence or absence of these animals affects the size and health of rich kelp forest ecosystems. Without otters to feed on sea urchins, the hungry urchins can devour entire kelp forests and create an urchin-dominated community.

Ocean temperature, light, nutrient availability, competition, and the condition of the rocky substrate (ocean bottom) all affect the abundance of kelp, the home of sea urchins, the otter's preferred food supply. The health of the kelp forest also depends on a process called upwelling, in which winds create currents that bring up nutrient-rich water from the bottom of the ocean. When certain naturally derived nutrients, such as nitrates and phosphates, are plentiful, the abundance of kelp increases, providing food for the sea urchins to thrive. Weather patterns, such as El Niño, warm the water and disrupt the process of upwelling, which in turn affects marine organisms that depend on coastal productivity. An invasive species of kelp called *Undaria* spp., which is growing along the California coast and is sold as wakame seaweed, competes with the kelp, reducing its abundance.

Sea otter

These changes to kelp forests affect the populations of the marine organisms that live there, including organisms that the sea otter depends upon for its diet.

Threats to the Otter

Today oil presents one of the greatest threats to the survival of sea otters. Oil spills leave slicks that float on the surface of the water and coat sea otters with a sticky film that mats their fur and destroys the protective warmth of their coats. If an otter's core body temperature drops a few degrees below normal, it can be fatal, especially in northern waters where the water temperature is much colder than in California.

The southern sea otter in central California faces a unique set of challenges. California otters often must compete with commercial fishermen for food.

Oil spill in ocean

Otter cleaned after oil spill

They are also more threatened by the effects of pollution than otters in the less-polluted northeastern Pacific. For these reasons the southern sea otter is listed as "threatened" under the Endangered Species Act.

Since their rediscovery by Sharpe in 1938, the number of southern sea otters off California's coast has increased, though not as rapidly as in Washington or Alaska. California otters still have a high mortality rate. As otter populations increase, they deplete populations of sea urchins, abalone, and large crabs. Without a steady supply of regular prey, the otters turn to filter-feeding mussels, clams, and worms, all of which contain high levels of bacteria, viruses, parasites, and contaminants. Large predators, such as great white sharks and killer whales, also threaten otter survival.

At the beginning of the 21st century, 2,692 otters lived off the coast of central California. The engaging sea otter has become a symbol of how environmental pressures can affect interdependent marine communities. Despite a small decline in the otter's population between 2005 and 2006, the trend for the last few years has been slightly upward. As Howard Granville Sharpe wrote in 1938, "Nature's immutable law was: 'once extinct, always extinct.'" Sharpe understood nature, but he still could not figure out how the otter eluded him until that historic spring morning!

Coastal Wetland Background Information

Coastal wetlands connect the watersheds of coastal areas with the ocean. Water moves through this ecosystem dynamically; both the inflow and outflow of rainfall runoff and tidal movement from the ocean affect this environment. Fluctuations in runoff and tidal movement can increase or decrease the salinity of water in wetlands; for example, an influx of rainfall decreases the salinity of water in wetlands, while tidal movement brings in salty water from the ocean. The movement of water from both sources also affects the amount of nutrients in the water. In California, tidal movement, which brings in cold ocean waters, strongly affects the temperature of water in wetlands.

Water movement also affects coastal wetland substrates. Runoff carries sediment into wetlands, where it settles out and deposits onto the wetland floor. Tidal flow carries some sediment out to the ocean, where it settles onto the ocean floor or gets transported to other areas.

Coastal wetlands support diverse aquatic plants and animals, as well as terrestrial vertebrates. The level of nutrients here strongly affects primary producers. Some, like pickleweed, are adapted to high salinity in the water. Animals depend on these plants for food and shelter. For example, the larvae of brine flies eat decaying vegetation in the water, and as adults these flies serve as food for many bird species. The muddy waters of wetlands provide an ideal habitat for animals like bat rays, which flap their fins to move the silt and expose their prey of mollusks, crustaceans, and small fish along the sandy bottom. Burrowing animals, such as worms, depend on the muddy substrate, while dragonfly larvae need shallow water to grow into adults.

In California, human activities have reduced the total area of wetlands, including coastal wetlands,

Shorebirds

Elkhorn Slough, California

mudflats, and salt marshes, by 97%. Development and water diversion especially affect wetland areas. Real estate developers prize coastal locations, and purchase and fill them in with dirt and sediment so they can build up residential and commercial projects. The development or expansion of airports in Santa Barbara, Los Angeles, San Francisco, and San Diego all involved the filling in of coastal wetlands.

Birds flying over salt marsh, Moss Landing, California

Water diversion, like development, also leads to the filling in of wetlands. In natural conditions, flowing water transports sediment from wetlands to the ocean. Decreased water flow as a result of diversion allows sediment to build up within a wetland and eventually in the waterways that flow to the wetland.

Pollution frequently contaminates water flow in local watersheds. Wetlands typically filter water moving off the land; if, however, the contaminant load is too great, the concentration of the pollutants may affect burrowing animals and other aquatic species.

As more and more people recognize the importance of wetlands as a habitat for migrating aquatic bird species and for the ecosystem services they provide, they are making greater efforts to restore many wetland regions. California has protected its remaining wetlands and begun habitat restoration programs in several areas where the wetlands have been substantially changed by human activities. The introduction of stronger regulations restricting terrestrial pollution has also decreased the number of contaminants that reaches wetlands.

Coral, Great Barrier Reef, Australia

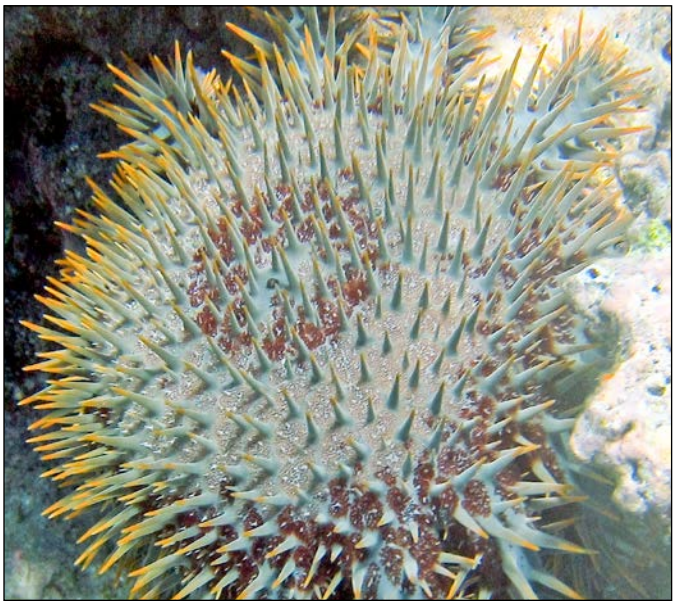
Introduction

The Great Barrier Reef along northeastern Australia supports more than 300 species of reef-building or hard corals. Light, water clarity (how clear the water is), and temperature all help determine where reef-building coral grows. The corals occupy a band between 30°N and 30°S latitude and grow in shallow regions of the tropical and subtropical western Atlantic and Indo-Pacific oceans. Coral reefs form highly diverse habitats that provide sanctuary to hundreds of species of fish and invertebrates. Sixty-five percent of marine fish live in or near coral reefs because this habitat provides shelter and food. A few organisms, including various marine snails, fish, and sea stars, prey on coral. The most aggressive predator on hard corals is the crown-of-thorns sea star.

Changes in water clarity, sea surface temperatures, and water quality resulting from the runoff of nitrates have led to declines in the amount of hard coral in the Great Barrier Reef.

Key Species

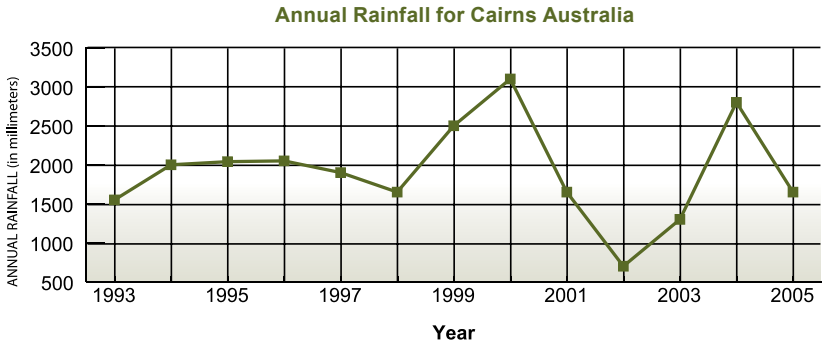
The crown-of-thorns sea star belongs to the phylum Echinodermata, which also includes sea urchins and sea cucumbers. Temperature and coral (a food resource) limit the distribution of this sea star. The crown-of-thorns sea star has a planktonic (microscopic, free-living) larval stage in which its larvae move along with the currents. Many larvae die off in this stage, especially when their food source of phytoplankton (plant-like plankton) is low. The amount of phytoplankton available depends on the level of nutrients in the water. An increase in nutrients leads to an increase in phytoplankton (referred to as a “bloom”) and thus an increase in the survival rate of the crown-of-thorns sea star larvae. More larvae mean more adult sea stars on the Great Barrier Reef.

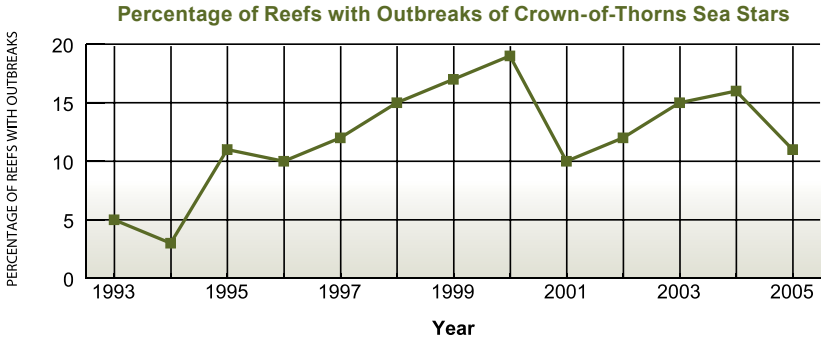


Crown-of-thorns sea star

Habitat Data

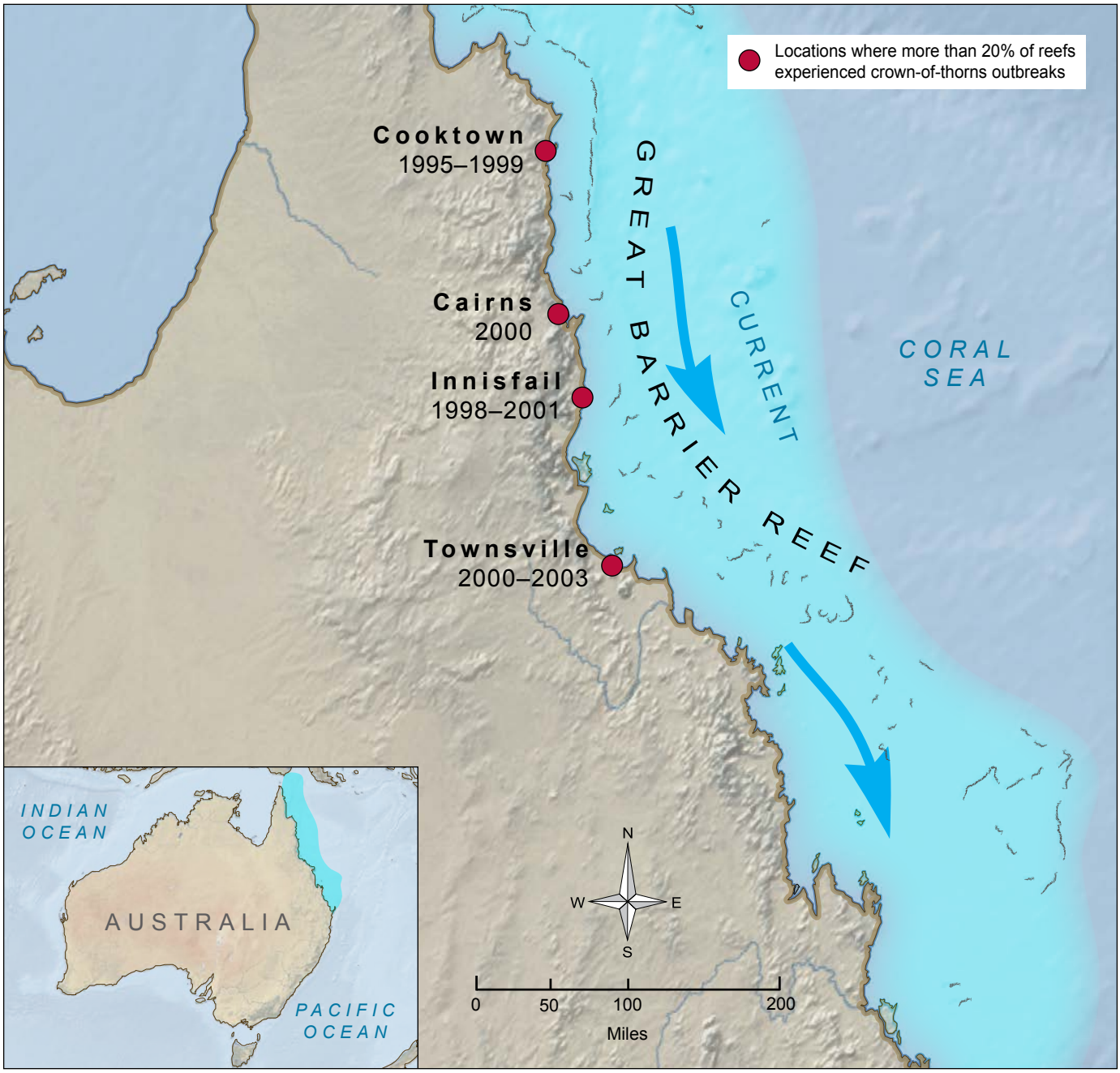
- Phytoplankton concentrations have increased along coastal regions.
- Nutrient levels along the eastern coast of Australia have increased in areas adjacent to where major rivers drain into the ocean.
- Nutrient levels along the coast are higher during rainy seasons, when more water from rivers runs into the ocean.
- The survival of crown-of-thorn larvae increases during the wet season.
- Ocean currents along the eastern coast of Australia run from north to south.
- In eastern Australia, agriculture has increased over the past several decades:
  - In the past 10 years, native vegetation has been replaced with crops planted for agriculture.
  - The use of fertilizers is unregulated in the Australian agricultural industry.
  - Fertilizers contain nutrients (nitrates and phosphates) that flow into rivers as runoff from farms.
  - The banks of the major rivers along agricultural regions have been altered for irrigation, increasing the amount of runoff that flows into rivers.
- The size of the region where outbreaks of crown-of-thorns sea stars occur has increased over the past 10 years.
- Coral bleaching, or die-off, along the Great Barrier Reef has increased over the past 25 years.





Source: Australian Institute of Marine Science, www.aims.gov.au

Years When More Than 20% of Reefs Experienced Outbreaks (Between 1993–2003)



SCIENTIFIC OBSERVATIONS

Scientist's Observations: Great Barrier Reef, Australia

Most of the time few crown-of-thorns sea stars populate healthy coral reefs because most of this organism's larvae die off instead of growing into adult sea stars. Outbreaks of crown-of-thorns sea stars have increased on Australian reefs due to a recent increase in larval survival. Larvae usually die because the phytoplankton, their favorite food, is often scarce. The recent increases in crown-of-thorn larval survival probably result from an increase in phytoplankton (microscopic plants). Scientists often use measurements of chlorophyll levels to calculate phytoplankton density. Some researchers have reported increased chlorophyll levels near crown-of-thorns sea star outbreaks. The researchers attribute the increase in phytoplankton to an increase in nutrient concentrations; for example, more phytoplankton grow when more nutrients are available in the water.

Researchers have also recorded a recent increase in nitrates in certain areas around the reefs. Agriculture, which often uses nitrate-containing fertilizers, is a common contributor of nitrates to water supplies. Surveys of land use along the main river near the reef areas containing increased phytoplankton indicate that brush has been cleared there for agriculture. Clearing and conversion of the land to agricultural production has resulted in the increased use of nitrates in the form of fertilizers. Without the roots of brush plants to hold the soil in place and protect it from rainfall, increased runoff from agriculture has resulted in higher levels of nutrients in the water. Consequently, phytoplankton continue to bloom, leading to an increase in crown-of-thorn sea stars.

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