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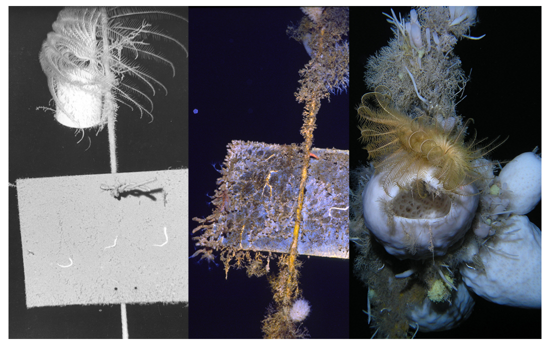
How Marine Life Responds to Upheaval

Recent episode in Antarctica set off a chain of ecological events and offered a study in resilience



Settling plates installed on the seafloor in Antarctica's McMurdo Sound show various levels of growth in 1974, 1989, and 2010. The last image was made after a collapse of icebergs around 2000 set a major ecological change into motion.

An event that occurred nearly 20 years ago led to a profound ecological upheaval in a corner of Antarctica frequented by U.S. scientists. Now researchers at Scripps Institution of Oceanography at the University of California San Diego and colleagues report on what that event and its aftermath can tell society about the ability of marine life to adapt to sudden change.

Paul Dayton is a pioneering marine biologist at Scripps who was among the first scientists in history to dive the waters of McMurdo Sound in the early 1960s. He and colleagues report on this history in a paper appearing in the January 2019 issue of the journal *Ecological Applications*.

The paper synthesizes two other Dayton-led studies published in 2016 and presents new insights on long-term ecological response to an event that took place around 2000 in which icebergs broke loose from an adjacent ice shelf.

"Ecologists are fundamentally interested in understanding processes controlling the distribution and abundance of species in nature. Data covering long time periods are very rare in ecology," said Dayton. "The chance to visit the site in 2010 was an exceptional opportunity to revisit areas that had been extensively studied in the 1960s and 1970s, and we were amazed at the changes."

McMurdo Sound is home to a U.S. research base and is also the southernmost open-water marine habitat in the world during the austral summer. It is bounded on its east side by a large island and the Antarctic mainland on the east side. To the south is the Ross Ice Shelf. The shelf's sea ice normally breaks up in summer along the east side of the sound. Because of contrasting ocean currents, the east and west sides of the sound have different benthic, or seafloor, marine life communities. The volcanic southeast side of the sound is dominated by sponges and invertebrate animals called bryozoans, while two study sites on the west side near a location called New Harbor are characterized by organisms found on muddy seafloors with similarities to the abyssal deep sea.

Dayton and others extensively studied both bottom habitats in the 1960s and 1970s. The researchers established artificial substrata – surfaces on which invertebrates could attach themselves and grow. They installed arrays of surfaces such as Plexiglass plates mounted on stakes or suspended beneath floats. By elevating some arrays off the seafloor, the scientists could observe how invertebrates such as sponges fared with less exposure to natural bottom predators and competitors. These substrata remain in place to this day and have been periodically revisited by researchers.

One of Dayton's return visits took place in 2010. That was ten years after the icebergs broke loose from Ross Ice Shelf, blocking the normal currents bringing food into McMurdo Sound. The ice cover plunged parts of the sound usually exposed to sunlight during part of the year into darkness for several years.

In a related development during this period, warming conditions induced increased glacial melting and runoff as well as melting from the bottom of the ice shelf. That melt apparently released to the sound significant amounts of iron that had been bound in the ice. Iron is an important nutrient for some photosynthetic phytoplankton.

One of the 2016 studies reported a massive flood that took place sometime between 1990 and 2010 from a relatively small glacier above Salmon Bay, the southernmost study site on the west sound. The flood carved a new channel to the sea, buried a beach under almost a meter of gravel, and deposited almost two feet of sediment on one of the underwater experimental sites the researchers had established. There had been virtually no sign of melting in aerial and satellite photos of the glacier, yet a remarkable amount of water from internal melting was released.

This observation demonstrates the complexity of glacial melting, which cannot be assessed solely by aerial measurements, Dayton said. Because ecologists are interested in understanding how ecological communities are formed, this was an opportunity to study the recovery of an ecological community from a situation in which almost all the organisms had been buried and killed by the large amount of sediment covering the bay.

Ecologists are interested in recruitment, the process by which larvae or young organisms are settled in the environment and allowed to mature. Dayton and colleagues had reported in a second 2016 paper on a striking change in recruitment on the artificial surfaces that had been suspended above the bottom decades earlier. They had virtually no activity for 25 years but were suddenly covered with normally very slow-growing sponges in the late 1990s-2000 after the icebergs had broken off the Ross Ice Shelf. By 2010 all the settling plates were sunk beneath the weight of sponges that settled about the same time the giant icebergs blocked the sound.

“This observation dramatized the difference between ‘potential recruitment’ or the presence of many young propagules available to settle and ‘realized recruitment’ in which the propagules survive the small predators on the natural bottom and grow into small sponges,” Dayton said.

Dayton reported that the recruitment on the artificial plates represented potential recruitment in the absence of predators, whereas the predators on the bottom apparently restricted the realized recruitment. This clear distinction between potential and realized recruitment is unusual and emphasizes the importance of understanding the predators that can have such a difference in the recruitment dynamics of natural habitats.

There were also differences on the other side of McMurdo Sound. Here, at New Harbor, the baseline transects on the soft-bottom habitats were established in the mid-1970s, and no important changes were observed through the 1980s. At first glance in 2010, the system appeared to still be unchanged despite the massive recruitment on suspended artificial plates. Careful resurveys of 1970s-era transects, however, showed changes in which filter feeders such as clams, deposit-feeding urchins, and sea stars virtually disappeared. These invertebrates, which are thought to depend on larger-sized phytoplankton particles in the water column for food, were replaced by other species such as some polychaete worms and bryozoans that consume tiny phytoplankton.

The normal ocean transport systems had been blocked by icebergs. The authors suggest that this altered the nature of the nutrients available to organisms there. Changes, especially a possible injection of iron into the system, had shifted the size distribution of the phytoplankton from relatively large particles necessary to the clams and sea urchins to very small particles the polychaetes consume. Dayton speculates that as climate warming proceeds and ice conditions open up, the earlier patterns of distribution and abundance will return.

Ten years after the flood that devastated the southern Salmon Bay site, there was very little recruitment of benthic invertebrates suggesting that recovery from a catastrophic disturbance is very slow.

The authors argue that funding should be continued to support efforts to understand these processes as it may give vital clues on how marine ecosystems might cope with climate change.

"These papers offer future ecologists an utterly unique set of long-term data enabling them to evaluate the many expected changes resulting from the changing ocean and ice environment," said Dayton. "This understanding could serve as the basis of conservation efforts in coming decades."

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