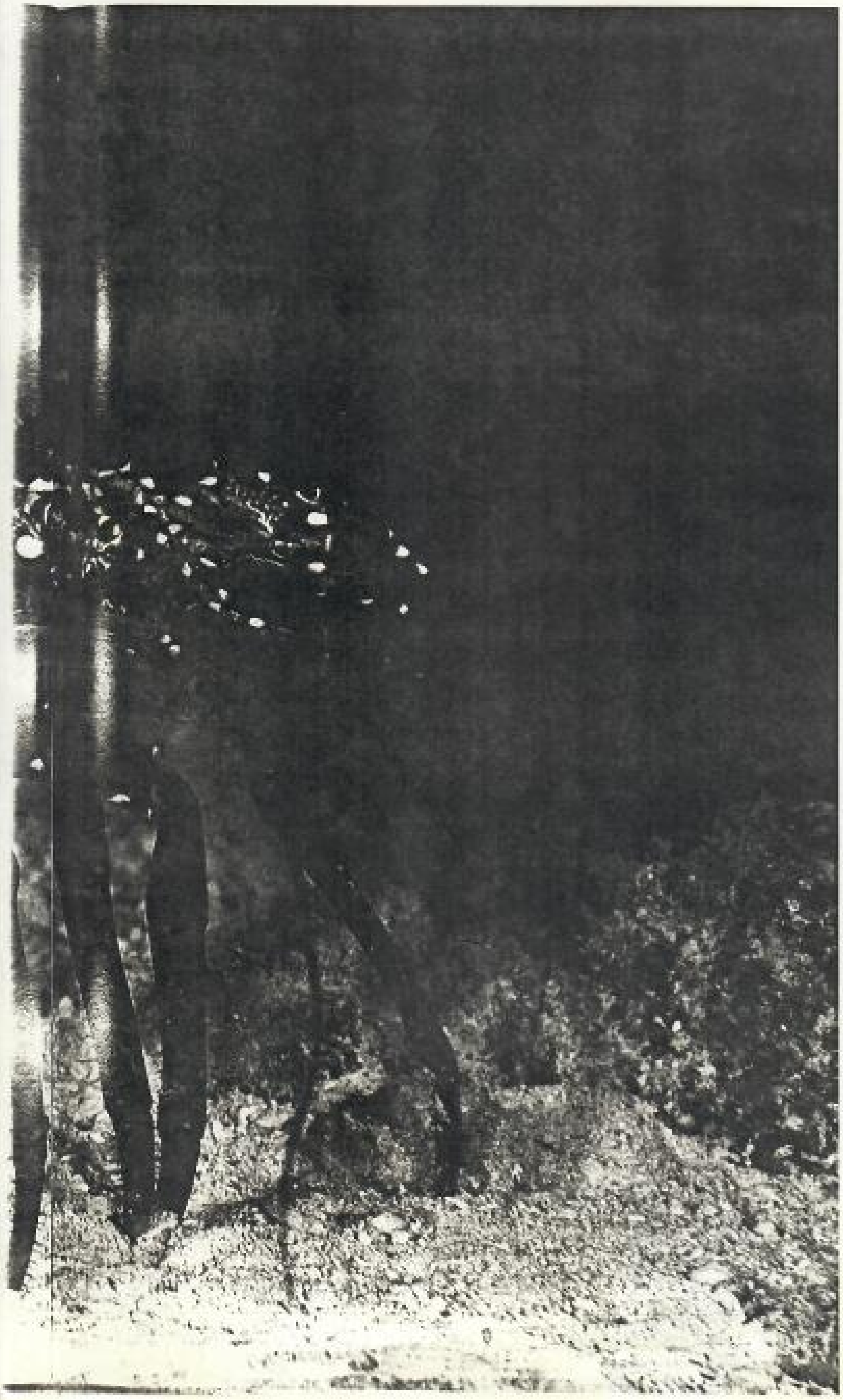
Natural History Vol. 103, No. 2 2/94

eCase of the Missing Lobsters

What does a low-pressure system over the North Pacific have to do with the complaints of disgruntled lobstermen?

by Jeffrey Polovina

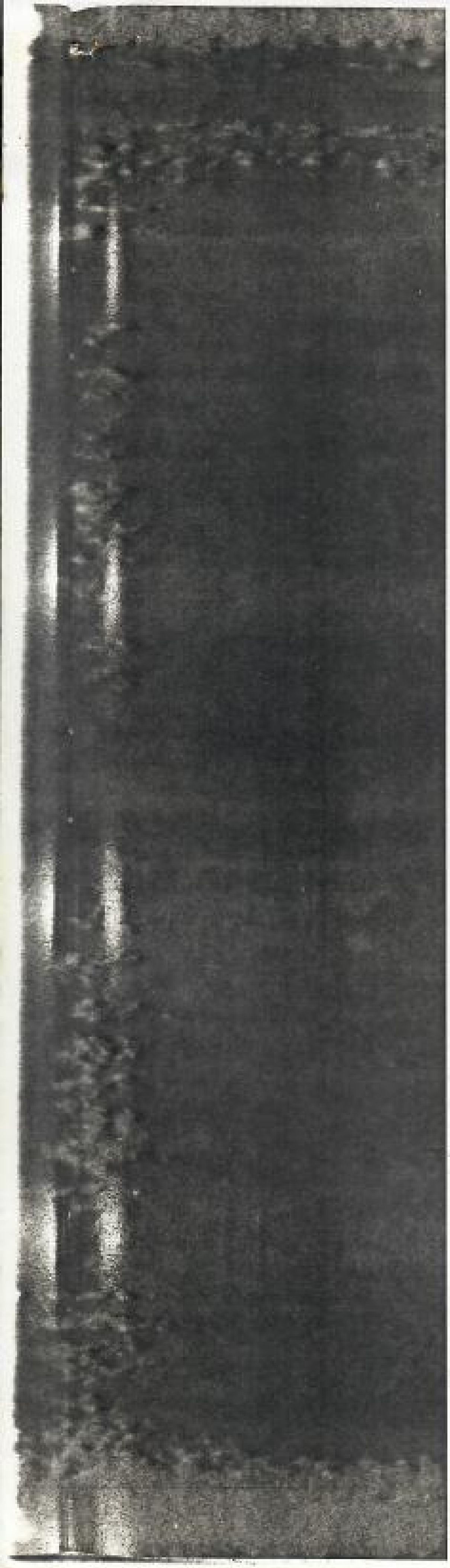


From the main islands of Hawaii, countless small islands, atolls, and submerged banks stretch northwestward a thousand miles to Midway Island. The islands are part of a wildlife refuge, and except for a few biologists camped out at research stations, they are uninhabited. The archipelago supports a wealth of marine life, including a large population of seabirds and a small population (1,600) of Hawaiian monk seals, an endangered species. This is where, in recent years, lobstermen have begun to harvest Pacific spiny lobsters.

As a marine biologist with the National Marine Fisheries Service in Honolulu since 1979, my job has been to provide lobstermen and managers of the fisheries in the northwestern Hawaiian Islands with biological advice. Thus, I am no stranger to phone calls from unhappy or even irate lobstermen. I still remember a call I received in September 1989. The caller was not angry despite his recent return from a sixty-day fishing trip that had yielded a very poor lobster catch. He was puzzled, however, because on a trip to the same areas a few months before, the catch had been excellent. I told him the reason for the drop was obvious: he had fished out all the lobsters! He was not amused. So I suggested that the low catch was just a temporary aberration. I reminded him that in 1987, colder water seemed to have restricted spiny lobsters' movements, making them harder to trap, and that by 1988, more favorable conditions—and good catches—had returned. I even went as far as telling him that he should look forward to a good year in 1990.

That was a mistake. By the summer of 1990, lobster catches had not improved, and my advice was proving to be an embarrassment. With fishermen grumbling and managers becoming nervous, I was under pressure to find the real reason for the persistent decline in lobsters.

Although my first reaction had been to blame the lobster decline on the usual suspect, overfishing, I had a number of reasons to doubt that this was the cause. First, the proportion of the lobster population



Bill Curtsinger

A red-tailed tropic bird, left, soars through the air above the northwestern Hawaiian islands. An unattended red-tailed tropic bird hatchling, below, waits for its parents to return with a meal.

Erwin and Peggy Bauer; Bruce Coleman, Inc.

being trapped in the islands was relatively low compared with other spiny lobster fisheries. Second, sizable areas of the wildlife refuge were closed to lobster fishing. And third, size limits allowed lobsters to mature and spawn at least once before reaching harvest size, which should have been giving the population a chance to renew itself. Furthermore, I had heard rumors of declining numbers of seabirds and monk seals in the area. These two species are often good indicators of changes in the ocean; the number of offspring they raise each year can be strongly affected by the abundance of food in the sea.

Hoping that other parts of the ecosystem would provide clues to the declining lobster catches, I paid a visit to Beth Flint, a seabird biologist working for the U. S. Fish and Wildlife Service. I was fortunate to find Flint in Honolulu; usually, she is out on the islands monitoring seabirds. When I told her my story, she was very interested and told me that since 1985, the reproductive success of the red-tailed tropic bird and the red-footed booby had dropped to half of what had been observed in the early 1980s. She explained that the birds' reproductive success is defined as the fraction of eggs that ultimately hatch and become fledgling chicks strong enough to fly. The number of eggs laid hadn't changed, but the fraction of hatchlings that survived to become fledglings had fallen. Although she didn't know the reason for the decline, she was able to rule out factors such as predators, diseases, and habitat loss and suggested that a scarcity of food would force the adult birds to abandon their nests for longer periods while foraging. This would increase the chances that their exposed eggs and chicks would perish in the hot, subtropical sun.

I spent the rest of the day poring over dusty files of seabird records dating back to the early 1980s. I found that at the beginning of the decade, about 70 percent of the eggs laid produced fledglings, but the success ratio declined steadily through the mid-1980s, so that by the end of the decade, this fraction dropped to about 40 percent, where it has remained. I also learned that red-footed boobies and red-tailed tropic birds feed almost exclusively on squid and flying fish. I wondered if these marine creatures had been reduced in number by some environmental change that had also affected the lobsters. If so, why did the decline in seabird reproductive success precede the decline in lobster catches by three or four years?

Maybe monk seal statistics had some-

Ed Robinson; Pacific Stock

Searching the reef for lobsters, fish, and other creatures on which to dine, a Hawaiian monk seal, left, rolls beneath the surf. A monk seal, below, basks on an atoll in northwestern Hawaii.

Erwin and Peggy Bauer; Bruce Coleman, Inc.

thing to tell me. I turned to Tim Ragen, a colleague at the National Marine Fisheries Service, who monitors the endangered animals. Ragen had worked as a carpenter before becoming a marine biologist. Now he builds models of marine mammal populations instead of furniture. Ragen explained that the records on monk seal pups only went back to 1986, but the data did show a decline in first-year survival rates from about 85 percent in the mid-1980s to about 45 percent in the early 1990s. Like Flint, Ragen didn't know the reason for the decline, but after eliminating possible causes such as disease, he felt that the most likely cause was a scarcity of reef fishes and lobsters, which make up a significant part of a monk seal's diet.

With lobsters, seabirds, and seals all showing strong evidence of decline, I became fairly certain that something had affected the entire marine ecosystem. To test my hypothesis, I looked to the reef fishes. In the early 1980s, their numbers had been surveyed at selected sites throughout the northwestern Hawaiian Islands. Because fishing is prohibited near these shallow reefs, any decline a decade later by a second survey of the same sites would be further evidence of environmental change. To coordinate a field survey to estimate reef fish densities at nine of the original sites, I enlisted the help of Ed DeMartini, a coral reef ecologist.

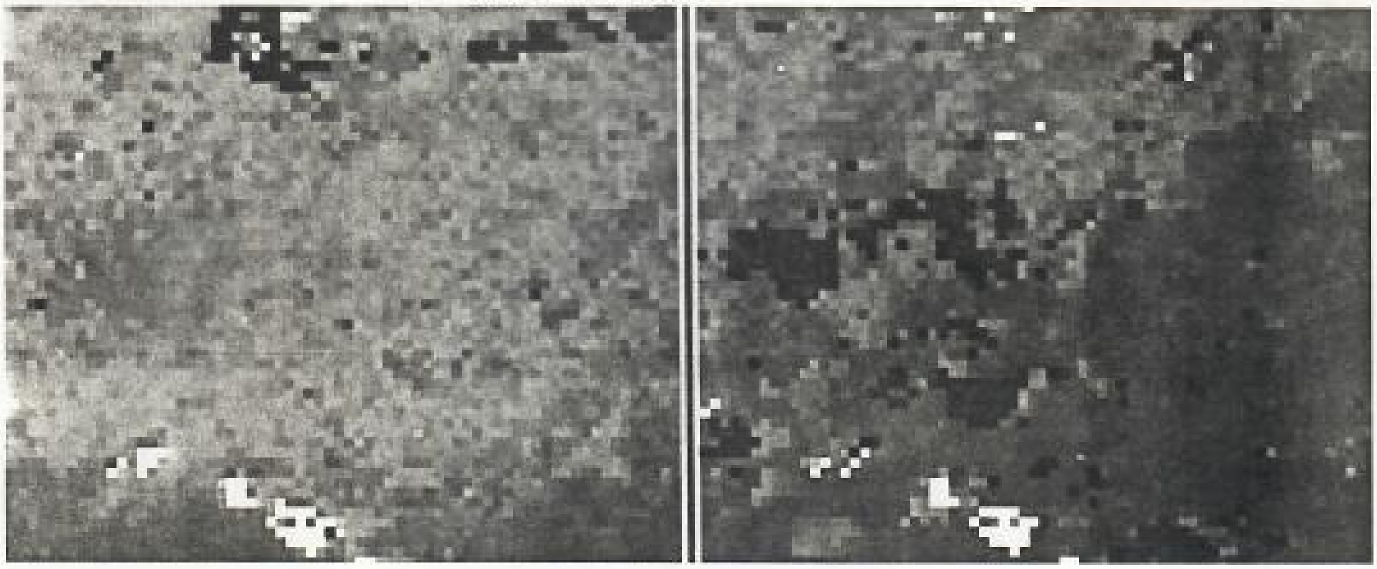
The last biological data would come from a satellite and would indicate how the marine life at the base of the food chain was faring. Either directly or indirectly, phytoplankton, the microscopic plant life that thrives near the ocean surface, provides almost all the food for the ocean's animal life. From space, the Coastal Zone Color Scanner, a special sensor mounted on a satellite, could measure an index of phytoplankton abundance. Unfortunately, the sensor, which was especially designed to pick up the light reflected from the chlorophyll in the phytoplankton, was only operational from 1979 to 1986, but it did record data during the crucial period of the early to mid-1980s.

While the reef surveys were being conducted, and Mei Zhou, a computer wizard, was computing phytoplankton estimates from satellite data retrieved from a giant NASA data base, I traveled to Victoria, British Columbia, to attend a conference on climate change and northern fish populations. I learned that weather patterns over the North Pacific had changed significantly since the last decade. Every year, the Aleutian low-pressure system is responsible for Hawaii's winter rainy season and the strong winds that blow from January to March, generating rough seas and the huge waves that surfers love. For about a decade, from 1977 to 1988, the Aleutian low was more intense and farther eastward than it had been at any period since the 1940s, causing unusually strong winds in the northwestern Hawaiian Islands. The climate change was not abrupt. There was a gradual increase in the intensity of the Aleutian low, and the winds that accompanied it, from 1977 to the early 1980s, followed by a gradual decline, so by 1988 the climate was back to long-term pre-1977

Jack Jeffrey; Photo Resource Hawaii

A red-footed booby, left, perches in a tree on Kure Atoll in Hawaii. Below: False-color satellite images show the changing distribution of microscopic plant life, or phytoplankton, in the northern Pacific. Green indicates a high phytoplankton concentration; blue, a low one. The white patches are the main Hawaiian Islands, and the black patches are clouds. A drop in productivity to the north of the main Hawaiian Islands is evident between the first quarter of 1982, below left, and the same period in 1986, below right.

Mei Zhou/Gene Feldman: NASA



levels characterized by a weak Aleutian low and weak winds.

I left the conference with a new insight into the changes in the marine community of the northwestern Hawaiian Islands. Since I had no biological data prior to the 1980s, I had assumed that the level of productivity in the early 1980s was the norm and that the recent drop signaled something unusual—a reasonable assumption given that the commercial lobster fishery had only been in operation since 1980, when lobsters were plentiful. Having learned that the early 1980s were characterized by abnormal climate patterns, I realized that the opposite was more likely. What originally looked like an ecological disaster, might be only a return to the usual population levels. The challenge that remained, however, was to determine if the atmospheric changes across the northern Pacific were reflected by equally dramatic changes in the ocean—changes that could effect an entire ecosystem.

Back in Hawaii, I went to see Gary Mitchum, a physical oceanographer at the University of Hawaii. A year before, Mitchum had shown me how a shift in current could have caused a change in lobster distribution, and he thought that his help entitled him to some of the lobsters caught on our research cruises. When I entered his office, he reminded me that he not received a single lobster for his trouble. Once I explained the reason for my visit, however, Mitchum forgot about free lobsters and became intrigued with the idea that a decade of unusually strong Aleutian lows could alter the ocean enough to have drastic effects on marine life. He agreed to sift through the oceanographic data to see if he could find any evidence of such a connection.

Several weeks later, Mitchum came to see me and was quite pleased with what he had found: several large-scale features of the ocean reflected the changing intensity and position of the Aleutian low. The match was good enough to convince him that the link between atmosphere and ocean was real. During the last decade, tide gauges recorded exceptionally high sea levels over the central and eastern North Pacific during the winter months. The increase, which reached about four inches, was probably caused by an eastward shift in ocean waters due to the change in wind strength and pattern resulting from the change in the low-pressure system. At the same time, Mitchum found that water-temperature readings taken from ships showed that from 1977 to 1988, the warm surface layer extended much farther down than it did from 1960 to 1976 or since 1988. This is evidence that from 1977 to 1988, there was an increase in the mixing of deep, nutrient-rich waters with nutrient-poor surface waters. Mitchum and I estimated that during this eleven-year period, the deeper mixing brought five times more nutrients into the surface waters than during the period from 1960 to 1976 or since 1988.

As a biologist, I was more excited by Mitchum's second finding, because it had great consequences for the marine life near the surface. Sun-warmed surface water is less dense and "floats" atop the colder water below. Usually there is very little mixing between the two layers. Without an influx of nutrients from deeper waters, the growth of phytoplankton near the surface—where the sunlight is—is severely limited. The problem is particularly acute in midoceanic regions, such as the waters around Hawaii, where the sea is often described as a desert. Whenever the deeper, nutrient-rich waters are brought to the surface, as in an upwelling system, phytoplankton production soars. This is apparently what happened from 1977 to 1988, when more nutrients from deep waters were mixed into surface waters.

By early 1993, the pieces were all coming together. Ed DeMartini had the results of the reef fish survey, which confirmed that the numbers of most species have dropped 30 percent from what they were in the early 1980s. Mei Zhou's analyses of

Andrew G. Wood; Photo Researchers, Inc.

In the northwestern Hawaiian Islands, pyramid butterfly fish, below, school above a reef. A small basslet fish, right, hugs the reef, looking for food.

Nikolas Konstantinou; Photo Resource Hawaii

the satellite data were also ready and showed that phytoplankton production around Hawaii was highest during the first quarter of each year when the Aleutian low was strongest. Mean chlorophyll density estimated from the satellite was about 40 percent higher during the first quarter of each year from 1981 to 1983 than during the same period in the years immediately before 1981 and after 1983.

From the bottom to the top, all four major levels of the nearshore marine ecosystem in the northwestern Hawaiian Islands reflected the changing atmospheric conditions. As the Aleutian low reached its greatest intensity and eastward position in the early 1980s, the westerlies blowing across northwestern Hawaii gathered strength. The resultant wind-driven currents and rough seas increased the amount of vertical mixing of ocean waters, so that nutrients were transported from deep waters to the surface, thus increasing phytoplankton production. Higher phytoplankton densities observed in the early 1980s, translated into more zooplankton, which in turn supports a greater abundance of flying fishes and squid, which are prey for seabirds. Abundant plankton could increase the survival of reef fishes and lobsters, which eat plankton during their long larval phase. And expanded populations of reef fishes and lobsters would provide more food for monk seal pups.

The first quarter of each year seems to be a critical time for many animals, so when the Aleutian low began to wane in the mid-1980s, it would have had an immediate effect. As juvenile flying fish and squid declined in number, seabirds would spend more time away from their nests looking for food, leaving their eggs or chicks exposed to the sun. An immediate decline in the survival of lobster larvae would have occurred, but because lobsters trapped by the lobstermen are three to four years old, the decline wouldn't be observed until the very late 1980s and early 1990s. Because monk seal pups will only eat lobsters and reef fishes that are at least several years old, a decline of monk seal pup survival would not have been evident until the late 1980s as well. Thus the time lag between declines beginning in the mid-1980s for seabirds but late 1980s for monk seals and lobsters is explained.

I went back to the lobster fishermen and told them I had good news and bad news: the good news was that the decline in lobster catches wasn't due to overfishing; the bad news was that, unless the Aleutian low strengthened again, they were stuck with the current low marine productivity and poor lobster catches for a long time.

While the case of the vanishing lobster appears solved, I've learned from years of experience that ecosystems are complicated characters. We should not always count on nature to provide the same harvest: natural changes in climate can work for or against us. □