Scientists investigate unusual ocean conditions along the U.S. West Coast

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For two years in a row, ocean life along the U.S. West Coast has suffered from the delayed appearance of conditions that normally support a highly productive marine environment. Instead of the usual upwelling of cold, nutrient-rich waters along the coast during spring and summer, ocean conditions early in the year have been similar to those of an El Nino, with warm surface waters and low nutrient levels. The effects have rippled through the food web, reducing the amount of food available for fish, seabirds, and marine mammals.

Scientists from the University of California, Santa Cruz, and other institutions have analyzed the events of 2005 in a series of papers published in the journal *Geophysical Research Letters* (GRL), and they are busy analyzing more data collected this year. At the back of everyone's mind is a troubling question: Are these unusual conditions part of the natural variability of the California Current system, or do they signal a shift to a new oceanographic regime?

"Once is a fluke, but two years in a row makes you think something might be happening. If it happened again next year I'd be really worried," said Raphael Kudela, associate professor of ocean sciences at UCSC.

The conditions are consistent with scenarios for the regional effects of global warming, based on the projections of climate models for future decades. Even if the current changes are not related to global warming, they may be giving us a preview of future oceanographic conditions in a

warmer world, Kudela said.

Kudela is involved in various ocean monitoring projects with researchers from UCSC and other institutions, and he contributed to several of the GRL papers examining the events of 2005. He said the studies underscore the importance of long-term monitoring projects for detecting and understanding changes in the coastal environment.

The normal upwelling of cold water in the California Current system is driven by wind patterns that push the top layer of warm water offshore, drawing cold, nutrient-rich deeper water to the surface. In 2005--and to a lesser degree in 2006--the spring onset of persistent winds favorable to upwelling was later than usual. Without the influx of nutrients from deep water, the typical springtime blooms of phytoplankton failed to materialize.

Phytoplankton are the "grasslands of the sea," the primary producers of food for the entire ecosystem. Zooplankton, such as the shrimplike krill, graze on the phytoplankton and are, in turn, food for larger animals. Kudela and other researchers were able to trace the effects of the 2005 warm water anomaly on phytoplankton, zooplankton, and animal life higher up the food chain.

UCSC researchers monitoring sea lions in Monterey Bay observed unprecedented feeding behaviors in 2005. Normally a strictly coastal species, the sea lions went hundreds of miles offshore in search of fish, the scientists reported in one of the GRL papers. The study was led by UCSC graduate student Michael Weise and professor of ecology and evolutionary biology Daniel Costa.

Kudela and his coauthors--William Cochlan of San Francisco State University, UCSC postdoctoral researcher Tawnya Peterson, and Charles Trick of the University of Western Ontario, Canada--found that the

phytoplankton recovered quickly when the winds finally kicked in and upwelling began later in the year. But the animals that graze on the phytoplankton took much longer to respond.

"There seems to be a window of opportunity that was missed when the upwelling was delayed," Kudela said. "A key organism is the krill, because krill feed directly on the phytoplankton and they, in turn, are fed on by all kinds of other organisms, from fish and seabirds to whales. So if the krill are affected it has a huge impact."

Phytoplankton blooms are essential for the reproductive success of krill, said Baldo Marinovic, a UCSC research biologist who monitors krill populations in Monterey Bay.

"About a week after the eggs hatch, the larvae start feeding, and they can't survive if there are no phytoplankton. The adult krill can survive without the phytoplankton, but they won't reproduce," Marinovic said. "In 2005, the adult krill that had overwintered layed eggs in the spring, but the larvae didn't survive. This year we had a similar situation, although it wasn't as bad because we did have some degree of upwelling."

The krill population recovered later in the year, but by that time it was too late for many of the seabirds and other animals that depend on a springtime boom in the krill population. Scientists reported widespread seabird mortality and nesting failures.

In addition to lower productivity of phytoplankton, the warm water anomalies of 2005 and 2006 have also favored different species of phytoplankton, Kudela said. Single-celled algae called diatoms that tend to dominate in cold, productive waters were replaced by warm-water dinoflagellates that are often associated with "red tides."

"This year we monitored one of the largest red tides I've ever seen in Monterey Bay," Kudela said.

Some dinoflagellates produce dangerous toxins, but so far the red tides along the Central Coast have been dominated by nontoxic species. A species that causes paralytic shellfish poisoning was detected in samples from the red tide, but researchers did not observe any harmful effects on wildlife.

"The dinoflagellates that cause paralytic shellfish poisoning are a minor part of what's turning the water red, but it's scary when they're here," said Mary Silver, a professor of ocean sciences at UCSC. "The state monitoring program does a good job of protecting consumers from toxins in seafood, but the effects on wildlife can be devastating."

One species that was abundant in the red tides produces a slimy mucus material and has been associated with fish kills in other parts of the world. But Kudela said the wildlife observed during surveys of the red tide did not seem to be bothered by it. "There were plenty of whales, birds, and fish in it," he said.

According to Silver, the shift to these warm-water species of algae is "scientifically interesting and potentially worrisome."

"It's a sign of a major shift in the ocean. The question is whether it is just a two-year deviation, or is it a longer-term change," she said.

Source: University of California, Santa Cruz

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