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UC San Diego
University Archives. RSS 6020

Warming Waters Identified as Cause of Marine Life Depletions off California

CalCOFI data used to pinpoint mechanism underlying decline

November 4, 2003

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A recent study led by a scientist at Scripps Institution of Oceanography at the University of California, San Diego, has found warming ocean temperatures as the likely driving force behind the 25-year deterioration.

Scripps's John McGowan and his colleagues used data recorded by the California Cooperative Oceanic Fisheries Investigations (CalCOFI) to examine the mechanism behind the changes seen in the California Current, the large current originating in the northern Pacific Ocean that passes along the western coast of North America.

"We had seen a big change in the California Current ecosystems since the late 1970s, and in this report we looked at the possible mechanisms accounting for that change. We found that the most likely cause is a change in the upper-ocean heat content," said McGowan, who published the results in *Deep Sea Research Part II*, in a special edition that focused on the California Current and CalCOFI. The paper was coauthored by Steven Bograd and Ronald Lynn of the National Marine Fisheries Service and Arthur Miller of Scripps.

The authors caution that similar forces impacting ecosystem populations could emerge elsewhere, especially if ocean temperatures continue to rise. They say their results demonstrate that significant changes in sea-temperature balances can "greatly alter the marine community ecosystem structure and productivity, sounding the alarm to the potential impacts of a global warming trend."

They further note that the ability to distinguish between human-caused and climate-caused changes will be necessary in the future in order to model marine population trends for conservation and management decisions.

In coming to their conclusion, McGowan and his coauthors looked at two other possible causes for the ecosystem decline, testing and ultimately showing that those are not likely. McGowan also shows that fishing pressure cannot be blamed solely for the decline. "The massive declines we've seen in fish eggs and larvae population after 1976 cannot be due entirely to fishing pressure because many of the larvae are from species that are simply not harvested, and they too have decreased," said McGowan.

Rather, the paper places the spotlight squarely on a "regime shift" to warmer upper-ocean temperatures. This led to a disturbance in the method in which lower, nutrient-rich water mixes with the upper ocean. Essentially, a thickening of the warmer water layer caused the nutrient-rich waters to deepen, disrupting the food supply for plankton and other sea life in the upper layers.

"After this regime shift we saw the massive changes take place, not just in plankton but in fish, seabirds, kelp beds, and nearshore invertebrates," said McGowan. "In the larger sense this paper confirms and reaffirms the notion that there are large-scale environmental changes happening on land, lakes, and in our ocean. It's uncertain how long it's going to continue and whether it will increase in velocity or decrease. It's fear of the unknown, but something *big* is happening. I think an awful lot has to do with global warming and that's going to continue."

The conclusions reached in the paper are one example of the value and importance of the CalCOFI program, launched more than 50 years ago to explore the dynamic California Current. Although initially focused on the disappearance of the sardine off the California coast, the data collected by the CalCOFI program-from recordings such as ocean circulation, temperature, oxygen levels, and salinity to observations of marine life-have become invaluable.

"There are a lot of principles of interactions that can be derived from this magnificent 50-year data set," said McGowan. "It's been called a 'national treasure' because it's so highly interdisciplinary and so accurate, so trustworthy."

Says Bograd: "CalCOFI is the world's longest-running multidisciplinary field program. The accumulation of physical, chemical, and biological data spanning more than five decades now allows us to explore the dynamics of the California Current and its ecosystems across a range of temporal scales. CalCOFI also has been instrumental in training numerous students and young scientists over the years."

McGowan believes the value of CalCOFI will increase in the years ahead as science and government continue to pursue questions of human-produced versus naturally produced changes. He says that since its beginning, the CalCOFI program has focused on distinguishing this separation.

The value of CalCOFI surfaced as far back as the 1950s, when a 1958-59 El Niño event was identified as having a profound effect on marine populations. That event was, as McGowan puts it, an "eye-opener" for future El Niño events.

Volume 50 of *Deep Sea Research Part II*, published this fall, was devoted to CalCOFI and the California Current. Fourteen research papers in the issue highlight various aspects of the California Current, including "CalCOFI: a half century of physical, chemical, and biological research in the California Current System" by Bograd and his colleagues and "Long-term change and stability in the California Current System: Lessons from CalCOFI and other long-term data sets" by Ginger Rebstock.

"It seemed fitting to present a sample of research papers from CalCOFI in a special volume, as a celebration of more than 50 years of successful scientific endeavors," said Bograd. "Hopefully it will also reinforce the notion that long-term sampling programs such as CalCOFI are absolutely necessary if we are to understand how marine ecosystems respond to climate change. As oceanographic sampling programs go, CalCOFI is the crown jewel."

California Current video

CALCOFI