Title
Temporal Variation in Fish Communities Off Santa Cruz Island, California

Author
Larson, Ralph

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Temporal Variation in Fish Communities Off Santa Cruz Island, California

Ralph Larson, San Francisco State University



Summary

Fish communities at sub-tidal reefs and kelp beds at Santa Cruz Island in the Santa Barbara Channel change in response to shifts in oceanic conditions associated with the Pacific Decadal Oscillation (PDO), a long-lived El Niño-like pattern of variability in the northern Pacific Ocean. During the "warm" phase of the PDO, there is a greater abundance of "southern" fish species and a concomitant decrease in fishes normally associated with more northerly waters. The opposite occurs during "cool" periods.

The researcher who led this project has also identified certain fish species that are especially affected by climatic variability and/or by the loss of giant kelp, which occurs during warm-water periods. Because these species may be commercially or recreationally exploited, the findings from this project can help ensure that fisheries are adaptively managed to sustain resources and ecosystem integrity under a range of environmental conditions.

Noteworthy, although several studies have attributed declining fish populations in California to an overall decline in primary and secondary productivity within the California Current system, no such general downward trend in fish abundance was observed in this project from 1971 to 2005.

Project

The data for this project are based on three major dive surveys conducted at Santa Cruz Island. The first and most extensive was conducted from 1971 to 1974 toward the end of a "cool" phase of the PDO. The second, in 1996, was in the middle end of a warm phase, while the last, in 2004–2005, occurred during another cool phase.

On each survey, divers carrying video cameras performed a set of consistent protocols at several sites to ensure the visual record being compiled would be representative of fish communities at that time. Scientists then counted the species of fish observed, their relative abundances and determined how these changed between warm and cool periods.

Santa Cruz Island, one of the Channel Islands, was selected as the study site for both scientific and practical reasons. From an oceanographic perspective, Santa Cruz is well situated for studying the effects of PDO cycles because it sits within the boundary zone separating the cold-water regime north of Point Conception from the relatively warm regime within the Southern California Bight. As these PDO cycles flip-flop, the boundary zone shifts across the island, accentuating changes that might be imperceptible further north or south.

From a practical standpoint, Santa Cruz Island is one of the very few places where there exists a record of fish communities prior to 1977, when the PDO cycle shifted into a warm phase that lasted until 1998. This early data set not only extends the data record but allows for insights to be made into the degree of elasticity of species to climate change, whether ecosystems can return to where they were "before" or whether some changes are permanent.

Species Affected

As already mentioned, the general pattern observed for the PDO cycles was that cooling was associated with a southward extension of the range of northerly species, while warming was associated with a northward extension of "southern" species.

For example, the "northern" blue rockfish was abundant in the early 1970s, not seen once in 1996, and then counted more than 100 times in 2004–2005. Other species that followed a less extreme version of this general pattern were striped perch and black-and-yellow and olive rockfishes. Species following the opposite trend, the "southern" species that expanded their range northward during the

California Sea Grant Program

Russell A. Moll, Director • Paul Olin, Extension Director • Marsha Gear, Communications Director

University of California, San Diego, 9500 Gilman Drive, Dept. 0232, La Jolla, CA 92093-0232

Communications Phone: (858) 534-4446 • Fax: (858) 453-2948 • Web: http://www.csgc.ucsd.edu

warm period, were señorita, blacksmith and rock wrasse. Their ranges contracted southward in 2004–2005, as expected.

Some species showed no meaningful change during the study period, including sheephead, garibaldi, pile and black perch and opaleye.

There was no evidence of an overall decrease in total fish abundance during the study period.

Temperature

Why are some fish sensitive to small temperature changes? PDO cycles raise or lower temperatures on the order of only two degrees Celsius, a seemingly minor amount. However, as cold-blooded animals, fish in general cannot tolerate a wide range of temperatures. Some have a physiology that is tuned to a very narrow range. PDO cycles are also associated with changes in ocean currents, which disperse fish larvae and hence may redistribute where these fish recruit. In addition, warming can have secondary effects, such as diminishing the extent of giant kelp beds.

Role of Kelp

One of the goals of this project was to evaluate how loss of kelp during warm periods affects fish communities and whether the return of cooler conditions restores kelp and fish to areas.

As expected, giant kelp plants died off significantly during the warm period in 1996 as compared to the early 1970s. The kelp did not universally rebound in 2004–2005. In some places it did re-grow; in other places it did not.

Most species of fish do not rely on kelp per se to survive. However, the surveys showed that some species disappear once kelp density drops below a threshold level. Kelp bass, kelp perch and kelp rockfish are three species whose abundance (generally) was positively correlated with kelp abundance. Other species such as sheephead, blacksmith, señorita and halfmoon thrived in the absence of large kelp beds. For these, abundances were negatively correlated with kelp extent.

Applications

In terms of monitoring the effects of marine reserves on fish communities, this work shows that "you have to keep monitoring for a long time, on the order of decades," said San Francisco State University emeritus professor Ralph Larson, to evaluate which changes are associated with climate and which are associated with fishing or the absence of fishing.

In terms of managing fisheries, this study shows that, "There will be background noise. If you fish heavily on a species that is naturally down," Larson said, "you drive the nail in its coffin."

Fisheries management plans that take a long view can ensure that there are enough fishes now and also in 20 years, at the end of a PDO shift.

Student

Michelle R. Graves, Master's Thesis

Collaborators

Moss Landing Marine Labs
The National Geographic Society
PADI Foundation
Romberg Tiburon Center
University of California Field Station, Santa Cruz Island

For More Information

Ralph Larson
San Francisco State University
Tel: 415.338.1027 • Email: rlars@sfsu.edu

Ralph Larson and Michelle Graves

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(Front left) Ralph Larson (Front center) Tom Niesen (Front right) UCSB (Back portrait) Tom Niesen

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