Title
New Model Links Ocean Conditions to Squid Biomass

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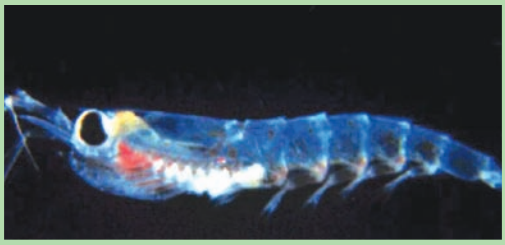


Background

Commercial landings of California market squid *(Loligo opalescens)* vary highly with oceanic conditions. An extreme example is seen with what happened during the 1996–97 La Niña and 1997–98 El Niño. In 1996–99, a record 110,000 tons were landed; the next year, during El Niño, landings plummeted to less than 1,000 tons.

Biologists believe these huge fluctuations are tied to changes in the availability of krill, the main diet of squid. The krill population, in turn, is linked to changes in primary productivity, caused by changes in wind patterns off the coast.

La Niña and El Niño are part of all this because they are associated with strong and weaker than normal winds respectively. These winds drive upwelling and hence primary productivity, krill and squid abundance. With stronger winds, upwelling is enhanced; primary productivity rises, and hence so do krill and squid abundances. El Niño works in reverse and so brings poor squid landings.

Project

In this project, a model was developed that simulates various scenarios linking variable oceanic and atmospheric conditions to krill production and hence squid productivity. A major part of this modeling effort was "to put numbers to" the connections between upwelling, primary productivity, krill and squid abundances. This was done largely with data collected at sea during a series of hydrographic cruises.

Scientists also gathered life-history data for squid that allowed them to link squid growth and reproduction with environmental factors such as upwelling, temperature and food abundance, in a consistent Darwinian framework. Commercial fishing data was also analyzed on "within-season" and "between-season" time scales to study migrations of squid cohorts.

Applications

The model the scientists developed predicts conditions under which squid will migrate inshore and their biomass when they do. Since fishermen harvest squid inshore, this modeling effort has the potential to help manage the squid fishery within the context of the larger ecosystem.

"If we can forecast krill dynamics, we may be able to forecast the fate of the squid fishery, and that could tell us how much squid the fishing boats should be allowed to take in a given year," said professor Donald Croll of UC Santa Cruz, who was a co-investigator on the grant.

The scientists reported several interesting patterns in zooplankton and krill abundance based on their fieldwork and modeling studies. Peak krill recruitment typically occurred in spring and early summer for all years between 1997 and 2002. There was, however, significant variability in both the magnitude of recruitment and persistence of krill abundance in late summer and fall. Squid catches also tended to be high in late spring and early summer, suggesting squid spawning coincides with peaks in krill abundance.

A sharp and significant increase in zooplankton abundance occurred between 1999 and 2000, and remained high through the end of 2002, presumably because of a shift in the Pacific Decadal Oscillation from a warm to a cool phase following the 1997–98 El Niño. Krill abundance in Monterey Bay, interestingly, did not follow this pattern and thus does not seem to be linked, in this instance, to the oceanographic regime change.

The taxonomic composition of zooplankton samples suggest that increases in zooplankton abundance were due to increases in gelatinous forms of zooplankton, in particular salps in 2000 and 2001, and ctenophores and medusae in 2002. This pattern is similar to what was observed within the larger Southern California region.

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Another interesting observation: the stomachs of inshore spawning squid were often empty, while those of animals caught in deeper water contained a variety of foods, including krill (most abundant), copepods, fish, zoea/megalopa and cephalopods.

Collaborator

NOAA Fisheries

Award

A co-investigator on this grant, Marc Mangel, a mathematician at UC Santa Cruz, was elected a fellow of the American Association for the Advancement of Science in 2002.

Student

Teresa Ish, M.S., Ocean Sciences, University of California, Santa Cruz

Publications

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