Ocean Data Confirms Fishing Puts Targeted Species in 'Double Jeopardy'

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For the first time, a research study has shown that fishing can promote boom and bust swings in supplies of targeted fish stocks. The study, authored by scientists at Scripps Institution of Oceanography at UC San Diego, the Southwest Fisheries Science Center (National Marine Fisheries Service), Imperial College London and the University of Oxford, shows that beyond the potential for fishery exploitation to cause systematic declines in targeted fish stocks, fishing carries with it a "double jeopardy" impact by also amplifying the highs and lows of natural population variability.

This increases uncertainty in estimating population levels and could put fisheries at greater risk of collapse than previously believed.

For decades, theoretical debates have swirled in scientific circles regarding how much impact—if any—commercial fishing activities held for the fish populations they target. Statistics and recent studies have shown that many commercially important fish populations have been declining over the past several decades, but how much can be traced to fishing rather than environmental influences?

The new study, published in the October 19 issue of the journal *Nature*, is based on data obtained by the California Cooperative Oceanic Fisheries Investigations (CalCOFI), a program that has been investigating the ecological conditions of the California Current for more than half a century.

"We found that the temporal variability of the targeted (exploited) populations was much higher, meaning that fishing tends to amplify both the peaks and the valleys of population numbers," said George Sugihara, a coauthor of the paper and a professor in the Physical Oceanography Research Division at Scripps. "Fishing can potentially not only lead to declining stock levels, but we show it actually causes populations to fluctuate more through time, which could put them at greater risk of collapse than we previously thought."

The researchers differentiated between environmental and fishing impacts by analyzing the populations of exploited versus unexploited species living in the same environments. Normally this comparison cannot be made with traditional fisheries data that are based on "landings" records, as there are no landings records for unfished species. The CalCOFI data was unique in this regard because it gathered data on larval abundances of both fished and non-fished species. Larval abundance is a well-known indicator of adult abundance. The study analyzed the quantity of larval fish recorded during systematic CalCOFI research cruises, which focus on the California Current, the large current originating in the northern Pacific Ocean that passes along the western coast of North America.

The authors believe that the reason fished populations become more variable is a consequence of the fact that fishing selectively culls the larger, older individuals, thereby removing the fish that are more able to buffer random environmental variation and add year-to-year continuity to the population. These individuals also tend to be the most reproductively active in their populations. As fishing proceeds, there is a tendency for the size and age of individuals in the population to decline, potentially leaving a stock of near-juveniles that are less able to cope with environmental pulses such as El Niño events.

"This so-called 'age truncation effect' (ATE) suggests that fisheries need to be managed not only to maintain a harvest target or total biomass level, but also to maintain a certain age structure in the stock," said Sugihara, who indicated that the fluctuations they identified tend to precede systematic declines of populations, meaning they can be viewed as a kind of early warning sign prior to collapse. "Instituting practical maximum size limits or encouraging the use of marine reserves to protect the larger individuals are possible solutions."

Beginning in the 1960s and '70s, debates over fishing impacts, which included coauthors John Beddington of Imperial College London and Robert May of the University of Oxford, were largely speculative arguments where some scientists argued that fishing activities would act to stabilize populations (through density-dependent harvesting), while others said that it would increase fluctuations. There were no data at the time to resolve the controversy. Sugihara says the new study, motivated by his student Chih-hao Hsieh's doctoral work, was made possible only through the unique and highly valuable data provided by the CalCOFI program. Data from fisheries are, by definition, plagued with a catch-22 situation in that they can only provide information about fished species and virtually no information about non-fished species. Without data on unexploited species, control comparisons for evaluating fishing effects are not possible.

"Our study points to the foresight of long-term observational programs like CalCOFI and the Long-Term Ecological Research (LTER) program, and helps to further justify the public investment in such nationally important programs," said Sugihara.

"The most immediate implication for fisheries management is that beyond the potential for causing a decline in abundance, fishing can provoke greater variability in exploited populations (and therefore reduced resilience) and thereby increase the risk of collapse of a fishery from (random) environmental events," the authors conclude in their study. “Obviously, this risk increases if fishing results in both higher variability and declining populations. That these two undesirable consequences of fishing can occur together represents double jeopardy and should be of concern to fisheries managers.”

In addition to Hsieh, Beddington, May and Sugihara, the study was coauthored by John Hunter of Scripps Oceanography and Christian Reiss of the Southwest Fisheries Science Center.

Source: University of California, San Diego

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