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What's the Catch? Researchers Wrangle Over How to Measure Commercial Fishing's Impact on Ocean Biodiversity

Two recent studies highlight a debate within the world of marine fisheries science over how to interpret available fisheries data

By Mike Orcutt | Tuesday, December 21, 2010 | 1 comments

The global demand for seafood is high, and over the past several decades the harvesting of wild fish from the oceans has grown into a huge business. In the 1950s most of the world's commercial fisheries were concentrated in the northern Atlantic and Pacific, near the coasts of heavily industrialized nations such the U.S., the U.K. and Japan. Since that time the industry has expanded rapidly southward, and into deeper waters in search of more fish to satisfy the growing market and to compensate for depleted legacy fisheries. Between 1950, the year the United Nations Food and Agriculture Organization (FAO) began releasing an annual report of catch statistics, and the late 1980s the global annual reported catch ballooned from around 18 million metric tons to peak at about 80 million metric tons. Since then, the catch has stagnated, dropping to near 79 million metric tons in 2005.

There is no argument the industry's massive growth has vastly affected ocean ecosystems, but the extent to which this disruption has depleted and continues to deplete the sea's biodiversity has become source of a heated debate within the world of marine fisheries science. At the center of the disagreement, which is highlighted by two recently published studies, is a question: What is the best way to measure the ecological footprint of commercial fishing?

The answer is complicated, due to the inconsistent nature of the data from a large portion the world's fisheries, especially those operated by developing nations. But the authors of a new study published December 2 in *PLoS One* say they have for the first time quantified, on a global scale, the ecological consequences of commercial fishing. They say their results, gleaned by analyzing global catch statistics, reveal that only the expansion into new fishing grounds has maintained seafood supply by making up for devastating destruction of the biodiversity in older fisheries. Now, they say, there is no more room to expand, and current fishing practices are not sustainable.

Daniel Pauly, a professor of fisheries biology at the University of British Columbia was a co-author of the new paper. Pauly, also the principal investigator of the Sea Around Us Project, says his group was able to measure biodiversity loss by developing a "'currency,' or common denominator, for the impact of fisheries on ecosystems," necessary because that impact varies depending on which species is harvested.

In previous work Pauly's group divided the planet's oceans into 180,000 individual cells and used catch statistics to determine the amount of every species caught in each cell between 1950 and 2005. Then, they determined the "primary production"—an ecological term referring to organisms at the very bottom of an ecosystem's food web—required to produce all the fish harvested from every cell. In ocean ecosystems primary production comes from phytoplankton. Each fish species needs a unique amount of primary production to survive, depending on their place on the food web. The higher in the web—or, as ecologists say, the higher the trophic level—the more that is required.

In the new paper the authors expressed the primary production required to produce the catch from each cell as a fraction of the total primary production—a value they inferred by analyzing satellite photos to measure pigmentation in the water—in each respective locale. The result is an illustration, say the authors, of the global "ecological footprint" of marine fisheries—one that, given current trends, cannot be sustained.

The limitations of catch data

Not all marine fisheries scientists, however, agree that primary production required is a reliable enough measurement of biodiversity loss.

Care must be taken not to overinterpret the metric, says Kevern Cochrane, the director of the resources use and conservation division of the FAO's Fisheries and Aquaculture Department. "I think it is a useful complement to other ways of looking at the picture," he says, but "it does introduce other uncertainties as well."

These uncertainties stem from the fact that it relies on records of fisheries catches. "If you really want to know what the health of the ecosystem is, it's better to focus on what is actually in the ecosystem, rather than what you get out of it," says Trevor Branch, a professor of aquatic and fishery sciences at the University of Washington (U.W.) in Seattle. "There are lots of reasons why catches go up and down, irrespective of what's happening in the ecosystem."

Catch data alone do not necessarily reflect abundance, Branch explains, as catches are also driven by additional factors like economics, technology and fisheries management. For example, he cites the U.S. west coast, where "10 or 20 species have by this measure completely collapsed." In fact, he notes, managers in that area have deliberately cut back on catches of those species. "Now those species are rebuilding, and many of them are not even overfished anymore, but the catches are still low," he says.

Researchers can more comprehensively evaluate an ecosystem by supplementing catch records with surveys of an area's biomass, and models, called stock assessments, which account for all available catch and survey data for individual species. "Wherever you have a scientific stock assessment, or the result of a rigorous scientific survey conducted using acoustic or trawl techniques, you should use that data as well," FAO's Cochrane says.

But stock assessments and scientific surveys are only available from a fraction of the world's fisheries—mainly high-value, intensely managed ones in the waters of developed countries. Often, catch data are the only information available. "It's the most globally available information—it's as simple as that," Cochrane says. He notes that the FAO is engaged in efforts to improve the quality and accuracy of global catch data, and to expand the world's library of surveys and stock assessments.

The "fishing down the food web" controversy

The authors of the new study argue that destructive overfishing by the industry has been masked by spatial expansion. "If people in Japan, Europe, and North America find themselves wondering how the markets are still filled with seafood, it's in part because spatial expansion and trade makes up for overfishing and 'fishing down the food chain' in local waters," said lead author Wilf Swartz, a PhD student at the University of British Columbia's Fisheries Center, in a statement.

"Fishing down the food chain" refers to a supposed phenomenon in which commercial fisherman, when they first move into a new area, target larger, longer-lived fish until they are depleted, at which point they shift to smaller, less desirable species lower on the food web until all that is left are species near the bottom of the web. Fisheries scientists have accepted this occurrence since 1998, when a landmark study, authored by Daniel Pauly and colleagues and published *Science*, concluded that the average food-web position of the contents of global catches—known to ecologists as the mean trophic index—was declining.

The mean trophic index has since become the most widely-used indicator of ocean ecosystem health. In 2004 the Convention on Biological Diversity named it one of eight indicators that would be used to monitor progress toward the accord's goal of reducing the rate of global biodiversity loss.

But a study published in *Nature* November 17, by Trevor Branch and colleagues, found that the decline in the mean trophic index Pauly had observed in 1998 is no longer present in the global catch data. Further, the study cites catch records, stock assessments and scientific surveys to show that in many cases the index does not correspond to the average food-web position of the organisms researchers directly observe in the ecosystem. On the contrary, Branch says, "just under half the time what you get from catches goes in the complete opposite direction from what you get from the ecosystems."

Pauly says the new *PLoS One* paper "completely invalidates" Branch's *Nature* paper because the authors failed to account for the spatial expansion described in the former. As fisheries move offshore, he says, they first target large fish high on the food web—just as they did closer to shore. "Hence, moving offshore will mask inshore declines in mean trophic levels."

Branch counters that the expansion paper actually reinforces his study's conclusion that mean trophic index is not a reliable indicator. "Fisheries expansion is just another reason why we shouldn't trust catches," he says. "That was the point of our paper—that we shouldn't be basing our judgment on catches."

The value of the mean trophic index depends on an assumption that is not supported by the available data, says Ray Hilborn, also a professor of aquatic and fishery sciences at U.W., although not an author on the *Nature* paper. In particular, he notes, recent evidence suggests fisheries do not necessarily begin by targeting fish higher up on the food web, but often simply pursue the most economically valuable species, regardless of their position. "If you think about it, what is the most expensive stuff at the market? It's lobsters, scallops, crabs and things like that. It's not yellowfin tuna," Hilborn says.

The (contested) state of marine fisheries

If catch data are not a reliable reflection of what is happening in ocean ecosystems, does that mean Pauly's argument that eventually our oceans will be left only with jellyfish and plankton overblown? Again, the answer is complicated by the inconsistent quality of the available information. But in the places for which there is good data, it appears things are actually improving, says Bill Fox, vice president and managing director for fisheries for the World Wildlife Fund. "For the last decade we have been making great progress—certainly in the U.S., northern Europe, Australia, New Zealand and many developing countries as well—in terms of improving the sustainability of fisheries," he says.

Hilborn agrees, citing a 2009 study in *Science* that brought together conservation biologists and fisheries scientists, and compiled multiple data sets—ecosystem models, stock assessments, trawl surveys and catch statistics—to assess the global state of fisheries. This study, on which Hilborn and Branch joined 19 other scientists as co-authors, showed that although the majority of commercial fish stocks for which there are data remain below target thresholds, fishing pressure has been reduced enough to expect that most of the ecosystems studied should be able to rebound to those thresholds.

Pauly, meanwhile, maintains the situation is direr, and compares current fishing practices with a Ponzi scheme. "It has been, throughout, a raid on the capital," he says, and it's happened under the cover of spatial expansion. "The supply has been guaranteed, and has been provided by expansion. When expansion is not possible anymore, how will we guarantee the supply?"