COMMENT

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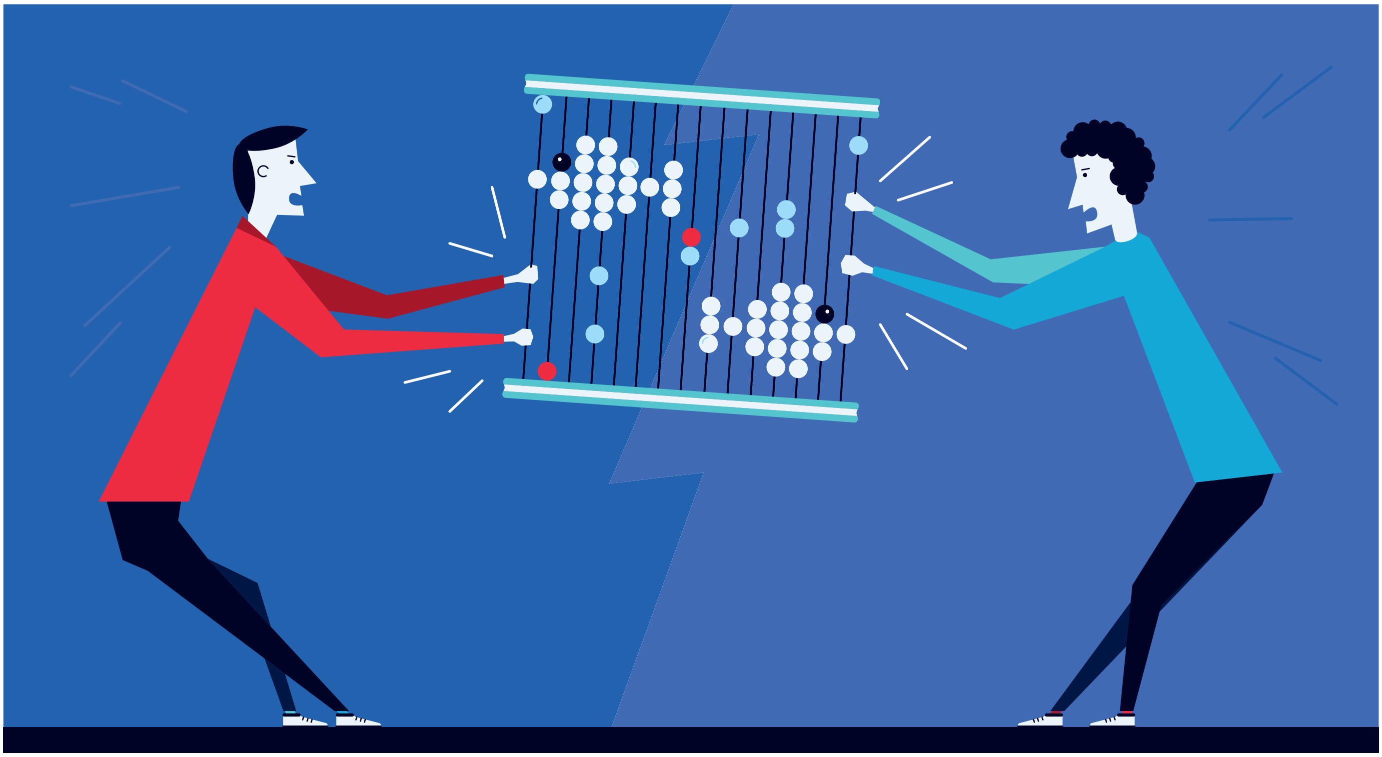
DENIS CARRIER



Does catch reflect abundance?

Researchers are divided over the wisdom of using estimates of the amount of fish hauled in each year to assess the health of fisheries.

POINT

Yes, it is a crucial signal

The only data available for most fisheries are the weight of fish caught each year, insists Daniel Pauly.

In developed countries such as the United States, Australia and members of the European Union, many fisheries are monitored by fisheries scientists using expensive stock assessments. To infer the size of the fish populations being exploited, scientists use the age and size distributions of the fish caught; the results of scientific surveys carried out from research vessels; and information about growth and migration from tag and recapture studies. Yet the only data ▸

COUNTERPOINT

No, it is misleading

Many factors as well as abundance determine the hauls of fishermen, warn Ray Hilborn *and* Trevor A. Branch.

The major database on all the fisheries of the world is the *FAO Yearbook. Fishery and Aquaculture Statistics*. This collates the amount (in weight) of haddock, bream, cod and more than 1,000 other species hauled in each year by fishermen, whether from commercial trawlers or canoes, using estimates sent in by officials from individual countries.

For the past few years, researchers have been conducting analyses ▸

POINT: YES, IT IS A CRUCIAL SIGNAL ▶ that are collected and made publicly available for the fisheries in about 80% of all maritime countries are estimates of the weight of fish caught each year. Since 1950, the Food and Agriculture Organization (FAO) of the United Nations has published these catch data (which are gathered by officials in around 200 countries) in the *FAO Yearbook. Fishery and Aquaculture Statistics*.

A debate is raging among fisheries scientists over the wisdom of using catch data to assess the health of fisheries. I agree that catch data should be used with care. But the current dispute is sending a message to policy-makers that catch data are of limited use. If countries — especially developing ones — start to devote even fewer resources to collating catch data, our understanding of fisheries, including their impact on marine ecosystems and their importance for local economies, will suffer.

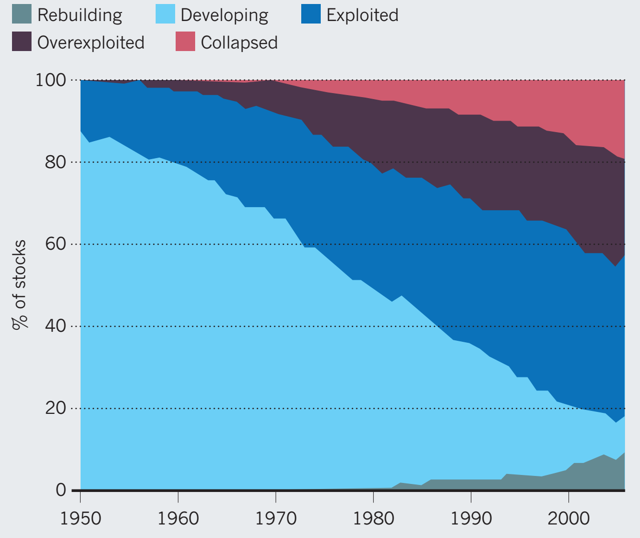
STOCK PLOT

The debate over catch data stems from an analytical approach that was pioneered by the FAO, and subsequently developed by others, myself included. In 1996, FAO researchers devised what became known as a stock status plot[1]. For 400 well-studied fisheries, the researchers plotted catch data over time, and used the slope of the graphs to assign the stocks to different categories, such as 'developing' where catches were increasing, or 'senescent' where catches had collapsed. The resulting chart was meant to show at a glance how the fisheries had fared since the 1950s (badly, apparently).

In 2001, the FAO method was modified by fisheries scientist Rainer Froese at the GEOMAR Helmholtz Centre for Ocean Research in Kiel, Germany. He and I then used the modified method to produce stock status plots for all the fisheries in the world for which catch data were available (see 'The stock status plot'; and go.nature.com/blfbma). Our results revealed a similar trend to that shown by the FAO: the number of collapsed stocks had steadily increased over the years, and by the mid-1990s, 20% of the stocks exploited in the 1950s had collapsed. (We classed stocks as collapsed if their annual catch had fallen to less than 10% of the highest ever recorded.) Unfortunately, it took another ten years, and a misguided claim, for the world to take notice.

THE STOCK STATUS PLOT

The Food and Agriculture Organization of the United Nations pioneered a way to visualize trends in fisheries using catch data.



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In 2006, a group of researchers from various institutions used a stock status plot to project, among other things, that all stocks would be collapsed by 2048 (ref. 2). Unsurprisingly, this projection, although a small part of the study, triggered an avalanche of alarmist headlines: "Seafood may be gone by 2048," wrote the *National Geographic*; "The end of fish, in one chart," said *The Washington Post*.

JEFFREY L. ROTMAN/GETTY

Fishermen have pulled fewer fish from the world's oceans in recent years.

The weirdly precise 2048 date, with echoes of George Orwell's *Nineteen Eighty-Four*, was widely derided within the fisheries community. Given the myriad factors that can affect fishing — shifts in policy, rising fuel costs, market crashes and natural disasters — it is impossible to predict where fisheries will be even ten years from now. But, of the various lines of attack that fisheries scientists have used to discredit the 2006 paper, one charge has since gained momentum and stands to do much more damage to fisheries science and management than the original paper. This is the idea that catch data are not useful for determining the health of fish stocks. This is wrong. Dangerously so.

WEIGHT OF EVIDENCE

Over the past two decades, the amount of fish caught from the world's oceans has declined. Factions of the fisheries community disagree over how to interpret this decline, and they dispute the methods used to assign stocks to different categories, such as collapsed or underexploited. And it is true that catch size is not just affected by fish abundance — numerous factors, such as a change in management or legislation, can also influence the annual haul of fish. But for the vast majority of species, no signal of this downward trend would even exist without the FAO catch data.

When only catch data are available, fisheries researchers can and should use these data to infer fishery status, at least tentatively[3,4]. Even when stock assessments or scientific surveys are conducted, such information should always be used in conjunction with any and all available catch data. Take, for example, the Canadian northern cod stock, which unexpectedly collapsed in Newfoundland and Labrador in the early 1990s, even as stock-assessment experts were monitoring it using state-of-the-art methods to model abundance[5]. In the years before the collapse, fishermen were using either net traps fastened on the sea floor or trawlers, but because the boats could track the shrinking shoal, their catch remained high, even as the trap fishermen started bringing in fewer and fewer cod. Stock-assessment experts had monitored only the trawler catches.

Discrediting catch data risks hampering analysis and might also discourage efforts to improve the quality of fisheries statistics worldwide. For the vast majority of species, expert stock assessments can cost from around US$50,000 to millions of dollars per stock — especially when research vessels are involved — so are often not feasible. If resource-starved governments in developing countries come to think that catch data are of limited use, the world will not see more stock assessments; catch data will just stop being collected.

Instead of questioning the usefulness of catch data in assessing stocks, scientists should be urging more governments to collect them (along with data on fishing effort, the economic value of catches and fishing costs), and devising cost-effective ways to improve their reliability.

As part of the Sea Around Us initiative — a collaboration between the University of British Columbia in Vancouver, Canada, and the Pew Charitable Trusts, which aims to monitor the impact of fisheries on marine ecosystems — I am leading a project to evaluate the entire body of FAO catch data collected since 1950. So far, my team has gathered information on fish consumption and the tonnage of fish imported and exported, for instance, to verify the catch data of 180 countries and island territories. Our findings suggest that catches, with the notable exception of domestic catches by China, are under-reported by about 100–500% in many developing countries[6], and by 30–50% in developed ones[7].

While fisheries researchers continue the important debate about which fisheries are in decline, why and to what degree, most fishermen worldwide are finding fewer fish in their hauls than their predecessors did. Knowing what tonnage is pulled out of the oceans each year is crucial to knowing how to reverse this trend. ■

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COUNTERPOINT: NO, IT IS MISLEADING ▶ to use these data to assess the health of the world's fish stocks. And high-impact journals, including this one, have published them. Such assessments consistently overlook the fact that the amount of fish caught does not necessarily reflect the number of fish in the sea.

Attempts to use catch data as an indication of fish abundance have spread alarm and confusion in policy circles, and fuelled the perception among the public and conservation organizations that fisheries management is failing. A much better approach is to deduce the health of stocks region by region and fishery by fishery using scientific stock assessments, which collate all sorts of data — from the results of surveys conducted from research vessels to the catch per fishing effort, and the age and size distributions of the fish caught. This can reveal which management strategies are actually effective.

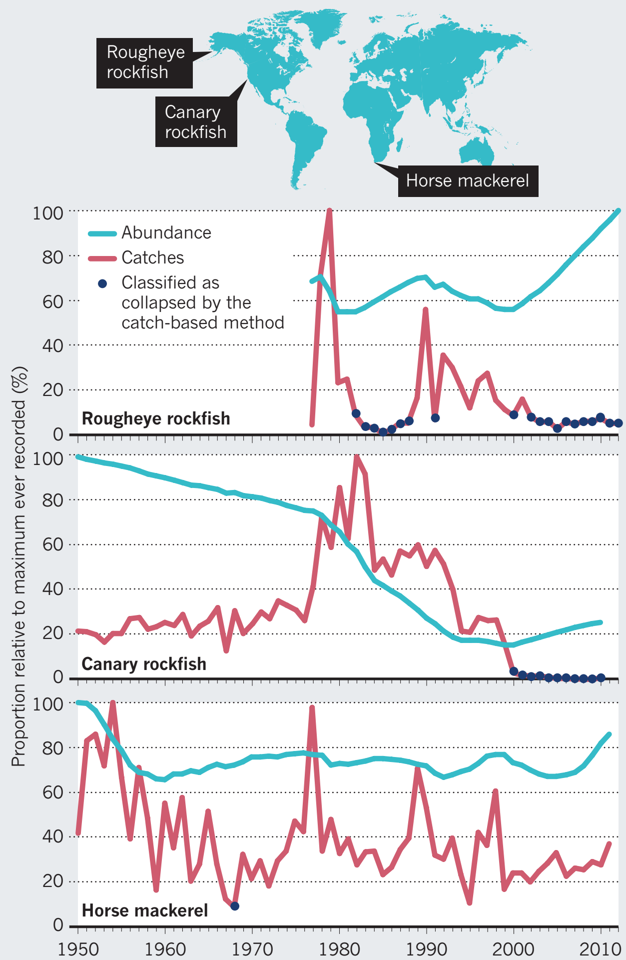
ON THE BRINK?

In 2006, researchers projected that all the fisheries in the world would collapse by 2048 (ref. 2). The group classed a stock as 'collapsed' if less than 10% of the highest catches ever recorded were being harvested each year[8], using an approach developed by others. For many of us in the fisheries community, the 2048 projection was hard to believe; Alaskan salmon fisheries, for instance, were in better shape than they had been in the history of industrial fishing.

Another paper soon followed[8], written by the authors of the original study[2] and some of their critics, ourselves included. This suggested ▶

WHAT'S THE CATCH?

The tonnage of fish caught each year can soar or plummet, regardless of how many fish are in the sea. For rougheye rockfish and canary rockfish, fishing regulations have helped to reduce catches in recent years.



ADAPTED FROM REF. 13 UPDATED WITH ADDITIONAL UNPUBLISHED DATA

COUNTERPOINT: NO, IT IS MISLEADING ▶ that many of the world's fisheries are not in nearly such a perilous state as the 2048 projection implied. In this study, we analysed trends only in those stocks that are closely monitored by research agencies[8]. Using stock-assessment data, we found that over the previous two decades, the number of stocks that had collapsed had indeed risen, but by the mid-2000s only 14% of the 166 stocks we analysed were collapsed. Also, for two-thirds of these stocks, which were mainly in Europe, North America and Australasia, populations had stabilized owing to fishing restrictions, and some were beginning to rebuild.

The 2048 projection and the controversy it sparked within the fisheries community undermined conservationists' confidence in the ability of governments to prevent overfishing. Even more misleading, in our view, is the most recent attempt to assess all the fish stocks in the world using catch data.

The Ocean Health Index, published in *Nature* last year[9], aggregates various measures, such as biodiversity, into a single score that is meant to indicate how healthy the seas are. To calculate the capacity of the oceans to generate food, the researchers estimated the maximum sustainable catches of 100 well-studied stocks using the results of stock assessments. They then used a previously devised equation relating these maximum sustainable catches to the highest catches ever recorded from these same fisheries to estimate the maximum sustainable catches for all the fisheries in the FAO database.

Hugely unreliable predictions result. For instance, the maximum sustainable yield for Antarctic krill assigned by the Ocean Health Index is 174 times lower than the estimate derived from detailed stock assessments conducted by the International Commission for the Conservation of Antarctic Marine Living Resources[10]. Overall, the health-index study implies that fishermen could theoretically catch several times more marine fish if fisheries were better managed. This wildly contradicts the findings of several other studies — that fishermen are already catching 80–96% of the potential global yield[11,12].

A LOW CATCH COMPARED WITH PREVIOUS RECORDS DOES NOT NECESSARILY MEAN FEWER FISH.

STOCK OPTIONS

So why do analyses using catch data as a proxy for fish abundance generate results that other studies throw into question?

The main difficulty is that a low catch compared with previous records does not necessarily mean fewer fish, and vice versa. For instance, 34 large stocks along the west coast of Oregon and Washington in the United States would seem to have collapsed based on recent catch data[13]. Yet according to detailed stock assessments, only three (anchovies, eulachons or candlefish, and abalone) have actually collapsed[13].

Catches can shift hugely for many reasons. For example, hauls of stocks along the west coast of the United States have tended to shrink because of markets or new fishing regulations (see 'What's the catch?'). Changes in taxonomy are another reason. In the 1950s, global shark catches were assigned to seven taxonomic groups. By the early 2000s, 36 groups were recognized in the FAO catch database. Catches of sharks categorized in the early groupings may have dwindled not because fewer sharks are being caught, but because they are being registered under different names.

Catch data can also be affected by alterations to national jurisdictions, such as the expansion of most nations' fishing rights to 200-mile expanses of ocean in the 1970s and 1980s; natural disasters such as the *Exxon Valdez* oil spill, which resulted in the closure of many Alaskan salmon fisheries for a year; civil war; increases in fuel costs; and low fish prices. Regime changes are also a factor. After the disintegration of the Soviet Union in 1991, the loss of government support meant that thousands of fishing vessels could no longer operate.

Furthermore, few countries monitor anything but their largest or economically most important fisheries with the rigour used in the United States and within the European Union. In most cases, officials simply give their best guess. Even in the United States, where the federal government allocates US$880 million to fisheries agencies each year, reliable catch data for smaller stocks, such as spiny dogfish, are hard to obtain.

BETTER MANAGEMENT

Analyses based largely on catch data are fuelling a view held by numerous non-governmental organizations and environmentalists that the only solution to marine conservation is a ban on fishing in large areas. Between 2007 and 2009, for instance, several non-governmental organizations and US foundations spent $58 million each year on efforts to create 'marine protected areas'. This campaign has been spectacularly successful in Australia, where 3.1 million square kilometres of ocean are now closed to fishing.

This approach overlooks the enormous successes of many management strategies. For example, on the east coast of the United States the total abundance of bottom fish, such as redfish and haddock, increased more than fivefold from 1995 to 2007 after fishing restrictions were strengthened from the mid-1990s.

If the FAO catch data were the only source of fisheries data, fisheries science would be flying blind. But scientific assessments of trends in fish abundance spanning three or four decades are now publicly available for the fisheries that constitute 40% of the total catch in the FAO global database. These data come mostly from developed countries (in North America, Europe and Australasia) or from major international fisheries such as those for tuna.

Various data collected by national fisheries agencies, fishing companies and marine scientists are also available for the rest of the world. Currently, there is no global database for this information. We (the authors) have recently begun working with more than 20 countries, the FAO and the World Bank to try to assemble a database for a good sample of the world's fisheries. We estimate that obtaining the kind of data needed for 40 countries (focusing on 6–8 fisheries in each country) will take 10 years and require US$20 million.

Meanwhile, we urge researchers to use all the available data in addition to the FAO database, and to validate their results by consulting local experts or other data sources. Catch data are a crucial part of any fisheries assessment — it is impossible to calculate the maximum weight of fish that could be harvested sustainably without knowing what is being caught each year. But on their own, catch data cannot answer the question at the heart of fisheries science: how many fish are in the sea? ■

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