Earth 2020

An Insider's Guide to a Rapidly Changing Planet

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Fish

U. Rashid Sumaila and Daniel Pauly

Humans have relied on coastal fish and other marine life for millennia. The first documented cases of human use of marine resources, include 165,000 year old abalone shells in a South African cave, 125,000 year old middens along the coast of Eritrea with shells of a now extinct giant clam species, and sophisticated harpoons from the Congo dating back 90,000 years.[1] For much of our history, our impact on fish species was small, and the supply of fish must have seemed inexhaustible.

In our early fishing days, energy was provided by the muscles of fishers, and later by the wind. Even with sophisticated sailing vessels, the energy density that could be used for fishing was limited, and ultimately dependent on sunlight, which grew the food that fishers ate and fueled the winds that powered sailing vessels. This changed radically in the 1880s, when steam-driven trawlers began to be deployed around the British Isles, the home of the Industrial Revolution.[2] This development heralded the replacement of muscle and wind power by fossil fuel energy accumulated over millions of years in the form of coal.

The new trawlers — although inefficient by today's standards — made short thrift of the accumulated biomass of large fish around the British Isles, and soon had to move offshore, into the open North Sea, and later into the open North Atlantic, to maintain their catch rates. As other industrialized countries adopted the wonderful British innovation,

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the highly concentrated energy of fossil fuels soon began to overwhelm the productive capacity of natural fisheries, much as motorized chainsaws would eventually overcome the productive capacity of many forests. It was during these final years of the nineteenth century, with the ascent of industrial fishing, that the world's marine fish populations first began to feel the mounting pressure of humanity.

The resulting declines in fish populations prompted the founding, in 1892, of the International Council for the Exploration of the Sea, the first international organization devoted to studying fisheries and fish populations, which was headquartered in Copenhagen, Denmark. Around the same time, declining fish stocks also prompted the emergence of fisheries science as a modern scientific discipline in the early twentieth century, first in Europe, the USA and Canada, then spreading worldwide, all the way to Japan. However, despite tentative efforts by the short-lived League of Nations between the two World Wars, it was only after the Second World War, with the establishment of the United Nations' Food and Agricultural Organization (FAO), that the systematic collection and analysis of global fisheries data began. Importantly, this was a time when most countries in Africa and large part of Asia still existed as European colonies, subjected to exploitative disruptions of their cultures and economies, including their national fisheries.

The FAO was tasked with providing scientific information on global food production, with the ultimate goal of eliminating hunger worldwide. To lay the foundation for this important goal, the organization began compiling global production data for key food commodities, including, marine fish. Thus began the FAO global fisheries catch statistics, issued annually since 1950. Until recently, the FAO statistics were the only source of global fish catch information, and it was these data that guided the development of fisheries management over the latter half of the twentieth century.

Unfortunately, the FAO data suffered a number of significant limitations, and these became apparent only gradually. For one thing, many catch data did not include important components, such as the contribution of small-scale and recreational fishers, as well as millions of tonnes of discarded bycatch. These catches were not considered, given the focus on industrial fishing and tradable commodities, as opposed to the employment and food security benefits of artisanal and subsistence fisheries.[3] Moreover, no attempt was made to

account for illegal, unreported and unregulated (IUU) fishing activities and catches, even when the former were blatant and the latter estimable.

These omissions resulted in a significant under-reporting of the global marine fish catch (by as much as 50%)[4] with the result that global fisheries management was based on incomplete information about the true fishing pressure. Moreover, the considerable catch of small-scale sectors (artisanal, subsistence and recreational) was systematically underestimated, thus providing a perverse 'justification' for the continued marginalization and neglect of small-scale fishers.

The FAO's early focus on commercial fishing was further entrenched by the establishment of national fisheries management institutions set up primarily to serve the interest of commercial fishing enterprises. It was all about how much could be caught and marketed. This meant that Departments of Fisheries were placed under the Ministry of Agriculture in many countries, and in the United State, under the Department of Commerce. During the post-war decades, conservation and the ecosystem effects of fishing were never explicitly part of fisheries management concerns. Also, small-scale fisheries were further marginalized, with few if any studies on, for example, subsistence fisheries, in spite of their importance to the food security of numerous small island developing states.[5]

The narrow focus on commercial fish catch during the post-war years posed a significant challenge for effective management of the world's fisheries. Without comprehensive knowledge of the total marine biomass removed from the ecosystem, management was conducted in the dark, resulting in highly variable and unsustainable catch levels. At the same time, global demand for seafood began to increase sharply with rising world population and income after the Second World War, while the development of ever more sophisticated fishing technology led to more efficient fishing.

Technological innovations and changing fishing practices led to rapidly increasing annual catches throughout the 1960s, and at the time of the first Earth Day, in 1970, there was little to suggest that the world's fisheries were in danger. In fact, global catches continued to increase year after year, if only through the continuous expansion of the fishing grounds

exploited by distant-water fleets, mainly toward southern latitudes and into deeper waters. It wouldn't be long, however, before signs of trouble began to appear.

The first collapses occurred in the California sardine fishery (of 'Cannery Row' fame) in the early 1950s, and the Peruvian anchoveta fishery in 1972, then the largest fishery in in the world. Both these collapses could be attributed to natural oceanographic processes, including, strong El Niño conditions in the case of Peru, which warmed surface waters and reduced the supply of nutrients for plankton. In contrast, the collapse of the Norwegian spring spawning herring in the 1960s was the first to be linked directly to overfishing. The most blatant case of overfishing, combined with the active suppression of the voices that warned about an impending collapse, would come about twenty years later, with the demise of the Northern cod fishery of Canada. Within just twenty to thirty years, giant trawler vessels reduced the cod population to less than one percent of its historical abundances, which had consistently yielded annual catches from small vessels and traps ranging between 100,000 and 200,000 tonnes over the previous five centuries.[6] And yet, when the fishery was closed in 1992 resulting in the loss of 40,000 jobs, Canada's fishery managers blamed the seal predators and a cold winter.

Other collapses, large and small, began to accumulate in various parts of the world, and, in 1996, the global catch trend began to decline for the first time since the post-war years. In other words, 1996 was the year of peak global catch, and catches have been dropping ever since, despite increasing fishing effort. Other impacts of fishing on fish populations also became apparent. Most notably, fishers began to see a change in the kinds of fish being caught, as large predatory fish on top of marine food web (e.g., cod, swordfish and tuna) became increasingly scarce, while smaller forage fish, such as herrings, sardines and anchovies, began to make up an increasing proportion of total catches. This 'fishing down the food web'[7] had a significant impact on ecosystem functioning, and also on ocean sea floor habitats, which became increasingly affected by the use of trawls and other bottom-impacting gear. This led to a decrease in the resilience of both fish stocks and marine ecosystems.

The 'fishing down' concept and the development of ecosystem-wide thinking began to broaden fisheries management to include the ecosystem effects of fishing in general.

This drew attention not just to the quantity of fish taken by fisheries, but the total removal of marine living organisms from ecosystems, and the impacts of various fishing gear on their habitats and biodiversity. And as fisheries and marine science began moving away from a narrow focus on the maximum catch that could be taken from marine ecosystems, fisheries economics, management, governance and policy were also having their moments of reckoning. With more and more stocks collapsing, the world could not continue pretending that the oceans and the great global sea fisheries were inexhaustible. This led to the introduction of various management measures that have continued to evolve with time.

Even before Garrett Hardin's famous paper, 'The tragedy of the commons' was published in *Science* in 1968, economists had argued that the problem of overfishing stems mainly from the common property nature of wild fish stocks, coupled with the absence of effective access or property rights to the fisheries resources.[8] In such an unregulated 'common pool', fishers are presented with a set of perverse incentives to overexploit the resource and dissipate its economic returns. By the late 1950s, this realization led managers, with support from fisheries scientists and economists, to begin putting in place restrictions to fishing. The motivation for this approach was to remove incentives to overexploitation with gear restrictions, and importantly, with global catch limits (total allowable catches, or TACs) enforced by monitoring and surveillance systems.

During the 1970s, TACs became increasingly adopted around the world, but it did not take long before it became clear that this approach, on its own, was insufficient to protect fish stocks. For one thing, appropriate TACs, based on sound ecological understanding of fisheries populations, were difficult to set, and even more difficult to enforce. Second, even if TACs could be properly determined and enforced, fishers would compete for catch shares, inevitably resulting in the build-up of excess fleet capacity and economic waste. Fisheries economists' termed this state of affairs 'regulated open access'.

Disappointed with regulated open access, management approaches evolved to include limited entry schemes in which TACs were combined with restrictions on the number of vessels that could participate in the fishery. Often, this approach was accompanied

by a vessel buyback program,[9] in cases where fishing capacity was already in excess of sustainable levels, as was the case for the Canadian Pacific salmon fishery. Once again, however, fisheries managers quickly became disillusioned by limited entry schemes, as these proved to have a limited effect on over-fishing, and fishing capacity continued to increase, resulting in both economic waste and ineffective controls over total catch.

Starting in the late 1980s and early 1990s, economists frustrated with the lack of success with existing management schemes came up with a new approach designed to better align fishers' incentives with the best interests of society. The foundational argument for this new approach was the need to create *de facto* access and property rights, whether at the community, public or private levels. A number of alternative ways to creating such rights were suggested, including individual transferable quotas (ITQs), fishers' cooperatives, community-based fisheries management, and various combinations of these approaches. But it soon became clear that there was no 'best' alternative for all cases, and that a fishery by fishery approach would be required. For example, ITQs can face monitoring problems, associated with 'quota busting' (illegally catching more than one's quota) and 'high grading' (catching one's quota, then discarding it to catch larger fish, which fetch a better price). And in almost all fisheries, monitoring, control and surveillance are still inadequate, particularly in the case of many developing country inshore fisheries, leading to a breakdown of ITQ schemes. In addition, there are social concerns with ITQs where a few individuals or groups get the right to exploit public resources, in most cases free of charge.

Based on the challenges of previous quota-based systems, the past decade has seen an increased movement towards outright protection of some global fish stocks in at least part of their natural range. In particular, there has been a growing focus on the establishment of marine protected areas (MPAs), where fishing activities are tightly regulated and more rigorously enforced. Small and large MPAs, ranging from fully protected marine reserves to partially protected ocean areas have been introduced in many maritime countries to protect marine biodiversity more broadly, and to serve as a buffer against management errors and scientific uncertainties. Several international frameworks, including the 2011 Aichi Targets of the Convention on Biological Diversity, and the United Nations Sustainable

Development Goals have set a target of creating MPAs covering at least 10% of the ocean surface area by 2020. Unfortunately, we have fallen significantly short of this target, with only 2% of the world's MPAs currently in strongly or fully protected areas.[10]

Over the past half-century since the first Earth Day, the nature of global fisheries has changed significantly. These five decades have seen large decreases in the abundance of fish almost everywhere, along with broader effects on the tropic composition that ripple throughout marine food webs. At the same time, fisheries science and management have evolved from narrow beginnings in the post-war years, to a suite of broader approaches designed to match the realities of overexploitation of fish stocks and the marine ecosystems in which they are embedded. Science and management are evolving from focusing on maximizing commercial catch to broader conservation and sustainable development goals that are inclusive of different ocean stakeholders.

Although things look dire, there is a path forward to a better future. The best fisheries science available shows that the decades-long global decline in fish catches could be reversed if the world's maritime countries reduced the fishing effort in their exclusive economic zones. This, together with the removal of harmful subsidies,[11] the elimination of illegal fishing, a greater emphasis on future benefits and the closure of the high seas to fishing, would allow the fish to rebuild their abundance, and allow for higher catches than at present. The problem is that either the politicians do not accept the results of fisheries science (as is sometimes also the case for climate science), and/or are unable to stand up to the industrial fisheries lobby, to which they have largely ceded the exploitation and quasi-ownership of public marine resources. Unless things change, largely uncontrolled industrial fishing is likely to continue until the bitter end — whatever that may be. Add marine pollution to this (including plastic) and the multiple ocean stressors generated by climate change (sea surface temperature rise, ocean acidification and deoxygenation),[12] and the future might look rather bleak. We desperately hope that the world takes suitable action on multiple fronts to chart a different path forward.

Endnotes

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