Unsustainable Marine Fisheries

*by Daniel Pauly**

Introduction

Many have long assumed that the expanse and mysterious depths of the world's oceans contain vast living resources, ready to be exploited in the ways that its more familiar coastal fringes have. This assumption is very wrong. Of the 362 million square kilometers of ocean on this planet, only 7.5 percent — the continental shelves — are shallower than 200 meters ("m"), and some of this shelf area is covered by ice. Shelves and the adjacent slopes, reaching down to 500 m, generate the bulk of the biological production supporting global fish catches, the rest consisting of tuna and other oceanic organisms, which gather their food from the vast, desert-like expanse of the open oceans.[1]

As a result of legislation in the 1980s, continental shelves are contained mostly within the exclusive economic zones ("EEZ") of maritime countries. According to the United Nations Law of the Sea, any country that cannot fully use the fish resources within its economic zone must make this surplus available to the fleets of other countries.[2] This, along with eagerness for foreign exchange, political pressure, and illegal fishing, has led to the trawling of all the world's continental shelves for bottom fish, the use of purse-seines for open-water fishes, and the illumination of the shelves to attract and catch squids.[3]

Perhaps the strongest factor behind these overgrown and often destructive fisheries, and their tacit support by the public at large, is the notion that, somehow, the oceans will yield what we need, simply because we need it. Indeed, demand projections for fish generated by national and international agencies largely reflect present consumption patterns, which the oceans ought to help us maintain, even as the global human population — and our taste for seafood — keeps growing. While much of the deep ocean is unexplored and mysterious, we know enough about ocean processes to realize that its productive capacity cannot keep up with an ever-increasing demand for fish.[4]

Global fish catches began to decline in the late 1980s,[5] and extrapolation of present trends suggests that large-scale fisheries throughout the world will collapse in a few decades, inducing losses that aquaculture cannot be expected to compensate.[6]

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Historic Antecedent

While fisheries[7] and localized overexploitation have occurred for millennia,[8] the massive impact of fishing on ocean ecosystems began only in the early nineteenth century, when English steam trawlers began to land their catches.[9] These trawlers were soon rendered more effective by power winches and, following World War I, diesel engines. The aftermath of World War II added other peacetime dividends to the industrialization of fishing: freezer trawlers, radar, and acoustic fish finders. The fleets of the Northern hemisphere were ready to take on the world, and they did, with help from American, Russian, and Japanese distant-water fleets.

Fisheries science had progressed as well: the two world wars showed that exploited fish populations (*e.g.*, those of the heavily mined North Sea) would bounce back when released from fishing pressure.[10] This prompted models of single-species fish populations whose size is affected only by fishing pressure.[11] The main point of these models, still very much in use (though in strongly modified forms), is that adjusting fishing efforts to some optimum level leads to a "maximum sustainable" yield, a notion that the fishing industry and the regulatory agencies eagerly adopted — if only in theory.[12]

In practice, the fishing industry rarely implemented optimum effort levels. Rather, fisheries simply moved once a stock was over-fished, gradually fishing in deeper waters and remote seamounts.[13] Fisheries were even moved to the then-untapped resources of West Africa, Southeast Asia, as well as other low-latitude and southern hemispheric regions.[14]

** Dr. Daniel Pauly is a Professor of Fisheries and Director of the Fisheries Centre at the University of British Columbia, Vancouver, Canada. Since 1999, he has been the Principal Investigator of the Sea Around Us Project, funded by the Pew Charitable Trusts, located in Philadelphia and devoted to studying the impact of fisheries on the world's marine ecosystems (www. seaaroundus.org). The concepts, methods and software he co-developed have been documented in over 500 publications, and are used throughout the world. Especially widely-applied is the Ecopath modeling approach and software (www.ecopath.org) and FishBase, the online encyclopedia of fishes (www.fishbase.org).* *This article is adapted from Daniel Pauly et al., Towards Sustainability in World Fisheries, 418* Nature *689 (2002).*

Throughout the 1950s and 1960s, this massive increase of global fishing efforts led to increases in catches, which masked local stock collapses, and which was so rapid that the catches exceeded the world population growth, causing an entire generation of managers and politicians to believe that launching more boats would automatically lead to higher catches.[15]

The Peruvian anchovy collapse, from 1971 through 1972, was the first fishery collapse with global repercussions. Though the El Niño event is often perceived as causing the collapse, much of the available evidence, such as the actual catches (about 18 million metric tons,[16] exceeding the officially reported catch by six million tons), suggests that overfishing should be implicated as well. Attributing the collapse of the Peruvian anchovy entirely to environmental effects allowed business as usual to continue, and in the mid-1970s, this led to the beginning of a decline in total catches from the North Atlantic.[17] This declining trend accelerated in the late 1980s and early 1990s when most of the cod stocks off New England and Eastern Canada collapsed,[18] ending fishing traditions reaching back for centuries. In 1996, the United Nations Food and Agriculture Organization published a chronicle of global fisheries[19] that showed that a rapidly increasing fraction of world catches originate from stocks that are over-fished, *i.e.*, that the collapse of the New England and eastern Canadian cod stock was only one of a multitude of other, smaller, and little-noticed collapses.

Effects on Marine Species Diversity

The major, direct environmental impact of fishing is that it reduces the abundance of the species it targets. It is a frequent assumption that fishing does not impose any direct threat of species extinction since marine fish generally are very fecund and the ocean expanse is wide. However, recent decades have witnessed a growing awareness that fish cannot only be severely over-fished, but could also be threatened with extinction through overexploitation.[20] Fisheries may also change the evolutionary characteristics of populations by selectively removing the larger, fast-growing individuals. It is not yet known whether these changes in the genetic constitution of species are reversible.[21]

Also worrisome is a phenomenon known as "fishing down marine food webs."[22] Most food fishes are high on the food chain — whether sardines feeding on zooplankton, cod feeding on bottom invertebrates, including shrimps, or tuna feeding on small oceanic fishes. When the top predators are fished out, we turn to their prey. For example, herring and shrimps in place of cod. Studies have indicated that there is a steady, global decline in the trophic level, or position on the food chain, of global fishery catches.[23] This implies the gradual extirpation of large, long-lived fishes from the ecosystems of the world's oceans, and, as well, the destruction of many animal communities of the sea floor (see Figure 1).

Many argue that fishing down marine food webs is both good and unavoidable, given a growing demand for fish.[24] Also, the initial ecosystem response to "fishing down" may be a release of predation and lead to increased catches of low trophic level fishes. Indeed, the Japanese whaling industry insists that removing whales from marine ecosystems would make large

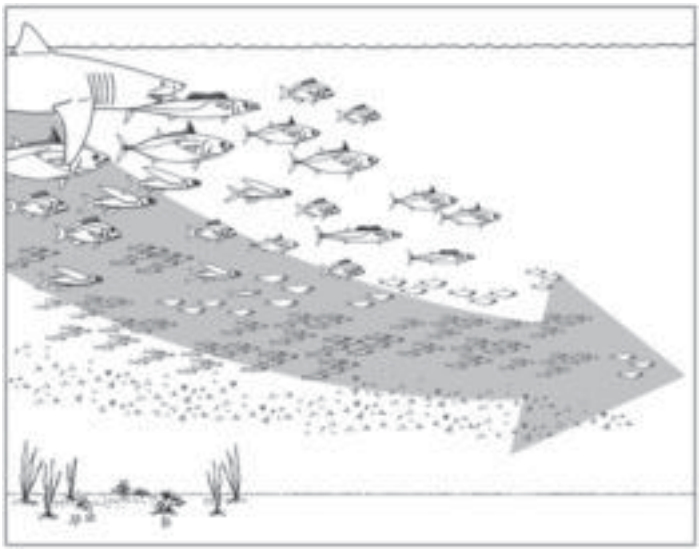

Figure 1. Schematic representation of the process now widely known as 'Fishing marine food webs,' wherein a fishery, at the onset, targets the larger fish at the top of marine food webs, then, as these get scarce, targets the smaller species that often are the food of larger fishes. In the process, ground trawling eliminates the animal communities at the bottom of the sea, which feed on suspended organisms. Hence, in the last stage of 'fishing down,' the waters are dominated by microbial processes, toxic algal blooms and jellyfish.

amount of prey species available to fisheries.[25] In the author's opinion, this would not be the case. Such effects are rarely observed in marine ecosystems, mainly because they do not function as would a number of unconnected food chains. Rather, these ecosystems consist of reticulated food webs, where a predator may have a direct negative impact on a prey and a positive effect by also consuming other predators and competitors of the prey.[26] Removing predators does not necessarily lead to an increased availability of prey for humans. Rather it leads to increases or outbursts of previously suppressed species, often invertebrates (*e.g.,* jellyfish).[27] Some of these species are exploitable, some are not, and some are outright noxious.[28]

Even more devastating impacts result from fishing technologies that fail to account for ecosystem processes.[29] Though odd in retrospect, bottom trawling, a process of dragging heavy, chain-studded gear through the animal communities on the sea floor, was once believed to have little, or even beneficial, impacts on the sea bottom that it "ploughed." Recent research shows that the plowing analogy is inappropriate, and that if an analogy is required, it should be that of clear-cutting forests.[30] The productivity of the sea floor organisms, many of which are at the base of marine food webs, is seriously impacted by bottom trawling, as is the survival of juvenile fish who feed on them.[31] Due to the extensive coverage of the shelf ecosystems of the world by this form of fishing, bottom fish throughout the world have tended to decline faster than open-water fishes.[32]

Aquaculture is Not an Alternative to Managing Fisheries

The biological constraints to fisheries expansion and declining catches have led to suggestions that aquaculture should be able to pick up the slack. The impressive reported expansion of aquaculture is often cited as evidence of the potential of that sec-

tor to meet the growing demand for fish, or even to "feed the world."[33]

However, modern aquaculture practices are largely unsustainable: they consume natural resources at a very high rate (fresh water, coastal mangrove forests, fish meal) and, due to their intensity, these practices are extremely vulnerable to the pollution and disease outbreaks they induce.[34] Thus, shrimp farms are in many cases fly-by-night operations, leaving devastated coastal habitats and human communities in their wake.[35]

Additionally, much of what is meant by aquaculture, at least in Europe, North America, and other parts of the developed world, consists of feedlot operations in which carnivorous fish (mainly salmon, but also various sea bass and other species) are fattened on a diet rich in fish meal and oil. The idea makes commercial sense, as the farmed fish fetch a much higher market price than the fish ground up for fish meal (even though they may consist of species that are consumed by humans, such as herring, sardine or mackerels). The point is that operations of this type consume much more fish flesh than they produce, and hence cannot replace fisheries. Indeed, this form of aquaculture represents another source of pressure on wild fish populations.[36]

Mitigation and Restoration

It is clear that a real and drastic reduction in fishing rates must occur if fisheries are to acquire some semblance of sustainability. The required reductions will have to be strong enough to reduce fishing efforts (*e.g.*, number of fishing vessels) by a factor of three or more in most areas. This can be best achieved by phasing out subsidies to the fishing sector, recently re-estimated at about U.S. $32 billion globally,[37] twice the value of the U.S. $14 to $20 billion estimated by the World Bank[38] and used in World Trade Organization negotiations. The idea of phasing out subsidies applies particularly to fuel subsidies, which make up 25 percent of global subsidies, and have, to date, enabled energy inefficient industrial fleets to remain afloat.[39]

Also, the global community must take account of the incessant technological innovations in fisheries, which now relies on Global Positioning Systems (GPS), and detailed bottom maps to zoom in on residual fish concentrations previously protected by rough terrain. This technological race, which allows some fishers to maintain their catches even when the underlying resource base is depleted, is also, jointly with shifting baselines,[40] the reason why fishers often remain unaware of their impact on the resources they exploit and object so strongly to scientists' claims of scarcity.[41]

Vessel decommissioning subsidies, which governments pay fishers to retire their boats, will not be sufficient to reduce the overcapacity of global fishing fleets.[42] Indeed, these subsidies can have negative effects. Decommissioning subsidies usually end up providing the collateral that banks require to underwrite fleet modernizations rather than achieving the intended fleet size reductions. And, in most cases, it is not the actual vessel that is retired, but its license. Hence "retired" vessels can still be used to catch species without quota, *i.e.*, "underutilized resources" (often the prey of species for which there is a quota), or deployed along the coast of some developing country.

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Conclusion

Whatever resemblance of sustainability fisheries might have had in the past can be contributed to the fisheries not being able to cover the entire range inhabited by the wildlife species that were exploited, which thus had natural reserves.[43] Re-establishing sustainability in the face of our vast technical capabilities requires, conversely, that we withdraw from part of the ocean. There is now strong evidence that such withdrawal, combined with a strongly limited effort in the remaining fishable areas, would enable fisheries to rebuild.[44] The appropriate size and location of marine reserves and their combination into networks may indeed represent the most profitable venue for fisheries research in the future — research that would contribute to the rebuilding of the ecosystem in which the fisheries are embedded, rather than slowing down the decline of an ultimately failed enterprise.

Practical restoration ecology for the oceans should take place alongside the extraction of marine resources for human consumption.[45] Reconciling these apparently dissonant goals provides a major challenge for fisheries ecologists, for the public, for management agencies, and for the fishing industry. There is no reason to expect marine resources to keep pace with the demand that will result from growing populations and, hopefully, growing incomes in now impoverished parts of the world. However, fisheries designed to be sustainable in a world of scarcity may be quite profitable. If we act soon, there is still time for restoration to get underway, while remaining fisheries continue to provide seafood and wealth for humans.

Endnotes: Unsustainable Marine Fisheries

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