Pauly, D. 2004. Empty Nets. *Alternatives: Canadian Environmental Ideas and Actions* 30(2): 8-13.

Empty Nets

Fisheries are in decline around the world as fishing technology outstrips ecological capacity.

Daniel Pauly

JUST AS A TROPICAL SCIENTIST might look at the impressive expanse of Canada and assume that this country has boundless potential for agricultural production, unaware that in reality only the thin sliver of land along its southern border (five percent) is arable, we terrestrial aliens have assumed that the expanse and depths of the world's oceans will provide us in the ways that their more familiar coastal fringes have. This is very wrong. Of the 363 million square kilometres of ocean on this planet, less than seven percent – the continental shelves – is shallower than 200 metres, and some of this shelf area is covered by ice. Shelves generate the biological production supporting about 85 percent of global fish catches; the rest consists of tuna and other oceanic organisms that gather their food from the vast, desert-like expanse of the open oceans.

Perhaps the strongest factor behind the overexploitation of fish is the notion that, somehow, the oceans will yield what we need – just because we need it.

The overwhelming majority of ocean shelves are now "sheltered" within the exclusive economic zones of maritime countries. According to the current Law of the Sea, any country that cannot fully use the fish resources of its economic zone must make this surplus available to the fleets of other countries, and this, along with eagerness for foreign exchange, political pressure and illegal fishing, has led to all of the world's shelves being trawled for bottom fish, purse-seined for open-water fishes and illuminated to attract and catch squid.

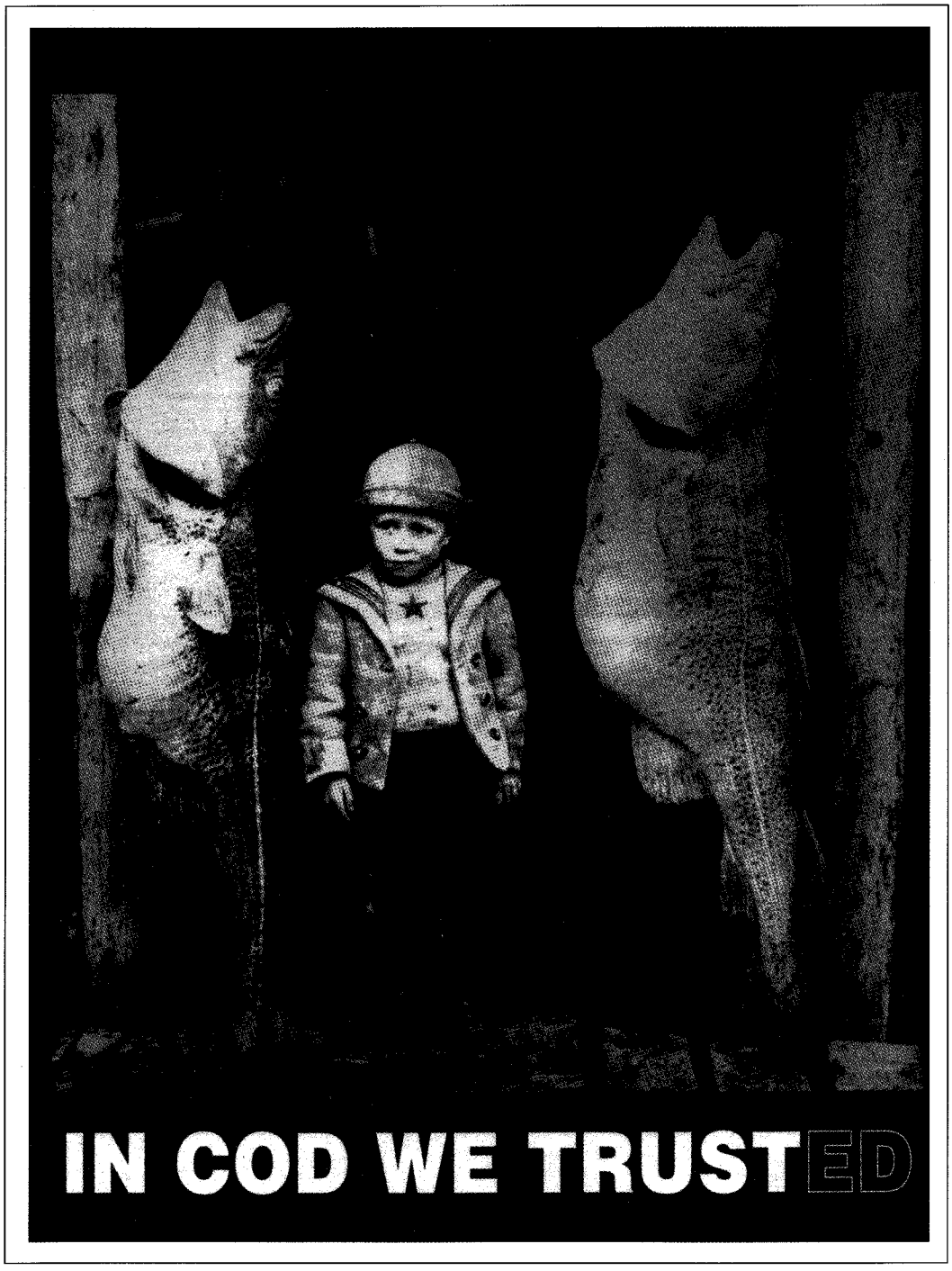
Perhaps the strongest factor behind these destructive fisheries and their tacit support by the public at large is the notion that, somehow, the oceans will yield what we need – just because we need it. While much of the deep ocean is unexplored and mysterious, we do know enough about ocean processes to realize that its productive capacity cannot keep up with an ever-increasing demand for fish.

Global fish catches began to decline in the late 1980s and extrapolation of present trends suggests that large-scale fisheries will collapse in a few decades throughout most of the world, inducing losses that aquaculture cannot be expected to compensate for. A shifting baseline as to what is considered a pristine ecosystem and continued reliance on single-species scientific models have prevented us from fully appreciating the extent of the changes fishing has wrought.

Historic miscalculations

The industrialization of fishing began in the early 19th century when English fishers started operating steam trawlers, soon rendered more effective by power winches and, following World War I, diesel engines.[1] The aftermath of World War II added another peace dividend 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.

Fisheries science had geared up as well: the two world wars had shown that exploited fish populations, such as those of the heavily mined North Sea, would bounce back when released from fishing.[2] This prompted models of single-species fish populations where numbers were presumed to be affected only by fishing pressure. The main point of these models, now still in use (though in strongly modified forms), is that adjusting fishing effort to some optimum level leads to a "maximum sustainable yield," a notion that the fishing


IN COD WE TRUSTED

The first fishery collapse with global repercussions was that of the Peruvian anchoveta in 1971-72.

industry and the regulatory agencies eagerly adopted – if only in theory.

In practice, optimum effort levels were rarely implemented. Rather the fisheries expanded their reach by fishing deeper waters and remote sea mounts and by moving onto the then untapped resources of West Africa, Southeast Asia and other low-latitude and southern hemispheric regions.

Throughout the 1950s and 60s, this massive increase of global fishing effort led to increases in catches so rapidly that their trend exceeded that of world population growth. An entire generation of managers and politicians was led to believe that launching more boats would automatically lead to higher catches.

The first fishery collapse with global repercussions was that of the Peruvian anchoveta in 1971-72. Often perceived as having been caused by an El Niño event, much of the available evidence, such as the actual catches (about 18 million tonnes, exceeding the officially reported catch by six million tonnes), suggests that overfishing was implicated as well.[3] However, attributing the collapse of the Peruvian anchoveta to "environmental effects" allowed business as usual to continue. The mid-1970s saw the beginning of a decline in total catches from the North Atlantic.

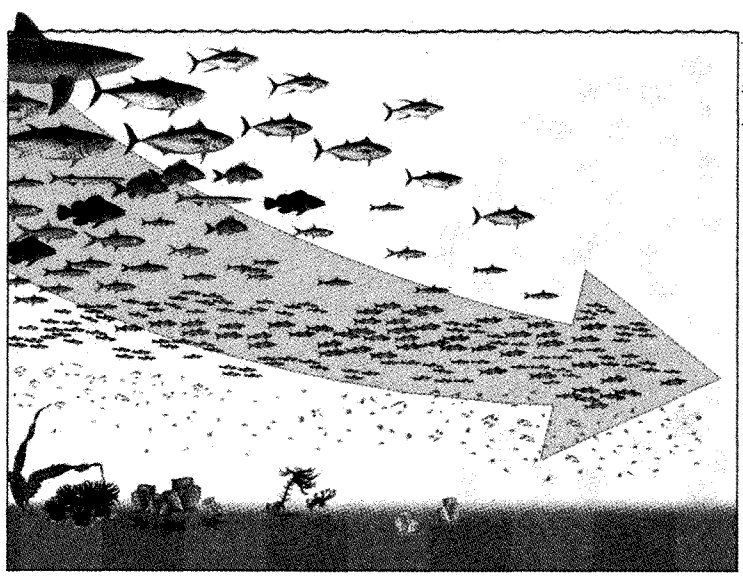
The declining trend accelerated in the late 1980s and early 1990s when most of the cod stocks of New England and Eastern Canada collapsed, ending fishing traditions reaching back for centuries. In 1996, the Food and Agriculture Organization published a chronicle of global fisheries showing that a rapidly increasing fraction of world catches originate from stocks that are depleted, or "senescent" in technical parlance.[4]

Biodiversity suffers

The major, direct environmental impact of fishing is that it reduces the abundance of species targeted for food. It has often been assumed that fishing does not impose any direct threat of species extinction since marine fish generally are very fecund and the ocean expanse is wide. The last decades have, however, witnessed a growing awareness that fishes can not only be severely overfished, but could also be threatened with extinction through overexploitation.[5]

Fishing 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 pool are reversible.

Even more worrisome is a phenomenon known as "fishing down marine food webs." Most food fishes are high on the food chain – whether mackerels feeding on zooplankton or large cod or tuna feeding on miscellaneous fishes. When the top predators are fished out, we turn to their prey, for example shrimp in place of cod.



Aque Atanacio

Fishing down marine food webs: Once populations of large fishes are exhausted, fishing fleets move on to smaller fishes (often the prey of larger fishes) and so on, until fisheries start to depend on very small fishes and zooplankton, such as jellyfish. At the same time, bottom trawling gradually eliminates sponges, gorgonians and other animals attached to the sea floor, changing the rich bottom habitat into sand- or mudflats.

Previous page *Photo circa 1903 – This tribute to the North Atlantic fishery was produced in support of the Canadian Marine Heritage Project <www.northernmaritimeresearch.com>.*

Earlier studies have indicated that there is a steady, global decline in the trophic level, or position on the food chain, of global fishery catches.[6] This implies the gradual extirpation of large, long-lived fishes from the ecosystems of the world oceans.

It may be argued that fishing down marine food webs is both a good and an unavoidable thing, given a growing demand for fish. Indeed, the initial ecosystem reaction to the process may be a release of predation and lead to increased catches among fish in the lower trophic levels. The seal hunt, some have argued, relieves pressure on cod in just this way. Such effects, however, are rarely observed in marine ecosystems, mainly because they do not function as would a number of unconnected food chains.

Predators operate within what are known as reticulated food webs, where a predator may have a direct negative impact on a prey species and an indirect positive effect by also consuming other predators and competitors of the prey. Removing predators does not necessarily lead to their prey becoming available for humans. Rather it leads to increases or outbursts of previously suppressed species, often invertebrates, some exploitable, some not and some outright noxious.

Even more devastating impacts result from fishing technologies that fail to account for ecosystem processes. It seems odd in retrospect, but there was a time when it was believed that ground trawling had little or even beneficial impacts on the sea bottom that it "ploughed." Recent research shows that the ploughing analogy is inappropriate and that if an analogy is required, it should be that of clear-cutting forest trees and their understory.[7] Just like the erosion-stopping roots lost in clear-cutting, the productive benthic organisms at the base of marine food webs are seriously affected by bottom trawling, as are the juvenile fish who feed on them. Due to the extensive coverage of the shelf ecosystems of the world by bottom trawling, bottom fish throughout the world have tended to decline faster than open-water fishes.

Aquaculture is no substitute

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, recent growth of reported aquaculture is often cited as evidence of the potential of that sector to meet the growing demand for fish, or even to "feed the world."

Three lines of argument suggest that this is unlikely. The first is that the global production figures

Freshwater Fiasco

ALBERTA has some of the best recreational fishing in the world. Premier Ralph Klein has used sport fishing to entice dignitaries to Alberta, such as US vice-president Dick Cheney to float the Bow River for trout. Unfortunately these valuable freshwater fish populations are in decline.

The same pattern of overfishing evident in the oceans can be seen in our freshwater lakes. Predators at the top of the food chain are fished out, causing their prey to flourish. These superabundant prey fish gobble up the invertebrates that help regulate the nutrients that algae thrive on. The end result is a lake barren of fish and blooming green with algae.

The most popular sport fish in Alberta, pike and walleye, are at the top of the aquatic food chain. They mainly eat minnows such as the spot-tailed shiner, which in turn eat everything that can fit into their mouths, including small, algae-eating micro-crustaceans called cladocerans. When the numbers or average size of pike or walleye decrease, the algae grows without inhibition.

The important role cladocerans play in the lake ecosystem means that they can be used to trace changes in the freshwater fisheries historically. Measurements of thousands of cladocerans taken from vertical plankton hauls archived by Government of Alberta Water Management show a statistically significant decrease in the average size and biomass of the crustaceans over time. This points to an explosion of the minnow population and decrease of its predators.

More evidence of fish population declines comes from test fisheries and anglers' creel surveys. Nevertheless, many lakes are still being fished, while the energy and forestry industries continue to extend highways deeper into the boreal forest, enabling access to even more lakes.

In a landmark article on the invisibility of the freshwater fishery collapse, fishery biologist John Post and a handful of other academic and government biologists suggest that the localized nature of the problem may mask its extent. Province-wide catches may remain stable or even increase as fish populations decline in one small lake after another.

But the underpinnings of our inability to manage anglers' use of fish resources in Alberta and across Canada are neither singular nor straightforward. Nationally, the reasons include a lack of resources and communication, but, most certainly in Alberta and potentially in other provinces, fisheries biologists often understand the problems but cannot convince policy-makers to stray from the *status quo*. For a senior official to accept and incorporate the conclusions outlined by the scientists would be tantamount to an admission that the fisheries collapsed on *their* watch.

A new paradigm must take hold. Currently, the onus is put on biologists to prove to other stakeholders that there should be changes to fishing regulations. Here is a critical first initiative: reverse the onus and make ecological health the first priority.

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Follow up

Read the full article by Post *et al.*, "Canada's Recreational Fisheries: The Invisible Collapse?" at the Web site of *Fisheries Management*: **www.fisheries.org**

underlying this trend are driven to a large extent by reports from China, which reported 63 percent of world aquaculture production in 1998. However, it is now known that China overreports its marine fisheries catches and the productivity of many other sectors of its economy.[8] Thus, there are reasons to believe that global aquaculture production in the last decades has not risen as much as officially reported.

Second, modern aquaculture practices are largely unsustainable. They consume natural resources (fresh water, coastal mangrove forests) at a very high rate and, due to their intensity, they are extremely vulnerable to the pollution and disease outbreaks they induce. Thus, shrimp farms are in many cases fly-by-night operations, leaving devastated coastal habitats and human communities in their wake.[9]

Third, 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 meal (even though they may consist of species that are consumed by people, 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.

Reductions and restoration

It is clear that a real, drastic reduction in fishing rates has to occur if fisheries are to acquire some semblance of sustainability. The required reductions will have to be strong enough to reduce fishing mortality by a factor of three or more in most areas. This must involve even greater decreases in fishing effort because catches can be maintained in the face of dwindling biomasses by increasing one's efficiency, even when nominal effort (e.g., the number of boats in a fleet) is constant.

This is the very reason behind the incessant technological innovation in fisheries, which now rely on Global Positioning Systems (GPS) and detailed bottom maps to zoom onto residual fish concentrations previously protected by rough terrain. This technological race, and the resulting increase in efficiency, is also the reason why some fishers often remain unaware of their impacts on the resource they exploit and object so strongly to scientists' claims of scarcity.

Vessel decommissioning schemes, where governments pay fishers to retire their boats, will not be sufficient to reduce the overcapacity of global fishing fleets. Indeed, they can even have negative effects. Decommissioning schemes usually end up providing the collateral that banks require to underwrite fleet modernizations

Ocean Oil Threatens Fisheries

IN A LAST-MINUTE attempt to prevent seismic surveying off the west coast of Cape Breton last December, the Roman Catholic Church asked its parishioners across the country to pray for non-life-threatening storms. Although harsh weather did delay the testing and a church in Cheticamp even lost its roof, the sound blasts were completed on Christmas Day. If the tests reveal valuable oil or gas deposits, it could mean wells and drilling platforms closer to the shore than anywhere else in the Maritimes.

Fishers, First Nations groups, tourism operators and conservationists have all expressed concern about the impact of seismic testing and of oil and gas exploration on the near-shore ocean, where most marine animals live. Seismic, which involves the use of intense sound waves (over 200 decibels) to locate petroleum deposits, can affect fish behaviour, kill and damage fish larvae, harm the hearing structures of fish and whales and interfere with fishing. Oil and gas extraction brings additional problems, including pollution and sea floor damage.

Two oil and gas exploration permits have been issued off the coast of Cape Breton, one extending right into the Gulf of St. Lawrence. Both areas are significant for the wealth of their fisheries, including lobster, snow crab, herring and mackerel. The cod and hake populations in the region are at precariously low levels. Whales migrate through the region, as do legions of summer tourists.

An environmental assessment would have to take place before any drilling begins but concerned groups remain convinced that a moratorium should be declared on oil and gas exploration in near-shore waters off of Cape Breton.

– Gretchen Fitzgerald

Follow up

For more information on oil and gas exploration, see the Ecology Action Centre: **www.ecologyaction.ca**
The Sierra Club of Canada posts regular updates and background information on the issue:
www.sierraclub.ca/national/oil-and-gas-exploration

rather than achieving the intended fleet size reductions. And, in most cases, it is not the actual vessel that is retired, but its licence; hence "retired" vessels can still be used to catch species without quota. The boats are used for fishing "underutilized resources" (often the prey of species for which there is a quota), or are deployed along the coast of some developing country, their access to fish again a subsidized affair.[10]

In the past, whatever resemblance of sustainability fisheries might have had was because fisheries were not able to cover the entire range inhabited by the wildlife species that were exploited, which thus had natural reserves. Re-establishing sustainability in the face of our vast technical capabilities requires, consequently, 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.[11] The appropriate size and location of marine reserves and their combination into networks may indeed represent the most important avenue of 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.

A practical restoration ecology for the oceans should take place alongside the extraction of marine resources for human food. Reconciling these apparently dissonant goals provides a major challenge for fisheries ecologists, for the public, for management agencies and for the fishing industry. Important here is to realize that 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, although 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.

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Notes

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