EMPTY NETS

Fisheries may be crippling themselves by targeting the big ones

BY JANET RALOFF

In the 1850s, 43 schooners from a single port, Beverly, Mass., plied the North Atlantic's Scotian shelf, which is prime cod territory in Canadian waters. Over the sides of the ships, crews dropped lines with single hooks and doggedly jigged their bait along the seafloor to entice the big predatory fish. Although the combined fleet used fewer than 1,200 hooks, the ships' logs indicate that these vessels hauled in more than 7,800 metric tons of cod from a portion of the shelf each year. That was some 625 metric tons more cod than the 90 modern ships fishing the entire Scotian Shelf—a far larger area than the Beverly crews covered—landed in 1999.

The reason the modern fishing crews didn't do better, despite employing fish-spotting sonar and massive nets, is simply that few cod remain to be caught, conclude Andrew A. Rosenberg of the University of New Hampshire and his colleagues in a new analysis.

The researchers estimated Scotian shelf cod stocks of 150 years ago from data on the time that each ship in the Beverly fleet was at sea, the amount of gear used, and the area that each schooner fished. Then, they compared these figures with census data on the region's cod population today. Rosenberg and his team report in the March *Frontiers in Ecology and the Environment* that 20th-century fishing reduced the tonnage of adult cod in the North Atlantic to a mere 4 percent of what it had been in 1852.

"Most of this drop occurred just since World War II," Rosenberg observes. He estimates that all the adult cod on the Scotian shelf today would fit into the holds of a mere 16 of the historic Beverly fleet's schooners.

Although the crash of the North Atlantic cod stock has garnered much attention over the past decade (*SN: 2/22/97, p. 124*), this fish is just one of many species to plummet disastrously from overfishing. Another new report documents a similar depletion among other large predatory marine fish, including tuna, swordfish, sharks, and rockfish. Most of these top-of-the-food-chain species survive as tiny remnants of their formerly abundant stocks.

New research is challenging long-held assumptions about the biology of these fish and the wisdom of the current industry tactic of targeting the biggest members of a species. Together, these studies suggest that for the ocean's fisheries to rebound, stocks must be managed quite differently, through approaches that view each species as part of a single ecosystem.

This is the way in which land environments have been managed for decades, notes Elliott A. Norse, president of the Marine Conservation Biology Institute in Redmond, Wash. However, applying this strategy to ocean species, he says, calls for nothing short of "a revolution."

GOING, GOING — Sharks, which are among the most severely depleted of species, have played a pivotal role in maintaining marine food webs.

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BIG TARGETS Fleets have become so numerous and technologically sophisticated that they can catch almost all the fish of any species. The result has been globally diminished stocks of desirable fish and, counterproductively, declining daily yields (*SN: 6/8/96, p. 367*). Almost invariably, the biggest species—such as tuna, sharks, and cod—in heavily fished areas have been the first to plummet, notes Ransom A. Myers of Dalhousie University in Halifax, Nova Scotia.

Fleets target big fish because they yield the highest profits. There is more marketable meat per landed fish. What's more, big fish tend to have milder flavor and fewer bones per pound than small fish do. Top-of-the-food-chain fish have always been the least numerous; so, overfishing such fish quickly sent their populations plummeting (*SN: 7/26/03, p. 59*).

Today, there are good stock estimates for dozens of species of the large fish that people prefer. In almost every instance, these species are in trouble, Myers says. Globally, abundances of nearly all these species have dropped to one-tenth of what they were before commercial fishing, he and Dalhousie's Boris Worm reported in the Jan. 29 *Philosophical Transactions of the Royal Society of London: Biological Sciences*.

Species that have unusually long maturation periods have suffered disproportionately. Bluefin tuna, for example, take from 5 to 8 years before they reproduce, and various rockfish take from 13 to 28 years. Many sharks take decades to reach sexual maturity. And although sharks are captured for both their meat and fins (*SN: 10/12/02, p. 232*), these animals have the dubious distinction of being so troublesome to fishing operations that fleets harvesting other species also kill them.

Clearly, a population won't remain robust if most of its members are caught before they get a chance to reproduce. And there are ample signs that this is happening in many waters, Myers says.

For instance, although Atlantic swordfish used to grow to more than 1,000 pounds, the average one landed in 1995 weighed just 90 pounds. A swordfish of that size is a couple years short of its first chance to reproduce (*http://www.sciencenews.org/pages/sn_arc98/7_4_98/food.htm*). Citing surveys of the Gulf of Mexico spanning 40 years, Myers' team reports that open-water sharks there have fallen to 1 percent of their 1950s abundance. Similarly, Myers notes, his team tallied Hawaiian coral-reef sharks at just 2 percent of 1950s levels.

Such declines haven't occurred only in long-fished waters. In the April *Ecology*, Myers and Peter Ward of Dalhousie compare two sets of fish-census data collected by U.S. government scientists in the central Pacific. The first, from the 1950s, preceded major fishing in that remote region. The latter figures were collected from 1994 to 2002. In the 40 to 50 years between those periods, the biomass—pounds of living fish—of tuna and sharks, the region's largest and most abundant predators, declined by 90 percent.

The mean adult size of large predatory species also fell by half between census counts. For the largest species, the 100-to-200-pound tuna and sharks, Myers adds, "the mean size is now one-fifth of what it was"—and in sharks, as in swordfish, that's below the size of sexual maturity.

Between censuses, the creatures on which large fish prey have thrived. The abundance of stingrays, pomfrets, and snake mackerels has mushroomed 10- to 100-fold.

Observes Myers, "In the middle of the ocean, out of sight, the open-water ecosystem has undergone a dramatic shift to these smaller species." Unfortunately for the fishing industry, people don't ordinarily eat these types of smaller fish.

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>
> — ELLIOTT A. NORSE
> MARINE CONSERVATION BIOLOGY INSTITUTE

BIG OLD MAMMAS Fleets have overfished boneless fishes, principally sharks, skates, and rays, along with boned fish, which are virtually all other fish of commercial value. However, the reproductive consequences of overfishing may differ between the groups.

Boneless fish tend to produce very few young—in some cases, only two to four every other year. Because many of these species are so depleted, biologists haven't done experiments to quantify the reproductive impacts of overfishing them.

Among the boned fish, however, studies have shown that egg production tends to increase with a female's age. Norse notes that fishery managers have generally assumed that a boat taking an older female producing 1 million eggs a year is equivalent, in terms of its effect on a fish stock's health, to taking 10 younger females, each producing 100,000 eggs a year.

However, this isn't necessarily the case, according to data presented at the American Association for the Advancement of Science (AAAS) annual meeting last February.

Steven Berkeley of the University of California, Santa Cruz and his colleagues reported on black rockfish, a deep-water species that grows to 8 pounds and can live 50 years. The researchers collected 5-to-17-year-old pregnant females from Oregon's coastal waters. While housed in lab aquariums, they released their live, 1/8-inch-long young. The biologists then fed the youngsters nutrient-rich food and tracked their growth.

Offspring of the oldest moms grew about three times as fast and were twice as likely to survive short periods of starvation as were the youngest moms' broods, Berkeley reported. He and his colleagues also noted that the oldest moms produced offspring with substantially larger oil globules in their bellies. These prepacked meals sustain young fish for their first few days in the water.

"I've been working with other colleagues to repeat these experiments with other species," Berkeley told *Science News*, "and generally, we find the same patterns."

"This is big," says Norse. If the eggs of older females are of higher quality than those of younger fish, then "the older, bigger females will be contributing disproportionately to the future of their population," he says.

Most fisheries selectively catch the biggest fish in the population. Under intense fishing following this practice, few individual fish reach old age. However, Norse speculates, if Berkeley's "big-old-mamma" effect proves widespread among seafood species, it could deal "a devastating and quite possibly fatal blow to the traditional fisheries-management paradigm in our country."

Currently, Norse argues, "we are systematically eliminating fish that produce the young most likely to survive [to adulthood]."

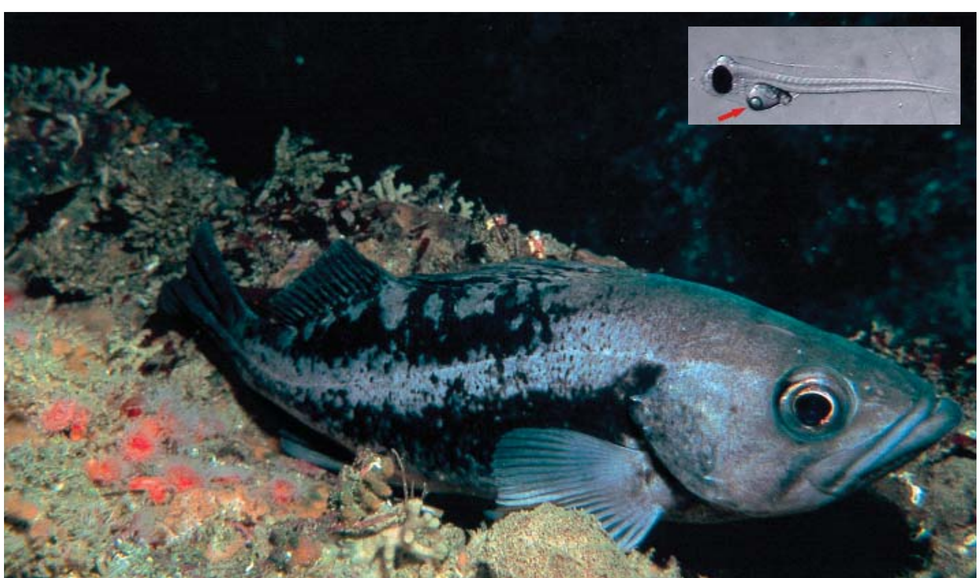
EARLIER MOTHERHOOD In some fish species, females respond to overfishing by beginning to lay eggs a year or more earlier than usual. For instance, black rockfish usually begin reproducing at about age 6. In the overfished waters from which the Santa Cruz scientists collected specimens, "we saw some fish maturing at age 4," Berkeley says.

Similarly, in the Barents Sea, which is north of Scandinavia and Russia, cod 70 years ago tended to mature when they were 9 to 10 years old. "Now, it's around 6 to 7 years—a substantial change," notes Mikko Heino, a population ecologist at Norway's Institute of Marine Research in Bergen. Heavily fished European plaice and grayling stocks experienced a similar reduction in age at maturity.

"What we have been able to show is that in almost every case we've looked at, this tendency to mature earlier reflects a genetic change," Heino says. "That means it will be difficult to reverse."

With big, older fish selectively culled from a stock, only fish with the genes to mature early have a chance to reproduce, Heino explains. This carries important implications for the fishing industry because, he notes, "this change in maturation age means that fish begin [prematurely] allocating energy into reproduction—instead of growth." The result, he says, are more slowly growing adults, which translate into lower fishing yields.

At the February AAAS meeting, David O. Conover and his colleagues at the State University of New York at Stony Brook



BIG LUNCH? — **Mature female black rockfish and newborn (inset), which sports an oil globule (arrow)—its prepacked lunch. Older moms give young a bigger starting meal, boosting the offsprings' growth and survival.**

R. BOEREMA; (INSET) C. CHAPMAN

demonstrated such an evolutionary change for slower growth (*SN: 2/26/05, p. 132*). By repeatedly culling the biggest fish in four generations of lab-reared Atlantic silverside, the researchers produced fish that grew at roughly 60 percent the rate of fish that had been culled randomly over that time and 40 percent as fast as populations where the smallest adults had been preferentially removed.

"Unless you deny the existence of evolution, you've got to come to grips with the fact that this change is going to be unavoidable [in wild stocks]," says Conover.

Indeed, Heino maintains, as fleets continue to target big fish, "we are profoundly changing fish in ways that we'd not anticipated."

BROKEN CONNECTIONS — Within a reef community, the fates of different species are tightly linked. Smaller fish may thrive or crash when there's overfishing of top predators.

E. SALA/SCRIPPS INST. OCEANOGRAPHY

ECOFISHING Today, fisheries are studied—and regulated—as if each existed in isolation, observes Mark Hixon, a marine-fish ecologist at Oregon State University in Corvallis. Studies and catch quotas seldom take into account the effect that fishing for one species may have on another.

A new analysis by Jordi Bascompte of the Spanish Research Council's Doñana Biological Station in Seville and his colleagues begins the task of mapping the predator-prey connections in marine waters. The researchers documented natural interactions among some 250 birds, fish, and invertebrates that fly above, swim in, or burrow beneath the Caribbean Sea. They mapped the relationships expected in an environment, such as a marine reserve, where fishing and other forms of human interference are prohibited (*SN: 4/28/01, p. 264*).

Then, the researchers ran a computer program designed to model what would happen if selected members of the community were culled, as by fishing. In the April 12 *Proceedings of the National Academy of Sciences*, the team reports that taking out top predators, particularly sharks, had the biggest impact. Loss of these keystone species, Bascompte says, caused their prey to flourish unchecked. That population explosion in turn created population declines in the prey of these species, and so on.

Losses of large, predatory fish only hint at the massively cascading changes that these losses can wreak throughout an ecosystem, Bascompte says. "Changes propagated throughout the entire food chain," he explains. He says that it's not simply one species replacing another but "a complete change in the architecture of the community."

Though simple, the computer model that his team employed "does allow people to test different [fishing]-management scenarios to see which would be better for an ecosystem," Bascompte says.

"We've always treated the ocean like a frontier, as if its resources were infinite and free to plunder. And several centuries ago, that may effectively have been true," says Norse. "However, humankind is now mining the ocean's living resources, making them nonrenewable." Instead, he says, "we must learn how to use them sustainably—by understanding and respecting their biology." ■