

## DEEP TROUBLE

### Overfishing has torn the sea's web of life. Mending it won't be easy

When Europeans first settled along the Chesapeake Bay in 1607, its waters teemed with whales, manatees, and five different species of sea turtle. Oysters, which saved the Jamestown colonists from starvation more than once, were so abundant they made navigation on the James River a nightmare of shoals and reefs. A 1585 painting of nearby Pamlico Sound in North Carolina shows native Algonquians harvesting a profusion of sea creatures including sturgeon and hammerhead sharks. Most of those animals are gone now, hooked, hunted, and dredged to extinction or ecological irrelevance. The bays themselves are profoundly changed, their waters murky and prone to infestations of jellyfish and toxic red tides.

Similar shifts have swept coastal waters everywhere. Once vibrant reefs in the Caribbean are now blanketed by sediment, the corals replaced by seaweed. San Francisco Bay, which used to support a commercial fishery, has been overrun with Asian clams and other invading species. The fishing boats are gone. "Dead zones," pockets of oxygen-depleted water where virtually nothing larger than a speck can survive, plague bays and the Gulf of Mexico. Ecologists have scrambled to find culprits, focusing on water pollution, dammed and diverted rivers, introduced species, and global warming. Now, a survey of fisheries data, archaeological excavations, and historical records, published in the journal *Science*, reveals a surprising thread uniting virtually every instance of marine ecosystem collapse. The cause, says lead author Jeremy Jackson of Scripps Institution of Oceanography in San Diego, is "fishing, fishing, and fishing."

Fishing can have these wide-ranging effects because, as Jackson puts it, "Hunting and gathering in the ocean does more than kill fish. It changes ecosystems." Each species in an ecosystem is linked to many others, as a predator, a scavenger, or a source of food or shelter. Remove some peripheral species from the web and the system as a whole may continue to function just fine, so long as all the roles are still filled. But knock out a keystone species and the system must find a new equilibrium. Other human impacts such as agricultural runoff and seafloor dredging may provide the final knockout blow to ecosystems, the authors note, but in every case the 19 scholars analyzed, excessive fishing set the process in motion. "We're causing fundamental shifts in ecosystems," says Jackson, and some of those shifts may be irreversible. Once a system has been altered, Jackson says, "It's much more difficult to go back from whence we came."

**Super suckers.** Take those Chesapeake oysters. Sediment cores recording some 2,000 years of environmental history show that the nutrient overloading often blamed for the bay's murky, oxygen-depleted water did not start with modern factory farms and the fertilizer-laden runoff they produce. It began in the mid-1700s, when forests were cleared and plantations planted. Still, the water remained clear until the early 1900s. "The bay didn't experience dead zones through 200 years of land clearing, industrialization, and animal operations," says University of North Carolina-Chapel Hill marine ecologist Charles Peterson. The credit goes to the oysters. These filter feeders were once so abundant that they could strain the entire volume of the bay in less than a week.

But when steamships replaced traditional sailing vessels, fishing fleets were able to dredge up the large oyster reefs in deep channels. After a major peak in oyster harvests 100 years ago, the beds were so depleted that it would have taken the remaining oysters over a year to filter the bay of all its suspended crud. The result? A cascade of effects that depleted the bay's characteristic rockfish and blue crabs and made room for decidedly less-desirable species, such as sea nettle jellyfish and toxic algae (graphic, Page 70).

In the shallow bays of the Caribbean and South Florida, green sea turtles turned out to be the keystone. The animals were once so abundant that Columbus feared his ships would run aground on their backs. The turtles, naturally enough, ate turtlegrass, cropping the extensive beds down like cows on spring pasture--until they were all turned into soup and hair combs. Between 1688 and 1730, one set of records shows, some 13,000 turtles were harvested annually just from Grand Cayman Island. Ungrazed, the turtlegrass rotted in place, soaking up oxygen from the water and choking fish and shrimp. The turtlegrass

beds in Florida Bay and the Gulf of Mexico hung on until the 1980s, finally done in by a disease caused by slime molds growing in the rotting vegetable matter. "The turtles were more than just charismatic megafauna," says Jackson. "They were ecosystem engineers. If we want the grass to come back and the shrimp to come back, we have to bring the turtles back."

A fundamental ecological change may also have taken place on the great fishing banks of New England and Atlantic Canada. When populations of cod, hake, and other groundfish crashed in the early 1990s, many regions were closed to fishing. Some populations have rebounded, but most have not. Untouched seafloor is covered by a prickly "forest" of sponges, deep-sea corals, bryozoans, and other obscure, sedentary animals, which provide young fish with refuge from predators. "But fishing gear like bottom trawls and scallop dredges flatten out and kill those animals," says University of Connecticut fish biologist Peter Auster. A healthy population of cod might well survive in this depleted habitat, he says, "but when there aren't enough baby cod, like now, the cover becomes essential." If the seafloor creatures don't return, it's unlikely the fish will either.

**Nothing new.** This pattern of exploitation and ecological collapse is nothing new, as Richard Hoffmann, an environmental historian at York University in Canada, has found. Sturgeon, a medieval delicacy, was once common throughout European coastal waters, says Hoffmann. The fish's coin-size lateral scales, called "scutes," persist in food dumps, their dwindling numbers tracing the fish's decline. "You see a downward trend in number and size from the 11th century through the 14th century," says Hoffmann, "then they disappear in the Low Countries and France." From that time on, reports of sturgeon are found only in royal palace records and even then the fish is reserved for the king's table only. By the 15th century, notes Hoffmann, French cookbook recipes for preparing the fish were replaced by directions on how to "make" sturgeon out of veal. The fishing had stopped, but the fish never returned.

As one species after another is decimated, we're learning to love--and destroy--previously ignored critters. The ecological effects are unknown. A fish called slimehead (creatively renamed orange roughy for restaurant menus) wasn't fished commercially until 1979; now it and fellow latecomer Chilean sea bass (nee Patagonian toothfish) have been virtually eliminated from much of their range. And while a plate of newly chic giant barnacles may look like an exotic culinary adventure, it represents something closer to desperation. "We're harvesting urchins and cucumbers and jellyfish," says University of British Columbia fisheries biologist Daniel Pauly. "We're fishing down the food web as we deplete one stock after another. We're moving toward a regime when all the big things are simply gone."

The good news is that even the most heavily fished creatures, like Chesapeake oysters, are not extinct yet. But, because the supporting ecosystems have already changed, simply lowering catch quotas is no longer enough to bring depleted species back. "Controlling killing is essential," says ecologist Elliott Norse, president of the Marine Conservation Biology Institute, "but living things [also] need a place to live." The key, say scientists, may be a combination of protected areas and ecosystem restoration--breeding and reintroducing sea turtles and the fish that clear coral reefs of seaweed and encouraging commercial oyster farming, for example. Less than 1 percent of U.S. waters are currently protected from human exploitation, but marine scientists and even some commercial fishers are banding together to push for new marine reserves. With reserves and reintroductions, Jackson says, "We can go back a little. If we intervene on a massive scale, we may be able go back quite far. It's too late now to do anything but try."

#### [A sea change](#)

Generations of fishing, hunting, and oyster dredging have devastated shallow coastal waters from the Caribbean to the Chesapeake. Removing keystones like sea turtles and oysters changes the entire system.

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