Fishing for Answers

Deep trawls leave destruction in their wake—but for how long?

By JANET RALOFF

In recent years, one after another of the world's major fisheries has collapsed or exhibited signs of severe stress. In hopes of saving their industry, fishers have been turning to species and fishing grounds they had formerly ignored.

For instance, some of those who had been plying their trade near shore now travel some 200 kilometers out. There, they harvest stocks along the continental shelves at depths of 300 meters. Others have even begun fishing the continental slopes—at such staggering depths as 1,200 meters.

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This 4-meter-wide beam trawl has a chain matrix to keep rocks and rough terrain from damaging the gear.

Commercial fleets are increasingly investing in seabed equipment known as mobile gear. Dragged along the ocean floor at even the greatest of these depths, their trawls and dredges scoop up everything in their path, bringing to the surface whatever doesn't sift through their nets. Those nets inevitably snag some rocks, turning them over and destroying animals attached to them.

Lately, marine ecologists have begun showing up at these fishing grounds with their own, even higher tech gear. Their trawls, sleds, and dredges come equipped with video cameras, sidescan sonar, and computer-driven mechanical shovels that can sample the seabed at the touch of a button.

Their goal is not to catch fish but to haul in hard data documenting trawling's impact on tube worms, sponges, anemones, hydrozoans, urchins, and other denizens of the deep. Ten or even 20 pounds of these animals, which are generally smaller than the target fish, may be caught—and discarded as waste—for every pound of commercial catch. Caught in the roiling waters, some of the sea dwellers remain on the ocean floor, crushed, uprooted, or displaced after chains, bars, or metal doors have plowed through the sediment that had been their home.

Worthless by fishing standards, these critters provide food and habitat for some or all of the commercial fisheries under stress. In fact, argues Elliott A. Norse, director of the Marine Conservation Biology Institute in Redmond, Wash., trawling's toll on these largely ignored seafloor species may underlie the recent collapse of many commercial groundfish stocks, which include cod, haddock, pollock, and flounder.

"What we've done is destroy the carrying capacity of the habitat to support those [fisheries] by removing the organisms that provide shelter for little fishes," he told SCIENCE NEWS. "We're talking about destruction of marine habitat that is, if not equivalent, at least in the ballpark with clear-cutting forests on land."

Not everyone concurs. "There's no question that certain habitats have taken a real pounding," says Andrew A. Rosenberg, northeast regional administrator of the National Marine Fisheries Service in Gloucester, Mass. Though he acknowledges that sharp declines in stocks of exploited fish, such as cod, have been "clearly associated with fishing," he adds, "I don't know that you'd conclude it's due to a clear-cutting type of effect on habitat."

Such a determination would require long-term monitoring of the nontargeted ocean floor communities—which, he notes, is not done today. So while he believes the clear-cutting issue "is a valid and important concern, [Norse's] conclusion may be a little premature."

Hoping to help resolve the issue, a number of research ventures have begun to identify vulnerabilities in the seafloor communities and to study how quickly damaged habitats bounce back. Their findings could influence whether and how fishing regulations might be modified to ensure that critical habitats receive a chance to recover.

A biological oceanographer who studies seafloor habitats, Les Watling of the University of Maine's Darling Marine Center in Walpole has become particularly concerned about fishing fleets moving into what had been inaccessible sites.

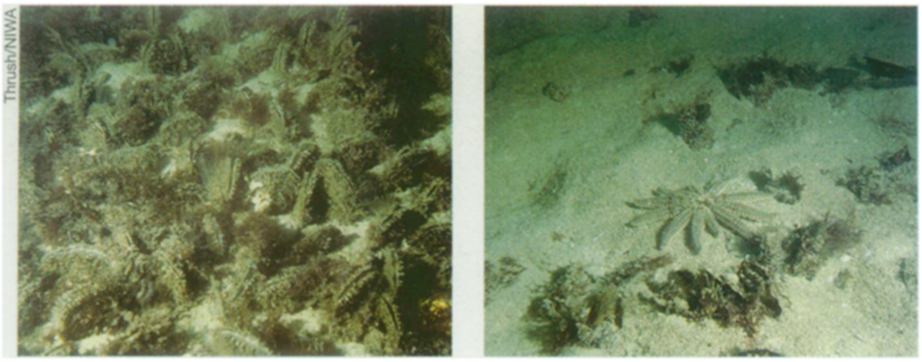
Rock-hopper gear, for example, introduced about 10 to 15 years ago, can roll over large seabed obstacles. Ropes that thread through a series of huge balls or rollers drag a net across the floor, often overturning rocks and, Watling says, "grinding to a pulp" any animals cemented to them.

In 1987, he videotaped Outer Falls, then a pristine community some 80 miles offshore in the Gulf of Maine. The boulder-strewn area teemed with ancient sponges, bushlike bryozoans, and other animals that form colonies and anchor themselves permanently onto solid footings.

Studies have shown that the fry of groundfish, such as cod, survive best in the shelter afforded by such structurally complex bottoms—seabeds strewn with cobbles or rocks and dense with organisms growing up from them. Areas like Outer Falls, some 100 meters below the surface, probably served as nurseries for vulnerable yearling fish, Watling says.

He could tell that Outer Falls hadn't yet been trawled 9 years ago, because "its stones were completely covered with animals." Marine fauna were even sandwiched into the crevices between rocks

Thrush/NIWA



A horse mussel bed before (left) and after (right) it was dredged for scallops. The mussels had provided a stable surface for many organisms to stick to, creating on the seabed a rough texture that camouflaged other marine animals.

and the sediment. Fearing the area's rocky prominences, which would have ripped apart any nets dragged over them, trawlers had shunned this obviously old and stable community, Watling says.

When he returned to Outer Falls 3 years ago, "it looked like a hurricane had been through." Boulders had been overturned and the area's slow-growing colonial animals, which have no natural predators, had vanished. Judging by size, some of the lost sponges may have been at least 50 years old, Watling says. Because these slow-growing animals also take a long time to reestablish themselves, replacement of such mature communities could take a century.

He now suspects that "the biggest factor behind the decline of fish in the Gulf of Maine is the rock-hopper."

Canada's Department of Fisheries and Oceans is also concerned about rock-hoppers and associated gear tearing through seafloor communities. So for the past 3 years, its scientists have trawled and examined a small area that is closed to commercial fishing on the Grand Banks off Newfoundland.

They surveyed the local inhabitants before and after conducting a dozen trawling runs down each of three 13-kilometer-long corridors. This trawling simulates on a local scale a year's commercial fishing. A synthesis of the findings could be completed by early next year, says Donald C. Gordon Jr., an ecologist at the Bedford Institute of Oceanography in Dartmouth, Nova Scotia and a coleader of the project.

Preliminary findings from the first 2 years of the study indicate some early warning signs of ecological change, Gordon's team noted last June at a small ecological conference on trawling held at the Darling Center. Sidescan sonar images revealed changes in the floor surface that persisted at least 1 year. Further acoustic studies detected millimeter-scale changes in the structure of the top 4.5 centimeters of sediment, where most animals live.

It looks as if trawling has homogenized the subsurface structure of the sandy sediment, a change that points to the removal or destruction of infauna—sediment-burrowing animals, says Peter Schwinghamer of the Bedford Institute. "Anything that's important to the infauna [here] is important to cod."

The net picked up fewer invertebrates—usually snow crabs, basket stars, and sea urchins—with each of the dozen passes of the trawl. However, what ended up in the trawl's net represents just a fraction of the damage to bottom dwellers. Many shell shards and other pieces of animals were visible on the seafloor.

In tropical waters half a world away, Ian Poiner and his colleagues at the Commonwealth Scientific and Industrial Research Organisation in Queensland are completing a 5-year study on the impact of prawn fishing between Australia's coast and the Great Barrier Reef. Like Gordon's team, they conducted a dozen research trawling runs down well-characterized corridors to simulate the intensity of local fishing. On average, Poiner notes, commercial trawls plow through most of these Australian waters at least once—and in many places up to eight times—annually.

With Japanese consumers willing to pay $25 to $35 per pound for tiger prawns, a single ship can earn $1 million in a couple of months of shrimping.

Poiner's findings, also reported at the Darling conference, showed that a single pass of the trawl removes some 5 to 20 percent of the seafloor animals. "So you get total depletion, certainly, by 10 or 12 trawls."

Here, mining the bottom does not appear to be hurting the short-term productivity of the exploited stock. One reason, Poiner suspects, is that across a given area, the trawls remove more predators than prawns.

Simon Thrush of New Zealand's National Institute of Water and Atmospheric Research in Hamilton has been working to estimate how quickly the disturbed seafloor communities recover. In one experiment, he kept patches of soft sediment covered with a concrete slab for 1 month. "We expected our plots to recover in 2 to 3 months," he says. However, 9 months later, the 0.2- to 3.2-meter-square test plots still exhibited less species diversity and lower abundances of each species than undisturbed tracts nearby.

In this environment, tube worms—on the menu of fish and birds the world over—normally make mats that cover the seafloor. Just 1 to 2 centimeters long, the worms glue fine sediment into fragile cylindrical homes that extend about 5 centimeters above the seabed. Thrush now suspects that their slow recolonization reflects his compaction of the sediment, which makes it difficult for would-be immigrants to remodel.

Because storms frequently reshape soft, sandy floors in waters less than 70 meters deep, Thrush notes, the conventional wisdom has held that trawling in these areas has minimal impact on sediment dwellers. "Our experiment illustrates that this is an oversimplification," he told SCIENCE NEWS.

Major changes in sediment structure could also alter both the chemical form and the release of nutrients, thus affecting the habitability of the entire water

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Paul Kay/Marine Wildlife Photo Agency

The slow-growing sponges and bryozoans in this patch of seafloor provide shelter and camouflage for many creatures, even fin fish. Trawling can destroy most of the species here—with one notable exception. Roughly 99 percent of starfish survive a pass of a trawl's net—though some may temporarily lose one to five arms, reports Michel J. Kaiser of the United Kingdom's Fisheries Laboratory in Conwy, Wales. He finds that limb loss in starfish populations correlates strongly with fishing intensity, possibly providing a gauge of how frequently a region has been trawled.

compact disc players. These lasers can be bought in a wide range of wavelengths and give exceptionally good output. The prototype display fits on a 1-foot-square breadboard. "You can literally hold it in your hand," Macfarlane says.

Other scientists in the imaging field are impressed. Guy A. Marlor of West End Partners Imaging in Fremont, Calif., says he saw her demonstrate the system. "I was totally fascinated," he says.

The technology has caught the fancy of the medical imaging community because of its potential for displaying data from computerized tomography (CT) scans, ultrasound, and magnetic resonance images (MRI) in three dimensions. At present, these techniques, for all their detail, show only flat slices of very solid human bodies. Doctors must mentally reassemble the slices to get a coherent picture of the body part.

Though still a long way from being able to display that kind of information, the new technology may allow doctors to see, for example, heart valves working or blood flowing in the brain, Marlor says.

Many groups are now experimenting with ways of displaying reassembled data slices on a computer screen, but one of the 3-D methods that has already penetrated the medical imaging market is digital holography, developed by Voxel of Laguna Hills, Calif. Exposing holographic film to multiple CT, MRI, or ultrasound scans builds up a composite image. The resulting hologram—a floating "sculpture of light"—can be viewed through a special light box.

Surgeons can insert instruments into the hologram to gauge distances, and they can overlay holograms of different tissues—a network of blood vessels over a tumor, for example—to see how they relate. The technique can't portray movement within the body, however.

Digital holography is especially valuable for seeing abnormalities in the spine and the brain, says William Orrison, director of the New Mexico Institute of Neuroimaging in Albuquerque. After his first look at a hologram, he says, the 20 years he has spent studying neuroanatomy became instantly clear. "If a picture is worth a thousand words, then a hologram is worth a million," he says.

For the past 2 years, the institute has sent MRI and CT data to Voxel for processing. The first on-site camera, which can take and develop such digital holograms in less than half an hour, is scheduled to be installed there this month.

All 3-D technologies have their advantages and disadvantages, says Raymond A. Schulz, a spokesman for Voxel. Downing's technology is "done in a solid cube, so it's not a piece of film you can transport from one place to the other," he says. "You can't stick a surgical screw in it." But it has the potential to show motion where holography does not, he adds.

"She's got a lot of technical hurdles to overcome yet, but it's certainly very interesting."

The big limitation of using this technique for medical imaging, Downing and Macfarlane acknowledge, will be the time it takes to transfer the enormous amount of data contained in multiple scans to the display. "You know how long it takes to write graphics on a computer screen in 2-D," Macfarlane says. "There's an awful lot of picture elements involved when you add a third dimension." Data compression techniques and arrays of lasers, each responsible for scanning smaller areas of the glass, might reduce the burden.

Downing estimates that 3D Technology Laboratories is 4 or 5 years away from having a salable product. "Our goal is to push a new technology into the marketplace," she says. "We want this in hospitals, schools, anywhere it can help engineers solve problems."

For now, though, the next step is simply to get the device to produce more complicated figures: the Eiffel Tower, a jumping frog, and Herbie the Love Bug, to name a few on the drawing board.

Those further investigations are temporarily on hold, however. Downing has gotten so much interest in the technology that she has been spending most of her time on the phone talking to reporters and potential investors rather than in the lab. □

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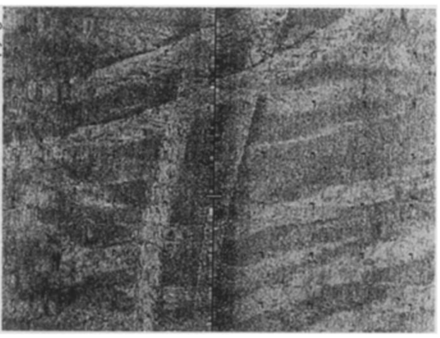
column, according to Lawrence Mayer, a biogeochemist at the Darling Center.

Sediments supply about half of the nutrients in waters to depths of perhaps 200 meters, he notes. Studies have shown that a host of environmental factors can affect how bacteria manipulate chemicals in their vicinity. For instance, a sediment's geometry can influence whether bacteria release nitrogen in biologically useful forms that serve as natural fertilizers or in inactive compounds that most animals ignore.

"As we trawl," Mayer notes, "we convert the geometry of the ecosystem from one containing a small number of large burrows to one that contains a large number of small burrows." This reflects the replacement of larger animals by small opportunists.

Will trawling prompt sediments to act as a source or as a sink of fertilizer for continental shelf ecosystems? "I haven't the slightest idea," Mayer says. Too little research has been done on this "terribly complex system" to offer a useful gauge.

Today, fisheries are managed largely in terms of how many animals can be harvested without reducing the vitality of the population. The new trawling studies raise questions about the extent to which commercially fished stocks depend on habitats that are being degraded by seafloor trawling, Rosenberg says. He would like to see long-term monitoring of the ignored seabed communities to establish their role in the productivity of commercial fisheries.



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Sidescan sonar image from Irish Sea depicts marks scored on seabed by passes of a 4-meter beam trawl.

So would Norse. Unfortunately, he says, this topic "has gotten very little attention" to date and even less research funding. Nor should the economic performance of commercial fisheries necessarily be the primary focus of such research, he argues. He would like to see the conservation of biodiversity accorded equal importance.

Toward that end, he advocates the development of marine reserves closed to fishing and other human disturbances.

Gordon, Schwinghamer, and some of their colleagues would also like to see the use of mobile gear in fisheries managed more conservatively, arguing that trawls and dredges should be permitted only in certain regions and be used only during specified periods, depending on the apparent vulnerability of the habitat and its role in the life cycle of other fishes.

Rosenberg would take more of a wait-and-see approach. He says that telling people not to trawl "is not a particularly viable strategy." He would like to see other management options explored through research that looks not only at biology but also at the sociology and economics of fishing.

John Williamson, a fisherman from Kennebunk, Maine, who does not use bottom trawls, worries that the answers to such questions may come too late.

Not long ago, he could motor out to where huge schools of fish congregated and reliably haul in the day's limit. Today, he says, "I'm not going to find a large concentration of fish anywhere"—and the situation is only getting worse. Already, he charges, it's as if fishers have been reduced to hunting down "small patches of fish in the middle of a barren desert." □