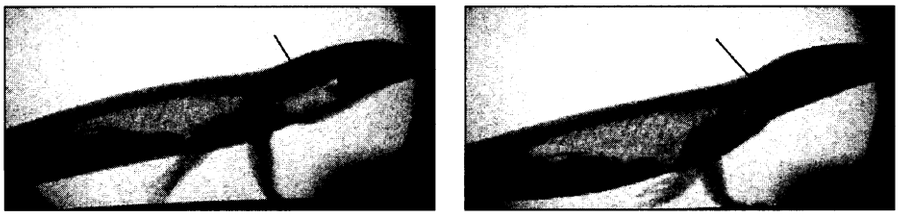


E. BRAINERD *ET AL.*

Breathe deeply. X-rays reveal the monitor's expanding and contracting throat pouch (arrow).

who can't breathe and run.

These results help explain why monitor lizards can chase down their prey while many of their reptilian cousins sit and wait to snag a meal that comes along. They also show how evolution can solve a single problem in different ways. They suggest that the lizardlike early tetrapods, thought to be the evolutionary ancestors of both mammals and modern lizards, could run only in short, quick bursts before they used up the available oxygen and needed to stop and take a breath, so to speak. "Unless there was a change in the basic body design, you couldn't have animals with high stamina," says Carrier. Mammals solved the problem by evolving a diaphragm muscle, and monitor lizards came to have gular pumps.

–Elizabeth Pennisi

MARINE ECOLOGY

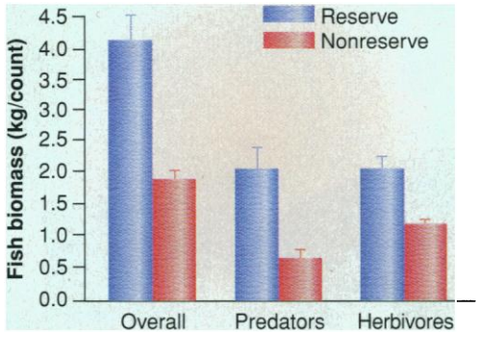
Overfishing Disrupts Entire Ecosystems

In the face of declining fish stocks, the managers of many of the world's fisheries have been forced to take often drastic measures to prevent total collapse. These include, for example, a complete ban on fishing the Grand Banks off Newfoundland and quotas that limit takes, such as those now imposed on fishing vessels in European Union waters. But a new analysis of global fish catches over the past 45 years, which appears on page 860, suggests that even more drastic action is urgently needed.

The study—conducted by Daniel Pauly and Johanne Dalsgaard of the University of British Columbia in Vancouver and colleagues at the International Center for Living Aquatic Resources Management in Makati, the Philippines—concludes that humans are inexorably fishing down marine food webs as larger and more commercially valuable species disappear, creating impoverished, less valuable ecosystems. Complete fishing bans currently apply to less than 1% of the world's fishing grounds, but fisheries experts say the findings of this new study indicate that more such protected areas must be created if there is to be any chance of salvaging vanishing ecosystems. "Most researchers work at the fishery or species level, but this study looks at the global picture and reveals just how unsustainable our exploitation of marine resources is. It's a wake-up call," says marine researcher Elliott Norse, president of the Marine Conservation Biology Institute in Redmond, Washington. (See Research Commentary on p. 821.)

To come to this conclusion, Pauly, Dalsgaard, and their colleagues first used an analysis of the diet of 220 key species to assign to each species of catch a trophic level, a rating describing its location in the food chain. Trophic level 1 comprises the primary photosynthetic plankton, while a top predator, such as the snappers inhabiting the continental shelf off Mexico's Yucatán Peninsula, gets a rating of 4.6.

Then, the team analyzed data collected by the United Nations Food and Agriculture Organization on catches in the world's major fisheries from 1950 to 1994 to determine whether the trophic levels had changed with time. This showed that there had been a gradual shift from long-lived, high-trophic–level fish (such as cod and haddock) to low-trophic–level invertebrates and plankton-feeding fish (such as anchovy). Overall, the researchers found a steady mean decline of about 0.1 trophic levels per decade in the worldwide catches. What's more, Pauly says, "this is probably an underestimate, as catch measurements from the tropics are poorly recorded."



SOURCE: D. PAULY *ET AL.*

Bouncing back. Fish stocks recovered 2 years after a small reserve was set up off St. Lucia.

The results also indicate that the quantities, as well as the quality, of the catches are decreasing. At first, skimming off the top of the food chain and then moving down to lower trophic levels can lead to increased catch sizes, because top predators require a large reservoir of prey to sustain them. But the new research shows that, in most instances, when the top predators are removed, catches stagnated or declined, apparently because the populations of the predators' competitors for food expand. "The Black Sea provides a good example," Pauly says. "There's been a huge increase in jellyfish as their economically valuable competitors have been removed."

As a result of this overfishing, the number of main fisheries in the Black Sea has fallen from 26 in the 1970s to five now, says Norse. "Present fishing policy is unsustainable. The food-web structure is changing," says Pauly. "At least 60% of the world's 200 most commercially valuable species are overfished or fished to the limit," says Claude Martin, director-general of the World Wide Fund for Nature.

Pauly argues that there is an urgent need to create protected areas, where fishing is not allowed. Although other measures, such as quotas, limiting fishing time at sea, changing fishing gear, and controlling pollution are crucial, they are difficult to implement quickly and control, he says. And there is growing evidence that protected areas can be highly effective in restoring and maintaining marine ecosystems. Such areas on the Georges Bank off Massachusetts were created only in 1994, but researchers are already finding an increase in the size and spawning populations of key fish species, as well as a rapid increase in the bottom-dwelling scallop population, says a spokesperson for the National Marine Fisheries Service in Woods Hole, Massachusetts.

Even tiny protected areas can be very effective in some regions. Callum Roberts of the University of York in the United Kingdom says reserves of just a few hectares on tropical coral reefs have boosted fish stocks and helped maintain long-lived large predators.

The fishing industry is also now beginning to back this policy. In the United Kingdom, the industry now backs plans for no-fishing areas as a key way to develop the European Union's fishing policy in the face of declining stocks, says Roberts. "At the very least, they can offer quick and simple protection while the complexity of long-term sustainable fishing policies are developed," says Norse.

But Pauly's results have set a clock ticking on the development of such policies. "In 30 to 40 years, our fisheries could have moved down another 0.5 of a trophic level in overall catch, which is an enormous change," he says. "If things go unchecked, we might end up with a marine junkyard dominated by plankton."

–Nigel Williams