

ECOLOGY

How a Little Fish Keeps Overfished Ecosystem Productive

From a food-web perspective, jellyfish are typically considered a dead end. Few organisms are thought to eat them, so they tend to sink to the ocean bottom, where they slowly decay, their carbon and energy wasted. But off the coast of southwest Africa, researchers have discovered that a small fish called the bearded goby feasts on jellies, and in doing so, helps to sustain seabirds, mammals, and larger fish in that ecosystem. On page 333, they describe this fish's unusual lifestyle, which includes hiding out on the muddy sea floor in water toxic to other fish. "An interesting and counterintuitive new food web [was] created by the [recent] jellyfish bloom," says Roberto Danovaro of the Polytechnic University of Marche in Ancona, Italy. "Certainly similar mechanisms are happening in many

gorged on the now-abundant plankton, and their numbers exploded.

At the same time, the numbers of bearded goby, *Sufflogobius bibarbatus*, a big-headed fish that grows to about 13 centimeters, increased. With sardines gone, the goby became the main prey of the hake and horse mackerel, as well as food for seabirds, penguins, and seals. Mark Gibbons of the University of the Western Cape in Cape Town, South Africa, and his colleagues were curious about how the goby is able to thrive in such an inhospitable ecosystem. They recruited two goby experts, Anne Utne-Palm and Anne G. V. Salvanes of the University of Bergen in Norway, to help make sense of this little fish.

Gibbons, Utne-Palm, Salvanes, and a cadre of students did a series of field and lab studies of the goby's habits and habitat. They also characterized the water column, assessing the oxygen content and amount of hydrogen sulfide at various depths. "The various elements combine to tell a compelling story," says Andrew Brierley, a marine ecologist at the University of St. Andrews in the United Kingdom.

Most of the region's sea bottom is covered by a thick mud rich in hydrogen sulfide and the bacteria that utilize this toxic gas. Little life exists in the bottom 20 to 60 meters of water, where oxygen levels are less than 10% of the expected level. The goby's predators, for example, can't survive there.

But echo soundings and trawling over a 24-hour period indicated that's where the gobies hang out during the day, Gibbons, Utne-Palm, Salvanes, and their colleagues report. Tests in aquaria with low levels of oxygen showed that these fish stop pumping water and oxygen over their gills in this hostile environment, in a sense holding their breath. Then at night, they ascend to where oxygen levels are higher, catch up on their

breathing, and spend time with jellyfish and other organisms.

Many fish, including one of the goby's predators, the horse mackerel, avoid jellyfish. But fishers find jellyfish associated with bearded goby six times more frequently than other fish, says Utne-Palm, and in the lab, gobies frequently hang out among a jellyfish's tentacles or on its bell. She thinks by swimming among the jellyfish, the goby shields itself from potential predators. Its thick, slimy skin may protect it against jellyfish stings.

The jellyfish apparently provide more than shelter: When the researchers examined the stomach contents of gobies and the stable isotope ratios of their tissue—which mimics that of the food they consume—they found that jellyfish represent up to 60% of the goby's diet. Up to a third of the rest comes from sulfur-containing bacterial mats on the sea floor or other components of the mud: The stomachs were often full of diatoms and worms called polychaetes. "It's feeding on things that usually fish don't feed on," says Utne-Palm. "They are bringing dead-end products back into the ecosystem, making the ecosystem more productive than it would be otherwise."

What gets eaten on the bottom gets digested later on, when fish then reoxygenate their tissues. Fish caught at the bottom had undigested stomach contents, whereas those caught at night had begun to process what they had eaten.

Lab experiments also showed that a low oxygen level doesn't impair gobies' behavior or damage their heart the way it does their predators. These fish can also survive what for other organisms are intolerable concentrations of hydrogen sulfide, perhaps by not breathing at all in its presence. "This goby can deal with both low oxygen and with jellyfish and hence loves the new environment we have created for it, by fishing the heck out of everything else," says Daniel Pauly, a fisheries biologist at the University of British Columbia, Vancouver, in Canada.

Utne-Palm thinks this new food web is fairly stable and that sardines will not make a comeback anytime soon. But at least the goby is helping to keep the new ecosystem productive. "Nobody could have predicted," says Gibbons, "that an insignificant little fish could have turned out to save the day—or at least stabilized the day for us."

—ELIZABETH PENNISI



Caught together. Most fish avoid jellyfish, but not the bearded goby, which hides in and eats them.

places, likely as a result of the ecosystem shift[s] related to global change and direct anthropogenic impacts."

Until the 1970s, this 9000-square-kilometer region off the coast of Namibia was a rich fishery, particularly for sardines. It's the site of the northern Benguela upwelling, where deeper, nutrient-rich water periodically flows coastward, promoting the growth of plankton. Filter-feeding sardines kept the plankton under control, but as overfishing depleted the sardine stocks, dying plankton sank to the bottom and decayed, using up almost all of the oxygen in the water and creating a so-called dead zone. Jellyfish