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Climate Change May Shrink the World's Fish

A new study suggests warming sea temperatures could result in smaller fish sizes.



A school of blue-striped grunts seeks safety in numbers.
PHOTOGRAPH BY BRIAN J. SKERRY, NATIONAL GEOGRAPHIC CREATIVE

By Craig Welch
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Warming temperatures and loss of oxygen in the sea will shrink hundreds of fish species—from tunas and groupers to salmon, thresher sharks, haddock and cod—even more than previously thought, a new study concludes.

Because warmer seas speed up their metabolisms, fish, squid and other water-breathing creatures will need to draw more oxyen from the ocean. At the same time, warming seas are already reducing the availability of oxygen in many parts of the sea.

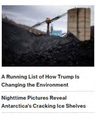
A pair of University of British Columbia scientists argue that since the bodies of fish grow faster than their gills, these animals eventually will reach a point where they can't get enough oxygen to sustain normal growth.

"What we found was that the body size of fish decreases by 20 to 30 percent for every 1 degree Celsius increase in water temperature," says author William Cheung, director of science for the university's Nippon Foundation—Nereus Program.

These changes, the scientists say, will have a profound impact on many marine food webs, upending predator-prey relationships in ways that are hard to predict. (Read about how climate change is resulting in smaller mountain goats.)

"Lab experiments have shown that it's always the large species that will become stressed first," says lead author Daniel Pauly, a professor at the university's Institute for the Ocean and Fisheries, and principal investigator for the Sea Around Us. "Small species have an advantage, respiration-wise."

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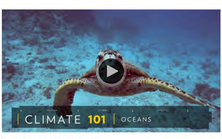
Still, while many scientists applaud the discovery, not all agree that Pauly's and Cheung's work supports their dramatic findings. The study was published today in the journal *Global Change Biology*.

Pauly is perhaps best known for his global, sometimes controversial, studies of overfishing. But since his dissertation in the 1970s, he has researched and promoted a principle that suggests fish size is limited by the growth capacity of gills. Based on this theory, he, Cheung and other authors published research in 2013 that showed average body weight for some 600 species of ocean fish could shrink 14-24 percent by 2050 under climate change.

"It's a difficult concept for people to imagine because we breathe air," Pauly says. "Our problem is getting enough food—not oxygen. But for fish, it's very different. For humans, it would be like trying to breathe through a straw."

Other scientists have linked oxygen to smaller fish sizes. In the North Sea, for example, haddock, whiting, herring and sole have already seen significant loss in size in areas of the sea with less oxygen.

Still, Pauly's and Cheung's 2013 results were criticized in some corners as overly simplistic. Earlier this year, a group of European physiologists argued that Pauly's basic premise about gill size was, itself, flawed.



CLIMATE 101: OCEANS

So Pauly and Cheung used more sophisticated models and re-examined their theory.

The new paper doubles down on their earlier case, explains the gill theory in more detail and argues that it can and should be used as a guiding principle. The new work goes on to suggests their original conclusions actually underestimated the scale of the problem fish will soon face.

The earlier paper, for example, suggested the size of some species, such as tuna, may be less affected by climate change. But the new research states that fast-swimming ever-mobile tunas, which already consume significant oxygen, may be more susceptible than some other fish.

In fact, in parts of the tropical Atlantic, Cheung says, there is a vast region where oxygen is already low in the open ocean. Other studies have shown tunas altering their range to avoid that bad water.

"Tunas' distributions have followed very closely the bounds of these oxygen minimum zones," Cheung says.

Some fish experts find Pauly's and Cheung's gill theory and new work convincing.

Jeppe Kolding, a biology professor at the University of Bergen in Norway, who studies fish in Africa, says Pauly's gill concept is the only thing he's found that elucidates the dwarfing he's seen in Nile tilapia, guppies, and a type of sardine found in Zambia and in Lake Victoria. "It does explain the phenomena I have encountered in Africa," he says.

Nick Dulvy, a marine biologist at Simon Fraser University, says his own research "tends to confirm" Pauly's ideas. "It is absolutely an inevitability that as fish grow heavier they will eventually reach a point where oxygen intake does not match their metabolic demand."

Hans-Otto Poertner, marine animal physiologist at Germany's Bremen University and Alfred Wegener Institute for Polar and Marine Research, says Pauly's work doesn't account for how well some species may acclimate or adapt to changing ocean conditions. But, he says, the authors "convincingly argue" that oxygen will affect fishes' sensitivity to temperature and curb body size.

Still, one of Pauly's earlier critics, Sjannie Lefevre, a physiologist with the University of Oslo in Norway, lead author of the critique published earlier this year in the same journal, continues to find Pauly's gill theory wanting.

"I am not at all impressed or convinced by their attempt to refute our arguments," Lefevre says, adding that she doesn't "consider the new results any more reliable."

She says fish absolutely are capable of growing larger gills. "There are no geometric constraints stopping gills from growing as fast as the body of a fish," she says.

She and Poertner could not view the work more differently. Lefevre says she hopes ecologists and modelers keep "an open and cautious mind" before accepting such unifying theories.

Poertner, on the other hand, maintains that Pauly's and Cheung's work is a great example of the right way to apply such theories.

The new research shows how "careful use of an overarching principle in a wide set of observations across species can support insight that is difficult to reach otherwise," he says.

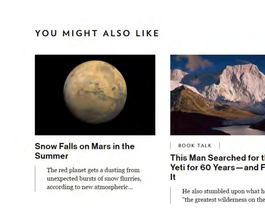
Update: The quote from Nick Dulvy has been updated to specify "metabolic demand" instead of "metabolic rate" in order to be more accurate.



Craig Welch writes about the environment for National Geographic.

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HUNGARIAN FEAST A woman straightens a decoration on the wall while others laugh and chat over dishes of duck and corn in 1930s Hungary.
PHOTOGRAPH BY RUDOLF BALOGH, NATIONAL GEOGRAPHIC

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