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Scientists Discover Global Pattern of Big Fish Diversity in Open Oceans

First global map reveals rapidly shrinking hotspots for tuna, marlin, swordfish
Diversity has declined by up to 50% over 50 years due to fishing

A new study released in *Science* (via Science Express http://www.sciencexpress.org) on July 28th reveals a striking downward trend in the diversity of fish in the open ocean – the largest and least known part of our planet. Teasing apart the effects of climate change and fishing over the past 50 years, the authors show a clear link to overfishing and highlight a surprising global pattern of open ocean hotspots - areas with predictable congregations of tuna, marlin, swordfish, and other ocean predators.

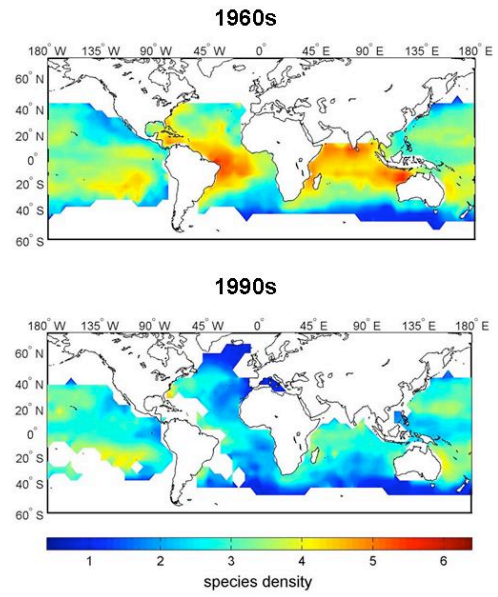

Figure: Changes in the number of species found on a standard longline in the 1960s and 1990s.

Scientists say these hotspots - off the east coasts of the US, Australia, and Sri Lanka; south of Hawaii; and in the South-Eastern Pacific – provide new insight into the structure of life in the open ocean and a focus for conservation efforts. Perhaps most surprising is the discovery that patterns of big fish diversity match those for tiny zooplankton, and both are linked to sea surface temperature. "This is the great joy of science," says first author Boris Worm. "It is like solving a giant puzzle and seeing the night sky in constellations for the first time – even as the stars are blinking out. It's beautiful – and tragic at the same time."

In a sequel to their groundbreaking study in *Nature* in 2003, showing the depletion of 90% of the big fish in the ocean, co-authors Boris Worm and Ransom Myers of Dalhousie University reveal that overfishing has not only reduced the number of fish in the sea, but also the variety: the diversity of tuna, marlins, and swordfish in the oceans has declined by up to 50% in the last 50 years.

"Everywhere you go, in every ocean basin, our "hotspots" today are only relics of what was once there," says Worm. "It really hurts to see this."

In the first global mapping of predatory fish diversity in the open ocean, the international team of scientists show where the diversity of the big fish was greatest 50 years ago – and the dramatic contrast of what remains today. The ocean off Northwest Australia, for example, was once the world's most diverse area for species of tuna and billfish – and an important tuna spawning ground. Now it is indistinguishable from the rest of the ocean.

The loss of diversity means that where fishermen might have once caught 10 different species in an area on average, now they catch only five. "It's not yet extinction; it's local fishing out of species," says Myers. "Where you once had a range of a species in dense numbers, now you might catch one or two of a certain species."

While other studies have looked at local or regional populations of fish over time, it has been difficult to discern the underlying cause of decreases or increases of catch. This study is the first to step back to examine climate impacts and fishing in unison at a global scale. It shows that environmental changes affect fish populations year-to-year, but overfishing is the primary driver of long-term declines in the variety of big fish.

"This study brings to the surface something that was buried," says Daniel Pauly, a fisheries biologist from the University of British Columbia Fisheries Centre. "The long-term trend of decline is not discernable at first because there are lots of things happening – like the short-term effects of El Nino."

"We know there are decadal patterns in climate and ocean ecosystems," adds Nathan Mantua of the University of Washington's Climate Impact Group. "If this were the only factor, we might expect declines to be quickly reversible. What they've shown here is that we're on a curvy one-way street, with clear trends towards a reduction in biodiversity. There is real cause for alarm here."

Scientists say losing the variety of fish does not bode well for the future health of open oceans. A robust portfolio of different species is a key to maintaining our supply of fish in the long term and the ability of these living resources to rebound from environmental changes.

Open Ocean Hotspots

Coral reefs have long been known for their rich diversity of fish and invertebrates, but examining the diversity of highly mobile fish in the open ocean has been elusive. Using the only global data set stretching back to the 1950's – Japanese longline fisheries data – and cross referencing these data with scientific observer data from the US and Australia, this study is the first to map communities of these open ocean travelers.

Pelagic longlines are the most widespread fishing gear in the open ocean – baited lines up to 100 km in length that catch a wide range of predators. While they target tuna or billfish, they catch many other species too, including sharks, sea turtles and seabirds. To see whether findings based on the Japanese longline data could be applied to a wide range of species, the authors examined independent scientific observer data collected by U.S. and Australian government agencies between 1990-99, which recorded more than 140 species in these same areas. The results suggest that tuna and billfish are indicators of wider patterns of diversity.

The emerging global hotspots map is a product of oceanographic patterns, but also of history, showing the distribution of big fish though space and time. It reveals that some areas recognized today as good fishing are perhaps even more important than we realize – which makes it all the more urgent to protect these last remaining bits, say the authors.

Today the east coast of the U.S., just south of Cape Hatteras and along the east coast of Florida, harbor some of the most important areas for big fish, as does the open ocean south of the Hawaiian Islands. The Southeast Pacific, particularly north of Easter Island; waters near Sri Lanka in the Indian Ocean; and the ocean east of the Great Barrier Reef in Australia also contain some of the best areas left.

"In fact, much of the east coast of the U.S. is really a hotspot," says Myers. "And this extraordinary pattern of diversity right off Florida needs to be appreciated and protected. We know that there has been a big shift already – we are replacing big tuna and billfish with things like snake mackerel and pelagic stingrays. This is a fundamental change in the world's oceans."

To understand what creates these patterns of diversity, the scientists collaborated with oceanographers to examine different open ocean "habitat" features. Sea surface temperature and the level of oxygen in the water were the most important factors in determining where the big fish in the open ocean congregate. These hotspots were mostly in subtropical areas with warm waters, sufficient oxygen, and sharp temperature gradients that serve to aggregate food supply such as zooplankton and small fish.

"The peak in big fish diversity is at middle temperatures," says Myers. "Like Goldilocks and the three bears- ocean animals don't like it too hot, or too cold, they like it just right." For these predatory fish, 22 degrees C (77 degrees F) seems to be the optimum temperature.

The only other global study of oceanic diversity is for foraminifera — tiny, single celled zooplankton. These two studies show surprising congruence. "The smallest animals in the ocean and some of the largest show the same pattern of diversity at the global scale," says Steven D'Hondt an author of the 1999 *Nature* paper on zooplankton. "I would have never woken up and said that tuna necessarily show the same diversity pattern as plankton. This study is just really neat. It tells us something about the connection of diversity and ocean structure and it shows that human activity is changing those patterns for the largest fish."

Hotspots for Conservation?

These open ocean hotspots appear vitally important for many different species, from zooplankton to tuna, and – despite shrinking – have stayed relatively constant in location over the past 50 years. This new information is timely for policy-makers as the United Nations General Assembly and Convention on Biological Diversity—who have been reluctant to put lines on the map—wrestle with how to save global fisheries and high seas diversity.

"The high seas are the least protected places on this planet – a region where legal and pirate fishers rub shoulders in the pursuit of big fish and even bigger profits," says Callum Roberts of

the University of York in the United Kingdom. "Conservationists are fighting to place some areas off limits to fishing. This study provides welcome advice on the best places to put them."

Some have doubted that marine reserves on the high seas would work because the big fish travel such great distances, but the new *Science* paper shows there are indeed consistent areas in which to prioritize conservation efforts. Overlaying detailed information on animal movements and shifts in local oceanographic habitats will help refine actual boundaries for marine parks.

Scientists hope that the global perspective provided by this paper will encourage fisheries managers to move out of a single species and single location mindset, addressing management decisions in a larger context that recognizes our cumulative and rapid impact on the ocean system.

The good news, say these scientists, is that there is hope for the future. The key pieces of the global biodiversity puzzle are still out there, including the physical structures upon which the big fish congregate. There are still a few remaining in formerly productive areas. If we allow these predators some reprieve, we could rebuild some of the lost biodiversity.

"Our paper suggests there is a solution – while some hotspots have already disappeared, there are still some very special places where species concentrate," says Worm. "We have the chance and the political measures to protect some of these areas. To me, it's the most important thing in the world right now – to keep as many pieces of the puzzle as we can before we destroy it."

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Please contact Jessica Brown at jbrown@seaweb.org or #202-497-8275 for additional information (photos, time lapse maps, and external contact) or visit www.fmap.ca/pressmaterial.php after embargo has lifted. B-roll is also available.

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