Lake Tanganyika fisheries declining from global warming

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The people in this small fishing village along the shore of Lake Tanganyika rely heavily on the small sardines from the lake for their own food and also probably sell them dried in a nearby market. Credit: Andrew S. Cohen/ University of Arizona

The decrease in fishery productivity in Lake Tanganyika since the 1950s is a consequence of global warming rather than just overfishing, according to a new report from an international team led by a University of Arizona geoscientist.

The lake was becoming warmer at the same time in the 1800s the abundance of fish began declining, the team found. The lake's algae - fish food - also started decreasing at that time.

However, large-scale commercial fishing did not begin on Lake Tanganyika until the 1950s.

The new finding helps illuminate why the lake's fisheries are foundering, said study leader Andrew S. Cohen, a UA Distinguished Professor of Geosciences.

"Some people say the problem for the Lake Tanganyika fishery is 'too many fishing boats,' but our work shows the decline in fish has been going on since the 19th century," Cohen said. "We can see this decline in the numbers of fossil fish going down in parallel with the rise in water temperature."

Lake Tanganyika yields up to 200,000 tons of fish annually and provides about 60 percent of the animal protein for the region's population, according to other investigators.

Cohen and his co-authors acknowledge that overfishing is one cause of the reduction in catch. However, they suggest sustainable management of the Lake Tanganyika fishery requires taking into account the overarching problem that as the climate warms, the algae - the basis for the lake's food web - will decrease.

Lake Tanganyika's industrial 'purse seine' fishing fleet operated in the late 20th century. This type of fishing became uneconomical 10-to-15 years ago because catches declined and people adopted less expensive catamarans for fishing. Credit: Andrew S. Cohen/ University of Arizona

Cohen and his colleagues figured out the lake's environmental history 1,500 years into the past by taking cores of the lake's bottom sediments and analyzing the biological and chemical history stored in the sediment layers.

The team's findings have important conservation implications. The largest and deepest of Africa's Rift lakes, Lake Tanganyika is famous

for the great diversity of species unique to the lake.

"The lake has huge biodiversity - hundreds of species found nowhere else," Cohen said.

The warming of the lake has reduced the suitable habitat for those species by 38 percent since the 1940s, the team found.

"The warming surface waters cause large parts of the lake's floor to lose oxygen, killing off bottom-dwelling animals such as freshwater snails," Cohen said. "This decline is seen in the sediment core records and is a major problem for the conservation of Lake Tanganyika's many threatened species and unique ecosystems."

The paper, "Climate warming reduces fish production and benthic habitat in Lake Tanganyika, one of the most biodiverse freshwater ecosystems," by Cohen and his co-authors, is scheduled for online publication in the *Proceedings of the National Academy of Sciences* the week of Aug. 8, 2016. A complete list of authors and funders is at the bottom of this release.

Previous research by Cohen's colleagues found Lake Tanganyika began warming in the mid-1800s and that the lake had warmed in the latter part of the 20th century faster than any similar time period since the year 500.

Artisanal fishing on Lake Tanganyika. Credit: Saskia Marijnissen, ©2005

The lake's fish production had also slumped in the latter part of the 20th century. Cohen has been studying the paleoenvironment of Lake Tanganyika and the surrounding region for decades. He wondered whether the drop in fish productivity was from increased fishing or because the lake was getting warmer.

In tropical lakes, increases in water temperature reduce the seasonal mixing between the oxygenated top layer of the lake and the nutrient-rich but oxygen-free bottom layer of the lake, Cohen said. Fewer nutrients in the top layer mean less algae and therefore less food for fish.

In addition, as a tropical lake warms, the mixing doesn't reach as far down into the lake. As a result, the oxygenated top layer becomes shallower and shallower. As the top layer gets shallower, the oxygenated area of the lake bottom shrinks, reducing habitat for bottom dwellers such as molluscs and arthropods.

The remains of fish, algae, molluscs and small arthropods are preserved in the annual layers of sediment deposited in the bottom of Lake Tanganyika. By examining cores from the bottom of the lake, Cohen and his colleagues reconstructed a decade-by-decade profile of the lake's biological history going back 1,500 years.

Co-authors Elizabeth Gergurich and Jack Simmons analyzed parts of the cores during their independent study projects while undergraduates at the UA.

The team found that as the lake's temperature increased, the amount of fish bits, algae and molluscs in the layers of sediment decreased. Based on instrumental records of oxygen in the lake water, the scientists calculated that since 1946 the amount of oxygenated lake-bottom habitat decreased by 38 percent.

"We're showing the rising temperatures and declines in fish food are resulting in a decrease in fish production - less fish for someone to eat. It's a food security finding," Cohen said.

"We know this warming is going on in other lakes," Cohen said. "It has important implications for food and for ecosystems changing rapidly. We think that Lake Tanganyika is a bellwether for this process."

More information: Climate warming reduces fish production and benthic habitat in Lake Tanganyika, one of the most biodiverse freshwater ecosystems, *Proceedings of the National Academy of Sciences*,

www.pnas.org/cgi/doi/10.1073/pnas.1603237113