# Study shows how climate impacts food webs, poses socioeconomic threat in Eastern Africa

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The research team spent 12 days on Lake Tanganyika collecting core samples from the lake's floor. They chartered a Congolese merchant vessel, seen here, and adapted it for their research project. Credit: Michael McGlue, University of Kentucky

A new study is sounding the alarm on the impact climate change could have on one of the world's most vulnerable regions.

Michael McGlue, Pioneer Natural Resources Professor of Stratigraphy in the University of Kentucky Department of Earth and Environmental Sciences, and his team conducted the study at Lake Tanganyika—a major African fishery. The results, which published today in *Science Advances*, show how certain changes in climate may place the fishery at risk, potentially diminishing food resources for millions of people in this area of eastern Africa.

"Lake Tanganyika's fish are a critically important resource for impoverished people from four nations (Tanzania, Democratic Republic of the Congo, Burundi and Zambia) and resilience to environmental change in that region is quite low," McGlue said. "Our study revealed that high frequency variability in climate can lead to major disruptions in how the lake's food web functions."

Small pelagic fish, known locally as dagaa, are abundant in Lake Tanganyika, and their conservation is pivotal to the food security and economy of rapidly growing and largely impoverished segments of these four nations.

Dagaa feed on algae and plankton, which means greater algae production in the lake results in more fish. How this aquatic food web responds to external forces, like climate, is critical for identifying vulnerabilities and maintaining healthy fish stocks. But until now, very limited information existed on how Lake Tanganyika may respond to such forces.

To understand how the lake reacts to climate changes, the team would need detailed information on the lake's upwelling—the process by which deep waters rise and fertilize surface waters, thereby increasing algae and photosynthesis. In order to observe this, the team would have to

obtain data from well-preserved sediment cores within the lake.

McGlue and his team traveled to one of the most remote regions of Lake Tanganyika, the southern basin, on a 12-day trip to collect these cores from the lake floor.

"The winds were especially violent that season, so most of our cruise was spent taking refuge from the waves in bays near the shoreline," McGlue said. "But in the narrow window when the winds dropped, we raced out to our stations and collected the cores."

McGlue and his team would later "read" the layers of sediment.

"The chemistry and fossil content of each layer tells us a specific story about how the lake functions," McGlue said. "Limnologists (scientists who study the lake today, like our co-author Dr. Ismael Kimirei) help us to translate the information in the sedimentary record and learn how climate change affects the lake's food web."

Until now, sedimentary records from Lake Tanganyika lacked the resolution needed to accurately measure the influence of frequent climatic events, such as the El Nino Southern Oscillation (ENSO). Most sedimentary datasets are low resolution, meaning that changes can only be detected over wide intervals of time, such as thousands of years. Conditions within certain areas of Lake Tanganyika converged to provide high temporal resolution of its sediment, which McGlue and his team were the first to sample.


Lead author and University of Kentucky Professor Michael McGlue (right) and chief engineer M. Mupape celebrate the successful recovery of core LT17-2A, the first of its kind from southern Lake Tanganyika. Until now, sedimentary records from the lake lacked the resolution needed to accurately measure the influence of frequent climatic events, such as the El Nino Southern Oscillation. Credit: J. Lucas

"We were able to detect changes that were happening in Lake Tanganyika over very short intervals of time (e.g., months or years) using these sediments," McGlue said. "This is quite rare—and crucial—for using the data to guide fisheries management and conservation practices. Designing effective strategies for fisheries management using low resolution data is a challenge, because

environmental changes that affect the food web can occur rapidly."

The team observed increases in algae production due to high solar irradiance—the amount of energy from the sun that reaches Earth's atmosphere. According to the study, the convergence of high solar irradiance and La Nina results in a strong monsoon and upwelling, which increases algae in southern Lake Tanganyika. In contrast, a monsoon weakened by low solar irradiance and El Nino, as well as warmer surface waters, results in weak or absent upwelling and low algae production.

"(These samples provide) the detail that is necessary to capture abrupt change associated with teleconnective (climate) processes," said Jeffery Stone, co-author from Indiana State University.

The team says the socioeconomic threat these conditions create for sub-Saharan Africa is the most severe of any region on Earth, but they believe their findings can help guide long-term management practices.

"Armed with this knowledge, fisheries management strategies can be designed to help cope with these challenges," McGlue said.

Kimirei, who is also director-general of the Tanzania Fisheries Research Institute (TAFIRI), says the findings of this study are a critical building block toward research-informed policymaking in the Lake Tanganyika region.

"The importance of fisheries to the food security of the east and central African nations cannot be overemphasized," he said. "There is a growing body of research on declining fish production from Lake Tanganyika and other great lakes—which coupled with the findings of this study, and the ever-increasing fishing pressure—paint a gloomy future for the region. Therefore, sustainable fisheries of the lake can be achieved/maintained only if conventional fisheries management marries

with ecosystem management and conservation approaches."

Co-author Sarah Ivory, with Penn State University, says the results make clear that changes in climate can have a cascading effect on the food webs in large tropical lakes.

"The impacts of this are akin to multi-year or multi-decade droughts in agricultural systems, from a food security perspective," she said.

Andrew Cohen, with the University of Arizona, says the findings have implications beyond tropical lakes as well.

"Climate impacts on freshwater resources in the tropics are a bellwether for global change worldwide," he said.

"This work is important, because climate changes that affect food security disproportionately hurt the poor," McGlue said. "This is one way science and social justice can become interwoven."

**More information:** "Solar irradiance and ENSO affect food security in Lake Tanganyika, a major African inland fishery" *Science Advances* (2020). advances.sciencemag.org/lookup … .1126/sciadv.abb2191

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