METER
ENVIRONMENT

WHAT'S CAUSING FISH KILLS IN THE EAST AFRICAN MARA RIVER?

A SURPRISING CULPRIT

Hypoxic floods can be catastrophic for river ecosystems, often leading to widespread fish kills or other alterations in fish community composition and behavior. Hypoxia in rivers is uncommon due to the high rates of re-aeration in flowing waters, and when it does occur, it's typically associated with human pollution (high nutrient loading). However, in the East African Mara River, hypoxic flooding events are not caused by humans, but by hippos.

Over the past ten years, Dr. Christopher Dutton, aquatic ecologist at Yale University, and other researchers have documented frequent hypoxic floods and fish kills in the Mara river system. He says, "Our research shows these floods are caused by the flushing of hippopotamus pools. There are over 4000 hippopotami in the Kenyan portion of the Mara River bringing in over 3500 kg of organic carbon into the aquatic ecosystem each day. Hippo pools within the three tributaries of the Mara become anoxic under low discharge, while increases in discharge flush out the hippo pools and carry a hypoxic pulse of water through the river downstream."

Dutton and his team aim to understand the drivers of variability in these hypoxic floods and how these floods are propagated downstream in order to predict how the frequency and intensity of these events will be influenced by climate and land use change.

UNEXPECTED PATTERNS IN DISSOLVED OXYGEN

Dutton says they first noticed unusual patterns in aquatic health while working on another project. "When we started working in Kenya, we were trying to determine the environmental flows needed to maintain proper ecosystem function. We sampled from up in the forest down through the protected areas in the Masaai Mara and the Serengeti. We found the traditional indicators of water quality started to get much

worse in the protected areas. This was surprising to us because we assumed water flowing through a protected area would be getting cleaner. But after we collected enough data, we could see that dissolved oxygen was crashing on average every 12 days for 8 to 12 hours and then rebounding. We hadn't seen that in other rivers. This drew us to wonder if it was being caused by the flushing of hippo pools."

Dutton says hippopotamus pools are slack water areas on the main river channel where hippos gather throughout the day because they don't like fast moving water. He explains, "Every day they lounge in the water because their skin is sensitive to UV and gets desiccated in the sun. But at night and in the early morning, they leave the pools, go to the grassland, and eat tons and tons of grass. Afterward, they go back to the pool to rest, sleep, and defecate. They defecate so much organic matter into the river, it alters aquatic metabolism in ways that haven't yet been fully understood."

Dutton wants to understand how the organic matter and inorganic nutrients the hippos bring in are altering the ecosystem and what's causing variability in the degree of hypoxia.

WHAT'S CAUSING THE VARIABILITY?

Dutton thinks there are two likely drivers of hypoxia: time since hippo pools were flushed and the size of the rainfall driving the event. He says, "Because rainfall in the Mara region is highly localized within and among catchments, the biogeochemistry that causes hypoxia can vary among pools and tributaries. Understanding these dynamics requires fine scale spatial and temporal data on precipitation patterns across the catchment."

ATMOS 41 all-in-one weather station

Dutton is using ATMOS 41 weather stations and METER data loggers in three Mara sub catchments to monitor the intensity and frequency of rainfall during these episodic floods where rains can be highly variable in space. He's also documenting hippo pool biogeochemistry along with discharge and dissolved oxygen (DO) response in the main stem and tributaries. He's using a water quality sonde to monitor DO and turbidity. He says, "We're trying to quantify these events in the various catchments because they are different geologically. One of them has more sulfur containing rocks which causes sulfates in the water. In a reducing environment, sulfates turn into hydrogen sulfide which is toxic to fish. So we're trying to parse out what's really killing the fish in these different catchments."

He says the data show there is such high biochemical oxygen demand from the bottom of these pools, that when the organic waste and reduced compounds are flushed, they continue to suck oxygen out of the river as the waste moves downstream. This often causes fish kills in the river. He adds, "We've seen thousands of fish dead after one of these events. But interestingly, the next day, it's like it never happened. There are no fish anywhere on the bank. They've already been consumed by hyena, vultures, marabou, storks, and even lions."

DATA COLLECTION CHALLENGES

Dutton says collecting precipitation data in East Africa has unusual challenges. He says, "One of our sites is close to a hyena den. They occasionally go and unplug wires. And one of our weather stations was taken by an elephant. I concreted it in, but the elephant took it and dropped it 100 meters away."

The team avoids losing data by locating their measurement stations near tourist camps, where locals can watch over the equipment. Dutton says, "We build fences around each of the stations, and we concrete them into the ground, but our biggest strategy is putting the site close to a camp. The Kenyans that run the camps are excited to have a weather station nearby. They enjoy seeing the data and sharing it with their guests."

The secret to a long-lasting equipment setup is to locate it where people can check on it

WHAT'S THE FUTURE OF THE RESEARCH?

Dutton says the team is still working on collecting data, which is not always easy. He says, "This year, a 100-year flood occurred in the Mara which destroyed our water quality sonde. The water got so high the compression on the sonde popped out all the sensors. We lost two months of data. So we haven't yet been able to look closely at the relationships between the rainfall, the different catchments, and these crashes, but that's something we'll do as soon as we can get to the data."

He says this research is important because the Mara River system is still a natural river system essentially untouched by humans with much of its megafauna intact, which is rare. He adds, "The hippos are a very natural part of this river, and these processes we're documenting help us understand how rivers may have functioned prior to the removal of larger megafauna. In the last 50 years, there has been large scale deforestation in the upper catchment. Some people speculate that this is causing more erratic flows. So what happens when the flows become more (or less) than normal?"

Dutton recently published a peer-reviewed paper on the detailed biogeochemistry of the hippo pools in Ecosystems Journal. You can read it here. And you can read the team's first paper documenting these events published on nature.com here.

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