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New NCEAS Research Shows Nature and Humans Are Leaving Indelible Mark on Rivers and Streams, Affecting Intricate Food Webs They Support

Rivers and streams supply the lifeblood to ecosystems across the globe, providing water for drinking and irrigation for humans as well as a wide array of life forms from single-celled organisms up to the fish humans eat. But humans and nature itself are making it tough on rivers to continue in their central role to support fish species, according to new research by a team of scientists.

Globally, rivers and streams are being drained due to human use and climate change. These and other human impacts alter the natural variability of river flows.

Some impacted rivers have dried and no longer run, while still others have actually seen increases in the variability of flows due to storm floods. The end result is that humans and nature are conspiring to shorten food chains, particularly by eliminating top predators like many large-bodied fish.

"Floods and droughts shorten the food chain but they do it in different ways," said John Sabo, an Arizona State University associate professor in the School of Life

Sciences. Sabo is the lead author of the paper, "The Role of Discharge Variation in Scaling of Drainage Area and Food Chain Length in Rivers." The research was conducted at UC Santa Barbara's National Center for Ecological Analysis and Synthesis. The study appears in Science Express, the online, early publication venue for the journal Science.

"High flows take out the middle men in the food web, making fish (the top predator) feed lower in the food chain; droughts completely knock out the top predator. The end result in either case is a simpler food web, but the effects we see for low flows are more catastrophic for fish and long lasting," Sabo said.

Sabo and his co-authors, Jacques Finlay, University of Minnesota, St. Paul; Theodore Kennedy, U.S. Geological Survey, Southwest Biological Science Center, Flagstaff, Ariz.; and David Post, Yale University, New Haven, Conn., suggest that the fate of large fish should be more carefully factored into the management of water use, especially as growing human populations and climate change affect water availability.

The researchers studied the food webs that live in and depend on rivers for their survival. They studied 36 rivers and streams in the U.S., ranging in size from the Mississippi and Colorado Rivers, down to and including their small tributaries. The rivers included in the study provide water to large cities such as New York City, Minneapolis, Phoenix, Las Vegas and Los Angeles.

The study employed naturally occurring stable isotopes of the element nitrogen to measure how high top predators were in the food chain. Nitrogen provides an indicator for how high a consumer is in the food chain because it bioaccumulates, increasing by 3.4 parts per million with each link in the chain.

"Floods simplify the food web by taking out some of the intermediate players in it so that the big fish begin to eat lower on the food chain," Sabo said. "With droughts, it's completely different. They just eliminate the top predator altogether because many fish just can't tolerate the low oxygen and high temperatures that result when a stream starts drying out," said Sabo.

He added that climate change will play a growing role in coming years. "Climate is giving us a new set of operating terms to work with," Sabo said. "We will experience overall drying and greater weather variability, both of which will further shorten river food chains.

"There will be drying in some regions, particularly along the equators and increased flow in some rivers, primarily at higher latitudes," Sabo explained. "We will see more variability because there will be change in the seasonality of storms. Ocean currents are changing and the way the ocean blows storms to us is going to be different."

The human effect on rivers and streams and the food chain they support are closely tied to land-use change, such as water diversion and regulation of flows due to dams.

Sabo outlined a classic scenario that humans face during drought years. As drought takes hold, the need for water for irrigation and agriculture increases and leads to a draw down of natural river flow. The effects downstream can be devastating. Natural drying through drought is not a human effect, but withdrawal of river water during a drought is, and it can have long-term consequences.

"We would not have guessed that infrequent drought would have had a big effect on the stream, but our results show that it does," Sabo said. "We found that some streams affected by drying 5 to 10 years ago, are still missing large-bodied fishes compared to same-sized streams that never dried. Our data show that food webs can recover sooner after a flood, in roughly a year, but it takes far longer to recover in the case of drying or drought."

The study hints that competing users of the river water –– agricultural production and recreational uses, like fishing –– need to work out amenable use of rivers and streams that not only look to the immediate future, but also project long-term effects of their use.

"The question becomes can you have fish and tomatoes on the same table," Sabo said. "They compete for the same resource and society depends on both –– agriculture for grain, fruits, vegetables, and fish for protein –– particularly in the developing world.

"Humans may need to make some really hard decisions about how to allocate water so that we grow the right food, but still leave enough in the rivers to sustain fish populations," he said. "Some river fish, like salmon in the U.S., are very important commercially."

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