Early lives of Alaska sockeye salmon accelerating with climate change

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Adult sockeye salmon returning to spawn in the lakes of Bristol Bay, Alaska. Credit: Jason Ching/University of Washington

An ample buffet of freshwater food, brought on by climate change, is altering the life history of one of the world's most important salmon

species.

Sockeye salmon in Alaska's Bristol Bay region are skipping an entire year in freshwater because climate change has produced more favorable conditions in lakes and streams, which allow the young fish to grow and put on weight much faster. Previously, these fish would spend up to two years in their birth lakes before heading to the ocean, where they feed and reach maturity two to three years later. Now they are more likely to head out to sea after only one year.

These findings were published May 27 in *Nature Ecology & Evolution* by University of Washington researchers.

"Climate change is literally speeding up the early part of their lifecycle across the whole region," said senior author Daniel Schindler, a UW professor in the School of Aquatic and Fishery Sciences. "We know climate warming is making rivers more productive for the food juvenile salmon eat, meaning their growth rate is speeding up. That puts the salmon on a growth trajectory that moves them to the ocean faster."

But this "jumpstart" in freshwater doesn't necessarily benefit salmon in the long run. The same fish are now spending an extra year in the ocean, taking longer to grow and mature. This extra year at sea is likely caused by climate stressors, as well as other fish: In the ocean, wild sockeye compete for food with close to 6 billion hatchery-raised salmon released each year throughout the North Pacific Ocean. That number has grown steadily since the 1970s, when only half a billion hatchery salmon were released.

Two-year-old juvenile sockeye salmon, like this one, are becoming less common in freshwater as warmer lakes have accelerated juvenile sockeye growth, leading them to enter the ocean after only one year. Credit: Jonny Armstrong

"Hatchery fish have really changed the competitive environment for juvenile salmon in the ocean," said lead author Timothy Cline, a postdoctoral researcher at the University of Michigan who completed this work as a doctoral student at the UW. "In Bristol Bay, the habitat is totally intact and fisheries management is excellent, but these fish are living in lakes warming with climate change, then competing with other salmon for food in the ocean."

The researchers drew on nearly 60 years of Bristol Bay sockeye data to tease out these changes over time, including information gathered by scientists and students in the UW's Alaska Salmon Program. Close to

half of the world's wild sockeye is caught from this region, and more than 40 million fish usually return each year to Bristol Bay's nine river systems to spawn.

Higher temperatures in the region have caused lakes and rivers to warm up earlier each spring, fueling the growth of tiny plankton that young sockeye eat. This extra food essentially fattens up the fish a year earlier, triggering their migration to the ocean.

Wild Bristol Bay sockeye salmon are competing for food in the ocean with hatchery-released pink salmon (pictured above) and chum salmon. Credit: Jason Ching/University of Washington

This trend could negatively impact the resiliency of the Bristol Bay sockeye population, the authors said. Before, not every fish in a particular "age class" would migrate to the ocean in the same year, and any given year would see fish of different ages moving out to sea. This diversity of ages has helped the species navigate risks and survive.

But now, most sockeye are migrating at the same time, as 1-year-olds. This could devastate an entire age class if the ocean conditions happen to be poor one year. Additionally, scientists don't know how many salmon the North Pacific can actually support.

"With climate change, is there a limit to how productive the ocean will become? We just don't know where there's a tipping point, especially as we fill the ocean with hatchery competitors," Schindler said. "We need to be really cognizant about overstressing the marine resources that support wild salmon."

The lakes and streams that support wild salmon in Alaska’s Bristol Bay region are

warming rapidly. Credit: Jason Ching/University of Washington

Co-author on the study is Jan Ohlberger, a research scientist at the UW School of Aquatic and Fishery Sciences.

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More information: Timothy J. Cline et al, Effects of warming climate and competition in the ocean for life-histories of Pacific salmon, *Nature Ecology & Evolution* (2019). DOI: 10.1038/s41559-019-0901-7

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