LARGE MARINE PHYTOPLANKTON COULD BE MISSING FACTOR IN PREDICTING SALMON NUMBERS

Sarah Loftus

Editor's Note: This contribution is part of the Journalist for a Day program for the 2019 Aquatic Sciences Meeting.

Sockeye salmon contributes the largest wholesale value of British Columbia's wild salmon, and is deeply respected by indigenous peoples. Fisheries managers predict sockeye numbers and set fishing limits based on forecasting models, but managing such an economically and culturally valuable species is a challenge. Sockeye numbers in the Fraser River of British Columbia have fallen short of predictions from fisheries scientists over the past couple of decades, raising concerns about future sockeye populations and catch limits.

Oceanographers at the University of British Columbia (UBC) therefore partnered with scientists in Canada's Department of Fisheries and Oceans (DFO) to test whether lesser-studied aspects of the sockeye life cycle were connected to Fraser River sockeye productivity. The more mysterious and dispersed lives of adult sockeye in the Pacific Ocean and Gulf of Alaska are understudied, but may influence variability in sockeye models. UBC postdoctoral researcher Sarah Rosengard and Professor Philippe Tortell focused on investigating phytoplankton abundance in the ocean and its potential relation to sockeye productivity.

Rosengard presented their findings at the 2019 ASLO Aquatic Sciences Meeting. She observed a link between sockeye productivity and large phytoplankton in the Gulf of Alaska during the summer, and suggested that updating models with phytoplankton data from this region could improve sockeye predictions.

The complex salmon life cycle, which all children of British Columbia learn, hints at how many variables influence salmon populations. After 1 to 2 years spent in freshwater lakes, sockeye venture down the Fraser River and out to the ocean, thousands of kilometers from their spawning grounds. Typically in their fourth year, the fish embark on an instinctive grueling journey back up the river to spawn.

The salmon consumes zooplankton, which themselves consume phytoplankton. Previous research has linked phytoplankton biomass with salmon productivity, but these studies used average phytoplankton concentrations over large time spans or areas, or focused on phytoplankton in locations where the presence of salmon was well known. Studying phytoplankton concentrations off the coasts of British Columbia and Alaska allowed UBC researchers to find specific associations between Fraser sockeye productivity and ocean phytoplankton over time.

Phytoplankton biomass is estimated from chlorophyll-*a* concentrations, which can be approximated from light reflected off the ocean at certain wavelengths. Rosengard used publicly available chlorophyll-*a* data sets from NASA, ranging from 1997 to 2013, to determine if phytoplankton patterns relate to sockeye variability. DFO scientists Sue Grant and Cameron Freshwater developed and provided sockeye productivity data from about 20 different sockeye stocks, or groups, in the Fraser River. Rosengard, along with Michael Dowd of Dalhousie University, found a strong connection between sockeye productivity and chlorophyll concentration in a certain area of the Gulf of Alaska during summer, likely during the summer phytoplankton bloom.

Rosengard cracked open the chlorophyll-*a* data further. Her research team, including Ph. D. student Chen Zeng, previously found that chlorophyll-*a* concentrations could predict the proportion of large versus small phytoplankton at the ocean surface (field work to validate this relationship is shown in Fig. 1). If chlorophyll-*a* concentrations are high, the abundance of large phytoplankton, or microplankton, relative to small phytoplankton, or picoplankton, is likely high.

From the NASA chlorophyll-*a* data set, Rosengard divided summertime chlorophyll concentrations into picoplankton and microplankton fractions, and found they correlated even better with sockeye productivity than total chlorophyll-*a* in the Gulf of Alaska. Higher microplankton fractions were linked to higher sockeye productivity, while higher picoplankton fractions were connected to lower sockeye productivity. Results differed based on phytoplankton size likely because of food web interactions (represented in art form in Fig. 2). Microplanktons are more edible to zooplankton than picoplankton are, so higher microplankton abundances can support more food for sockeye.

These findings mean that adding summertime Gulf of Alaska microplankton proportions to sockeye models could lead to better forecasting and management of Fraser River sockeye stocks. "We hope these efforts contribute to improving

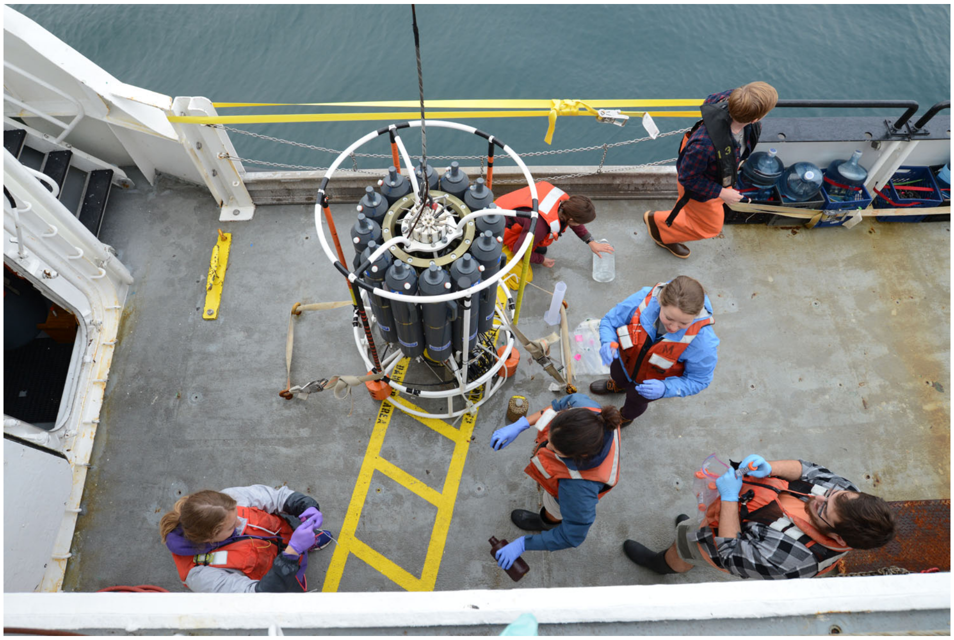

FIG. 1. Scientists onboard a research cruise take samples to measure the phytoplankton size classes in the Northeast Pacific Ocean. Photo by Frank Xavier Ferrer-González.

FIG. 2. Artwork linking phytoplankton and salmon in the Pacific Northwest. Provided by Thayne A. Yazzie, The Salish Sea Research Center, Northwest Indian College. Special thanks to Misty Peacock, Roas Hunter, and Rachel Arnold.

our understanding of sockeye productivity in the ocean," Rosengard expressed.

As 2019 celebrates the International Year of the Salmon, further research efforts are focused on discovering where adult salmon travel in the ocean. A research cruise boarded by international scientists, including those from UBC and DFO, spent time in the Gulf of Alaska to resolve sockeye numbers in this environment. "In the future we could relate their findings to oceanographic variables," explained Rosengard. "If government fisheries scientists and oceanographers worked together more, their research efforts could have better management outcomes."

Sarah Loftus, Duke University Marine Laboratory, Beaufort, NC; sarah.e.loftus@gmail.com