# DELTA SCIENCE FELLOW 2020

Delta Stewardship Council
Delta Science Program

Sea Grant California

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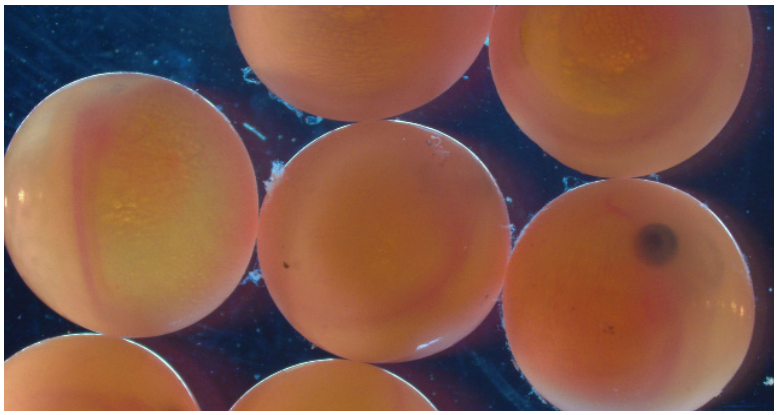
## WHY THIS RESEARCH MATTERS

Chinook salmon in California's Central Valley are at risk of extinction, and face multiple challenges including competition with humans for water resources, habitat loss, watershed degradation, and negative effects of hatchery propagation. Climate change is expected to add a new layer of stressors for Chinook salmon, including higher water temperatures and decreased oxygen concentrations in waterways. In order for natural resources managers to help support salmon recovery, it will be important to understand how these climate-related factors affect salmon, in particular in combination with each other.

# *Multiple stressors in the San Francisco Estuary and watershed: Effects of high temperature and low oxygen on the survival and physiology of early life stage Chinook salmon*



Salmon embryos under microscope.

## PROJECT

The aim of this project was to investigate the effects of elevated temperature and low oxygen encountered by early life stage salmon. The project included both a field study and a laboratory component. Del Rio and colleagues created 24 artificial salmon nests (known as redds) containing freshly spawned salmon eggs and equipment to log the water conditions. They then monitored the nests to see how many fish hatched. Using the field data, the researchers then developed a model to determine which environmental variables—such as temperature, oxygen, water flow and depth, and substrate size—best predicted hatching success.

To study how salmon are affected by warming, low oxygen, and the combination of stressors she also conducted a laboratory study where salmon eggs were exposed to one or both stressors at different developmental stages to investigate the short and long-term effects of each stressor.

## RESULTS

The field study found that overall, hatching success was low and variable. The results indicated that both egg quality and environmental conditions were important in hatching success. They found that the model of environmental variables could explain approximately 40% of the variability in hatching success. Through the data loggers, the researchers were able to collect valuable fine-scale data for temperature and dissolved oxygen, capturing greater variability than they would have had with manual measurements. The study showed that in addition to temperature, other water quality variables such as hypoxia are important in spawning success.

The laboratory study found that salmon embryos were most sensitive to the combination of warming and low oxygen shortly before hatch. Exposure to warming and/or hypoxia during embryonic stages also had lasting effects on the physiology and development of salmon during larval and juvenile stages, even when the stressors were no longer present, indicating sublethal effects may be important to consider.

## MANAGEMENT APPLICATIONS

The study identified water quality variables that can be targeted in salmon management plans in addition to temperature, especially plans that aim to support early life stages of salmon in their freshwater habitat. Differences in water quality and survival observed across salmon spawning habitat can be used to identify areas for spawning habitat restoration efforts. The laboratory study found that salmon embryos were most sensitive to stressors shortly before hatching, which could inform water management strategies that can allocate water for salmon embryos when they need it most. The long-term effects of developmental exposure to stressors also suggest that sublethal effects should be considered for salmon in the Bay Delta system in addition to lethal thresholds for water quality.

Sampling river water quality (photo by Wilson Xiong).

### SELECT PUBLICATIONS AND PRESENTATIONS


Del Rio, A. Critical windows in Chinook salmon development: Differential sensitivity to warming and hypoxia during development and long-term effects of developmental exposure. *American Fisheries Society Annual Meeting*, Reno, NV 2019.

Del Rio A. 2019. Critical windows in Chinook salmon development: Differential Sensitivity to warming and hypoxia during early development. *State of the San Francisco Estuary Conference*. Oakland, CA, October 2019.

Del Rio, A. 2020. American River Chinook Salmon Survival in Relation to Redd Water Quality: The Role of Spatial and Temporal Variability. *American Fisheries Society Annual Meeting*. Virtual, September 2020.


Adult salmon near our artificial redd in the American River

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This publication is sponsored by a grant from the Delta Science Program, part of the Delta Stewardship Council, and is based on research findings from project R/SF-96. The views expressed herein are those of the authors and do not necessarily reflect the views of the Delta Stewardship Council or any of its sub-programs. This document is available in PDF on the California Sea Grant website: caseagrant.ucsd.edu
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