Russian River Salmon Viability Under Climate Change

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Introduction and Background

Chinook Salmon migrate from the Pacific Ocean up freshwater rivers, like the Russian River in Northern CA, to spawn during a 3 month period from November to January (California Department of Fish and Wildlife). The temperature and Dissolved Oxygen (DO) of the freshwater and the amount of streamflow can significantly impact the salmon-run population, the time of freshwater entry, and duration of entry (Carter). We chose to study the impact of climate change on future Chinook Salmon which runs in the Russian River by using outputs from a coupled hydroclimate model (GSFLOW) and historical streamflow, temperature, and DO data collected at a USGS streamgage on the Russian River for the years 2000-2014. Both the salmon and their eggs need a DO level of above 9 mg/L to survive without impairment. Oxygen solubility in water decreases as temperature increases, so increasing temperature under climate change has the potential to impact the DO levels necessary for salmon to survive.

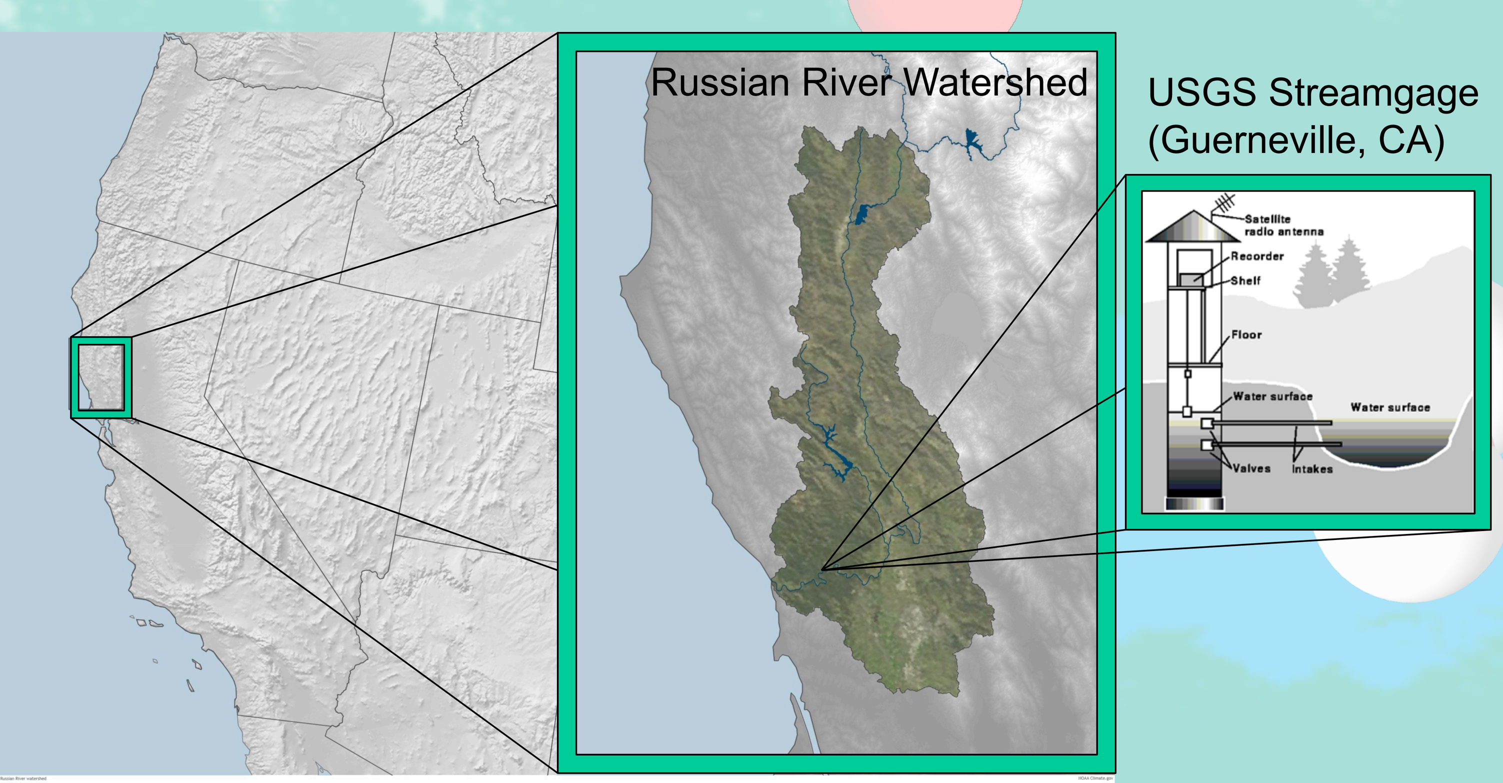
Objectives

Salmon are a vital part of the California ecosystem. Any change in their environment affects their migration and therefore, the future salmon population and survival. Our goal was to predict future changes in dissolved oxygen levels, streamflow levels, temperature levels, and population levels. We believe that as dissolved oxygen and streamflow decrease, the population will decrease, and as temperature increases, the DO level will decrease, therefore lowering salmon population.

Data Collection

Historical Data

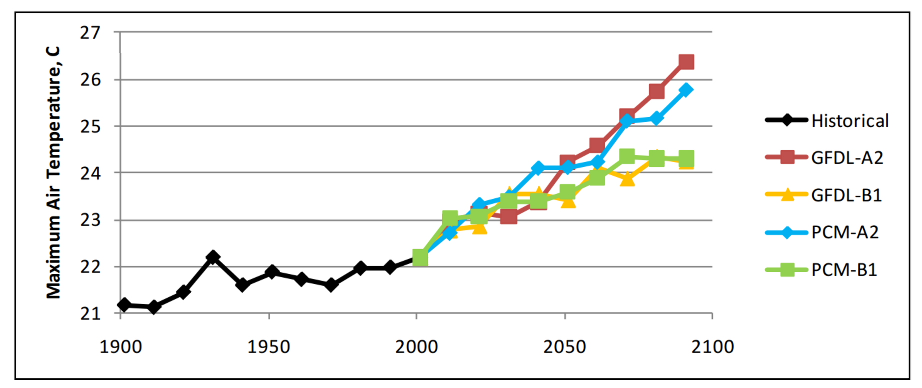
Streamflow, temperature, and DO are measured at 15-minute intervals at the USGS streamgage in the Russian River near Guerneville, CA. We downloaded the daily and monthly averages of these data for 2000-2012 from the USGS website for this study (http://waterdata.usgs.gov/nwis). We obtained historical salmon population data for the Russian River from the Nature Conservancy from 2000-2012

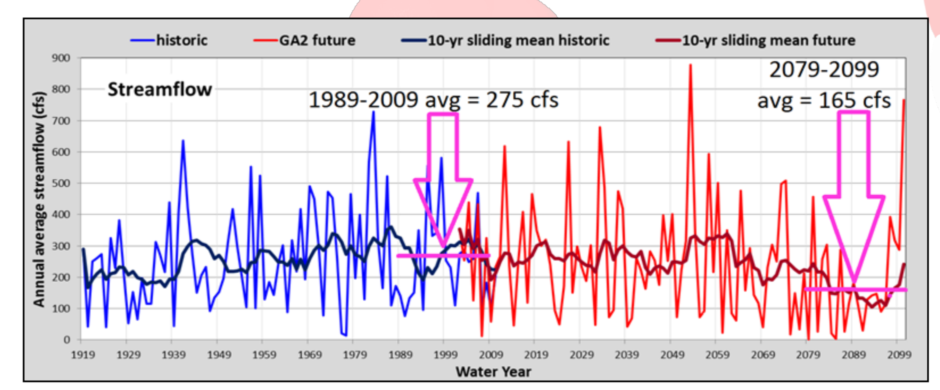


Data Collection (Continued)

GSFLOW Hydroclimate model

A GSFLOW hydroclimate model of the Russian River Basin predicts that there will be about a 3 deg. Celcius increase in temperature and about a 40% decrease in streamflow in 2050. **How will these changes the future climate affect salmon populations?**



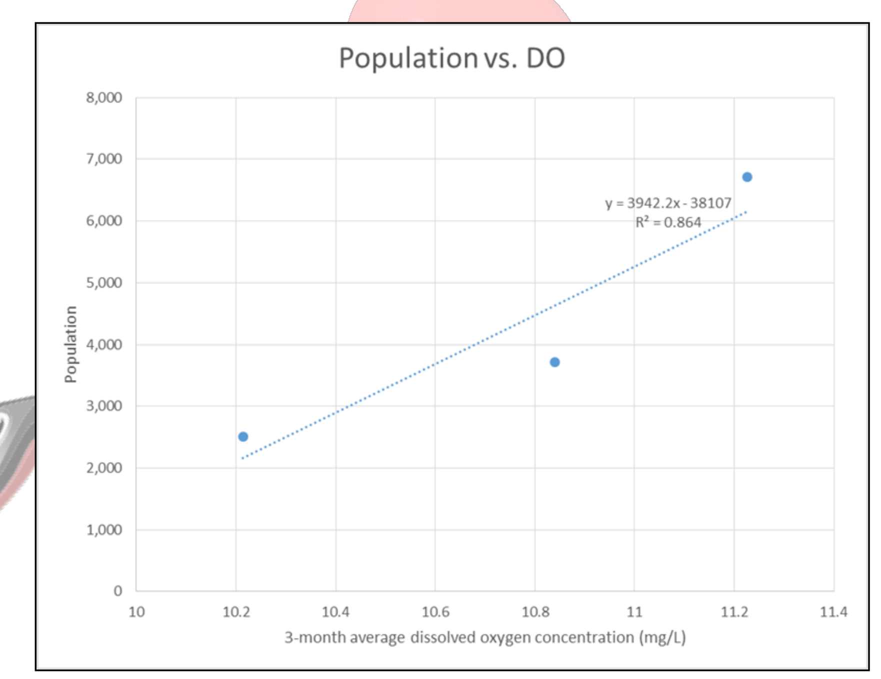


Materials and Methods

Relationships in the Historical Data

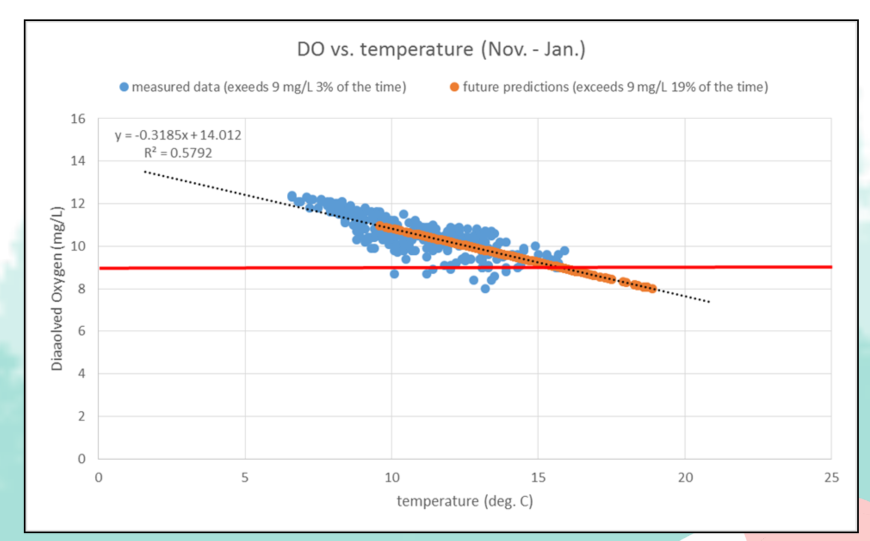
Population vs. Dissolved Oxygen (DO)

We downloaded data from the USGS on DO for the specific spawning months of November-January for years 2010-2012 (no data before 2010). We then found data on chinook salmon populations over the same course of year. We made a graph of Population vs. average DO, to see if the salmon population increased or decreased as dissolved oxygen levels changed. We used Microsoft Excel to fit a trend line to the data.



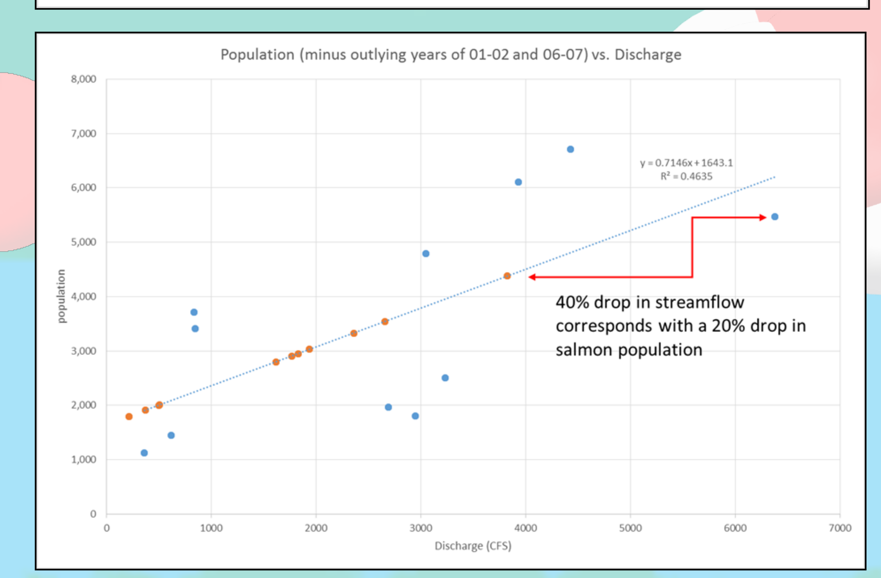
DO vs. Temperature

We then made a graph illustrating the relationship between daily average DO and daily average temperature between the specific spawning months of November-January for years 2010-2012. We included the DO threshold of 9 mgL that salmon need to survive (and that eggs need to ensure that fry are born with minimal to no birth defects) to show the approximate number of fish in danger of survival. We used Microsoft Excel to fit a trend line to the data.



Population vs. Streamflow

Finally, we made a graph illustrating the relationship between salmon population and average streamflow for each year (2000-2012). We used Microsoft Excel to fit a trend line to the data.



Future Predictions

To predict future DO, we took each data point from the DO vs. Temp. plot and used Microsoft Excel to add 3 deg. C to simulate future temperature increases. We then used the equation for the trend lines of the historical data (y = mx + b) to predict future DO for these temperatures. We used the same process to predict future populations from the trend line for population vs. streamflow plot, but instead we decreased the historical streamflow by 40% and predicted population.

Results

Historical Data

Plots of Population vs. DO, DO vs. Temperature, and Population vs. Streamflow show that there is a relationships for these variables that can be used to predict future changes.

Future Predictions

DO vs. Temperature

DO only went below 9 mg/L 2% of the time for the years 2010-2012; however, the predicted DO for a 3 degree increase in temperature will be below 9 mg/L almost 20% of the time.

Population vs. Streamflow

The average population for all the salmon runs from 2000-2012 was 3,550 fish. Population predictions for a 40% decrease in streamflow were 2,790 fish. This is about a 20% drop in population due to the decrease in streamflow.

Summary

Although there are factors we cannot fully account for, such as debris in the river, amount of decomposition occurring, and photosynthesis by plants, the salmon population is most significantly affected by DO levels and streamflow. Data points from years 2001-02 and 2006-07 were removed from our analyses due to significant deviation from the overall trend line. Anything from climate, weather, or increased human activity could have caused this variation in data. Despite varying data, we were able to prove our hypotheses correct and make predictions on the impact of climate change for future chinook salmon populations.

Resources

California Department of Fish and Wildlife

Katherine Carter, Environmental Scientist

National Oceanic and Atmospheric Administration

United States Geological Survey

Acknowledgements

Thank you most of all to my mentors, Trent and Stephen for all their help and time put into the project. Thank you to my parents for their support, as well.