Eye lenses as a potential alternative to otoliths for reconstructing life history of juvenile salmon

Miranda Tilcock[1] , Carson Jeffres[1], George Whitman[1], and Rachel Johnson[1,2]

1 UC DAVIS CENTER FOR WATERSHED SCIENCES

2 NOAA

ABSTRACT

Traditional methods use to track movement and habitat/dietary shifts in fish have relied on measuring carbon ($\delta^{13}C$), nitrogen ($\delta^{15}N$) and sulfur ($\delta^{34}S$) isotopes in different tissues (gut content, blood, organs, muscle, bone, otoliths) with varying turnover rates (days, weeks, months, lifetime) to reconstruct diet over time. Fish eye lenses are a promising alternative for chronicling shifts in fish feeding ecology. Proteins (OMP-1 and Otolin-1) are small constituents in calcium-carbonate otoliths. In contrast, lenses, are made primarily of protein. Eye lenses are small, onion like spheres that lay within the eye of a fish. Each lens is comprised of layers that continue to accumulate throughout the life of a fish. Therefore, lenses represent an ideal tissue to measure light isotopes such as carbon, nitrogen, and sulfur typically derived from diet sources which are in high concentrations in body proteins. Our study shows that this method is a promising approach to reconstruct the proportion of Chinook salmon (*Oncorhynchus tshawytscha*) that use and benefited from growth on isotopically distinct floodplains.

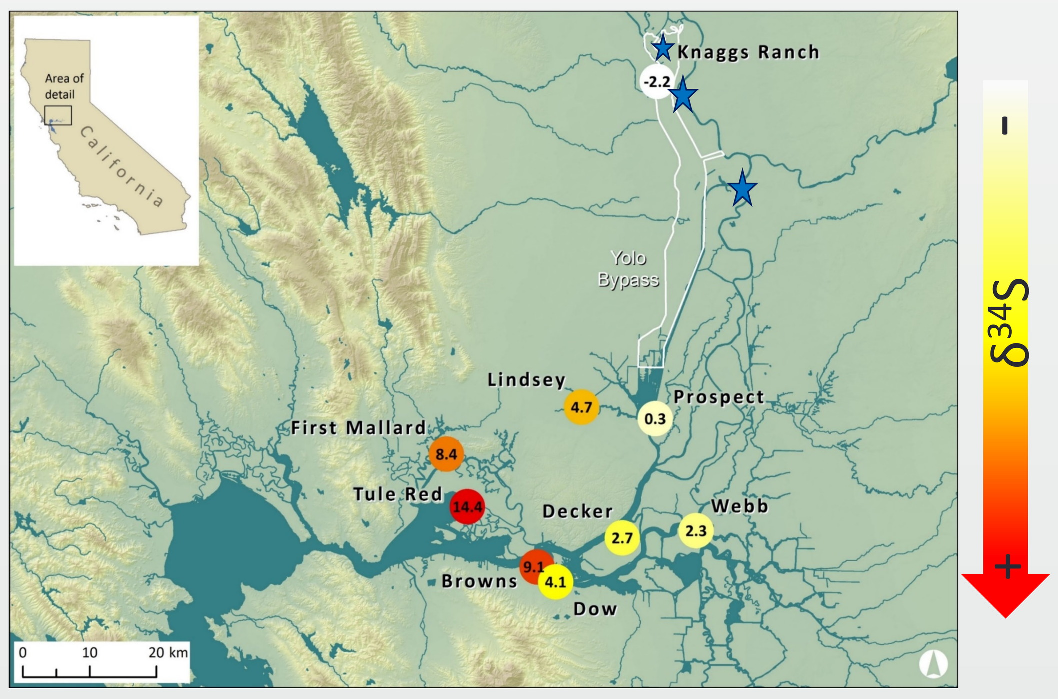
OBJECTIVES

- Compare the $\delta^{13}C$, $\delta^{15}N$, $\delta^{34}S$ isotopes in fish eye lenses among fish rearing in floodplains, tributaries, and main stem rivers
- Investigate the relationship between fish fork length and eye lens diameter using juvenile Chinook salmon of known rearing history and age.

METHODS

- A cage experiment was conducted with juvenile Chinook with a Juvenile Chinook salmon from the Feather River Hatchery were placed in experimental cages on the Yolo Bypass floodplain and Sacramento River (see star insert for locations on map);
- Fish were sacrificed from cages weekly and lengths and weights were assessed;
- Chinook salmon at liberty were also collected in the Sacramento River using a trawl;
- For each individual muscle, gut content, and fish eye lenses were extracted, placed in tin capsules, and dried for 24 hours prior to isotopic analyses at the UC Davis isotope facility;
- For lens extraction, an incision was made near the top of the eye to allow the removal of the lens and the aqueous humour;
- Lens layers from both eyes were removed within DI water and layers were consolidated for bulk analyses;
- Additional fish from each treatment group were sacrificed to assess the relationship between fork length and eye lens diameter.

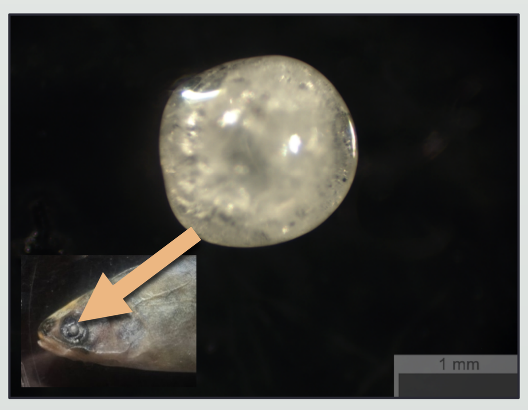
THE SULFUR ISOTOPE LANDSCAPE



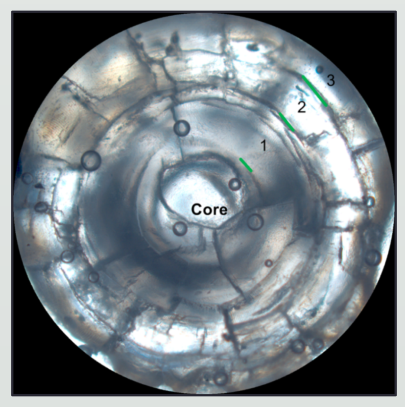
Map courtesy of Dr. Amber Manfree

Amphipods (*Gammarus sp.*) were collected from tidal wetlands with potentially depleted $\delta^{34}S$ throughout the central valley. The Yolo Bypass floodplain was the only site with an extremely depleted $\delta^{34}S$ value. Stars represent locations where fish were captured.

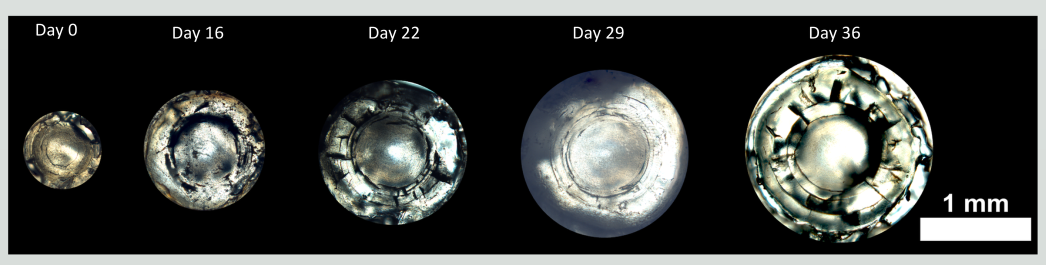
SALMON LENS FORMATION



Whole lens from a juvenile Chinook that has reared on the floodplain for 6 weeks.



Cross section of a fish eye lens shows how the lens develop layers as the fish grows.



Eye lens growth of juvenile Chinook while on the floodplain.

RESULTS

Figure 1.

Fish Growth

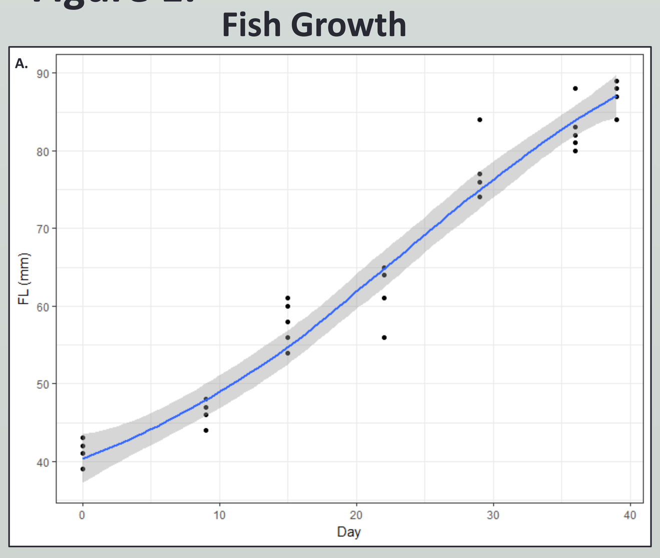


Figure 1A. Fork length growth of juvenile fish while on the floodplain.

Lens Growth

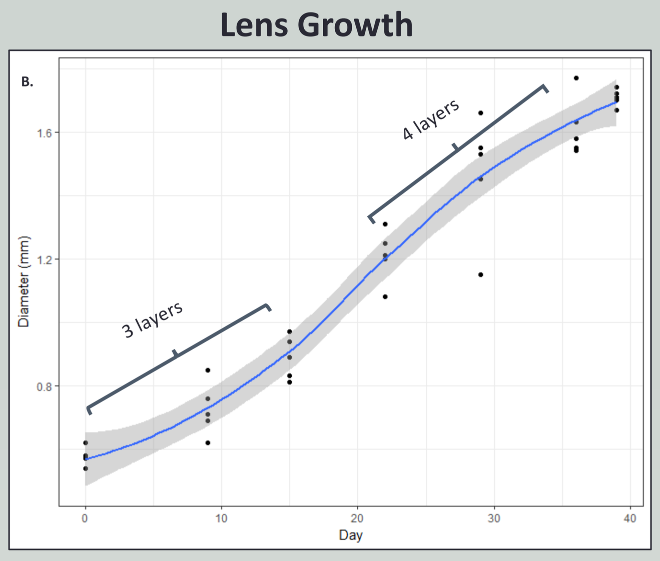


Figure 1B. Lens growth of juvenile fish reared on the floodplain with the addition of a layer at ~20 days.

Special thanks to the Yolo Basin Foundation and the Department of Water Resources for funding this work; UC Davis Stable isotope facility for analytical assistance; and the IEP Delta Juvenile Fish Monitoring Program for collecting samples.

RESULTS

Figure 2.

$\delta^{34}S$ in lenses by location

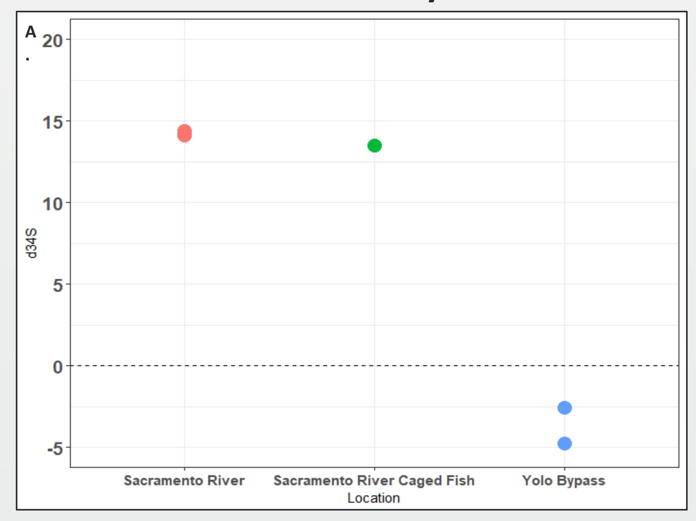


Figure 2A. Lenses from juvenile Chinook were significantly depleted on the floodplain compared to the river sites.

$\delta^{34}S$ in lenses, muscle, & stomach contents on the floodplain

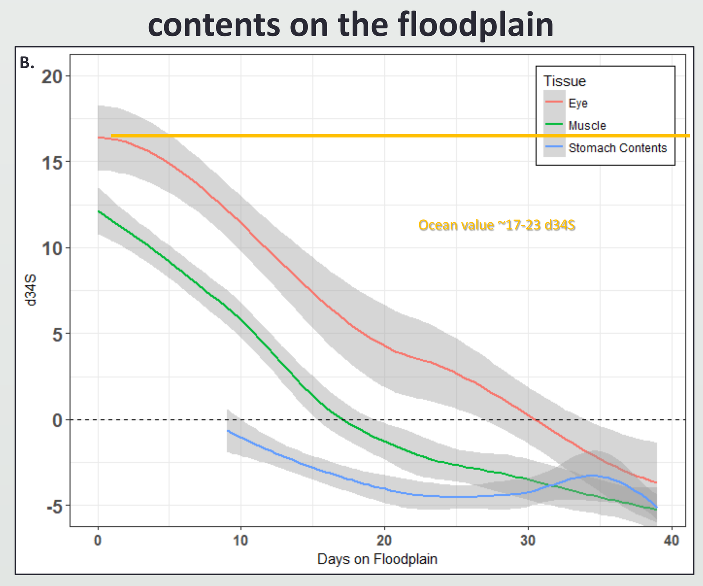


Figure 2B. Stomach contents, muscle tissue, and eye lenses reach equilibrium after ~32 days on the floodplain.

Figure 3.

$\delta^{13}C$ & $\delta^{15}N$ in lenses by location

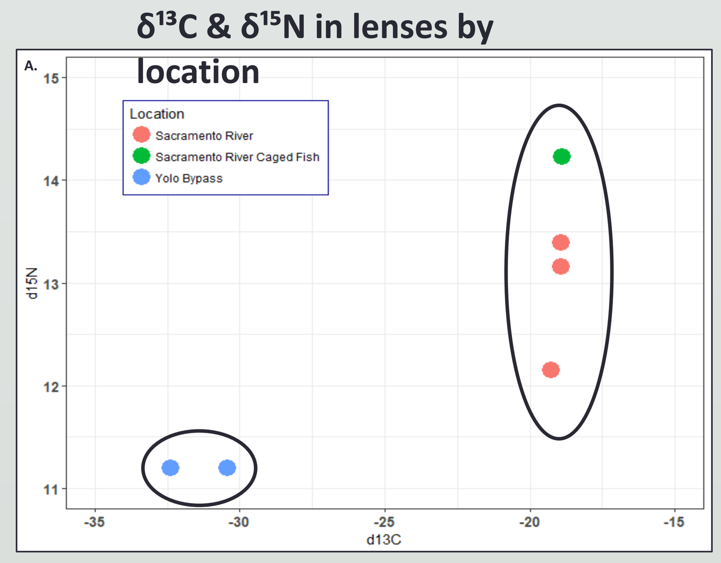


Figure 3A. The river sites show higher $\delta^{15}N$ compared to the floodplain, showing two different basil isotopic sources between the floodplain and river. The floodplain was also more depleted in $\delta^{13}C$ than the other sites.

$\delta^{13}C$ & $\delta^{15}N$ in lenses on the floodplain

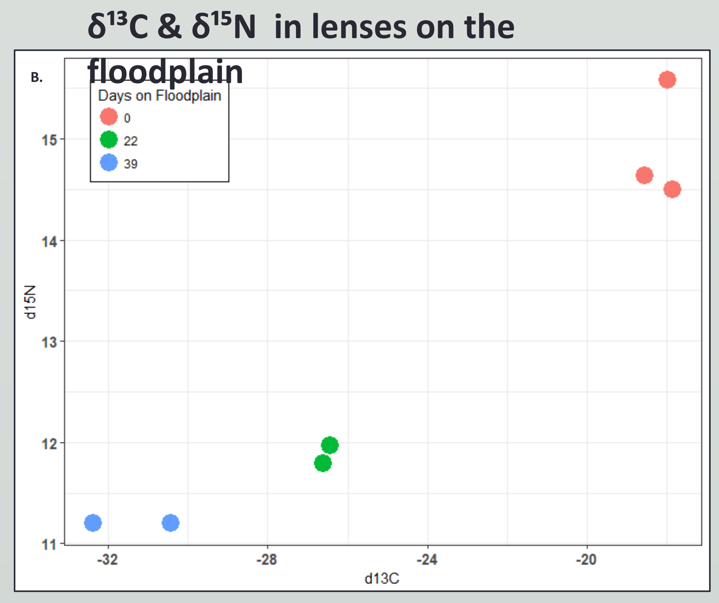


Figure 3B. Overtime, $\delta^{13}C$ becomes depleted in fish that have reared on the floodplain compared to those in the river.

CONCLUSIONS

- There is a strong relationship between fish size and lens diameter suggesting lens formation in salmon conforms to the expectation of lens growth scaling with fish growth;
- Eye lenses of fish reared in the Yolo Bypass floodplain show a distinct depleted value similar to what was seen in the isoscape created from sampling amphipods across different tidal wetland habitats;
- Eye lenses have the potential to be used as a more cost effective alternative or in conjunction with otoliths for measuring isotopic shifts in salmon diets;
- Future work will involve analyzing the isotopic composition of individual layers [instead of homogenizing all layers] to reconstruct shifts in diet and habitat over time for individual fish.