Characterizing the impacts of ocean acidification and food availability on the growth and development of juvenile pink salmon (*Oncorhynchus gorbuscha*)

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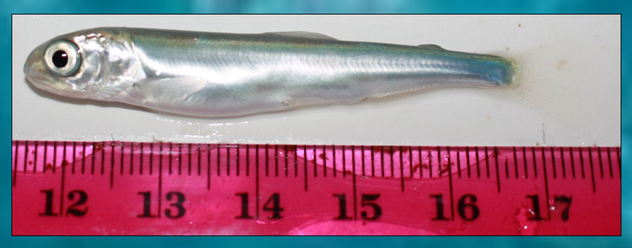

Fig. 1. Juvenile pink salmon *(O. gorbuscha*) at the 6-week mark of experimentation.

Background:

Anthropogenically produced carbon dioxide is currently fueling a long-term decrease in oceanic pH, a process known as ocean acidification (OA). Previous studies have demonstrated that OA can have a negative effect on a variety of marine organisms, particularly during early life stages. Additionally, OA can have detrimental effects on food web dynamics via removal or reduction in lower trophic level species, leading to an additional, indirect effect of OA on higher trophic level organisms. This study aims to examine the response of juvenile pink salmon (*Oncorhynchus gorbuscha*) to both the direct effects of OA, and the indirect effect of reduced food availability. Given the importance of pink salmon as a commercial resource, it is vital to characterize their response to this marine change to better inform future management of this vital Alaskan species.

Methods:

All aspects of the experimental work were conducted at the Alutiiq Pride Marine Institute for six weeks during the summer of 2021. Juvenile pink salmon from the Wally Noerenberg Hatchery in Prince William Sound were transitioned to salt water, and then divided between four treatments, with five culture vessels per treatment, and 20 individuals per culture vessel. The treatments included an ambient pCO_2 (400 µatm)/ambient food availability (3% body mass) treatment, an ambient pCO_2/reduced food availability (1.5% body mass) treatment, an elevated pCO_2 (1,100 µatm)/ambient food availability treatment, and elevated pCO_2/reduced food availability treatment. Individuals were measured every seven days for growth and development analysis, and sampled for otolith characteristics, as well as hormone and gene expression analysis.

Fig. 2. Experimental setup at the Alutiiq Pride Marine Institute (left).

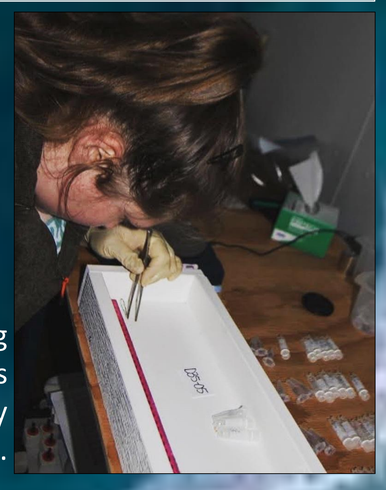

Fig. 3. Measuring individuals during weekly sampling (right).

Results:

Growth

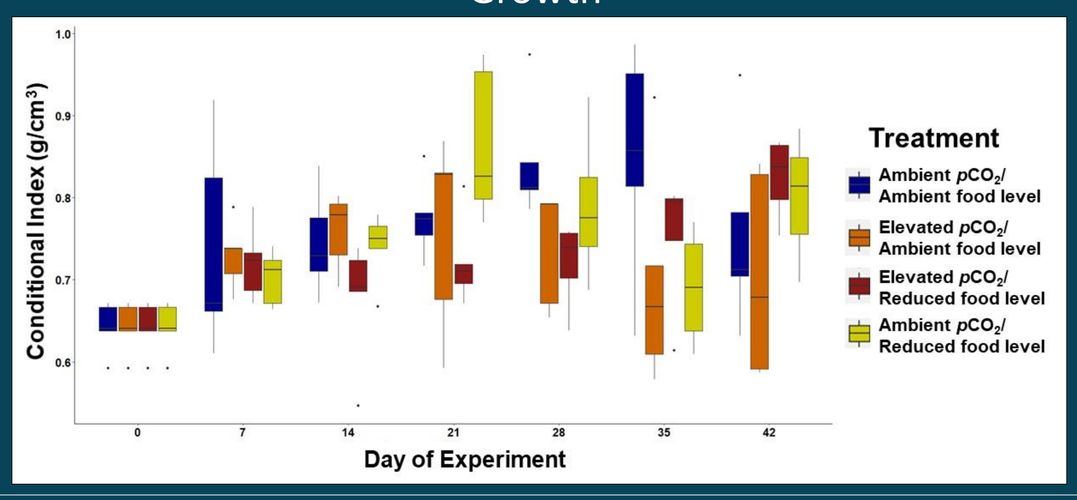

Fig. 4. Conditional index (g/cm^3) over the course of the experiment. There was a negative effect of elevated pCO_2 on the conditional index of juvenile pink salmon (p=0.001).

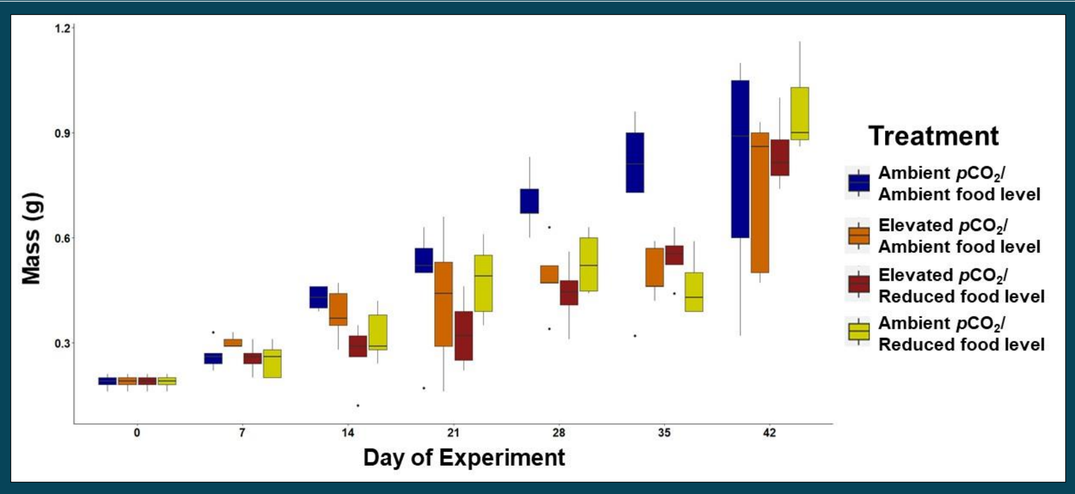

Fig. 5. Mass (g) of individuals over the course of the experiment. There was an overall negative effect of reduced food availability on fish mass (p=0.001). Additionally, there was an overall negative effect of elevated pCO_2 on the mass of fish (p=0.025).

Otolith Growth

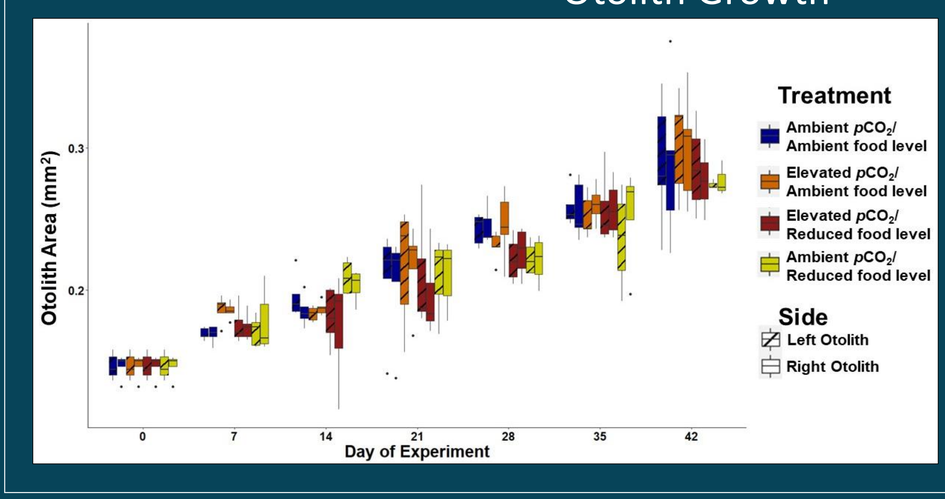

Fig. 6. Otolith Area over the course of the experiment. Overall, there was a significant, negative effect of reduced food availability on otolith area (p=0.0002).

Otolith Minerology

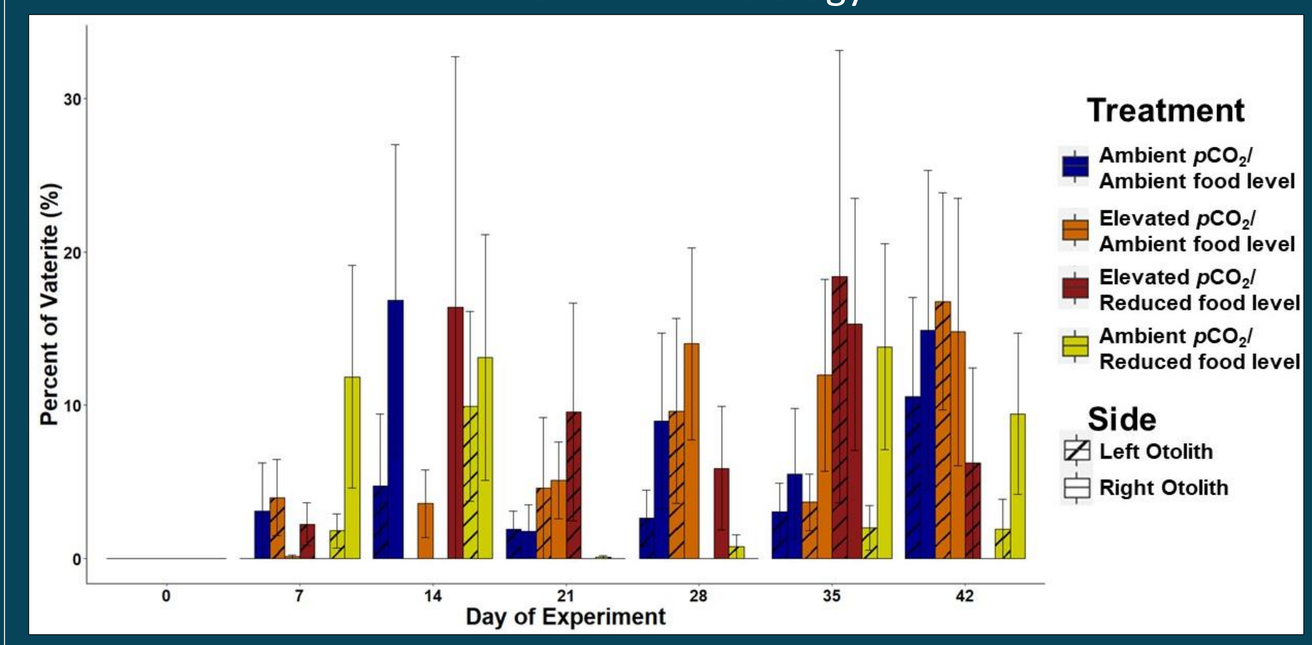

Fig. 7. Percent of vaterite present in otoliths. There was a significant effect of time on the percent of vaterite present (p=0.001), but no effect of pCO_2 or food availability.

Summary and conclusions:

I. Exposure to elevated pCO_2 (reduced pH) results in a reduction in the conditional index, and mass of juvenile pink salmon.
   I. Suggests smaller and lower quality fish under future OA conditions.
II. Otolith size (area) was reduced for juvenile pink salmon reared under reduced food conditions.
   I. Alterations to otolith development could have negative implications for organismal survival and fitness.
III. There was no significant effect of elevated pCO_2 on the percentage of vaterite present, but there was an effect of time, with individuals sampled later in the experiment having a larger percentage of vaterite present.
   I. Could potentially help in identifying critical vateritic otolith developmental patterns and timing of vaterite formation.

Project video

Acknowledgements:

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