

Effects of elevated CO₂ on lipid composition of walleye pollock (*Theragra chalcogramma*) larvae



Michelle A. Stowell^{a,b}, Thomas P. Hurst^c, Louise A. Copeman^{a,d}, and Jessica F. Andrade^{b,c}

^aCooperative Institute for Marine Resources Studies, Oregon State University, Hatfield Marine Science Center, Newport, Oregon, USA

^bMarine, Ocean, and Coastal Science and Information Group, Lynker LLC, USA

^cFisheries Behavioral Ecology Program, Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA, Hatfield Marine Science Center, Newport, Oregon USA

^dCollege of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, Oregon, USA



Introduction

- Increasing atmospheric CO₂ lowers ocean pH (more acidic) → ocean acidification

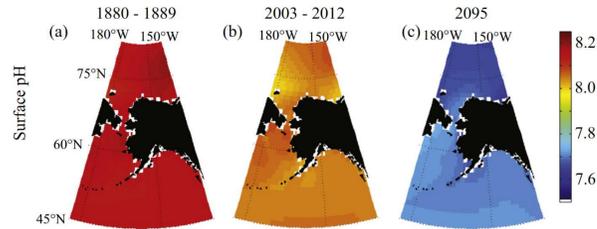


Fig. 1 Surface pH as projected by the National Center for Atmospheric Research Community Earth System Model¹.

- Our focus species: Walleye pollock

- Largest single-species fishery in U.S.A.
- Important as prey
- Early life in stable habitat → may not adapt well

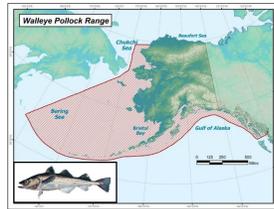


Fig. 2 Walleye pollock distribution (Alaska Dept. of Fish & Game; inset from fishbase.org).

- Resilience of larvae & juveniles to elevated CO₂?
 - Previous studies: Growth & survival are resilient^{2,3}
 - Current study: Adding lipid analyses

- Direct effects of CO₂: One piece in a larger picture

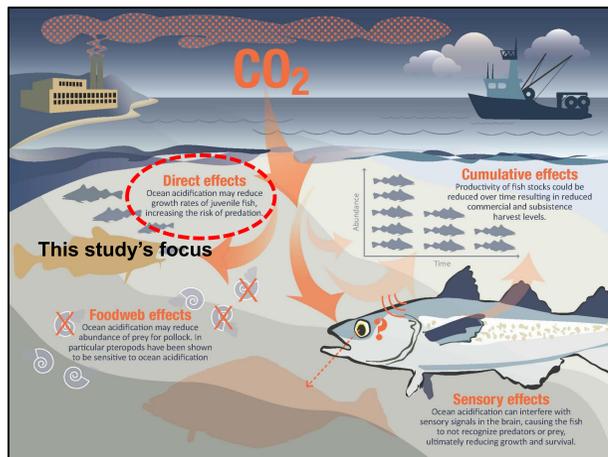


Fig. 3 Potential effects of ocean acidification on individuals, ecosystems, and populations (Dr. Thomas Hurst, Alaska Fisheries Science Center, NOAA).

Objective

Use a controlled laboratory experiment to examine direct effects of elevated CO₂ on larval walleye pollock

- Total lipid content & lipid class composition
- Fatty acid content & composition

Methods

- Two treatments: Ambient CO₂ & High CO₂

- Offspring of captive broodstock
- Egg incubation in glass jars → CO₂ exposure started at 1 DPF
- Transferred to larval rearing tanks at 9 DPF → 4 replicate tanks for each treatment
- Hatched at 10-13 DPF → exposed to CO₂ treatments for 4 more weeks
- Fed enriched rotifers (5 prey·mL⁻¹) twice daily



Fig. 4 Egg incubation setup (above) and larval rearing tanks (right).

Treatment	pH	pCO ₂ (μATM)
Ambient CO ₂	8.01	428
High CO ₂	7.57	1229

Temperature: 5.6 °C
Salinity: 31.5
Light:dark schedule: 12 hr:12 hr

- Larval sampling at 2 weeks & 4 weeks post-hatch

- Size
 - Standard length
 - Dry weight
- Lipid analyses
 - Extraction
 - Lipid class composition (TLC-FID, Iatroscan)
 - Fatty acid composition (GC-FID)

Fig. 5 Larval walleye pollock photograph for standard length determination (right top), Iatroscan for lipid class analysis (right center), gas chromatography system for fatty acid analysis (right bottom), and Marine Lipids Lab in Newport, Oregon (below).



Results & Conclusions

Total Lipid Content & Lipid Class Composition

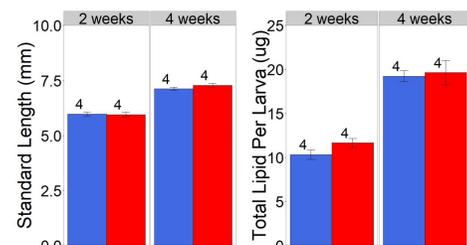


Fig. 6 Standard length and total lipid per larva, averaged over 4 tanks for each treatment and age.

- Older fish: Larger, with greater lipid content
- Higher CO₂: No effect

Conclusion: CO₂ treatment did not affect fish size and total lipid content.

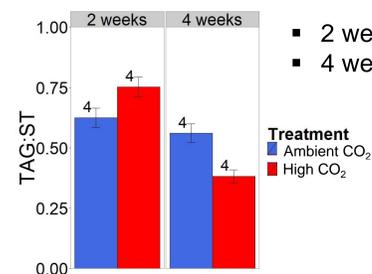


Fig. 7 Ratio of triacylglycerol (TAG, storage lipid) to sterol (ST, structural lipid) averaged over 4 tanks for each treatment and age.

- 2 weeks: Higher storage lipid at elevated CO₂
- 4 weeks: Lower storage lipid at elevated CO₂

Conclusion: Effect of elevated CO₂ on storage lipid appears stage-specific.

- Also observed for Pacific cod, though TAG:ST trends differed in directionality⁴ (species-specific)

Fatty Acid Content & Composition

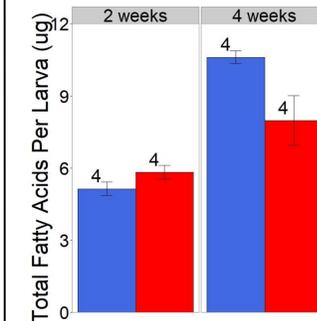


Fig. 8 Total fatty acids per larva, averaged over 4 tanks for each treatment and age.

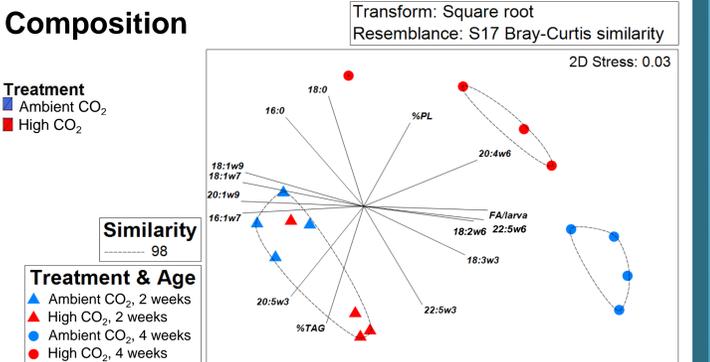


Fig. 9 Results from non-metric multidimensional scaling analysis (nMDS) showing the level of similarity among tank-mean FA proportions. Overlay shows vectors with R² > 0.75.

- 2 weeks: No CO₂ effect
- 4 weeks: Total FA content lower at elevated CO₂
- FA profiles differ most between ages (2 vs. 4 weeks)
- FA profiles also differ between CO₂ treatments
 - Larger differences at 4 weeks than at 2 weeks

Conclusion: Effects of elevated CO₂ on FA content and composition appear to take longer than 2 weeks.

Lipid analyses indicate that larval walleye pollock may be more sensitive to ocean acidification than indicated by growth and survival analyses alone, particularly at later larval stages.

Acknowledgements

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