

The Sea Star, *Evasterias troschelli*, is Adapted to Ocean Acidification and Warming in Alaska



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Introduction

Ocean acidification is a decrease in pH caused by dissolution of anthropogenic CO₂ in the oceans. The chemical changes, including a decrease in the saturation states of calcium carbonate, can have physiological effects on marine organisms. Commensurately temperatures are projected to increase. The sea star *Evasterias troschelli* is an important low-intertidal to sub-tidal predator in the Gulf of Alaska, but little is known about its sensitivity to changes in pH or temperatures

Objectives

- Determine how ocean acidification and increased temperature affect sea star
 - Growth
 - Behavior
 - Condition
 - Feeding
 - Respiration
 - Temperature tolerance

Methods

Experimental setup

- Two pH treatments (water acidified with CO₂)
 - Ambient (pH ~ 8.0)
 - pH 7.5 (Global pH predicted for c. 2200)
- Two temperature treatments
 - 8°C (current Kodiak summer maximum in cold years)
 - 14°C (2°C higher than Kodiak summer maximum in a warm year)
- Fully crossed pH and temperature treatments
- 2 years (2023, 2024)

Animals

- Juvenile *Evasterias troschelli* collected locally by hand
- Arm length average 52 ± 11 mm
- N = 24 (2023) and 14 (2024) per treatment

Holding

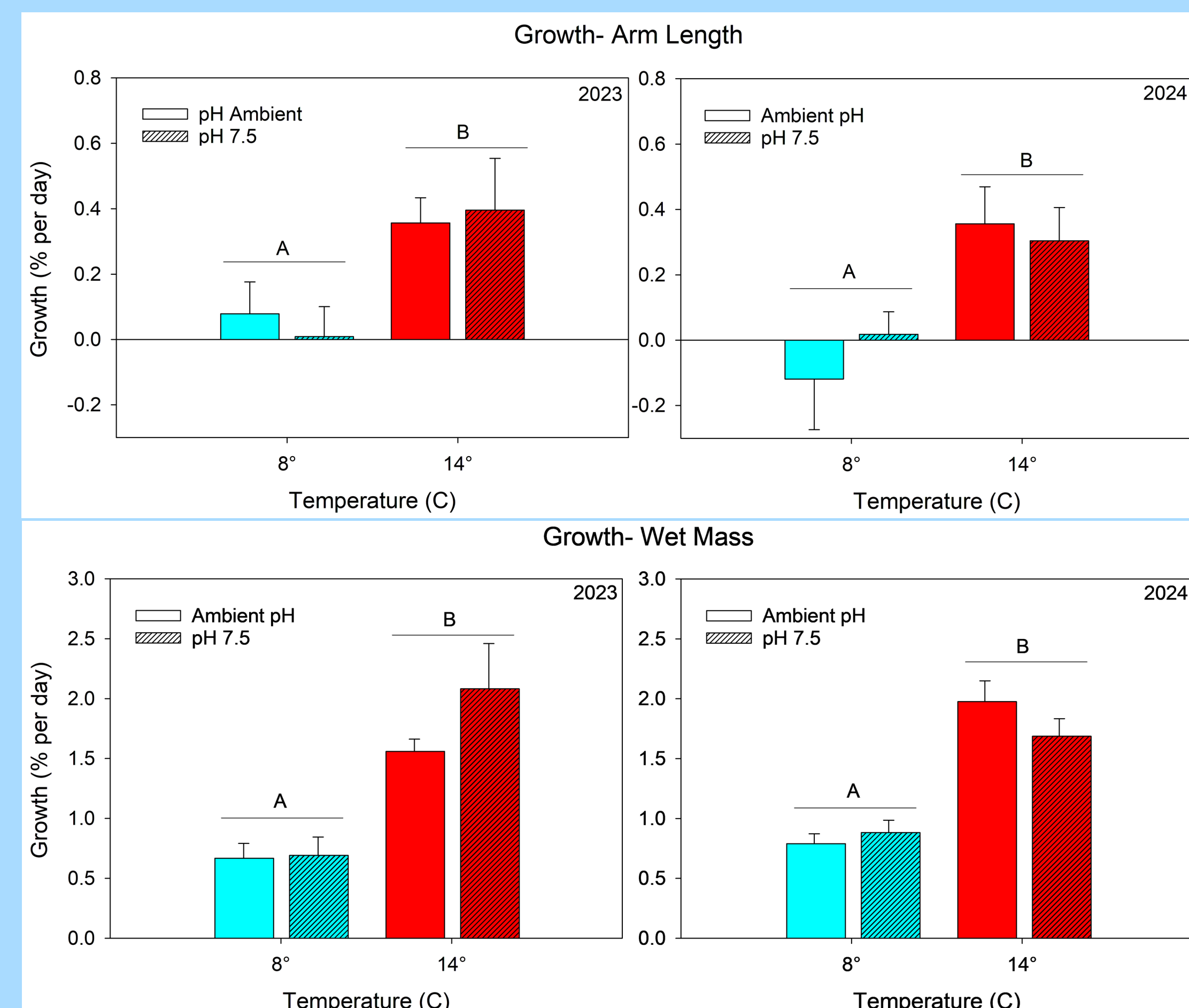
- Individual holding tubs with water flow
- Temperature and pH measured 3 times a week
- Duration 25 days (2023) and 40 days (2024)

Measurements

- Size- arm length and wet mass
 - Measured at the beginning and end
 - Growth calculated as % change per day
- Dry mass determined at the end of the experiment
- Condition index
 - Calculated at the end of the experiment
 - Using both wet mass and dry mass
 - Mass/arm length³
- Feeding ration (2024)- repeated four times
 - Given pre-weighted food
 - Allowed to feed for 3 days
 - Amount eaten normalized by mass
- Respiration rate (2024)
- Behaviors- repeated four times
 - Righting behavior when inverted (2023)
 - Food seeking (2024)
- Lethal temperature to 50% mortality (2023)
 - Beginning and end of the experiment
 - Temperature increased by 2°C every 30 minutes until all stars were dead

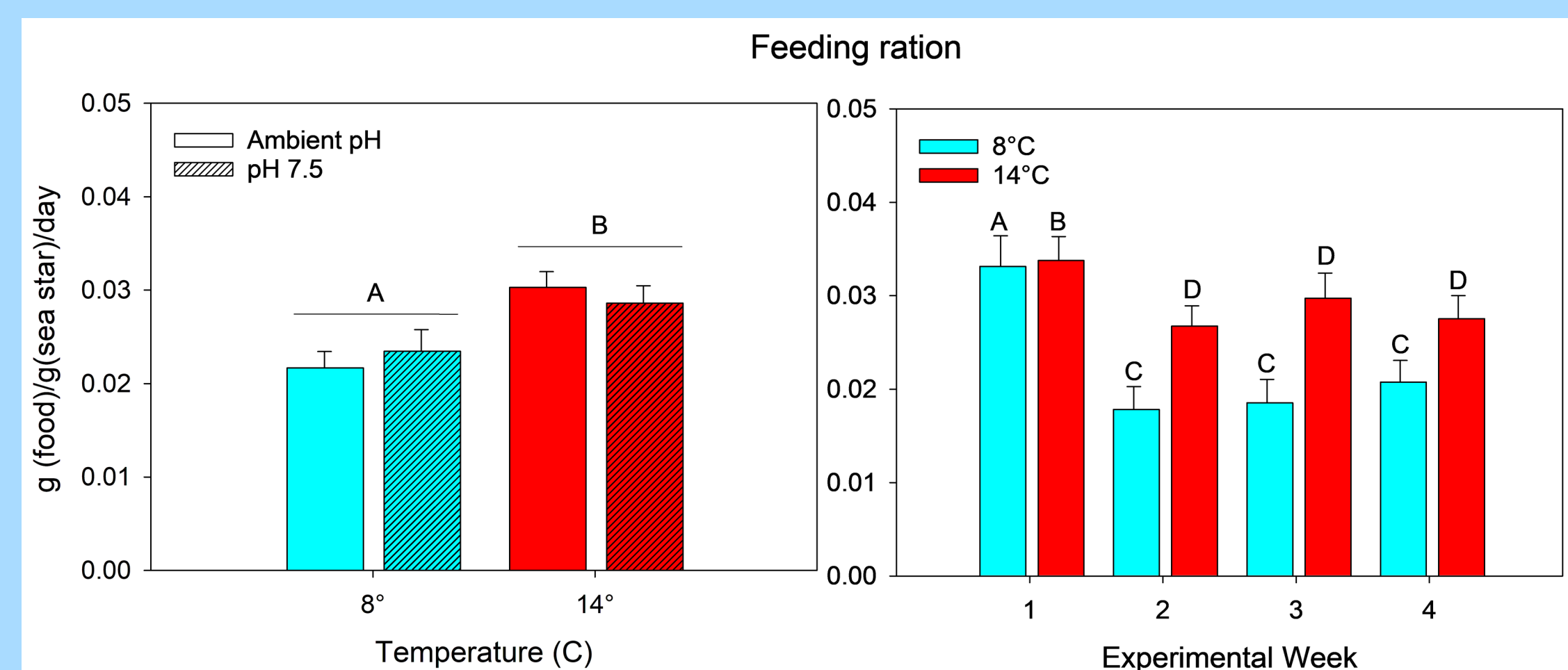
Results

Figures except for LT50 all show mean + SE. Significant difference among treatments are indicated with different letters.



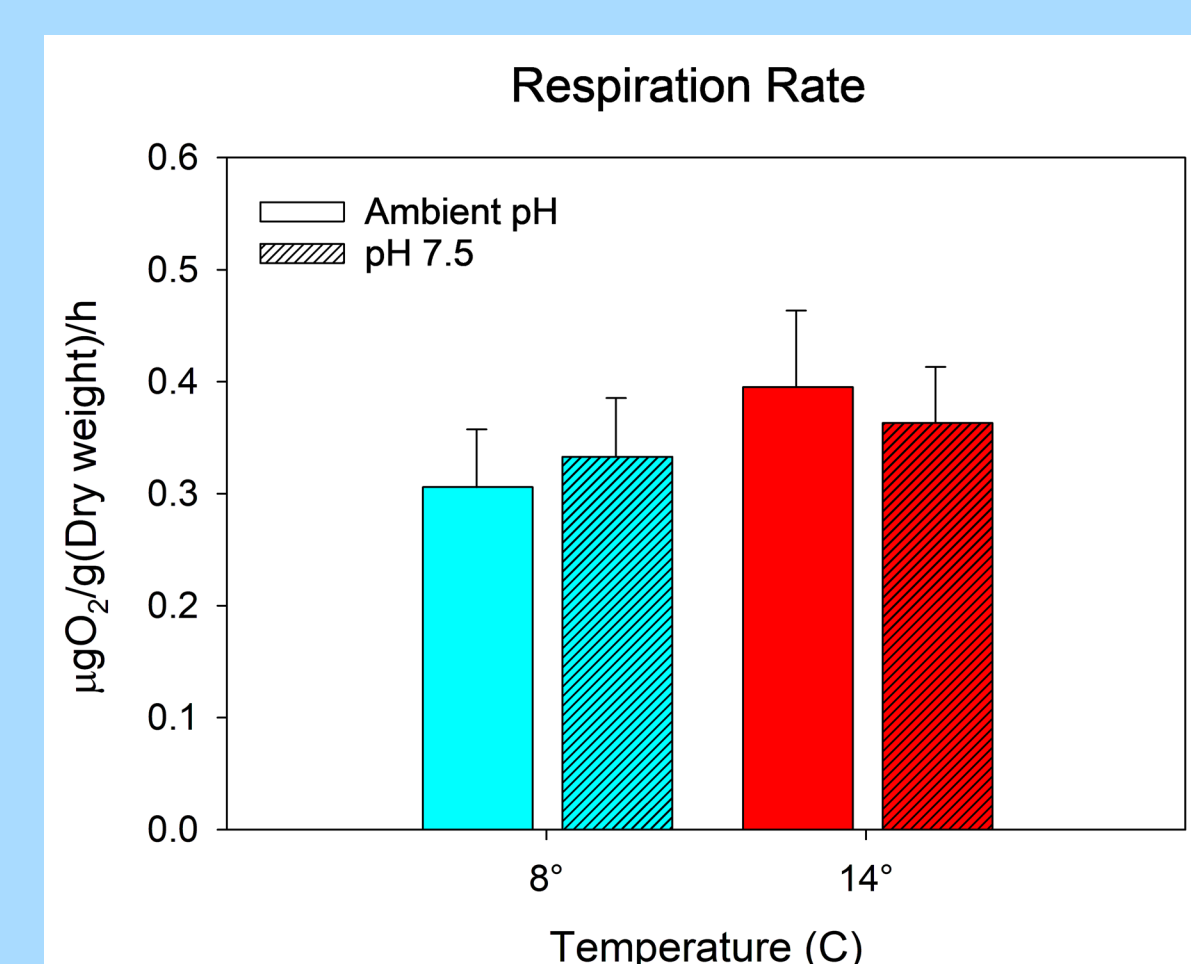
Growth

- Growth was faster at higher 14°C than at 8°C
- pH did not have an effect
- No difference between the two years



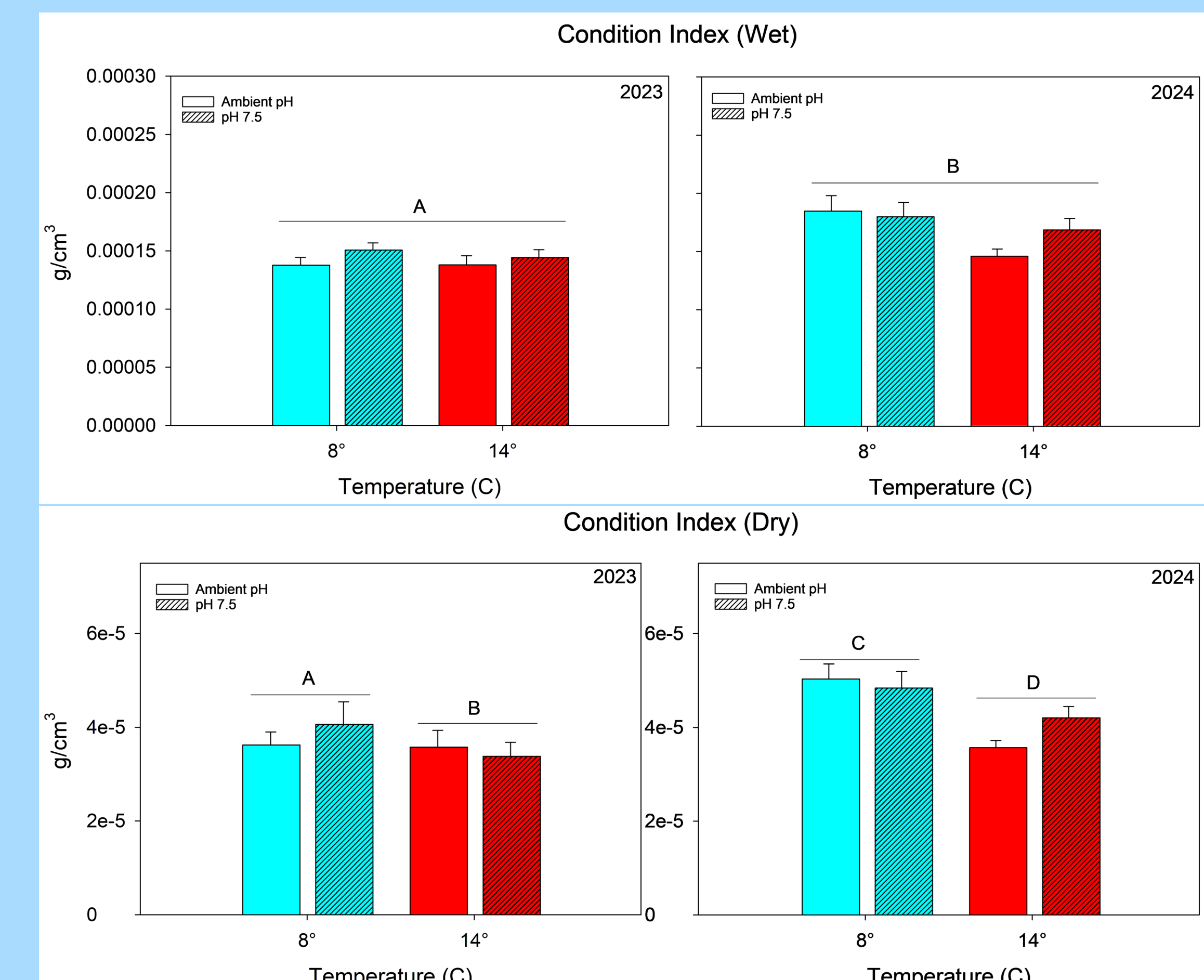
Feeding ration

- Feeding rate was higher at higher 14°C than at 8°C
- pH did not have an effect
- Feeding was higher in the first week than in subsequent ones



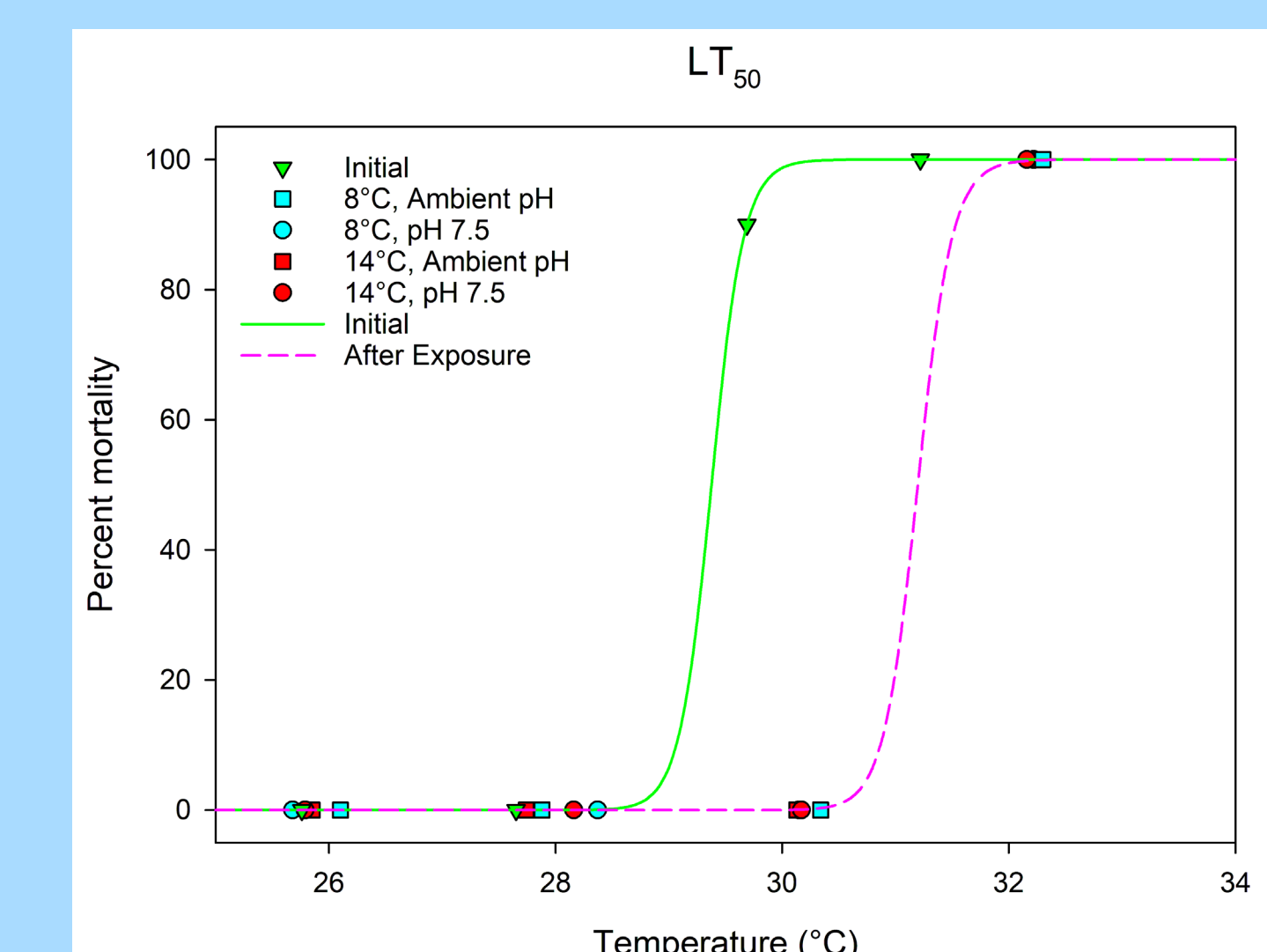
Respiration

- No significant difference between 14°C and 8°C
- pH did not have an effect



Condition Index

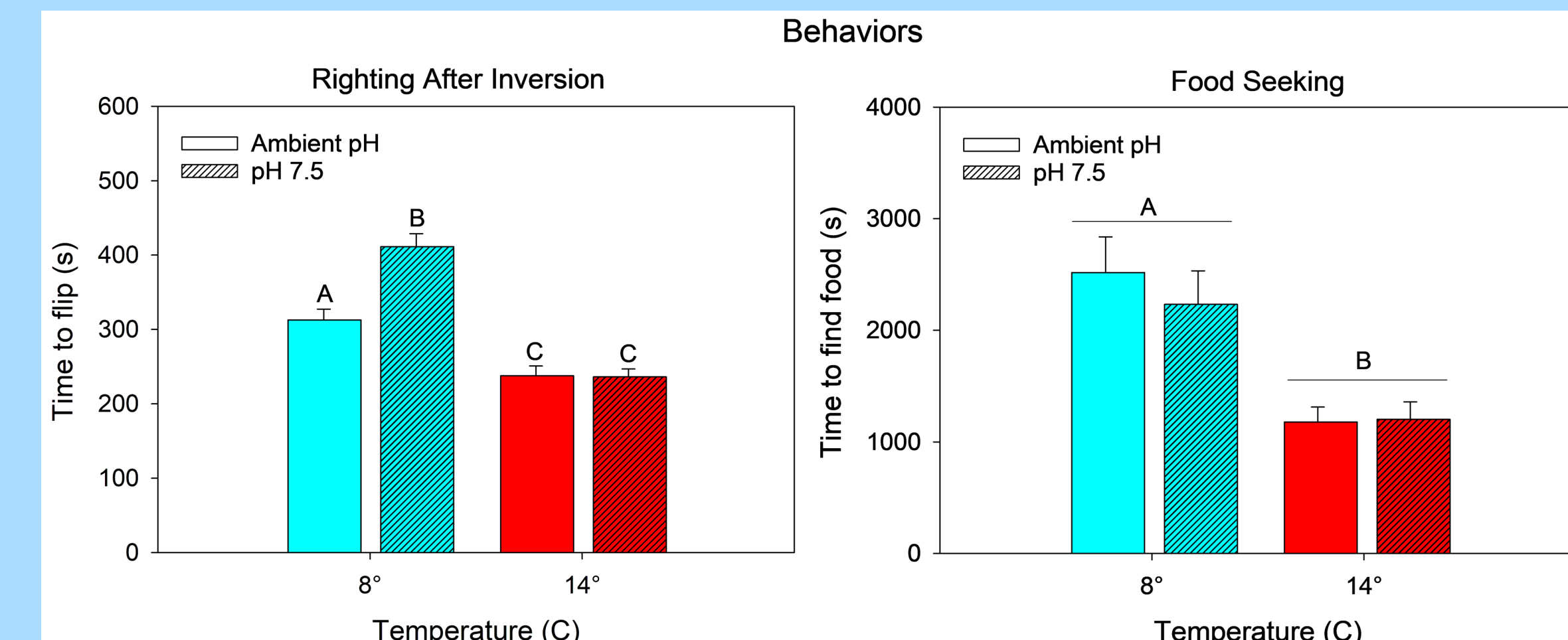
- Condition index slightly higher in the 2023
- Sea stars held at a higher temperature had a lower dry mass (but not wet mass) condition index
- No effect of pH treatment



LT₅₀

- Sea stars had about a 2 degree higher temperature tolerance after holding than before
- No effect of either temperature or pH

Lethal temperature to 50% mortality. Points are the mean mortality within each treatment. Lines are the best-fit logistic regression curves.



Behaviors

- Sea stars both flipped and found food faster at 14°C than at 8°C
- No effect of pH on time to located food
- pH increased the time to flip at 8°C but not 14°
- No difference among weeks

Conclusions

- Temperature is a strong driver of *Evasterias troschelli* physiology
- Evasterias troschelli* is mostly unaffected by low pH and is well adapted to hypercapnic exposure
- Juvenile *Evasterias troschelli* appear well adapted to near-term projections for ocean acidification and warming
- Sensitivity at other life-history stages needs to be assessed
- Indirect effects of ocean change, such as changes to prey species, should also be considered

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