Effects of Ocean Acidification on Juvenile Snow Crab Survival, Growth, and Morphometrics

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Introduction

Ocean acidification is a decrease in pH caused by dissolution of anthropogenic CO_2 in the oceans. The chemical changes, including a decrease in the saturation states of calcium carbonate, can have physiological effects on marine organisms. Juvenile Tanner crabs (*Chionoecetes baridi)* exhibits increased mortality and decreased growth in acidified waters. Snow crab (*Chionoecetes opilio*), an even more valuable fishery species, are very closely related and dwell in colder waters. Previous work suggest snow crabs may be more resistant to ocean acidification than Tanner crab. In this study we examine how CO_2-driven acidification affected juvenile snow survival and growth.

Study objectives

Determine how ocean acidification affects juvenile snow crab

- **Growth**
- **Morphology**
- **Survival**

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The findings and conclusions in the paper are those of the authors and do not necessarily represent the views or official position of the Department of Commerce, the National Oceanic and Atmospheric Administration, or the National Marine Fisheries Service.

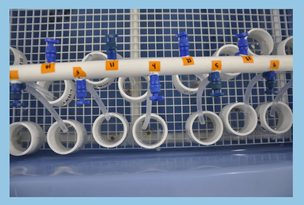
Methods

Animals

- Juveniles collected from the Bering Sea
- Transported to Kodiak in a fishing vessel
- Crab were just under a year old

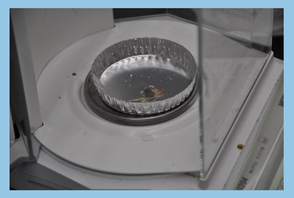
Water acidification

- Filtered seawater at ambient salinity
  - Salinity- 31 psu
  - Water chilled to 3 °C
  - Water acidified with CO_2
    - Direct bubbling into tank
    - Controlled with Honeywell/Duraft III pH probe
- Three treatments
  - Ambient (pH ~ 8.1)
  - pH 7.8 (Global pH predicted for c. 2100)
  - pH 7.5 (Global pH predicted for c. 2200)



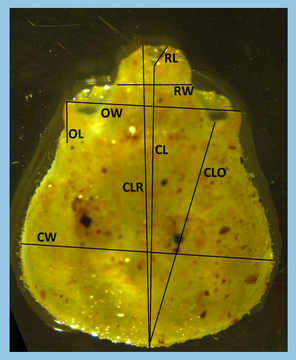
Experimental setup

- Crabs held in individual containers
- Tanks received flowing treatment seawater
- Water flow was provided to each crab
- 30 crabs per pH treatment
- Fed to excess 3x per week
- Held for 396 days



Data collection

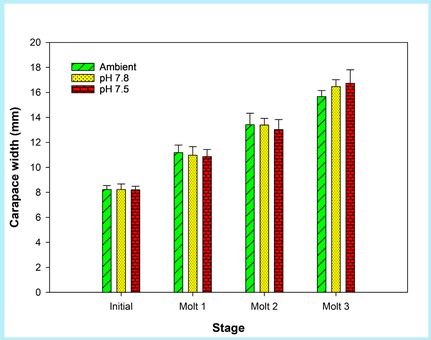
- Water chemistry
  - pH and temp measured daily
  - Dissolved inorganic carbon (DIC) and total alkalinity measured every 2 weeks
- Checked daily for molting and mortality
- After each molt
  - Measured wet mass 7 days after molt
  - Carapace photographed under microscope
  - Measured carapace using image analysis program
    - Carapace length (CL)
    - Carapace width (CW)
    - CL to rostrum horn (CLR)
    - CL to eye orbit (CLO)
    - Rostrum width (RW)
    - Orbital spine width (OW)
    - Orbital spine length (OL)
    - Rostrum horn length (RL)



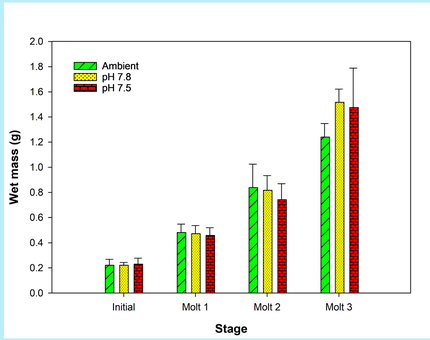
Results

Growth

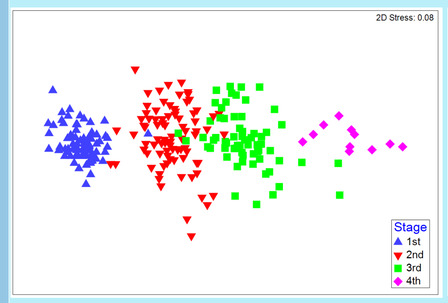
- Crabs CW and wet mass were not different between treatments at any molt stage
- There was no difference among crabs in size at the end of the experiment
- Time to molt did not differ among pH treatments



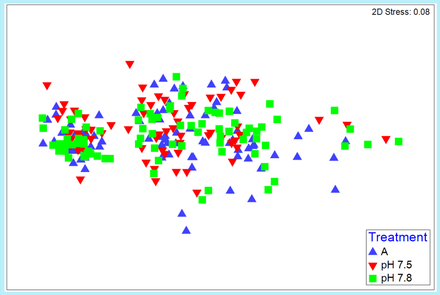
Size of snow crab at the beginning of the experiment (initial) and after each molt. Bars are means with standard error. Bars with different letters above them differ significantly (ANOVA).



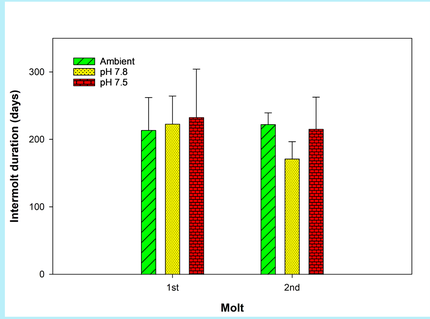
Wet mass of snow crab at the beginning of the experiment (initial) and after each molt. Bars are means with standard error. Bars with different letters above them differ significantly (ANOVA).



Non-metric multidimensional scaling plot of snow crab morphometrics grouped by molt stage.



Non-metric multidimensional scaling plot of snow crab morphometrics grouped by treatments



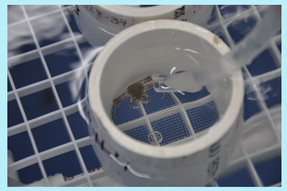
Intermolt duration of snow crab between the first and second molts (1st) and the second and third molts (2nd). Bars with different letters above them differ significantly (ANOVA).

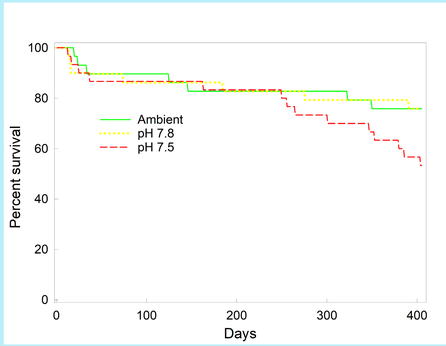
Morphology

- Morphology changed after molting
- No differences in morphology among treatments at any stage

Survival

- Mortality was associated with molting
- Crabs at pH 7.5 suffered much higher mortality
- Differences in mortality did not appear until later in the experiment, around 250 days after the start





Survival of juvenile snow crab at three pH treatments over 396 days

Conclusions

- Long-term decrease survival suggest negative effects of ocean acidification snow crab
- Lack of sublethal effects is puzzling
  - Selection for crabs that were better adapted?
  - Perhaps sublethal effects would have appeared after later molts
- Less sensitive than juveniles of other species (e.g. Tanner crab)
  - Snow crabs better adapted?
  - 1-year old crabs more resistant than young of year?

NOAA OCEAN ACIDIFICATION PROGRAM