Ocean acidification does not affect embryo development, hatch success, or calcification in snow crab, *Chionoecetes opilio*

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Introduction

Ocean acidification is the reduction of seawater pH due to the dissolution of anthropogenic CO_2. Global mean surface water pH has decreased 0.1 pH units from pre-industrial levels. The decreased pH has the potential to affect the acid-base balance of marine organisms. The availability of carbonate ions are also reduced with ocean acidification which may affect the formation of shells and support structures of calcifying organisms. Snow crab (*Chionoecetes opilio*) are a commercially valuable crustacean in the North Pacific and extend from the eastern Bering Sea through the high Arctic.

Technical Approach

Ovigerous females collected from the eastern Bering Sea were transported to the Kodiak Laboratory.

- Treatments: ambient pH (~8.1), pH 7.8, and pH 7.5 maintained with Durafet pH probe and automated dosing
- Duration: 2 annual reproductive cycles
- Temperature: 2°C
- Sample size: 16 females/treatment
- Seawater chemistry: Dosing tanks monitored weekly for alkalinity and dissolved inorganic carbon

YEAR 1: Embryos and larvae from oocytes developed, fertilized, and extruded *in situ*.

YEAR 2: Embryos and larvae from oocytes developed, fertilized, and extruded under acidified conditions in the laboratory.

NOAA OCEAN ACIDIFICATION PROGRAM

https://oceanacidification.noaa.gov/Home.aspx

Acknowledgements: *The authors thank the NOAA Ocean Acidification Program for funding and the staff of the Kodiak Laboratory who assisted with this study: Allie Bateman, Nikki Gabriel, Nick Sisson*

Selected references:

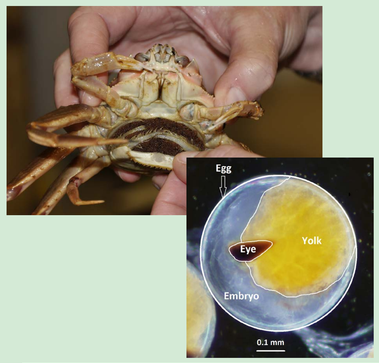
Swiney, K. M., W. C. Long, and R. J. Foy. 2016. Effects of high pCO_2 on Tanner crab reproduction and early life history—part I. ICES Journal of Marine Science, 73(3), 825-835.

Long, W.C., K. M. Swiney, and R. J. Foy. 2016. Effects of high pCO_2 on Tanner crab reproduction and early life history, Part II: carryover effects on larvae from oogenesis and embryogenesis are stronger than direct effects. ICES Journal of Marine Science, 73(3), 836- 848.

Sigler, M. F., J. N. Cross, M. G. Dalton, R. Foy, T. P. Hurst, W. C. Long, K. Nichols, I. Spies, and R. P. Stone. 2017. NOAA's Alaska ocean acidification research plan for FY18- FY20. Alaska Fisheries Science Center, NOAA, National Marine Fisheries Service, 7600 Sand Point Way NE, Seattle WA, 98115. AFSC Processed Report 2017-10: 71. Doi: 10.7289/v5/afsc-pr-2017-10.

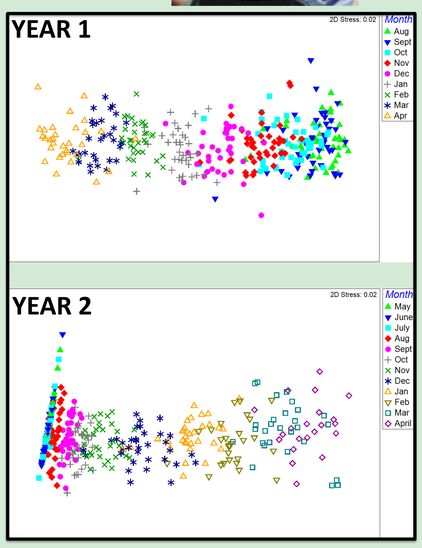
Embryo morphology

Method: Morphometric changes during development and hatching success were measured for embryos both years.

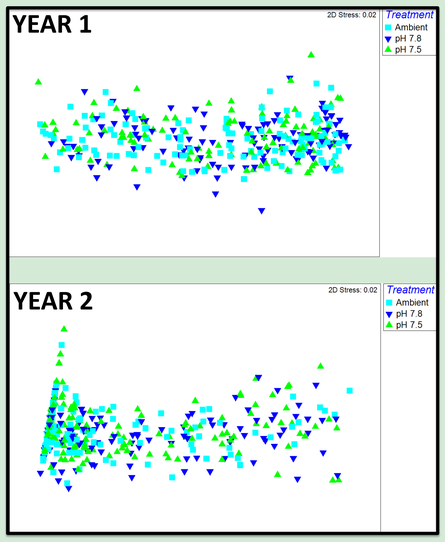


- 10 eggs randomly sampled per female each month
- Uneyed eggs stained
- Embryos staged at 50x magnification
- Digital images: egg area, diameter, embryo area, yolk area, eyespot area, eyespot diameter measured; percent yolk calculated

➢ **Embryo morphology NOT affected by pH during development in either year**



Multidimensional scaling results for embryo morphological measurements by **month**.

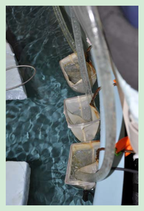


Multidimensional scaling results for embryo morphological measurements by **treatment**.

Viable larval hatch

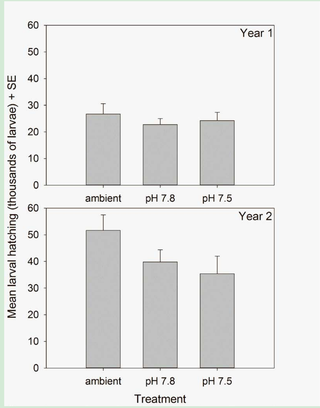
Method: Number of larvae successfully hatched was averaged across all females in each year of the study.

- Larvae hatched at the end of year 1 and year 2.
- Nets placed on tank outflow to collect larvae
- Viable larvae: estimated using dry mass. 5 counted subsamples per female used to calculate total



- Total viable: summed daily larvae hatched

➢ **Number of viable larvae hatched NOT significantly different among three pH treatments**



Mean (SE) number of viable larvae hatched after one and two years of expose to three pH treatments.

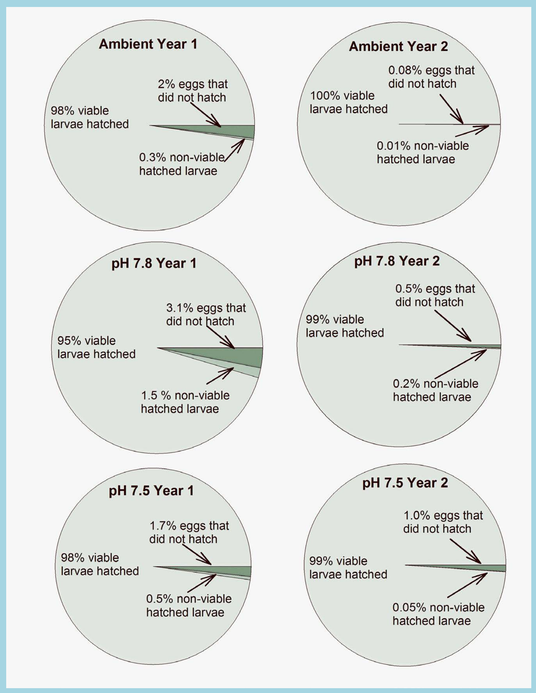
Embryo hatching success

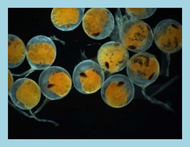
Method: Hatching success determined at the end of each year of the study and across each pH treatment level.

- Hatching success: viable larvae as a percent of total number of embryos.
- Non-viable larvae: did not molt past the pre-zoea stage to the zoea 1 stage.
- Dead eggs (eggs that did not hatch) determined by microscopic examination of clutches remaining after hatch

➢ **No carryover effect found in any treatment for oocytes exposed to lower pH**

➢ **Embryo hatching success NOT significantly different among three pH treatments**

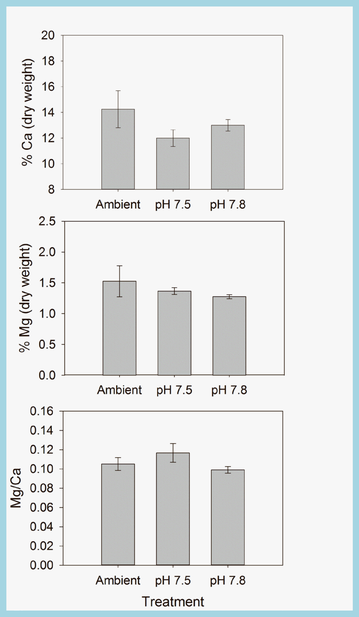




Mean percent of viable larvae hatched, non-viable larvae hatched, and eggs that did not hatch in each year of the study for each of the three pH treatments.

Adult female shell calcification

Method: Calcification was measured for the adult females at the end of the 2-year experiment.



- Females sacrificed at the end of the experiment and carapace samples taken
- % dry weight of calcium determined

➢ **Percent calcium in adult females' carapaces did NOT differ among treatments**

Mean (SE) percent Calcium, percent magnesium, and magnesium:calcium ratio for adult female snow crab after two year exposure to three pH treatments.

Conclusions

1) Snow crabs are well adapted to projected ocean pH levels within the next 2 centuries. This is in sharp contrast to southern Tanner crab, *Chionoecetes bairdi*.
2) If snow crab are increasing metabolic response to increased physiological stress sue to ocean acidification, macro-scale responses are not evident.
3) Juvenile life-history stage still needs to be examined for sensitivity.
4) Future work will examine the physiological responses in *Chionoecetes opilio* and *C. bairdi* to elucidate what mechanisms drive the differential outcomes in these two sympatric congeneric species.