

Comparative Response of Littleneck and Manila Clams From The Puget Sound to Ocean Acidification Conditions Year 1

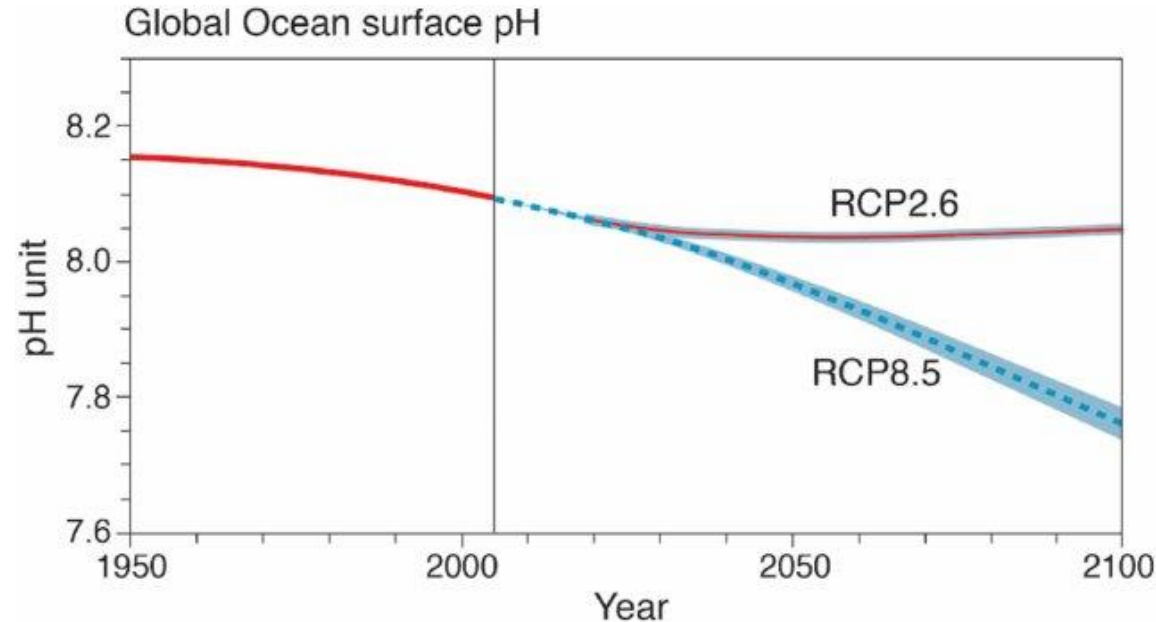
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Ocean acidification (OA)

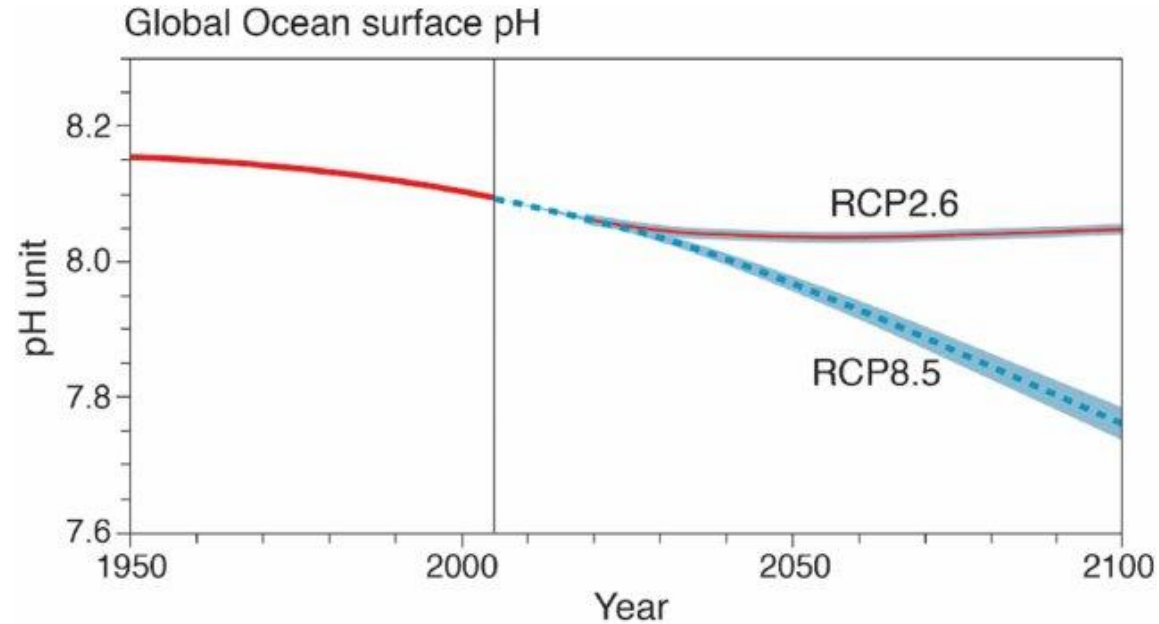


Increasing carbon dioxide in the atmosphere leads to increased concentration in oceans due to diffusion.

Increased $p\text{CO}_2$ leads to lowering pH through a series of reactions with water

Ocean pH is projected to decrease by up to 0.4 units by 2100

Ocean acidification (OA)

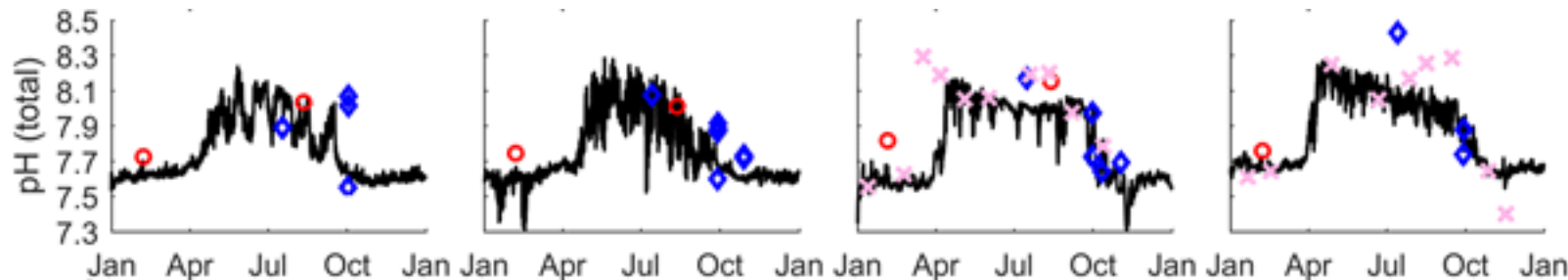


(1) Gordon Point

(2) West Point

(3) Hood Canal

(4) Saratoga Passage



From Bianucci et al. 2018

Impact on Bivalves

Research has identified several potential impacts of OA conditions on shellfish, including:

- Biomineralization – the ability of an animal to precipitate and incorporate calcium into the shell
- Energetics – changes in energy requirements and the impact on growth
- Larval development and growth – impacts on early life stages

Bivalves are most impacted in larval growth

Impact on Aquaculture

Evidence indicates that native Pacific coast bivalves may be more tolerant to low pH as it is a naturally occurring condition.

Are non-native Manila clams more susceptible to OA than native Littleneck clams?



Clams collected in Liberty Bay

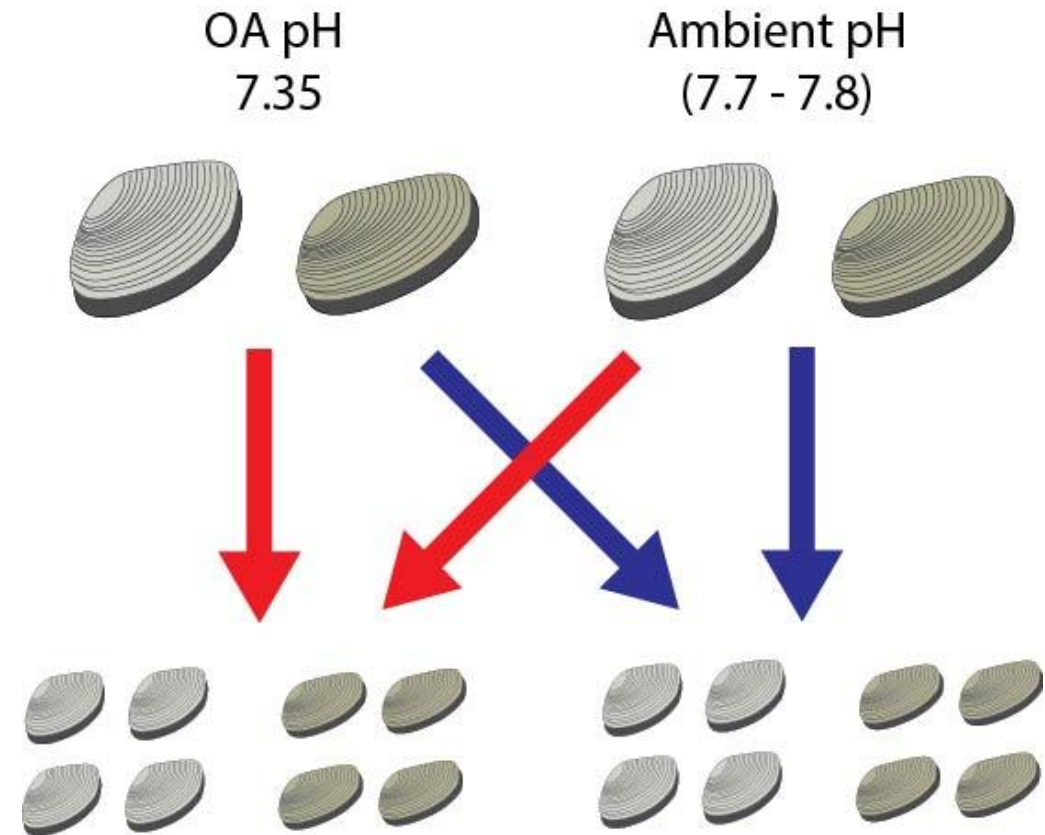
Research questions

Adults

Are native clams more tolerant of OA conditions, as seen in other bivalve species native to the Puget Sound?

Larvae

Can exposure of adults to OA conditions “prime” subsequent larvae to be more tolerant?



Can alternative **species** or **husbandry practices** improve resiliency to OA?

Experimental set-up

4 weeks preacclimation to common conditions



2 weeks at OA condition



2 weeks temperature increase



2 weeks at final temp and pH



First spawning



Respirometry testing



2 weeks Larval Rearing



Second spawning



Final sample collection



Sampling

Adults

- Survival
- Spawning success
- Final reproductive stage
- Oxygen respiration
- ATPase activity
- Gill gene expression
- Gamete gene expression and small RNA profile

Larvae

- Survival
- Growth
- Gene expression

Stage

Data analysis

Data collection

Sample prep

Redo in Year 2

Results - overview

| Treatment | Survival | Spawning |
|-----------------------|----------|----------|
| Littleneck Ambient | 90.9% | 20% |
| Littleneck OA | 88.6% | 29.5% |
| Manila Ambient | 97.7% | 25.6% |
| Manila OA | 93.2% | 11.6% |

Survival was high in all groups, indicating that adults from both species of clams are capable of living for extended times at low pH.

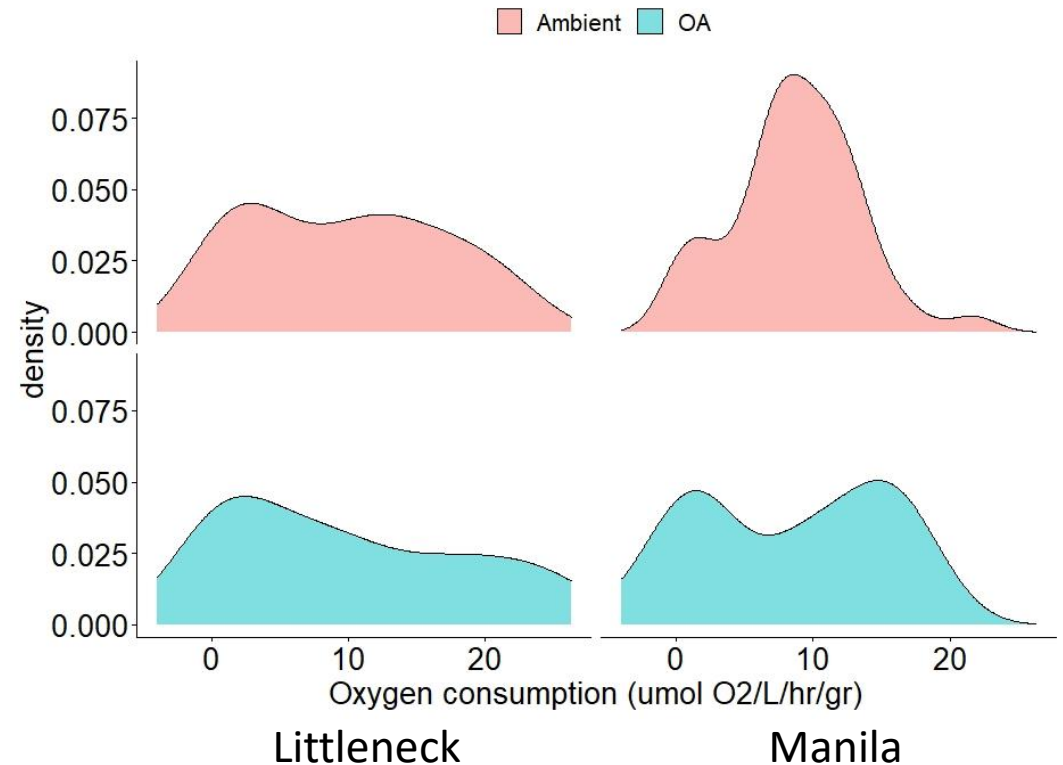
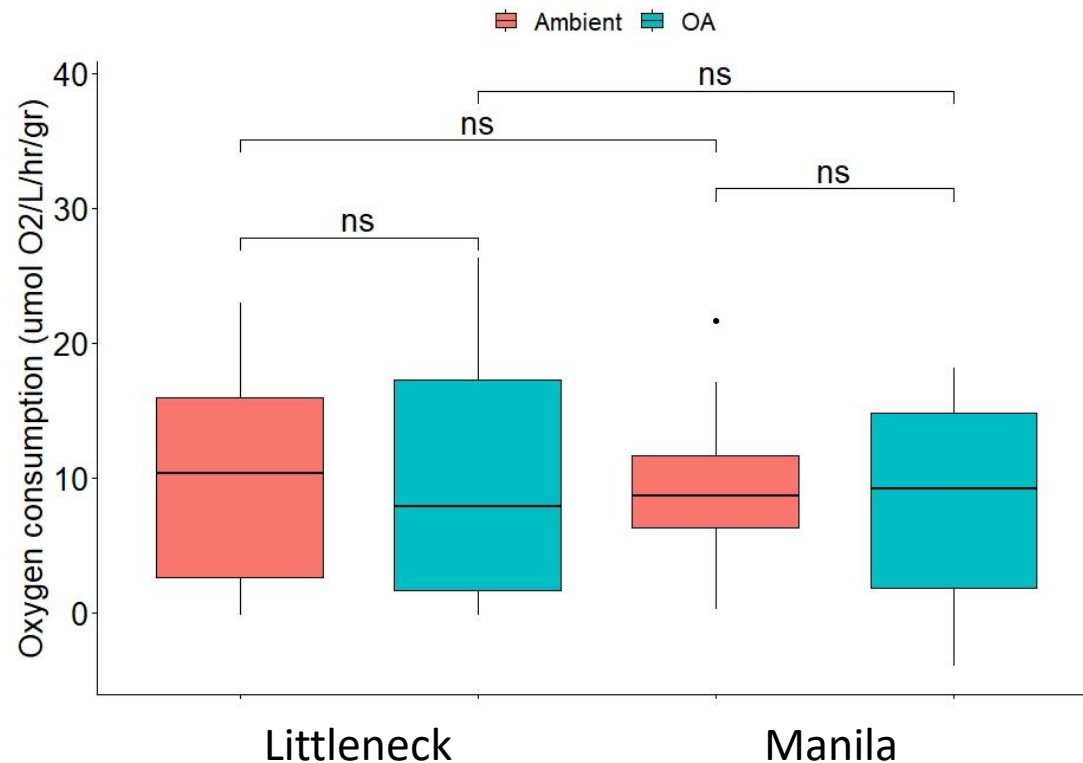
Spawning success was low, likely due either to insufficient maturation or issues with the methodology. Further analysis of histological sections can help clear this up

Complications with spawning and larval rearing led to no data collection for larvae

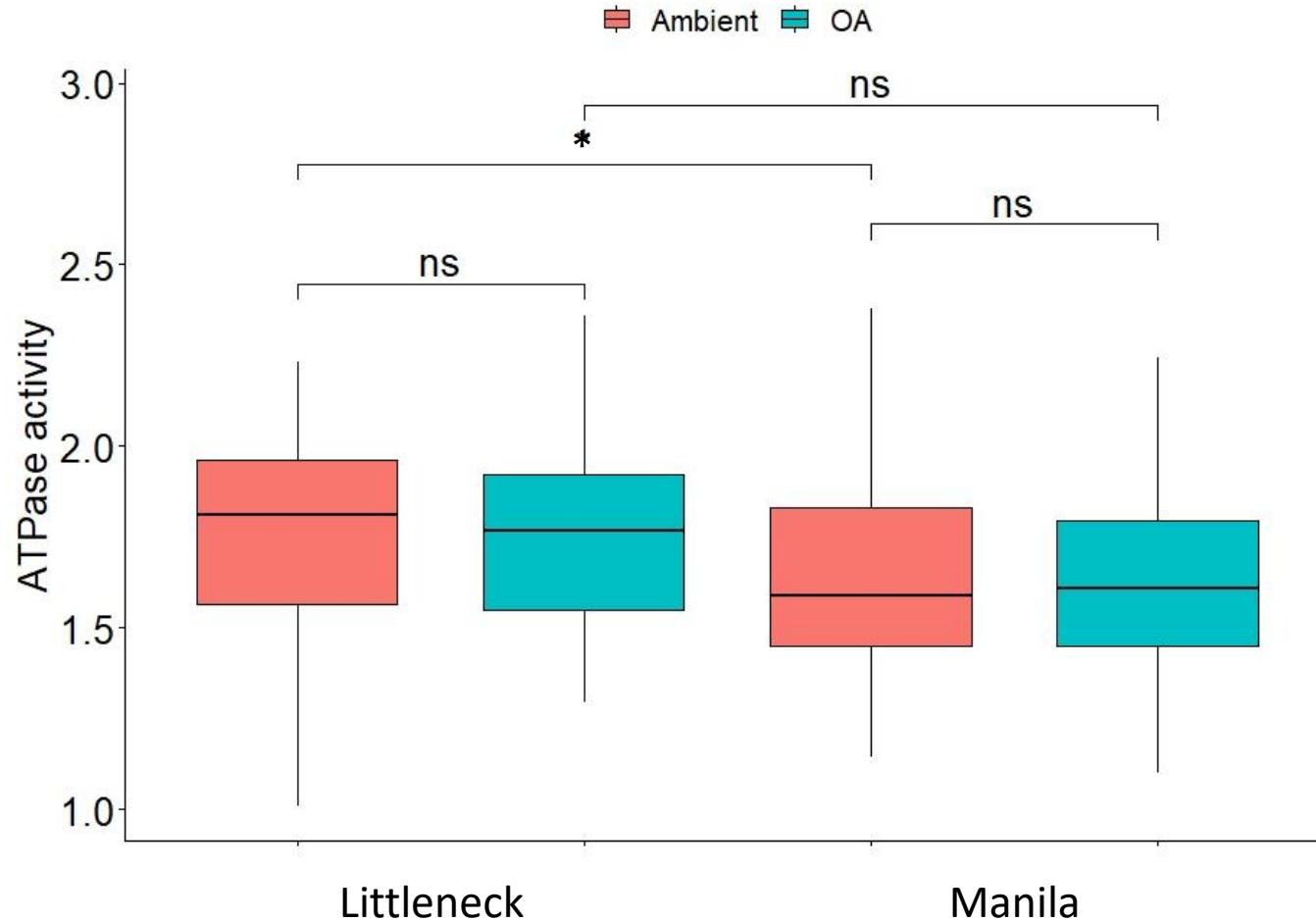
Respirometry

Measurements of oxygen consumption by individual clams over approximately one hour

No difference was seen between treatments or species, but data distributions show more “closed” behavior in littlenecks and treatment groups



Na⁺/K⁺ ATPase activity



ATPase activity is an indicator of ionic balance and metabolic activity.

Littleneck clams at ambient pH had significantly higher activity than Manila clams, but there was no difference within either species due to low pH.

Early conclusions and next steps

So far, there is no evidence that either species is more tolerant of low pH, or that either is very sensitive as adults.

Further investigation of gene expression may reveal differential responses, as well as comparing response based on reproductive maturation.

Future experiments with improved spawning and larval rearing will help us understand sensitivity in **larvae** to OA, and the potential of parental priming in improving outcomes.

Survey

The goal of this project is helping growers, and we need to make sure the research is making an impact

We plan to set up grower interviews before and during PCSGA 2023

For growers, we want to know;

What experiences do you have with OA?

Given upcoming results, what practices might you be open to adopting to prepare for OA in the future?

Acknowledgements

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Mollie Middleton, NOAA

Questions?