



Carbonated Communities

HOW IS ACIDIFICATION AND RISING TEMPERATURE AFFECTING OCEAN ORGANISMS IN THE INTERTIDAL?



Carbonated Communities

Part One

YOUR JOB

- Explore a phenomenon affecting ocean animals.
- Learn how scientists are understanding this phenomenon's effect on ocean animals.
- Examine relationships between intertidal species.



Watch *Molluscs: Pycnopodia Chases Abalone*



Consider:

- What are examples of natural animal behaviors and interactions?
- What challenges face ocean animals?

<https://www.shapeoflife.org/video/molluscs-pycnopodia-chases-abalone>

What are examples of natural ocean animal behaviors and interactions?

What challenges do organisms face in the ocean?

(natural- and human-caused)





Unusual Behavior

Clownfish often stay very close to coral reef, their home.

But some clownfish are wandering farther and farther from home.



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Unusual Behavior

Hermit crabs
retreat into shell
for protection.

But some aren't
hiding as quickly
as normal.



Unusual Behavior

Abalone, giant sea snails, attach to rocks to withstand heavy waves.

When dislodged, some aren't righting themselves and reattaching as quickly. Some even turned towards predators claws.

Human-Released Carbon Dioxide (CO₂) in the Atmosphere

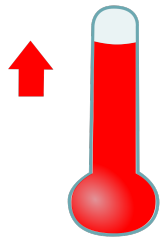
- **CLIMATE CHANGE**
 - Global warming; leads to sea level rise and higher ocean temperatures
 - Melting glaciers, heavier rainstorms, more frequent drought, etc.
- **OCEAN ACIDIFICATION
(LOWER OCEAN pH)**



How might lower pH (ocean acidification) and higher water temperatures affect behaviors and growth of ocean animals?



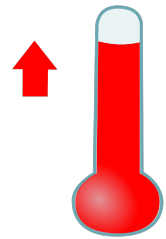
Ocean Temperature Warming



In ocean surface waters, **TEMPERATURE** is expected to **RISE** an average of **3 to 5°C** by **2100**. (IPCC 2014)



Effects of Ocean Warming



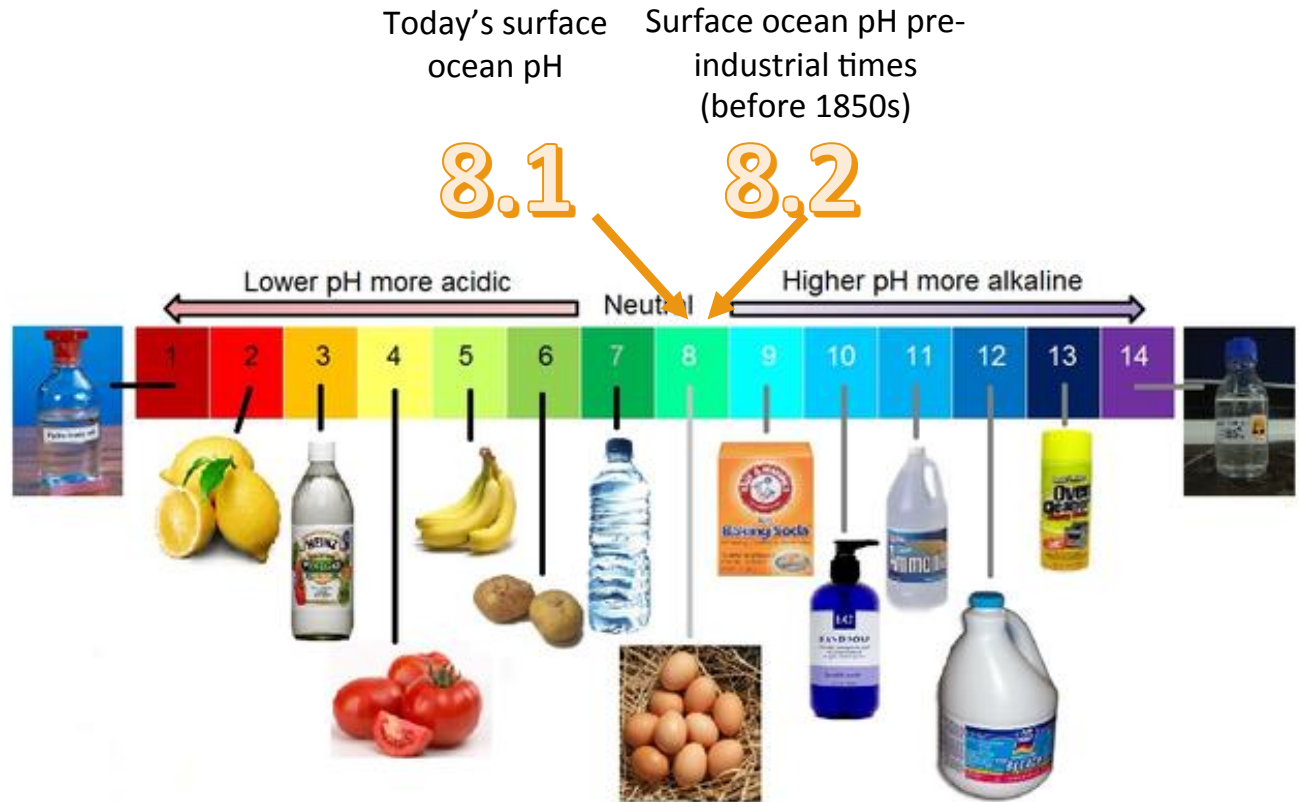
- **CORAL REEF BLEACHING** and damage
- **DISRUPTED MIGRATION** patterns (e.g., tuna, sharks, whales, turtles, etc.)
- **CHANGES** to organism **GROWTH, REPRODUCTION, FEEDING** patterns, etc.
- And **MORE...**



Lower Ocean pH

Ocean surface waters have **INCREASED** in **ACIDITY 30%** since pre-industrial times (before 1850s).

In ocean surface waters, pH is expected to drop an average of 0.3 units by **2100**. That is a **99% INCREASE IN ACIDITY**. (IPCC 2014)



How Does Ocean Acidification Work?

**Alliance for Climate
Education's Science Short:
Ocean Acidification**

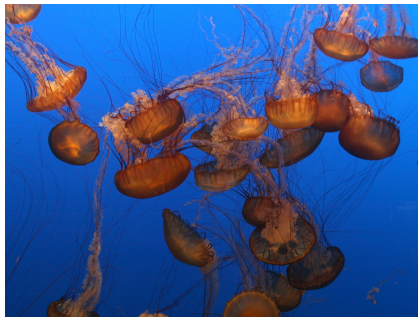
[https://www.youtube.com/
watch?v=6SMWGV-DBnk](https://www.youtube.com/watch?v=6SMWGV-DBnk)



Effects of Lower Ocean pH (acidification)

CHANGING OCEAN COMMUNITIES.

Some species, like jellies, may thrive while others struggle.



REDUCES ABILITY of reef-building corals to **PRODUCE THEIR SKELETONS. IMPACTS GROWTH AND REPRODUCTION** of other organisms too.



DISRUPTED FOOD WEBS. Pteropods form the basis of some marine food webs. Their shells dissolve over 30 days in seawater with 7.8 pH.



ECONOMIC EFFECTS for shellfish fisheries and consumers. Oysters, abalone, clams and mussels have a harder time building shells and staying alive.

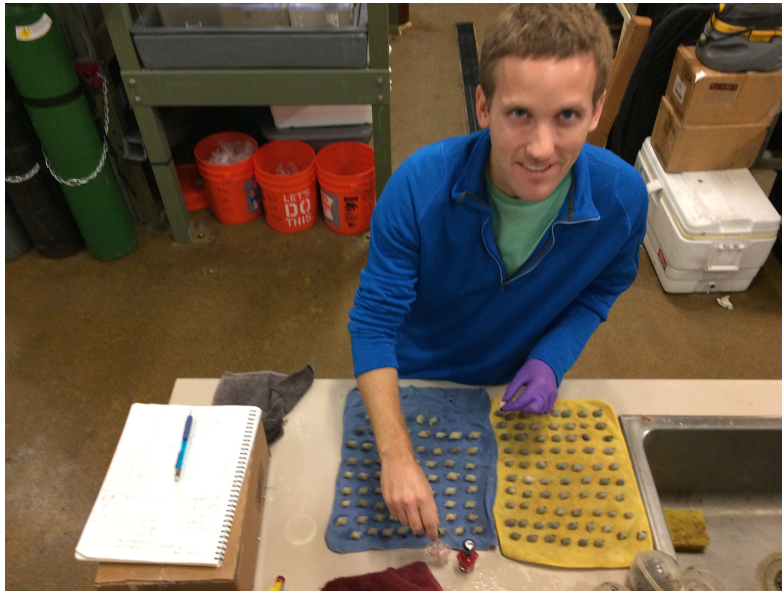




MOST RESEARCH on effects of higher temperature and acidity have focused on **INDIVIDUAL SPECIES**.

But **WHAT ABOUT OCEAN COMMUNITIES**, like in the intertidal?

These Scientists Decided to Investigate



DR. JOSH LORD: Painting the edge of a whelk (snail) shell with nail polish. This helps him measure how much a shells grows.



DR. JIM BARRY: Surfing in Santa Cruz and observing a tank of abalones in the lab.



Investigation: Testable Question

How does **CLIMATE CHANGE** (lower pH and higher temperatures) affect **FEEDING, GROWTH AND INTERACTION** between species in the **INTERTIDAL**?



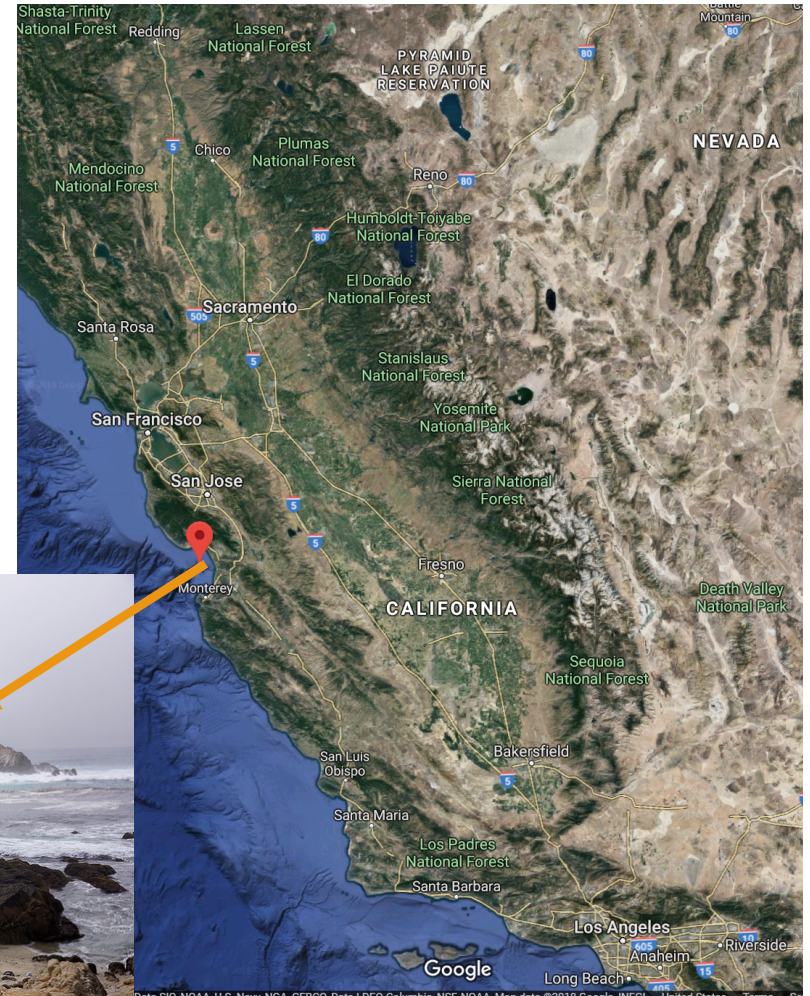
Investigation Setting

Location:

Rocky shore intertidal zone,
Monterey Bay, CA

Intertidal=

*Area between the high
tide and low tide mark
(above water at low tide
and underwater at high
tide)*



Species Studied in Investigation



Intertidal Habitat



Mussels,
Mytilus galloprovincialis



Whelk,
Nucella ostrina



Abalone,
Haliotis rufescens



Lined shore crab,
Pachygrapsus crassipes



Sea Lettuce,
Ulva lactuca



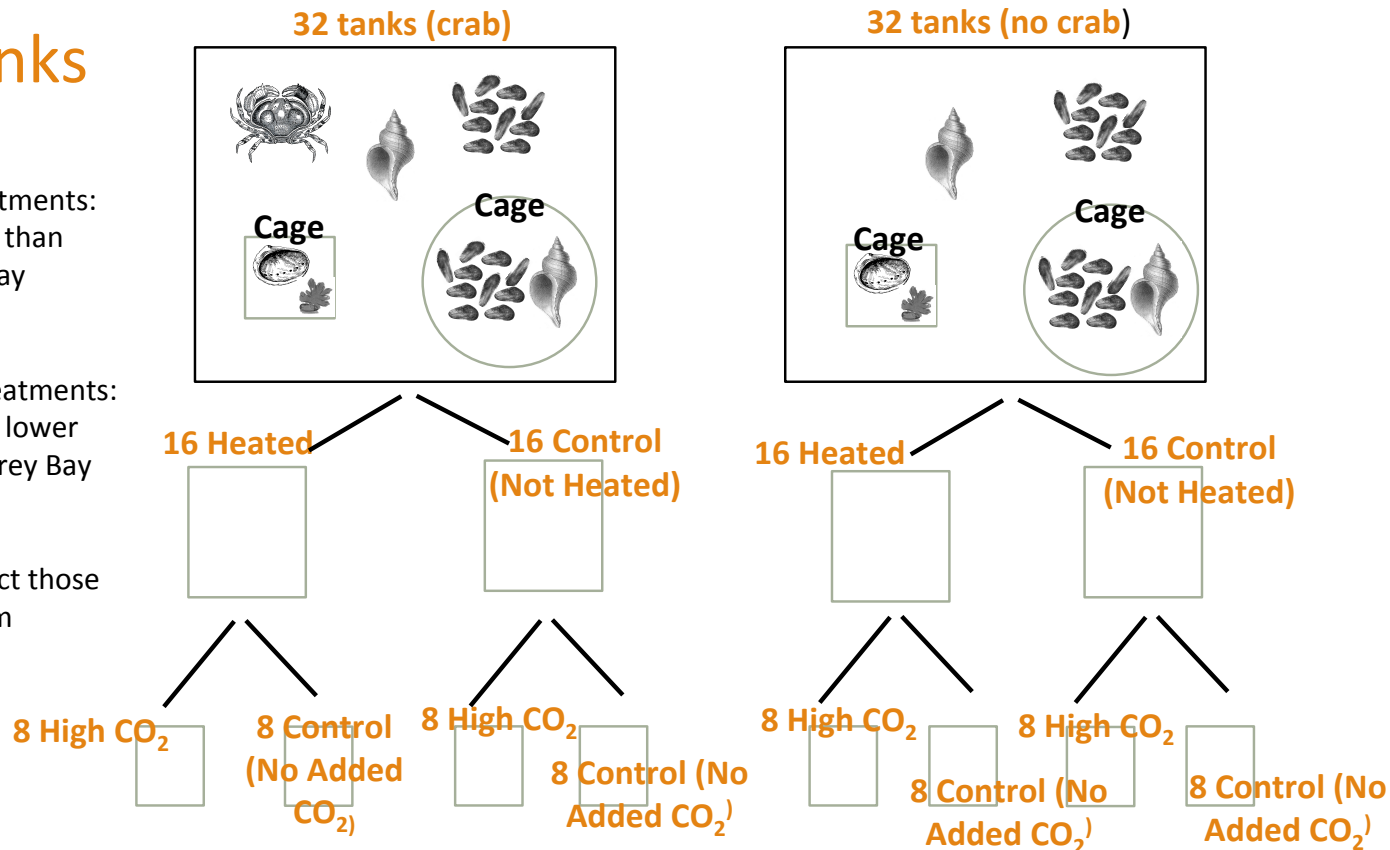
Investigation: Experimental Set-Up

64 tanks
total

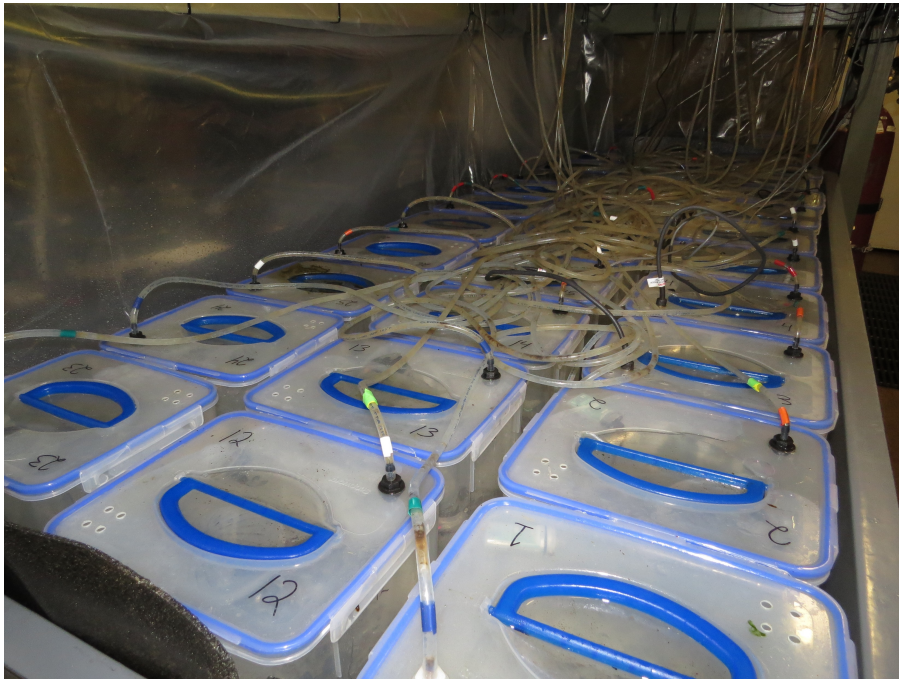
Heated treatments:
2°C warmer than
Monterey Bay
seawater

High CO₂ treatments:
0.3 units pH lower
than Monterey Bay
seawater

Cages protect those
animals from
predators.



Investigation: Experimental Set-Up



Tanks with Animals



Carbon Dioxide Tank



Investigation: Experimental Set-Up



Coolers Contain
Aquarium Heaters:
*tubing carrying sea
water coils through
each heater and
continues down to
heated tanks*

Spotlight on the Species



How do these species NORMALLY feed, grow and interact (relationships between species)?

How might LOWER pH (higher levels of CO₂) and TEMPERATURE AFFECT feeding, growth and interactions?

Dr. Lord and Dr. Barry's Hypothesis

Lower pH (added CO₂) and higher water temperature will have:

DIRECT EFFECTS

Crabs: minimal effect
because less calcified than
molluscs

Whelks & Abalone: reduced
shell growth due to decrease
in carbon saturation states

INDIRECT EFFECTS

Whelks: eat less mussels
Abalone: eat less seaweed

Overall decline in whelk and
abalone populations due to
robust response of crabs and
negative impacts of low pH
on shell production

