

Carbonated Communities

HOW IS LOWER pH (ACIDIFICATION) AND RISING TEMPERATURE AFFECTING OCEAN ORGANISMS IN THE INTERTIDAL?



Carbonated Communities

Part Two

YOUR JOB

- Watch a video exploring how shells grow.
- Analyze and interpret data collected by Dr. Lord and Dr. Barry.
- Make an evidence-based claim answering: *How does climate change (lower pH and higher temperatures) affect feeding, growth and interaction between species in the intertidal?*



Watch *Mollusc Animation: Shell Repair* and *Arthropods: Blue Crab Molting*



<https://www.shapeoflife.org/video/mollusc-animation-shell-repair>

<https://www.shapeoflife.org/video/arthropods-blue-crab-molting>

- How might lower pH and higher temperature affect shell building and repair in the investigation species (abalones, whelks, mussels)?
- How might that be similar or different to effects on exoskeletons and molting in crabs?

How does lower pH and increased temperature affect feeding, growth and interactions between these species?



Intertidal Habitat



Mussels,
Mytilus galloprovincialis



Whelk,
Nucella ostrina



Abalone,
Haliotis rufescens



Lined shore crab,
Pachygrapsus crassipes



Sea Lettuce,
Ulva lactuca





Name _____ Period _____ Date _____

Claim-Evidence-Reasoning Page 1
Student's Edition

Question: How does climate change (lower pH and higher temperatures) affect feeding growth and interaction between species in the ocean?

Claim I believe the question	
Evidence I can use the following evidence to support my claim	Claim "What" Reason "How"
Reasoning I can use the following reasoning to support my claim	

Claim-Evidence-Reasoning



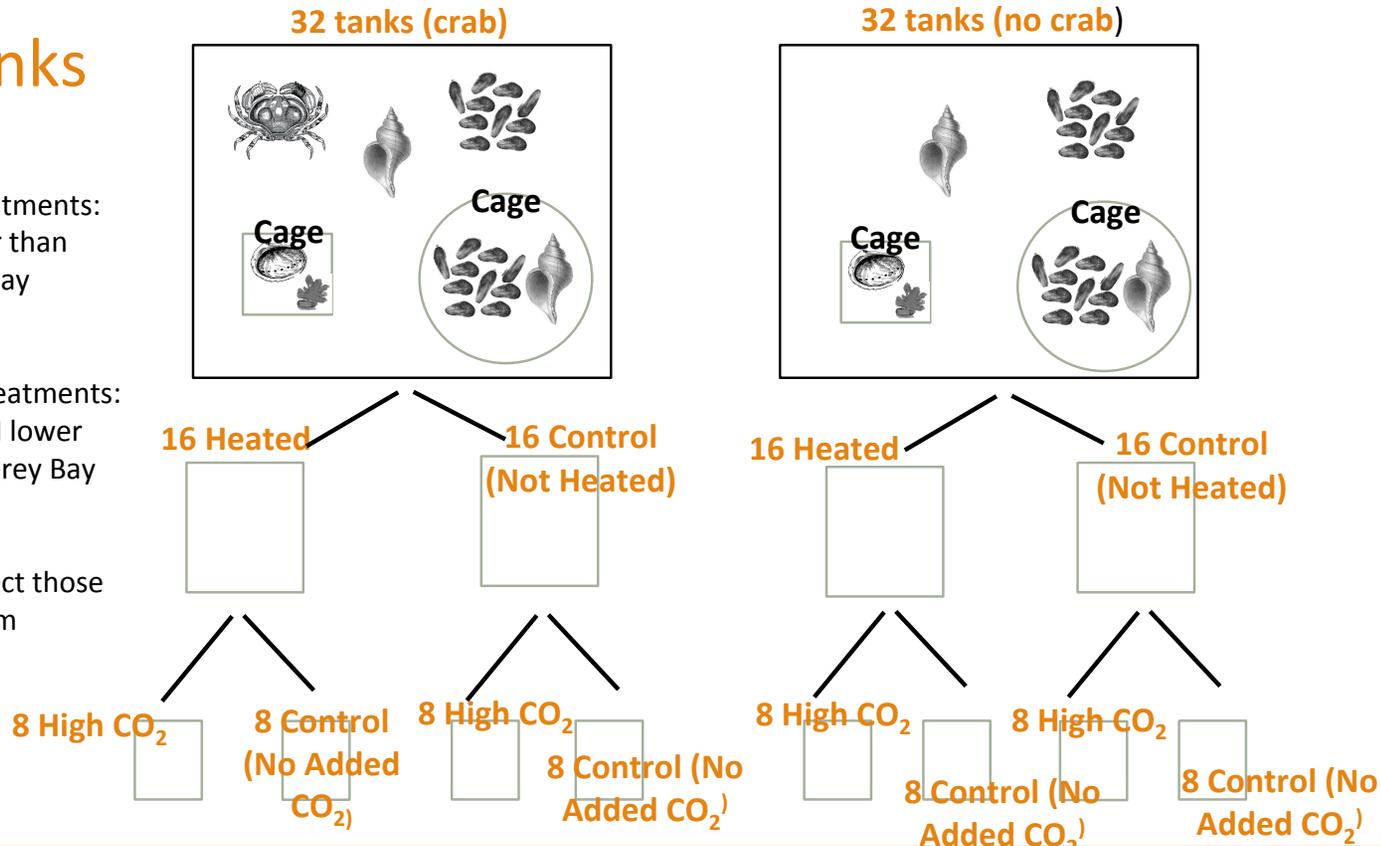
Investigation: Experimental Set-Up

64 tanks
total

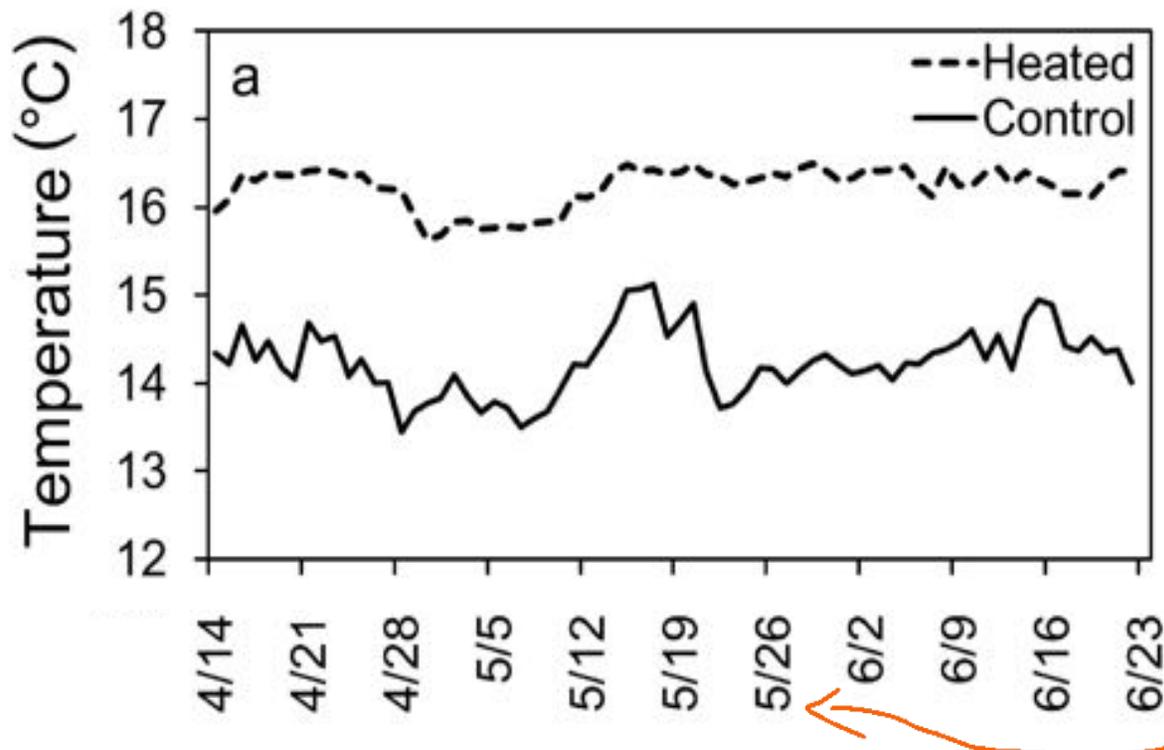
Heated treatments:
2°C warmer than
Monterey Bay
seawater

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

Cages protect those
animals from
predators.



Analyzing Data: Identify and Interpret (I²)



What Do I See?

What Does it Mean?

What I see: x-axis shows dates-every week from April 14-June 22

What it means: temp of sea water was measured over time from April 14-June 23

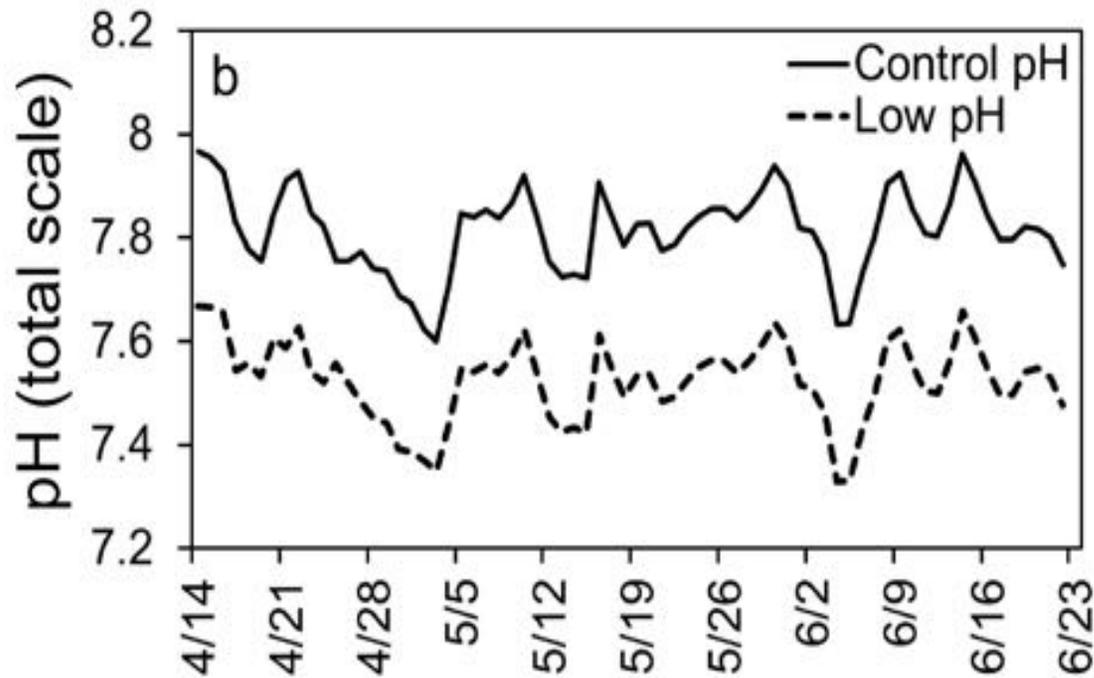
Analyzing Data: Identify and Interpret (I²)

Caption: This line graph shows the temperature of Monterey Bay sea water over the 10-weeks of the investigation. The x-axis shows that temperature was measured over time between April 14 and June 23. The y-axis shows temperature from 12-18 °C (54-64 °F) which the natural temperature of the sea water fluctuated between. There was one peak of warm water between May 12-19. The temperature of the water naturally goes up and down in 2-3°C range.

Questions I have: Why does the temperature of the bay naturally go up and down so much? Why was the water so warm between May 12-19?



Analyzing Data: Now You Do It



- What Do You See?
- What Does It Mean?



Name _____ Period _____ Date _____

Claim Evidence Reasoning Page 1
Student's Edition

Question: How does climate change (lower pH and higher temperatures) affect feeding growth and interaction between species in the ocean?

Claim I can answer the question	
Evidence I can identify key facts/evidence to support my claim	Claim Warrant Reason Claim
Reasoning I can explain how the evidence supports my claim	

Let's Share Our Claims



Conclusion:

Effects of Lower pH and Higher Temperature on Intertidal Community

All species more affected by pH change (added CO₂) than temperature change (heated water).

Little effect of 2°C increase on all animals. Likely because the temperatures were still within the seasonal range of the animals. (However if temperature was raised during warmest time of year, they may have been more effect.)

Abalones	Whelks	Crabs
Decreased shell growth with CO ₂ (feeding and tissue growth weren't affected by elevated CO ₂).	No response to higher CO ₂ (doesn't align with other studies). Differing response than abalone may be due to different shell chemistry.	High mortality and effect on feeding with increased CO ₂
Temperature and presence of crabs didn't affect significantly.	Presence of crabs affected feeding and growth the most.	Crabs ate more in heated conditions.

Indirect effects on community: Whelks didn't eat as much because they were avoiding crabs. Crabs benefited mussels by reducing predation by whelks.

Debrief Questions

- How might you change/modify the investigation?
- How easy or hard was it to use the identify and interpret (I^2) method to understand the data? To develop an evidence-based claim?
- How does the conclusion compare to your original prediction?
- What was surprising?
- What else do you wonder or want to know?



Conversation with the Scientists (Dr. Lord and Dr. Barry)

BIGGEST SURPRISE...

Weren't expecting such negative effect on the crabs-over 50% mortality in the experiment. Other crab species weren't so affected in other investigations.

CHALLENGING DESIGN...

Dale Graves was the master engineer and designed and built the system that controlled the pH of the sea water. This was tricky because the pH of the water in Monterey Bay naturally fluctuates. The set up had to measure the incoming pH and turn the carbon dioxide gas supply on and off to keep the acidified treatments 0.3 pH units below incoming pH.

ON THOSE HUNGRY CRABS...

The crabs ate more than we expected. Some could eat 30 mussels/day. We had to get creative and call a bunch of aquaculture farms on the west coast. Finally we found one but had to make a few orders-the crabs ate so much!



Conversation with the Scientists (Dr. Lord and Dr. Barry)

ON WORKING TOGETHER...

It's an advantage to have expertise in different fields.

Often there are difficulties in designing experiment or dealing with a challenge, troubleshooting is easier and even fun when working with people who have different ideas or perspectives.

SCIENTISTS HAVE LIVES TOO...

Dr. Josh Lord plays soccer and mountain bikes among other things. Dr. Jim Barry like to surf.

ON SCHOOL AND CAREER...

Find something you care and are passionate about. So many people get caught up doing a job or research they feel they should.



On Climate Change



“What can we do about climate change?
We can talk with one another about climate
change, vote with the climate in mind and
use less energy.

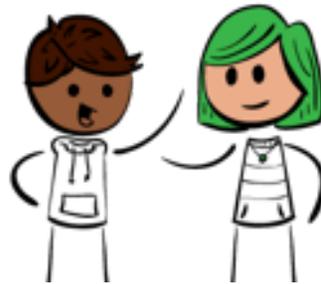
Get out and enjoy the ocean. The more you
do, the more you’ll want to protect it for
generations.”

-Dr. Jim Barry

What are people doing about climate change?



UNPLUGGING as often as possible to use less electricity (e.g., soccer instead of a screen)



TALKING TO OTHERS about it



PAYING ATTENTION to the **NEWS/CURRENT ISSUES** and **VOTING** when you can

What are people doing about climate change?



Green Ninja,
www.greenninja.org
[https://greenninja.org/
Green_Ninja_Show/31](https://greenninja.org/Green_Ninja_Show/31)



Alliance for Climate Education:
Do One Thing (DOT), www.acespace.org
[https://www.youtube.com/watch?
time_continue=100&v=37t5UT-39nM](https://www.youtube.com/watch?time_continue=100&v=37t5UT-39nM)

What might be your “DOT” to slow down climate change and help intertidal communities?



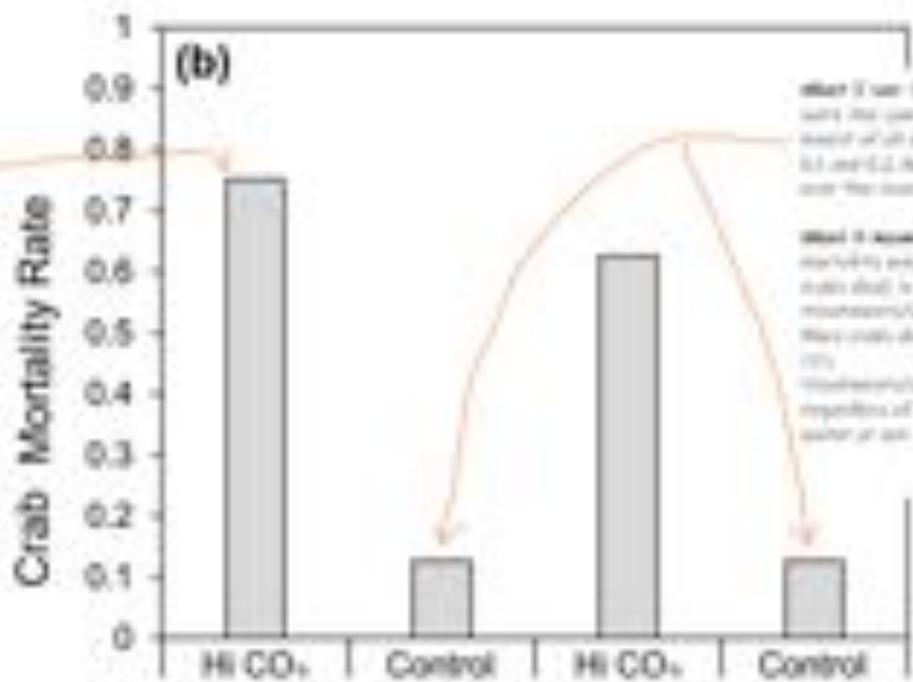
Data Sheets-Teacher Keys



Question 1: What was the rate of crab mortality in the control group? (0.13)

What 1 was the rate in the highest CO₂ condition? (0.75)

What 2 was the rate in the highest CO₂ condition in the high pH group? (0.63)



What 2 was the rate in the highest CO₂ condition in the high pH group? (0.63)

What 3 was the rate in the highest CO₂ condition in the high pH group? (0.63)

Table 1: Crab mortality rates in control and high CO₂ conditions. The bars show crab mortality rates in the control and high CO₂ conditions. The line graph shows crab mortality rates in the control and high CO₂ conditions in the high pH group. The bars show crab mortality rates in the control and high CO₂ conditions in the high pH group. The line graph shows crab mortality rates in the control and high CO₂ conditions in the high pH group.

Question 1: What was the rate of crab mortality in the control group? (0.13)

Crab Mortality Rate: More crabs died (higher mortality rate) in higher CO₂ conditions than any other conditions.





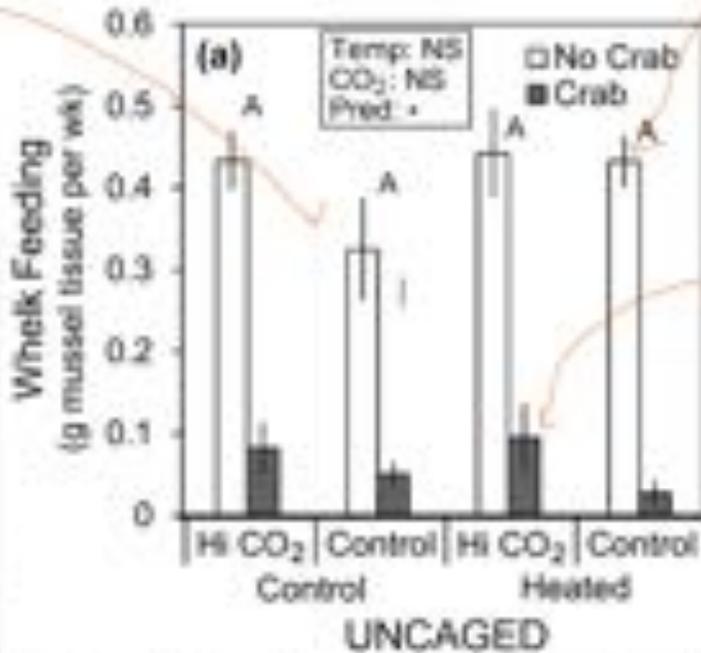
Effects on Whelk Feeding-Page 1 Student's Edition

What 2 can you learn from looking at the 2 bars within each of the 4 groups? Write 2-3 sentences.

What 3 trends can you see in the graph? Write 3 sentences.

Graphs tell very interesting stories. They can show trends that help us understand the world around us. In this graph, the y-axis represents the amount of mussel tissue eaten by whelks. The x-axis represents the different experimental conditions. The legend tells us that white bars represent whelks with no crab and black bars represent whelks with a crab. The graph shows that whelks ate significantly more mussel tissue when there was no crab present than when there was a crab present. This was true for all four experimental conditions: High CO₂, Control, High CO₂, and Control. The amount of mussel tissue eaten was also significantly higher in the High CO₂ conditions compared to the Control conditions. This suggests that both the presence of a crab and the concentration of CO₂ in the water affect whelk feeding.

Question 2 asks you to compare the amount of mussel tissue eaten by whelks with and without a crab. The graph shows that whelks ate significantly more mussel tissue when there was no crab present than when there was a crab present. This was true for all four experimental conditions: High CO₂, Control, High CO₂, and Control.



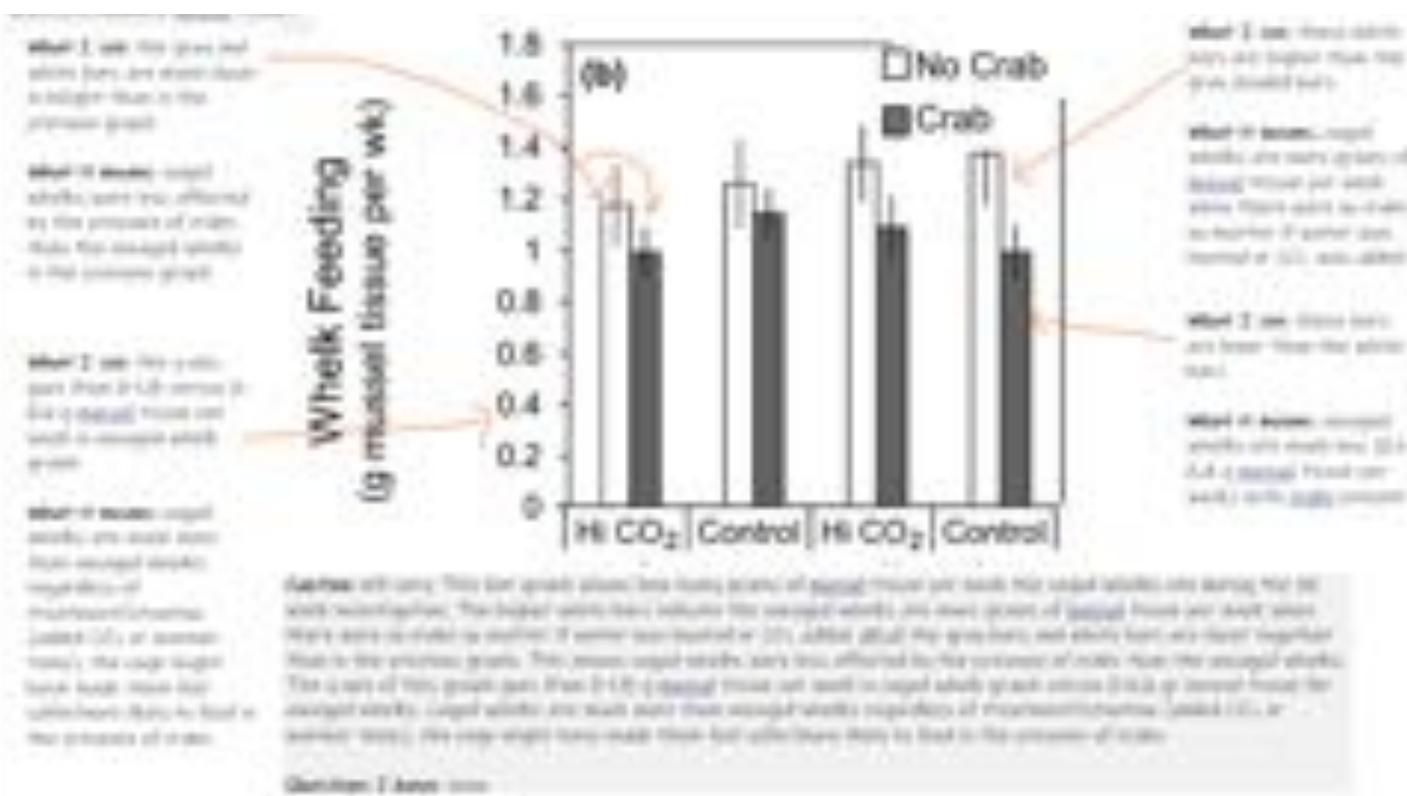
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Uncaged Whelk Feeding:
Uncaged whelks ate significantly less with a crab present. Lower pH and higher temperatures didn't affect feeding significantly.



Caged Whelk Feeding:
 Caged whelks ate more than uncaged whelks with crabs present. Lower pH and higher temperatures didn't affect feeding significantly.





Name _____ Period/Class _____ Date _____

Shape of Life

Effects on Whelk Shell Growth-Page 1 Student's Edition

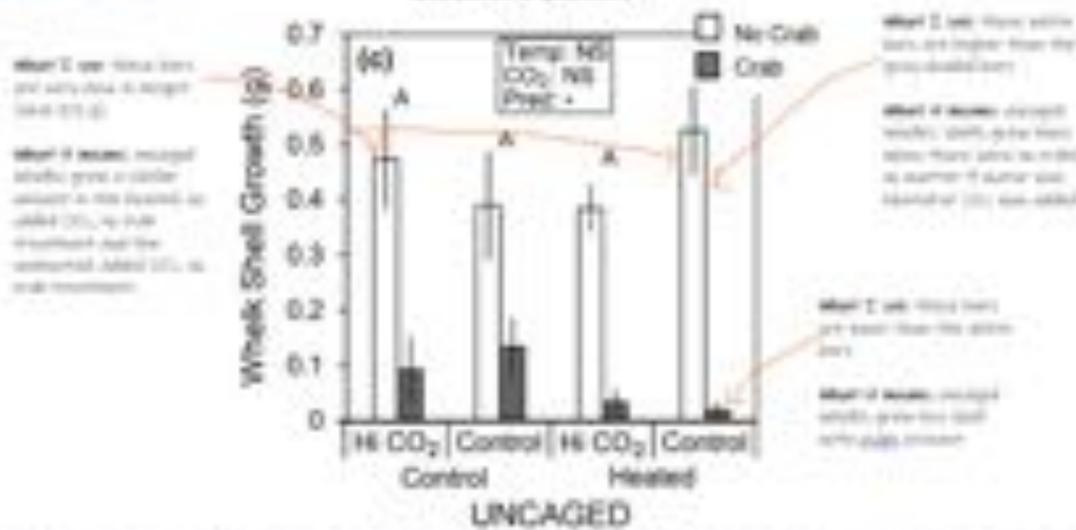
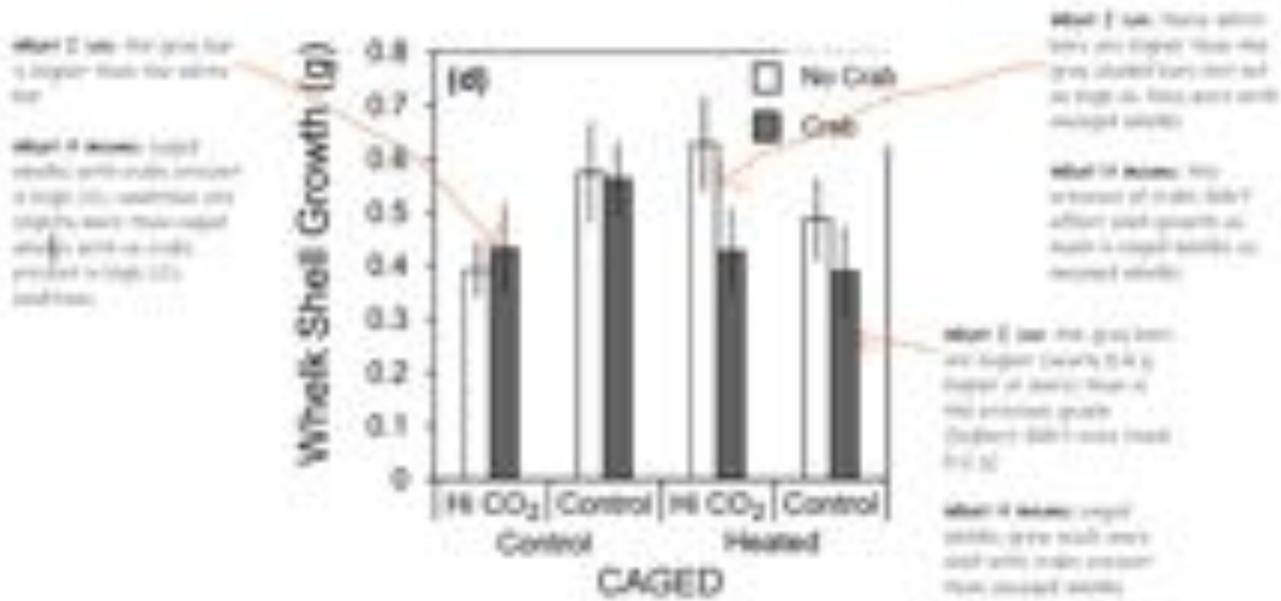


Figure 1 shows the effects of pH and temperature on whelk shell growth. The data show that whelk shell growth is significantly reduced (decreased growth) when crabs are present. Shell 2 with 100 ppm CO₂ and 100 ppm pH is larger than the control (100 ppm CO₂). Shell 4 with 100 ppm CO₂ and 100 ppm pH is larger than the control (100 ppm CO₂). There was a slight difference when crabs were present in the heated treatments (100 ppm CO₂ and 100 ppm pH).

Table 1 shows the effects of pH and temperature on whelk shell growth.

Uncaged Whelk Shell Growth: Uncaged whelks grew significantly less with a crab present. Lower pH and higher temperatures were not as significant.





Caged Whelk Shell Growth: Caged whelks grew significantly more than uncaged whelks with a crab present. Lower pH and higher temperatures were not as significant.

Question 1: How does the presence of crab affect whelk growth? Do you think whelks grow more in the presence of crab than they do without? Why or why not? (Consider the growth of whelks with and without crab.)

Question 2: How does the presence of crab affect whelk growth in high CO₂ conditions? Do you think whelks grow more in the presence of crab than they do without? Why or why not? (Consider the growth of whelks with and without crab.)



Name _____ Period/Class _____ Date _____

Shape of Life

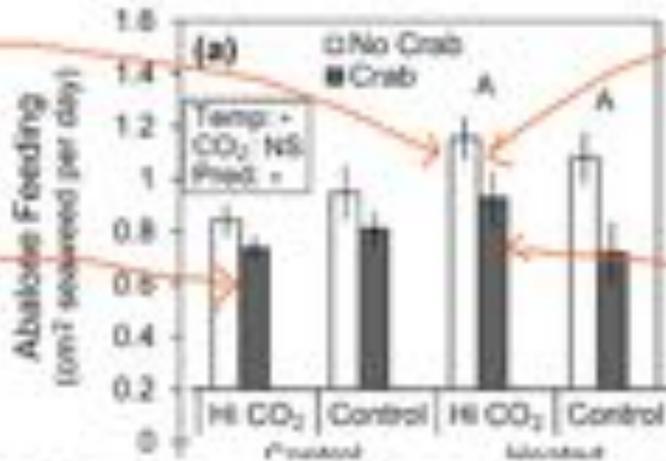
Effects on Abalone Feeding and Shell Growth-Page 1 Student's Edition

What I see: The abalone fed less in the presence of crabs than the control group.

What I know: Abalone fed more in warmer water and less in high CO₂ water, regardless of whether crabs were present.

What I see: The abalone fed less in the presence of crabs than the control group.

What I know: Abalone fed more in warmer water and less in high CO₂ water, regardless of whether crabs were present.



What I see: The abalone fed more in the presence of crabs than the control group.

What I know: Abalone fed more in warmer water and less in high CO₂ water, regardless of whether crabs were present.

What I see: The abalone fed less in the presence of crabs than the control group.

What I know: Abalone fed more in warmer water and less in high CO₂ water, regardless of whether crabs were present.

Caption: (a) Abalone feeding rates (cm² searated per day) for abalone in the presence of crabs (black bars) and in the absence of crabs (white bars) under four different conditions: Fasted, HI CO₂, HI CO₂ + Crab, and Control + Crab. Error bars represent standard error. Significance letters 'A' indicate significant differences between HI CO₂ and Control conditions.

Source: T. S. Lee, et al. (2010). *Journal of Experimental Biology*, 233(1), 1-10.

Abalone Feeding:
Abalone ate less in the presence of crabs and more in warmer water. Lower pH didn't have a significant effect.

