Carbonated Communities: Effect of Climate Change & Carbon Pollution on Ocean Animals, Part Two

Lesson by Lacey Moore

Video Titles:

- *Mollusc Animation: Shell Repair*
- *Arthropods: Blue Crab Molting*
- *Mollusc Animation: Abalone (optional)*

Activity Subject: climate change/carbon pollution, intertidal communities, constructing an explanation

Grade Level: 6-8 grades

Introduction

Students continue to explore effects of climate change/carbon pollution (lower pH and higher temperature) on a community of intertidal species. They watch a video(s) on shell and exoskeleton growth and then examine data on one of three species collected in a scientific investigation using the "identify and interpret (I^2)" method developed by BSCS science learning. They meet in groups to share data on all three species and construct an explanation making an evidence-supported claim.

Assessments Claim-Evidence-Reasoning worksheet

Time 80-100 min (depending on student familiarity analyzing data)

Group Size Varies; individual, groups of three

NEXT GENERATION SCIENCE STANDARDS

MS-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

Related:

MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations

MS-ESS3-5 Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century

LEARNING OBJECTIVES

After this lesson, students will be able to:

- Interpret and analyze data displayed in graphs using the I^2 (what I see, what it means) method.
- Construct an explanation about how climate change (lower ocean pH and temp) affects ocean animals (growth and interactions).
- Give three examples of what they can do to slow carbon pollution/climate change down.

Materials

- Computer with internet connection per student group or internet connection, computer and projector to watch *Mollusc Animation: Shell Repair* and *Arthropods: Blue Crab Molting (Mollusc Animation: Abalone* is optional*)* (available to download)
- "Lesson Two-Carbonated Communities presentation" (separate file) to project for whole class
- "Presentation Talking Points-Part Two" for teacher
- Claim-Evidence-Reasoning worksheet" pages one and two per student
- "Identify and Interpret (I^2) worksheet" pages one through three per student

- Four data sheets: "Effects on Crabs," "Effects on Whelk Feeding," "Effects on Whelk Shell Growth," and "Effects on Abalones." Each student will get one copy of one of the four sheets.
- "Data Sheets Teacher Key" for teacher (separate file) but also at the end of "Lesson Two-Carbonated Communities presentation" (separate file)

Preparation

1. Check to ensure video(s) are compatible with your technology. They are all downloadable.

2. Make double-sided copies of "Claim-Evidence-Reasoning worksheet" and "Identify and Interpret (I^2) worksheet" for each student.

3. Review the data sheets and decide how you will distribute them to the class. If it will be too overwhelming to give one data sheet with two graphs on it to your students, cut the data sheet in half or have students fold it in half so they focus on one at a time. You may also let students work in pairs, although it would be best for each student to have their own copy of the sheet. There are four data sheets: "Effects on Crabs," "Effects on Whelk Feeding," "Effects on Whelk Shell Growth" and "Effect on Abalones." See "Data Sheets Teacher Key" (separate file) or the end of "Lesson Two-Carbonated Communities presentation" (separate file) for sample answers.

4. Review "Lesson Two-Carbonated Communities presentation" and "Presentation Talking Points-Part Two" (or notes in PowerPoint). Decide if you will share the two videos on slide 18 (one is of a "Green Ninja" taking action to lower someone's carbon footprint at https://greenninja.org/Green_Ninja_Show/31 and the other is a video produced by Alliance for Climate Education showing what actions students are taking to "Do One Thing" (DOT) at https://www.youtube.com/watch?time_continue=100&v=37t5UT-39nM).

Procedure

1. **SHARE LESSON OBJECTIVES AND WATCH *MOLLUSC ANIMATION: SHELL REPAIR*. (5-10 MIN)**
   Project "Lesson Two-Carbonated Communities presentation" and on slide two share what students will be doing in this lesson (watching a video about how shells grow, analyzing and interpreting data collected by Dr. Lord and Dr. Barry and making an evidence-based claim.) Then have them watch "Mollusc Animation: Shell Repair" and "Arthropods: Blue Crab Molting" (the links are on slide three) considering how lower pH and higher temperature may affect shell building and repair and exoskeletons and molting. Then have students think-pair-share. (You may also wish to show "Mollusc Animation: Abalone" at https://www.shapeoflife.org/video/mollusc-animation-abalone).

2. **INTRODUCE CLAIM-EVIDENCE-REASONING ASSESSMENT. (5 MIN)**
   Continue with "Lesson Two-Carbonated Communities presentation" and use "Presentation Talking Points-Part Two" for talking points. Stop on slide five and pass out "Claim-Evidence-Reasoning worksheet" to each student. They will use data collected by Dr. Lord and Dr. Barry as evidence to address the question: *how does lower pH and higher temperatures*

affect feeding, growth and interaction between species in the intertidal?) Go over the worksheet with students and share the rubric as well. This is how they will be assessed for this lesson series.

3. **MODEL "IDENTIFY AND INTERPRET (I^2)" STRATEGY. (10 MIN)**
   Use slide seven and the temperature graph of the heated and control treatments over the ten-week investigation to model how to analyze and interpret data using the identify and interpret strategy. First, students note what they observe about the graph (What I see…) and annotate a figure or graph. Then students interpret that observation (What I mean…) and annotate the graph. Pass out "Identify and Interpret (I^2) worksheet" pages one through three per student. Have student use the pH graph on page three to practice it again. Go over as a class. (See "Data Sheets Teacher Key" for the sample observations and inferences.) Note: This strategy works well with a science notebook. Students tape or glue the graph or figure in and annotate.

4. **IN PAIRS, STUDENTS ANALYZE AND INTERPRET DATA ON ONE SPECIES. (20 MIN)**
   Pass out one of the following four data sheets: "Effects on Crabs," "Effects on Whelk Feeding," "Effects on Whelk Shell Growth" and "Effect on Abalones" to each student. Let them work in pairs to use the I^2 strategy to annotate the graphs with "What I see" and "What I mean." (See #3 in Preparation for suggestions on how to facilitate this.)
   Circulate to assist and provide formative feedback. Once they finish annotating the two graphs on their data sheet and write a caption for each graph, have them use their data interpretation as evidence on their "Claim-Evidence-Reasoning worksheet." They will share their data interpretation with other students in the next step.

5. **STUDENTS MEET IN MIXED GROUPS WITH ALL SPECIES (WHELKS, ABALONE, CRABS) REPRESENTED TO SHARE DATA AND MAKE AN EVIDENCE-SUPPORTED CLAIM. (20-30 MIN)**
   Have student pairs find two other student pairs each representing a different animal. In those groups, have students share their data analysis and how it addresses the question: *how does lower pH and higher temperatures affect feeding, growth and interaction between species (or for their species) in the intertidal?* They should write down how each species responded to the lower pH and higher temperature in the investigation under "Evidence" on the "Claim-Evidence-Reasoning worksheet." Then work as a group to develop a claim answering the above question and provide reasoning linking the evidence to their claim. Although students can work together to come up with the claim, to encourage participation have each student write their own answer. (Note: since there are multiple whelk data sheets, it's likely not all groups will get data on whelk shell growth or whelk feeding. You can address this in the class debrief when you go over the data in "Carbonated Communities presentation.") Also, if this part is too complicated for your students, you can have them make a claim addressing how lower pH and higher temperature affected the species they interpreted data on (just one species).

6. **USE "CARBONATED COMMUNITIES PRESENTATION" TO FACILITATE WHOLE CLASS DISCUSSION ABOUT CLAIM-EVIDENCE-REASONING. (10-15 MIN)**
   Project "Carbonated Communities presentation" at slide 11. Have students share some of their claims with the class. (Depending on time, you could have student groups write their claims on chart paper or dry erase white boards and place them around the room for a gallery walk. Students could use sticky notes to ask questions or give feedback about different groups claims.) Then share Dr. Lord and Dr. Barry's conclusions (which ideally match their claims). See "Data Sheets-Teacher Keys" starting on slide 21 to share a sample Claim-Evidence-Reasoning. You may want to mention that there is a mathematical way of determining whether differences are significant or not since some of the measurements and bars in the graph are close.

7. **CONTINUE TO USE "CARBONATED COMMUNITIES PRESENTATION" TO SHARE SCIENTISTS INSIGHTS AND DISCUSS PERSONAL ACTION TO SLOW CLIMATE CHANGE. (10 MIN)**
   The final slides include thoughts shared by the scientists to students doing this lesson as well as some things people are doing to slow climate change. Share one or both of the following videos: "Green Ninja" taking action to lower someone's carbon footprint at https://greenninja.org/Green_Ninja_Show/31 and the other is a video produced by Alliance for Climate Education showing what actions students are taking to "Do One Thing" (DOT) at https://www.youtube.com/watch?time_continue=100&v=37t5UT-39nM. Challenge students to choose one action they can take to slow climate change and carbon pollution down.

Slide One: Carbonated Communities: How is lower pH (ocean acidification) and rising temperatures affecting ocean organisms in the intertidal?

Slide Two: Carbonated Communities, Part Two
Tell students this is what they will be doing in this lesson:
- 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?*

Slide Three: Watch Mollusc Animation: Shell Repair
Have students consider: *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?* Then have students think-pair-share after watching *Mollusc Animation: Shell Repair (*https://www.shapeoflife.org/video/mollusc-animation-shell-repair)

Slide Four: How does lower pH and increased temperature affect feeding, growth and interactions between these species?
Review the testable question of the investigation. The students will be analyzing data collected by Dr. Lord and Dr. Barry.

Slide Five: Claim-Evidence-Reasoning
Then students will be using that data to make an evidence-supported claim using this graphic organizer. (As mentioned in the lesson procedure, decide if students will make a claim about one species or all species in the investigation.)
The claim answers the question. Evidence is scientific data that supports the claim. Reasoning describes why and how the evidence supports the claim. (See "Data Sheets-Teacher Key" and/or "Data Sheets-Teacher Key" at the end of this presentation for a completed example.)
Note: If the Claims-Evidence-Reasoning framework is new to students, there are many lessons you can Google online that introduce it.

Slide Six: Investigation: Experimental Set-up
Remind students of the investigation set-up. 64 tanks with 8 tanks for each of 8 treatments (various conditions/variables). The pH of Monterey Bay seawater was lowered by 0.3 units by adding carbon dioxide for half of the treatments. Temperature of Monterey Bay seawater was raised by 2°C by heating the sea water for the other half. Some tanks included lower pH and heated conditions.

Slide Seven: Analyzing Data: Identify and Interpret (I^2)
Introduce the Identify and Interpret (I^2) strategy to your students if it's new to them. Review if they've used it before. This strategy comes from BSCS Science Learning (the originator of the 5E Instructional Model): https://bscs.org

Often graphs and figures contain a lot of information. This strategy helps break down the information into smaller parts. First, you identify what you see in the graph or figure. Then you interpret each of these observations by deciding what they mean. Once you've determined what the smaller parts mean, then you put the parts together in a caption.
Note to teacher: Use the animation on this slide to practice with the class or show the completed example. Pass out "Identify and Interpret (I^2) worksheet" pages 1-3 to each student.

Slide Eight: Analyzing Data: Identify and Interpret (I^2)
Here is an example of a caption.

Slide Nine: Analyzing Data: Now You Do It
Now try practicing on your sheet with a partner.

Slide Ten: Analyzing Data: Now You Do It
How does yours compare? (Note to teacher: go through "What I see," "What I mean," "Caption," and "Questions I have." Zoom into the slide as you go through each section.)
Pass out data sheets-one to each student and give them time to go through the "Identify and Interpret (I^2)" strategy.

Stop here and pass out the data sheets to each student. Give them time to use the "Identify and Interpret (I^2)" strategy and share their analysis with students who have other species.

Slide Eleven: Let's Share Our Claims
Use this slide while students share claims with the class. (Depending on time, you could have student groups write their claims on chart paper or dry erase white boards and place them around the room for a gallery walk. Students could use sticky notes to ask questions or give feedback about different groups claims.)

Slide Twelve: Conclusion
See the slide for Dr. Barry and Dr. Lord's conclusions. Ask students: Based on this conclusion, how might the intertidal community be affected in conditions of future low pH and increased ocean temperatures?

Slide Thirteen: Debrief Questions

Debrief:

- 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?

Slide Fourteen: Conversation with the Scientists (Dr. Lord and Dr. Barry)

The scientists were very generous in sharing their research and providing photos, fact checking and general info. So we asked them some questions:

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

- One of the challenges of the 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.
- Other unexpected developments-like the 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!

Slide Fifteen: 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.
- What do scientists do for fun? Dr. Josh Lord plays soccer and mountain bikes among other things. Dr. Jim Barry like to surf.
- What advice do they have 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.

Slide Sixteen: On Climate Change

Climate change is a serious issue that should concern us all. Dr. Jim Barry says, "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."

Slide Seventeen: What Are People Doing About Climate Change?

Dr. Lord and Dr. Barry's investigation highlights just a few of the species and relationships affected by carbon pollution and resulting climate change. It's a serious issue. But what can we do about it?

- Unplugging as often as possible to use less electricity (e.g., soccer instead of a screen).
- Talking to other about climate change.
- Paying attention to news/current issues and voting when you can.

Slide Eighteen: What Are People Doing About Climate Change?

There are many great individuals and organizations devoted to education about climate change. Green Ninja is a project out of San Jose State University in which a climate action super hero inspires personal action (through brief videos, a film festival and middle school curriculum). Alliance for Climate Education asks people about their "DOT." "Do One Thing" and choosing one action, be it taking reusable bags to the store, asking for no straw or unplugging more often, is something they encourage us all to do.

Slide Nineteen: What Might Be Your "DOT" to Slow Down Climate Change and Help Intertidal Communities?

What is one thing you might do?

Slide Twenty: Data Sheets-Teacher Key Title Page

Slide Twenty-One: Claims-Evidence-Reasoning Sample

Slide Twenty-Two: Effects on Crab Feeding

Crabs ate more in heated conditions. They ate less in lower pH (added CO^2) conditions.

Slide Twenty-Three: Effects on Crab Mortality

More crabs died (higher mortality rate) in higher CO^2 conditions than any other conditions.

Slide Twenty-Four: Effects on Uncaged Whelk Feeding
Uncaged whelks ate significantly less with a crab present. Lower pH and higher temperatures didn't affect feeding significantly.

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

Slide Twenty-Six: Effects on Uncaged Whelk Shell Growth
Uncaged whelks grew significantly less with a crab present. Lower pH and higher temperatures were not as significant.

Slide Twenty-Seven: Effects on 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.

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

Slide Twenty-Nine: Effects on Abalone Shell Growth
Abalones grew less shell in lower pH (higher CO_2) conditions. Crabs and warmer temperatures were not as significant. However, abalones did grow more shell compared to tissue when a crab was present (this data not included in lesson).

Shape of Life
The Story of the Animal Kingdom

Name___________________________ Period/Class_____________ 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 intertidal?

Claim (answers the question)	
Evidence (scientific data that supports the claim)	Crabs Whelks Abalone Other
Reasoning (describes why the evidence supports the claim)	

Shape of Life
The Story of the Animal Kingdom

Claims-Evidence-Reasoning-Page 2
Student's Edition

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

	4	3	2	1	0
Claim – a conclusion that answers the original question	• Scientifically accurate • Completely answers the question • Common inaccurate claim(s) are clearly addressed.	• Scientifically accurate • Nearly completely answers the question • Inaccurate claim(s) are only generally addressed, no specifics	• Partially scientifically accurate • Partially answers the question • Inaccurate claim(s) are not addressed	• Is not scientifically accurate overall • Does not adequately answer the question	No claim
Evidence – scientific data that supports the claim	• The data are scientifically appropriate to support the claim. • The data are thorough and convincing – enough details and evidence provided. • Proper units are used in data • Shows with evidence why alternate claims do not work	• The data are scientifically appropriate to support the claim • The data are basically sufficient and convincing, but tend to be more general and not as specific and in depth • Does not address why alternate claims do not work • Evidence may be repetitive	• The data relate to the claim, but are not entirely scientifically appropriate • The data are not sufficient, though generally support the claim	• There is some evidence provided, but it is not logically linked to the claim or scientifically appropriate	No evidence provided
Reasoning – describes why the evidence supports the claim	• Reasoning clearly links evidence to claim • Shows why the data count as evidence by using appropriate scientific principles • There are sufficient scientific principles to make links clear between claim and evidence	• Reasoning adequately links claim to evidence • Includes related scientific principles, but only passably clarifies why this data count as evidence • Reasoning tends to be more general and shows only partial depth of content understanding	• Reasoning does not adequately link claim to evidence, or clarify why data count as evidence • Includes related and non-related scientific principles, and shows little depth of content understanding	• Reasoning is clearly insufficient and relates only tangentially to question and claim at hand • Scientific understanding is very limited	Does not provide reasoning

Rubric adapted from one by Kevin J. B. Anderson from K. McNeill and J. Krajcik, NSTA, and SBAC Argumentative Writing Rubric for grades 6-11
https://dpi.wi.gov/sites/default/files/imce/science/CER%20Rubric.docx

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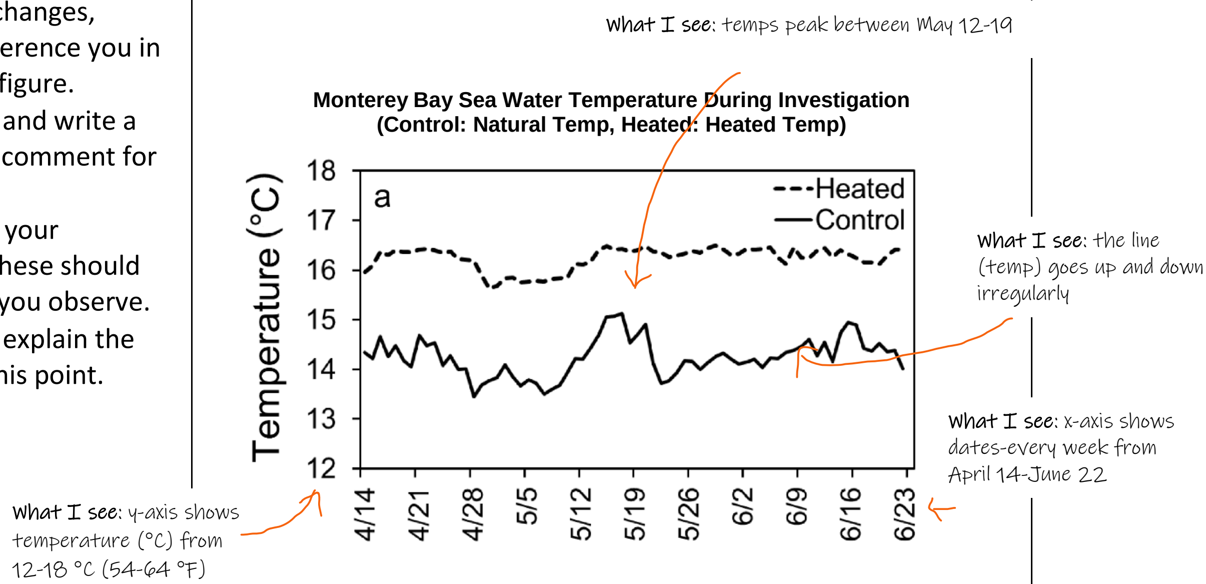
Identify and Interpret (I^2)-Page 1

Student's Edition

Step One: Identify ("What I see" comments)

- Identify any changes, trends or difference you in the graph or figure.
- Draw arrows and write a "What I see" comment for each arrow.
- Be concise in your comments. These should just be what you observe.
- Do not try to explain the meaning at this point.

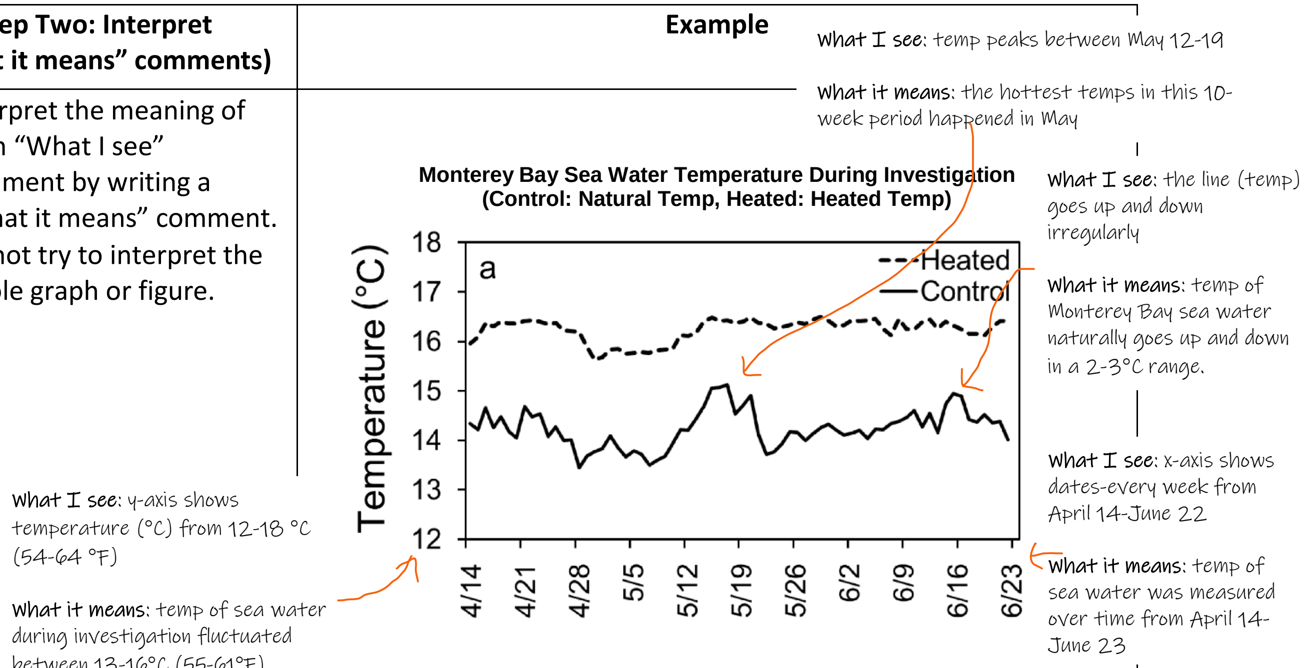
Example



Step Two: Interpret ("What it means" comments)

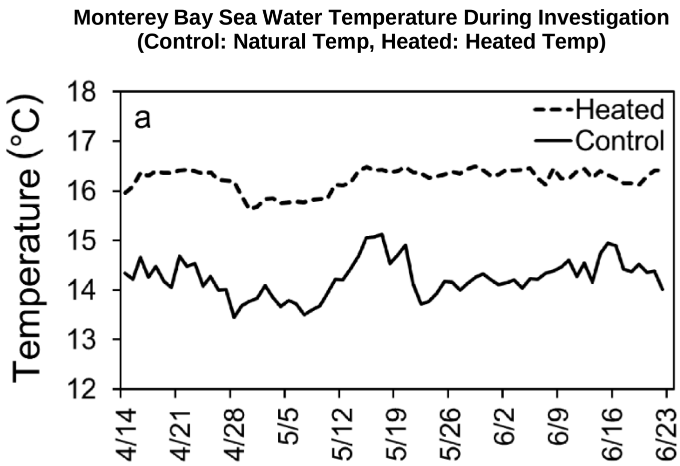
- Interpret the meaning of each "What I see" comment by writing a "What it means" comment.
- Do not try to interpret the whole graph or figure.

Example



Adapted from BSCS Science Learning, bscs.org

Identify and Interpret (I²)-Page 2
Student's Edition

Step Three: Caption and Questions	Example
• Write a caption for the graph or figure. • Start with a topic sentence that describes what the graph of figure shows. • Then join each "What I see" comment with its "What it means" comment to make a sentence. • Build a coherent paragraph out of your sentences.	

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?

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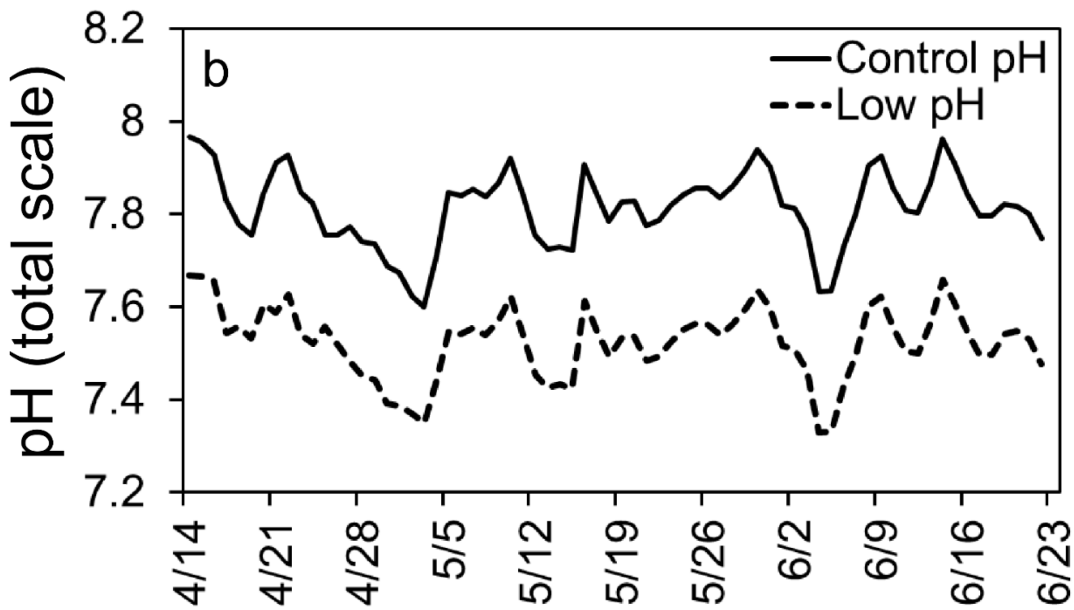
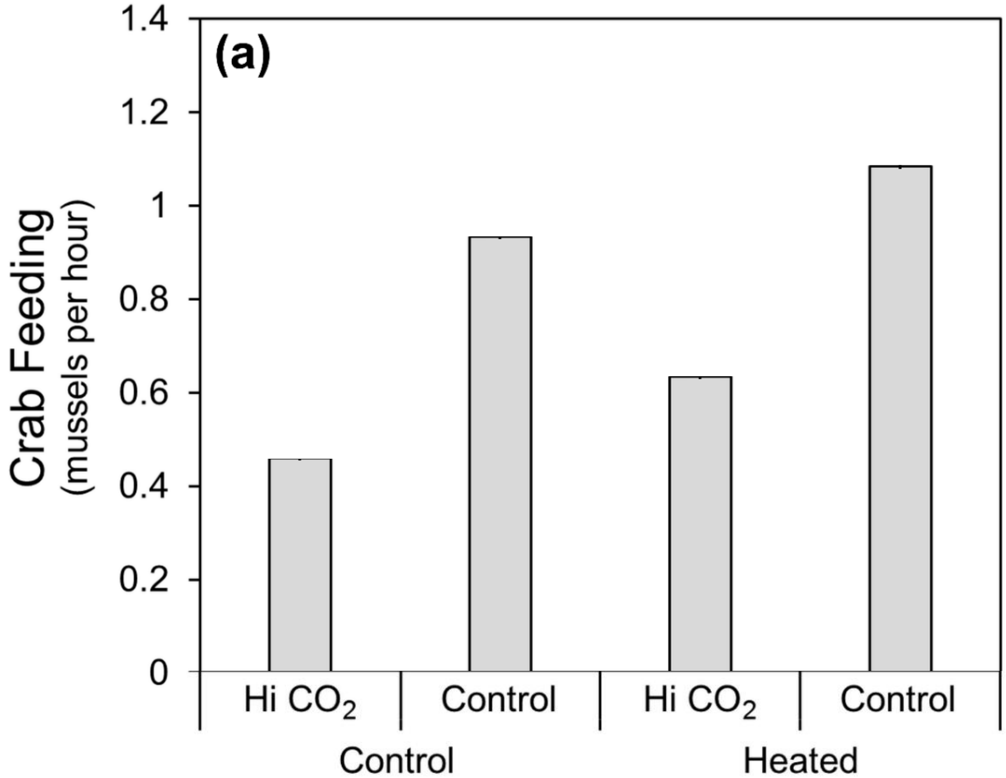
Identify and Interpret (I^2)-Page 3
Student's Edition

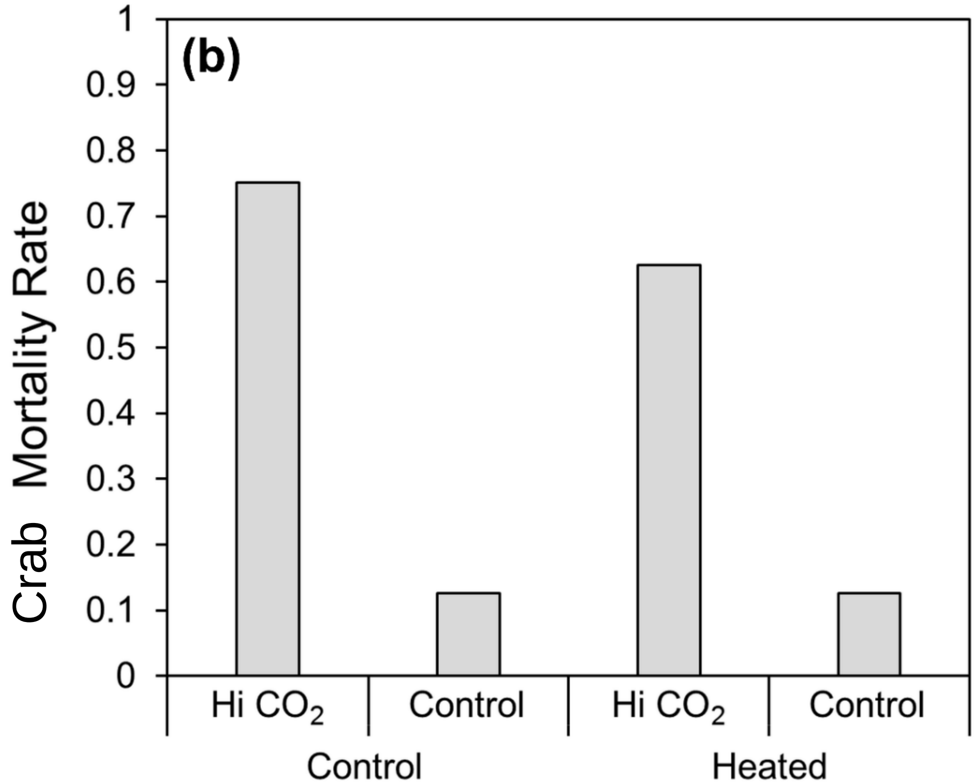


Name________________________ Period/Class___________ Date________

Data Sheet: Effects on Crabs-Page 1

Student's Edition

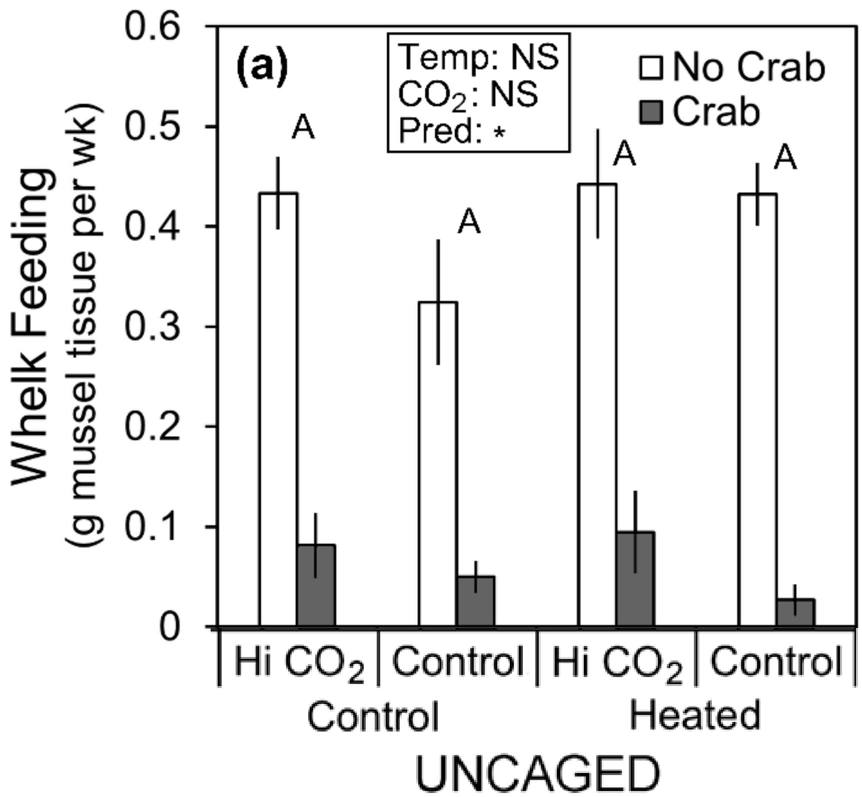


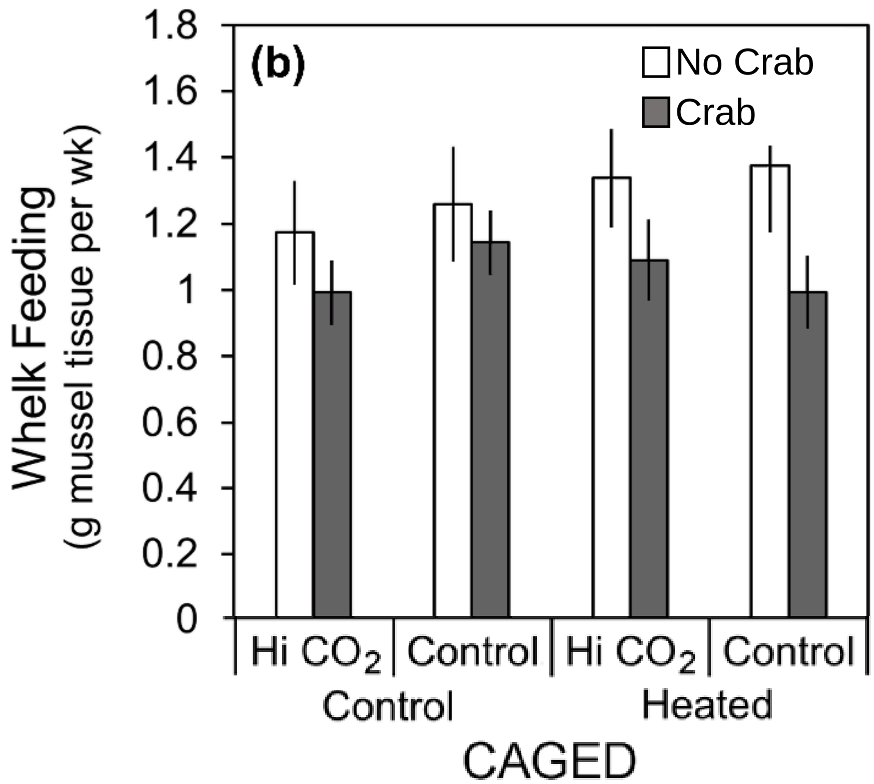


Name___________________________ Period/Class_____________ Date________

Data Sheet: Effects on Whelk Feeding-Page 1

Student's Edition

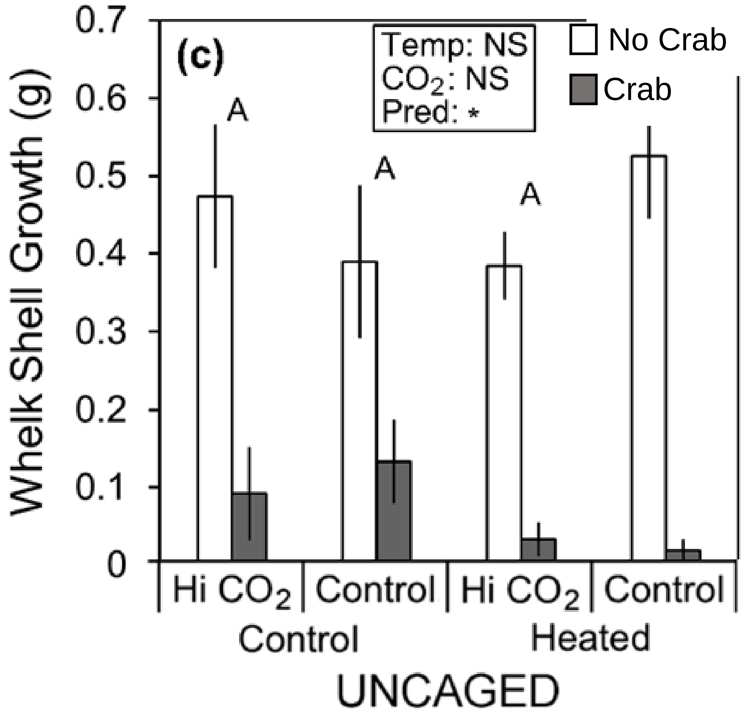


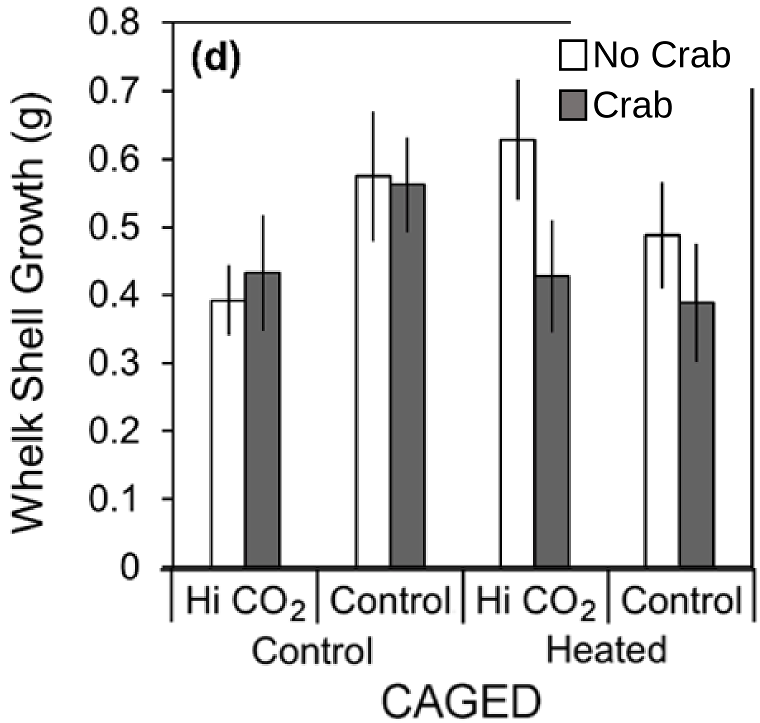


Name____________________________ Period/Class_____________ Date_________

Data Sheet: Effects on Whelk Shell Growth-Page 1

Student's Edition





Name________________________ Period/Class____________ Date________

Data Sheet: Effects on Abalone Feeding-Page 1

Student's Edition