SUNNY SIDE UP: TEMPERATURE & LOBSTER EGG DEVELOPMENT

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Grade Level
7th Grade

Subject area
Life Science

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Title: Sunny-Side-Up: Temperature & Lobster Egg Development

Focus: This lesson allows students to use math and science to characterize the effects of temperature on lobster egg development. Students will measure features of lobster eggs at different time points and plot how they change across development. This development will be compared between lobsters from different environments, and students will be asked to draw conclusions about how these differences may relate to lobster performance and climate change.

Grade Level: 7th Grade Life Science

VA Science Standards:

LS.1 The student will demonstrate an understanding of scientific and engineering practices by

a) asking questions and defining problems

c) interpreting, analyzing, and evaluating data

LS.7 The student will investigate and understand that adaptations support an organism's survival in an ecosystem.

LS.8 The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic and change over time.

LS.9 The student will investigate and understand that relationships exist between ecosystem dynamics and human activity.

M7.1The student will represent relationship with tables, graphs, rules and words.

M7.2 The student will solve practical problems involving operations with rational numbers

Learning Objectives

- Students will identify and measure features of lobster embryos, including the membrane, yolk, and eye-spot
- Students will calculate the area of a lobster embryo
- Students will graph eye-spot diameter as a function of time
- Students will compare the rate of development for embryos from different populations
- Students will explain how differences in temperature may affect lobster populations, using embryo development as an example

Total Time Needed:

1 hour

Key Words:

- Embryo: Unhatched animal that is still developing
- Eye-Spot: Eye of a lobster embryo that grows in size over the course of embryo development
- Eye-Spot Index: A numerical indicator of embryo development, calculated from the size of the eye spot
- Larvae: A recently hatched offspring that resides in the plankton
- Setae: Hair-like substance that holds lobster embryos to the abdomen of the female
- Yolk: Fat-rich substance that provides energy to a developing embryo
- Ovigerous Female: An adult female lobster that is carrying eggs
- Diameter: A straight line through a circle that passes through the center point
- Gulf of Maine: Region off the coast of Maine where lobsters can be found
- Southern New England: Region off the coast of New England, south of Maine, where lobsters can be found

Background Information:

The American lobster is of interest to many scientists because it supports a fishery worth $484.5 million in Maine alone (Maine Dept. of Marine Resources, 2018). Understanding the early life stages of the lobster, such as the embryonic stage, is important for predicting how lobster populations will change in the future. Ovigerous (egg carrying) lobsters typically hold their embryos connected to their abdomen for nine months as the embryos develop until they hatch. Once hatched, lobster larvae live for several weeks at the water's surface, eating plankton and avoiding predators as they develop into juveniles that will settle on the ocean floor for the remainder of their lives. The timing of development, and subsequently hatching, is highly dependent on temperature. Just like a human's heart beat will get faster when it is hot outside, the metabolism and biological processes of lobsters increase as the water temperature rises. This means that lobster from locations with different water temperatures will develop at different rates. The same phenomenon will likely be observed with climate change as a result of warming oceans. In this activity, students will have the opportunity to measure and graph different aspects of embryo development, compare development between locations based on temperature, and relate their findings to the effects of climate change. The two regions that will be compared are the Gulf of Maine and Southern New England. These locations were chosen because of the changes in lobster population they are currently experiencing. Climate change has resulted in far warmer waters in both of these regions. This has made Southern New England too warm for some lobsters in the summer, and their population has fallen (Atlantic States Fishery Council,). The same warming has made the normally very cold Gulf of Maine just right for lobsters, and the population has grown there (Maine Dept. of Marine Resources, 2018). The features of development that will be measured are the diameter of the egg, the length of the eye-spot, and the approximate diameter of the yolk. From that data, students will calculate the area of the egg and yolk, and the percent of the egg that is yolk. The students will also graph the eye-spot size over time. Eye-spot size increases with developmental stage, and is commonly transformed into an Eye-Spot Index value to track development over time (Perkins, 1972). In the final portion of the activity, students will graph and compare the provided Eye-Spot Index value over time for both the Gulf of Maine and Southern New England.

Materials:

- Student Worksheet
- Printed Images
- Metric Ruler
- Calculator
- Pencils/Pens
- Magnifying Glass (optional for examining embryo photos)
- Expo Marker (optional if photos are laminated)

Classroom Set-up:

This activity is recommended for groups of 2-3, but students can work individually if needed. If in groups, students should be able to sit with their group members. Each group (or student, if working individually) will need a printed worksheet, including the photos of the lobster eggs. The photos can be laminated and used over and over again. If using laminated photos, you may choose to also provide each group with an expo marker to identify the features they will be measuring. If working virtually, students can use a ruler to measure the egg features as they appear on their computer screen.

Procedure:

1. **Prepare Materials**

   The instructor will pass out the worksheets and images, assign groups (if applicable), and set up the Power Point slides. The printable images can be laminated and used for future iterations of this activity.

2. **Introduction**

   The instructor will introduce the lesson and activity using the provided PowerPoint. Talking points are included in the notes section of each slide. Throughout the PowerPoint, students will be exposed to the basic lifecycle and ecology of the American lobster, key features of embryo development, and techniques used to measure development. To accompany the PowerPoint, the instructor will demonstrate how to measure the different embryo features covered in the PowerPoint and required on the worksheet.

   <u>Optional</u>: In a virtual setting, the instructor may choose to forgo the printed worksheets and instead use an online whiteboard to identify different embryo features and demonstrate how to measure them.

3. **Activity/Assessment**

   The instructor should allow time for students to complete each part of the worksheet with their group and discuss the accompanying questions. Over the course of the activity, students will use a ruler to measure different embryo features in millimeters from the provided images.

   They will use their measurements of egg and yolk diameter to calculate egg area and % yolk. The instructor may have to walk through the formulas for area and percent for the class. It is important to note that none of the features shown are perfect circles, but for the sake of this activity we are assuming they are. Diameters should be measured as the longest length of a given feature, unless noted otherwise. Students will then graph development over time.

   Finally, students will be asked to graph and compare development between two different locations with different temperature conditions. Instructors should emphasize to students that they only need to choose one embryo from each image to measure, based on its visibility. The instructor should move from group to group to assist with the measurements and calculations. Depending on the time available and goals of the instructor, parts of the activity may be omitted.

   <u>Optional</u>: In a virtual setting, instructors may choose to have students use a ruler (virtual or physical) on the screen for students who may not have access to printed materials. For more advanced students, the instructor may choose to modify the calculation portion of the activity so that students determine egg and yolk volume, rather than area.

4. **Discussion/Reflection**

   The last three questions on the student worksheet are intended for class discussion and reflections. Students are asked to apply the information they learned in the activity to new scenarios, and reflect on the importance of their findings. Students should be given an opportunity to provide their own thoughts during this section, but the instructor should guide the discussion to summarize the main points.

References

Maine Department of Marine Resources. (2020). Historical Maine Fisheries Landings Data. Retrieved December 07, 2020, from https://www.maine.gov/dmr/commercial-fishing/landings/historical-data.html

Perkins, H. (1972). Developmental rates at various temperatures of embryos of the northern lobster (*Homarus americanus* Mile-Edwards). *Fishery Bulletin*, 70(1), 95-99.

Atlantic States Marine Fisheries Council (2020). American lobster stock status. Retrieved December 20, 2020, from http://www.asmfc.org/species/american-lobster

Appendices

Appendix I Worksheet

Name______________________________________

Introduction: You are interested in tracking the development of lobster embryos in the Gulf of Maine, so that you can predict when the eggs will hatch. For this activity, imagine you have the opportunity to accompany a lobster fisherman each month from October to April. Every time you find an ovigerous lobster, you take a picture of some of her eggs under a microscope. You decide to measure the eye-spot, egg diameter, yolk diameter, and to estimate the egg and yolk area.

Instructions:

Part One

Using a ruler, measure and record in millimeters the longest egg diameter, eye-spot length, and shortest yolk diameter of one clearly visible embryo from each month. Then, use the equation for the area of a circle to calculate the approximate area of the egg and the yolk. Finally, calculate the percent of the egg that is made up of yolk. The yolk and the eggs are not perfect circles, but we will assume they are for this activity.

Table A

Month	Egg Diameter (mm)	Egg Radius (mm)	Yolk Diameter (mm)	Yolk Radius (mm)	Eye Spot Length (mm)
October					
November					
December					
January					
February					
March					

Equation for area of a circle:

$A = \pi r^2$

A = Area

Pi = 3.14

r = radius (diameter/2)

Equation for calculating percent:

$$\% \, Yolk = \frac{Area \; of \; Yolk}{Area \; of \; Egg} \times 100$$

Table B

Month	**Egg Area (mm^2)**	**Yolk Area (mm^2)**	**Percent Yolk Remaining (%)**
October			
November			
December			
January			
February			
March			

1. How did egg diameter, yolk diameter, and eye spot length change over time?

Egg Diameter:

Yolk Diameter:

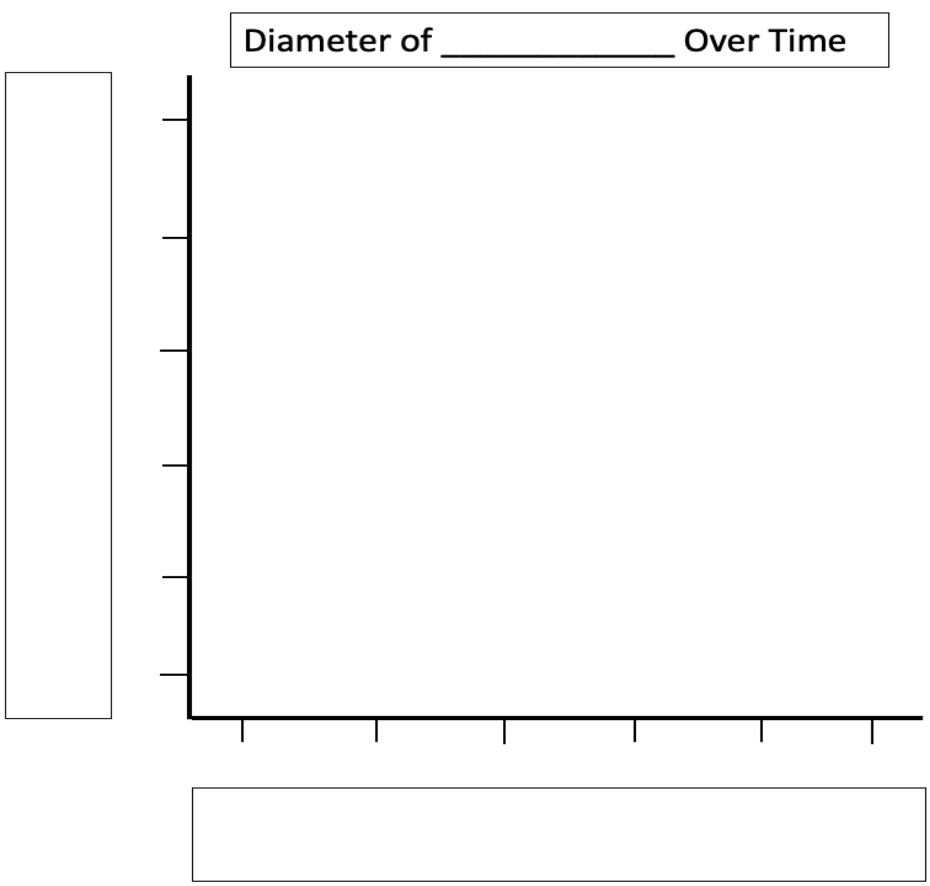
Eye Spot Length:

2. Why might the % yolk in the egg be decreasing over time?

3. Do you think your results would have been different if you selected a different egg to measure? Why or why not?

Part Two

Plot the eye spot diameter that you measured in Table A on the graph below. Fill in the x and y axis labels and complete the graph title. Connect the dots (data points).

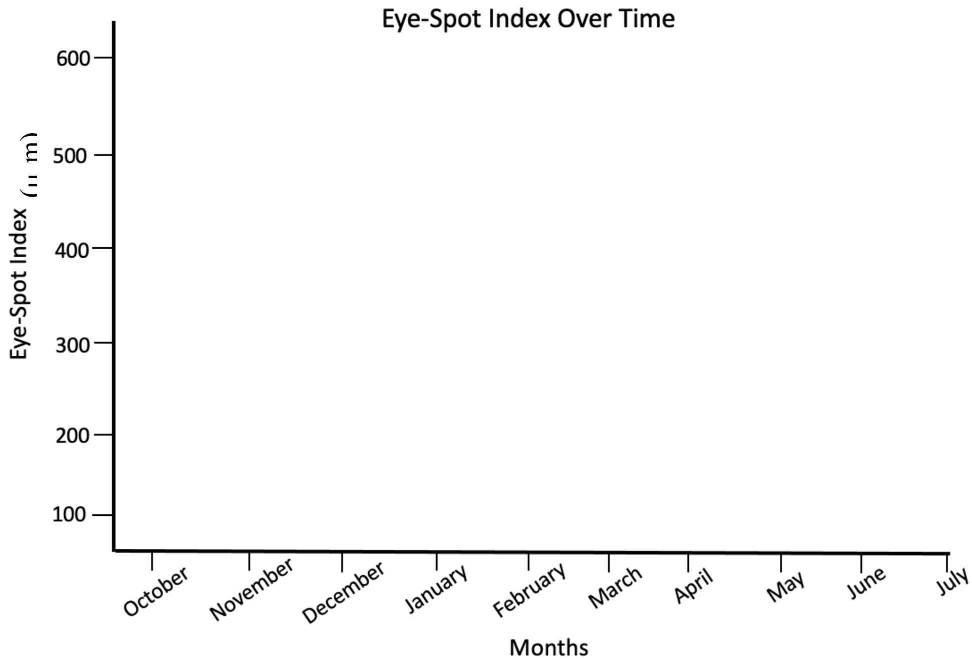


1. What does the slope of the graph you plotted represent? (Think about your axis labels and "rise over run")

When scientists measure eye-spot diameter, they convert the length into an Eye-Spot Index, which is typically reported without units. The Eye-Spot Index is directly related to how developed the embryos are. If an embryo has a higher Eye-Spot Index value, it is more developed. Imagine that instead of just photographing and measuring eggs from one boat in one location every month, you measure the eye-spot diameter and calculate the eye-spot index value for embryos from two locations: one in the Gulf of Maine, and one in Southern New England (shown below). Using the eye-spot index value in the table below, graph the eye-spot index for each location and connect the data points to create a line graph. Use a different color or symbol for each location so you know which data point corresponds with which location, and include a legend showing which color goes with which location.

Table C

	Eye-Spot Index Value	
Month	**Gulf of Maine**	**Southern New England**
October	75	75
November	150	150
December	200	200
January	250	275
February	250	275
March	250	275
April	300	350
May	350	450
June	400	550
July	550	NA - hatched



1. Compare and contrast the graphs of eye-spot index for the Gulf of Maine and Southern New England. What do you notice?

2. Based on your answer from above, which location has faster embryo development? How do you know?

Class Discussion Questions & Reflection

1. One of the major differences between the Gulf of Maine and Southern New England is the temperature. Why might temperature affect the rate of embryo development?

2. Consider the information we learned in the PowerPoint – How might the differences in development/hatching time affect the way lobster embryos and larvae interact with their environment?

3. Climate change, caused by the influx of CO_2 to the atmosphere due to burning fossil fuels, is expected to cause warmer temperatures in both the Gulf of Maine and Southern New England. In fact, it has already caused lobster populations to shift north – away from Southern New England – because the region experiences too many days hotter than lobsters can handle.

A) What effects may climate change have on lobster embryo development, hatching, and interaction with their environment?

B) If a scientist is interested in how lobster embryos respond to climate change, why might they choose to compare the development of embryos from the Gulf of Maine and Southern New England?

Appendix II Worksheet

Introduction: You are interested in tracking the development of lobster embryos in the Gulf of Maine, so that you can predict when the eggs will hatch. For this activity, imagine you have the opportunity to accompany a lobster fisherman each month from October to April. Every time you find an ovigerous lobster, you take a picture of some of her eggs under the microscope. You decide to measure the eye-spot egg length, and to estimate the egg and yolk volume.

Instructions:

Part One

Using a ruler, measure and record in millimeters the longest egg diameter, eye-spot length, and yolk diameter of one clearly visible embryo from each month. Then, use the equation for the volume of a sphere to calculate the approximate volume of the egg and the yolk. Finally, calculate the percent of the egg that is yolk. The yolk and the eggs are not perfect spheres, but we will assume they are for this activity.

*Answers will vary between students and based on size photo is printed at. Example given for one month below

Table A

Month	Egg Diameter (mm)	Egg Radius (mm)	Yolk Diameter (mm)	Yolk Radius (mm)	Eye Spot Length (mm)
October					
November					
December					
January					
February					
March	3 mm	1.5 mm	1 mm	.5 mm	.5 mm

Equation for area of a circle:

***Note: Teacher should walk through an example calculation using these equations**

$A = \pi r^2$

A = Area

Pi = 3.14

r = radius (diameter/2)

Equation for calculating percent:

$$\% \, Yolk = \frac{Area\ of\ Yolk}{Area\ of\ Egg} \times 100$$

*Answers will vary. Example given for one month below

Table B

Month	Egg Area (mm^2)	Yolk Area (mm^2)	Percent Yolk
October			
November			
December			
January			
February			
March	7.07	.79	11.17%

1. How did egg diameter, yolk diameter, and eye spot length change over time?

Egg Diameter:

Egg Diameter increases over time

Yolk Length:

Yolk length decreases over time

Eye Spot Length:

Eye spot increases over time

2. Why might the % yolk in the egg be decreasing over time?

The embryo uses up the yolk as energy to fuel development

3. Do you think your results would have been different if you selected a different egg to measure? Why or why not?

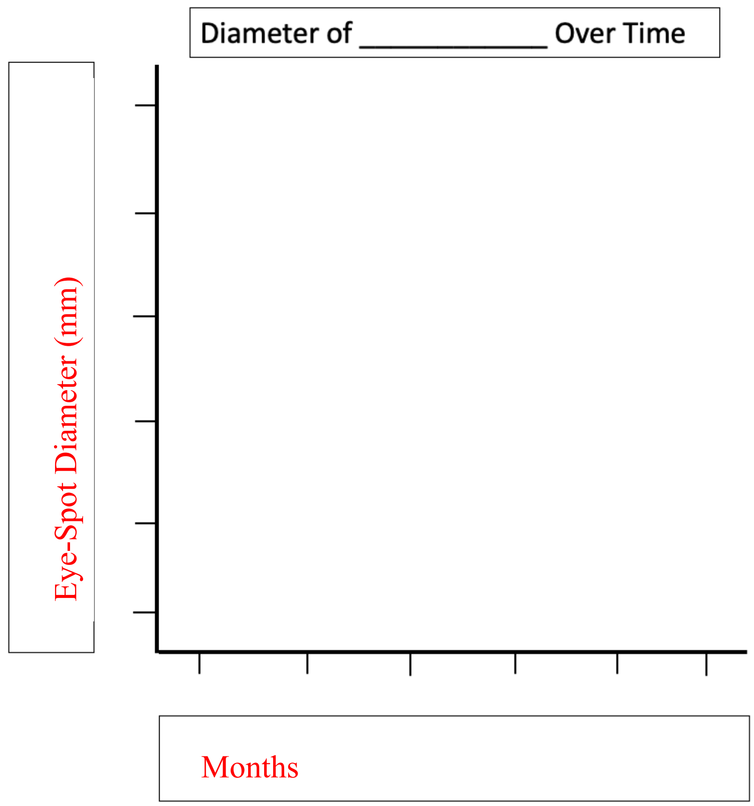
Yes, the eggs are not all the exact same size so they would have different values. Not all the eggs are in the same position, which could also make the measurements different.

Part Two

Plot the eye spot diameter that you measured in part one (Table A) on the graph below. Fill in the x and y axis labels and complete the graph title. Connect the dots (data points).

*Answers will vary, but should be approximately linear

Lobster Egg Eye-Spot



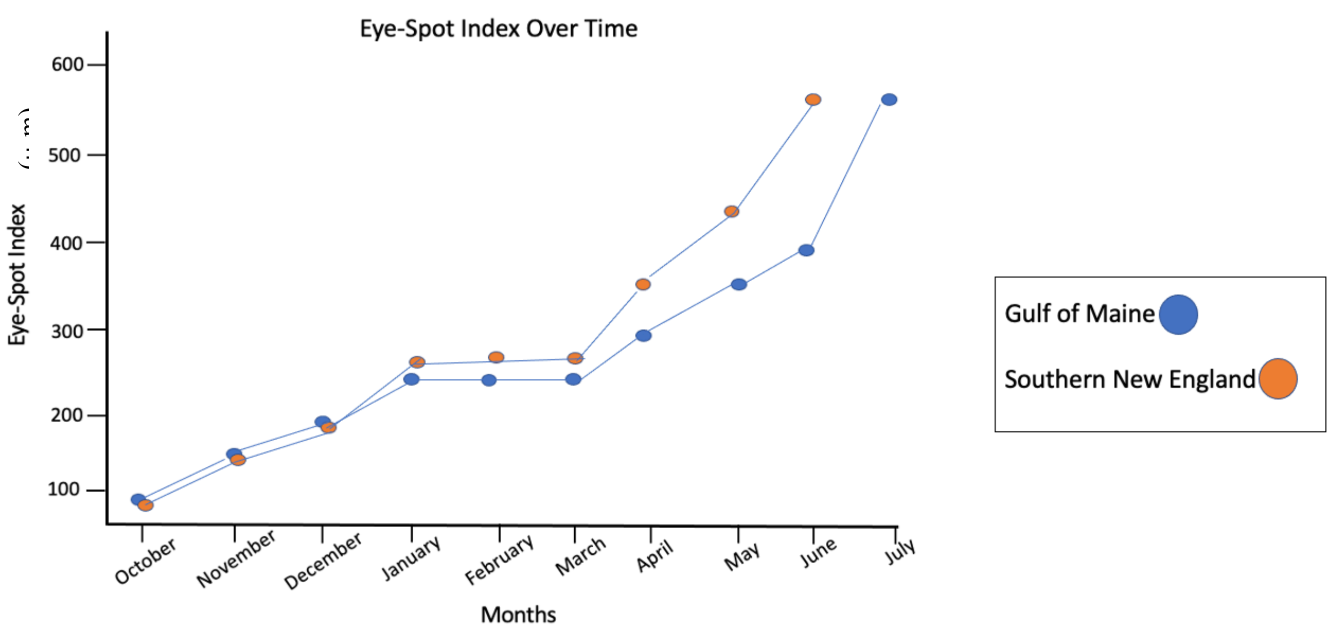
1. What does the slope of the graph you plotted represent? (Think about your axis labels and "rise over run")

The rate of development

When scientist measure eye-spot diameter, they convert the length into an Eye-Spot Index. The Eye-Spot Index is directly related to how developed the embryos are. If an embryo has a higher Eye-Spot Index value, it is more developed. Imagine that instead of just photographing and measuring eggs from one boat in one location every month, you measure the eye-spot diameter and calculate the eye-spot index value for embryos from two locations: one in the Gulf of Maine, and one in Southern New England (shown below). Using the eye-spot index value in the table below, graph the eye-spot index for each location and connect the data points. Use a different color or symbol for each location so you know which data point corresponds with which location.

Table C

	Eye-Spot Index Value (µm)	
Month	**Gulf of Maine**	**Southern New England**
October	75	75
November	150	150
December	200	200
January	250	275
February	250	275
March	250	275
April	300	350
May	350	450
June	400	550
July	550	NA - hatched



1. Compare and contrast the graphs of eye-spot index for the Gulf of Maine and Southern New England. What do you notice?

At first the two locations have embryos with similar eye-spot indices. However, over time the eyespot index for embryos from Southern New England increases faster than the embryos from the Gulf of Maine.

2. Based on your answer from above, which location has faster embryo development? How do you know?

A higher eye-spot index is related to greater development, so the rate of development for embryos from Southern New England is faster than for embryos from the Gulf of Maine.

Class Discussion Questions & Reflection

1. One of the major differences between the Gulf of Maine and Southern New England is the temperature. Why might temperature affect the rate of embryo development?

This is a good opportunity to solicit student suggestions. Eventually lead into a discussion of how metabolism increases at higher temperatures in most organisms. You can use humans as an example, and how when it is hot outside, heart rate increases. When metabolism is faster, so are most biological processes, including development. So, lobster populations in warmer climates (like Southern New England) typically have embryos that develop faster and hatch earlier than lobsters from colder climates (like the Gulf of Maine).

2. Consider the information we learned in the PowerPoint – How might the differences in development/hatching time affect the way lobster embryos and larvae interact with their environment?

There may be many different answers to this question, and you can steer the conversation in the direction that most closely aligns with your objectives. When lobster eggs hatch will determine what/how many predators they are exposed to in the plankton and what/how much food is available to them. Just like warmer temperature lead to faster egg development, they also lead to faster larval development, which means the amount of time larvae are in the plankton and exposed to predators will vary with temperature/location.

3. Climate change, caused by the influx of CO_2 to the atmosphere due to burning fossil fuels, is expected to cause warmer temperatures in both the Gulf of Maine and Southern New England. In fact, it has already caused lobster populations to shift north – away from Southern New England – because the region experiences too many days hotter than lobsters can handle.

A) What effects may climate change have on lobster embryo development, hatching, and interaction with their environment?

B) If a scientist is interested in how lobster embryos respond to climate change, why might they choose to compare the development of embryos from the Gulf of Maine and Southern New England?

Similarly to the difference in development based on temperature that the students examined in the activity, lobster embryos will likely develop faster and hatch earlier in the future due to climate change warming their environment. This will likely have similar effects to those described in question 2. However, climate change could also cause a mis-match between hatching and food availability. If lobsters hatch before phytoplankton bloom, they won't have the same amount of food. Or the "wrong" type of phytoplankton might be present and the lobsters won't get the same nutrition. It is important to note here that climate change includes other effects beyond just temperature that lobsters may be affected by, including ocean acidification. However, scientist can compare embryo development between the Gulf of Maine and Southern New England to get an idea of how development in the Gulf of Maine may change in the future when temperatures in that location more closely resemble current temperatures in Southern New England.

Appendix III Photos for Activity

I. October

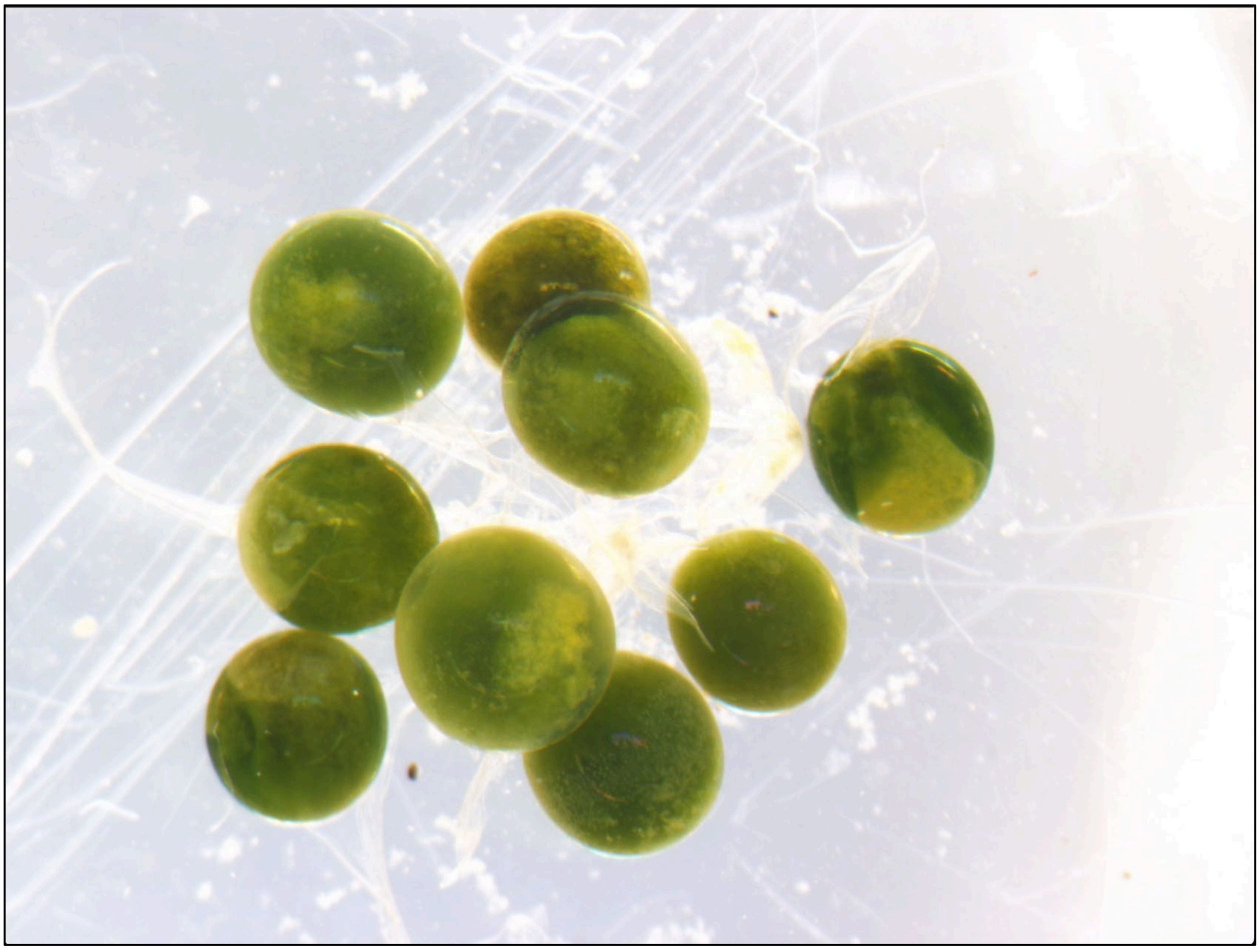


Image Credit:
Jeffery Shields

II. November

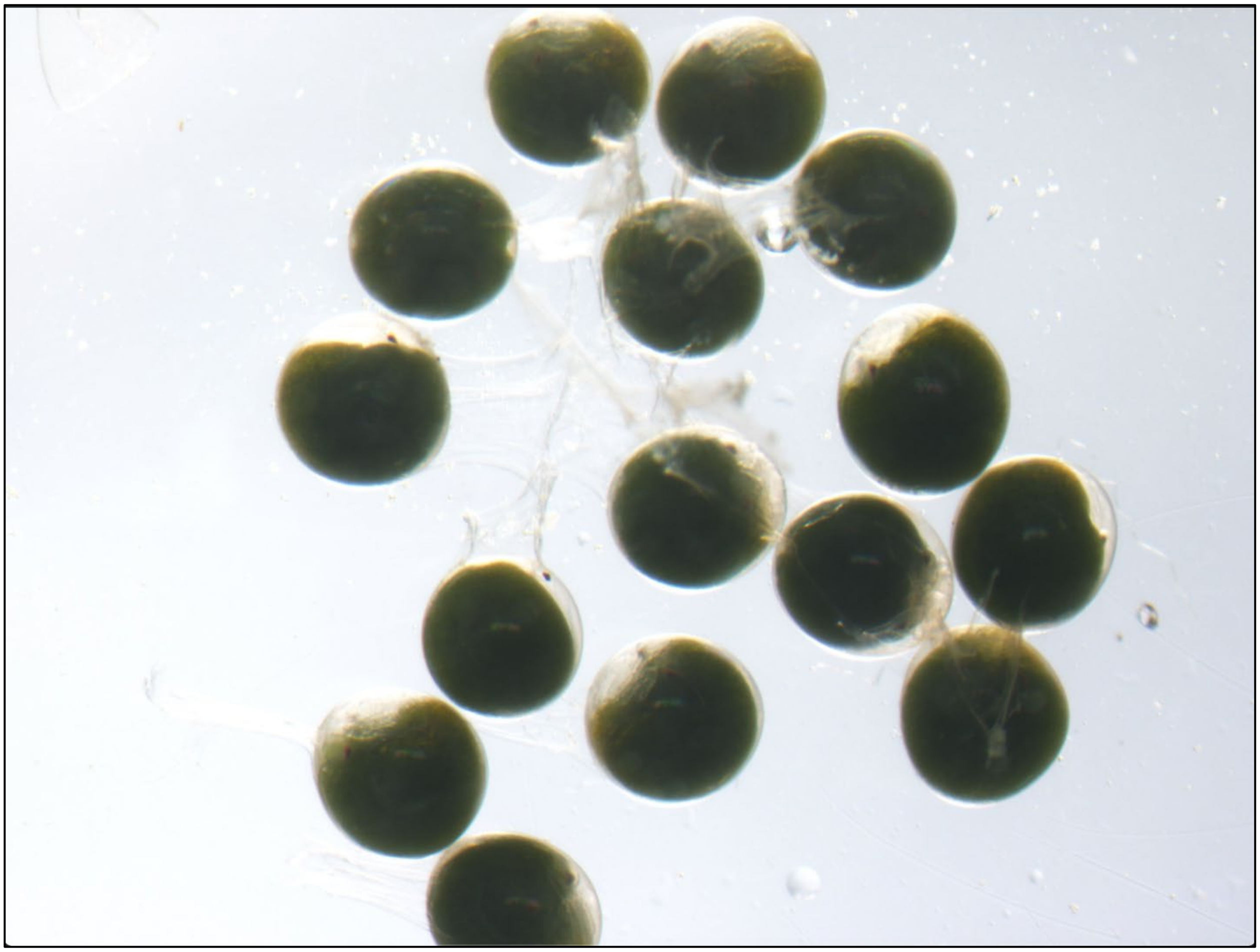


Image Credit:
Jeffery Shields

III. December

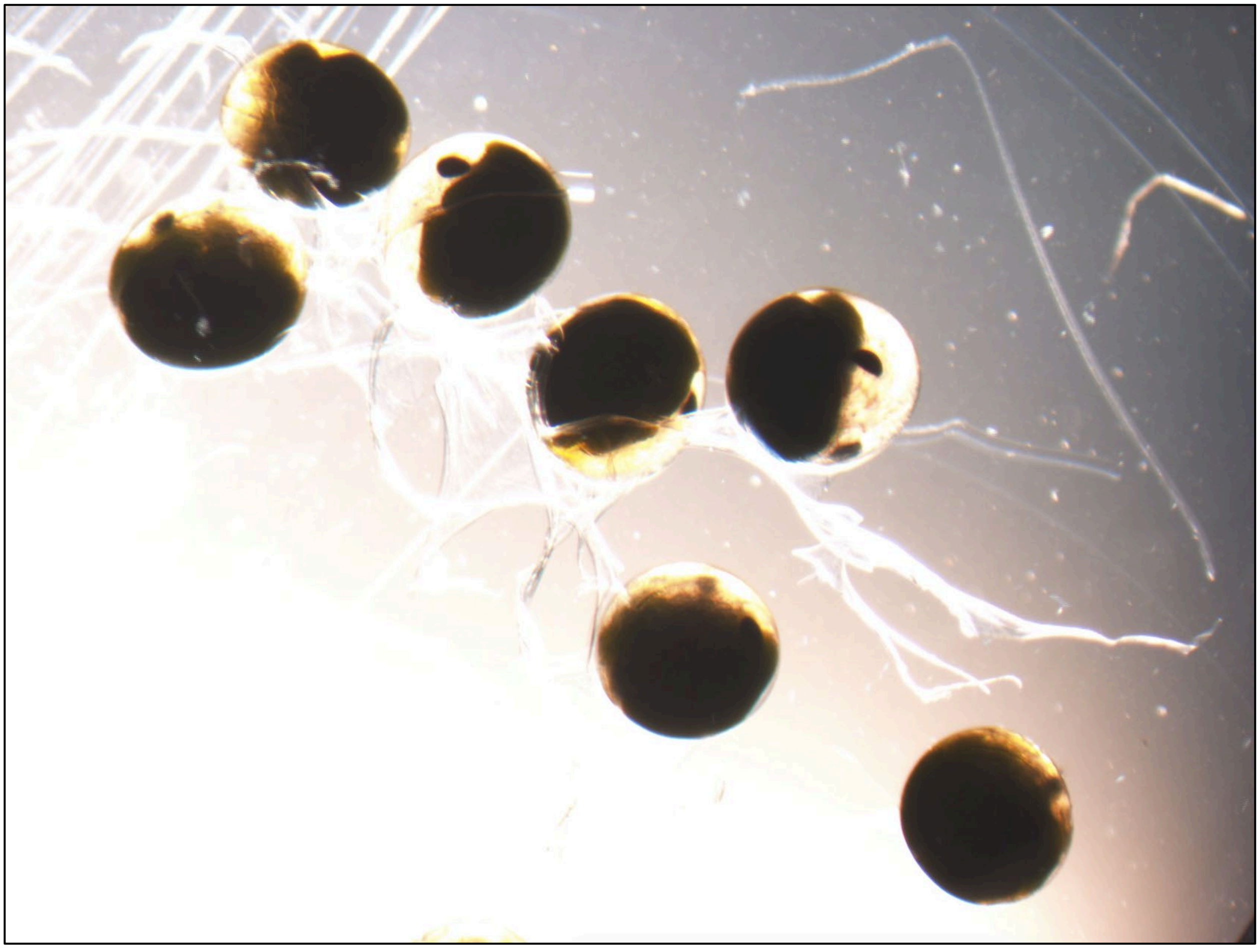


Image Credit:
Jeffery Shields

IV. January

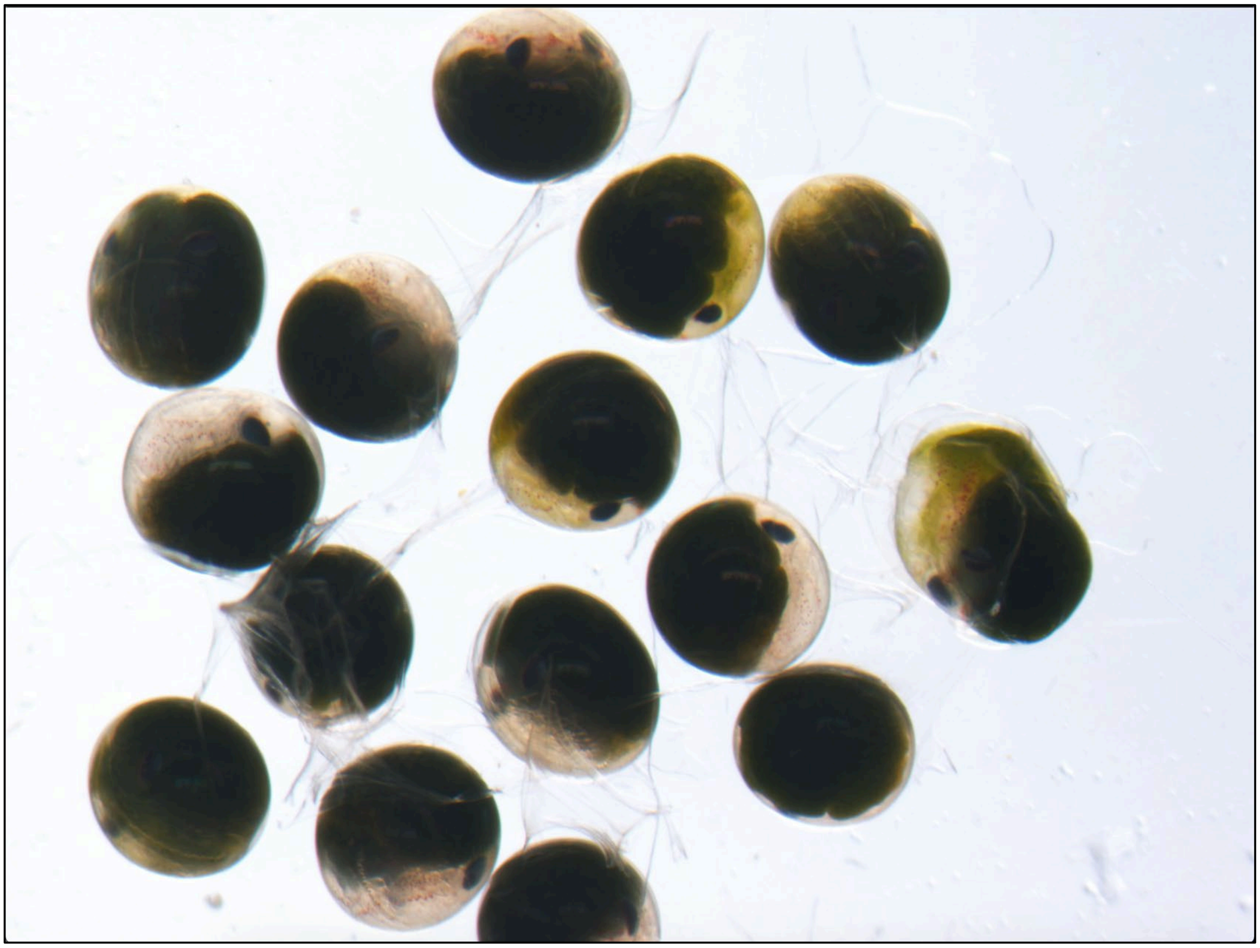


Image Credit:
Jeffery Shields

V. February

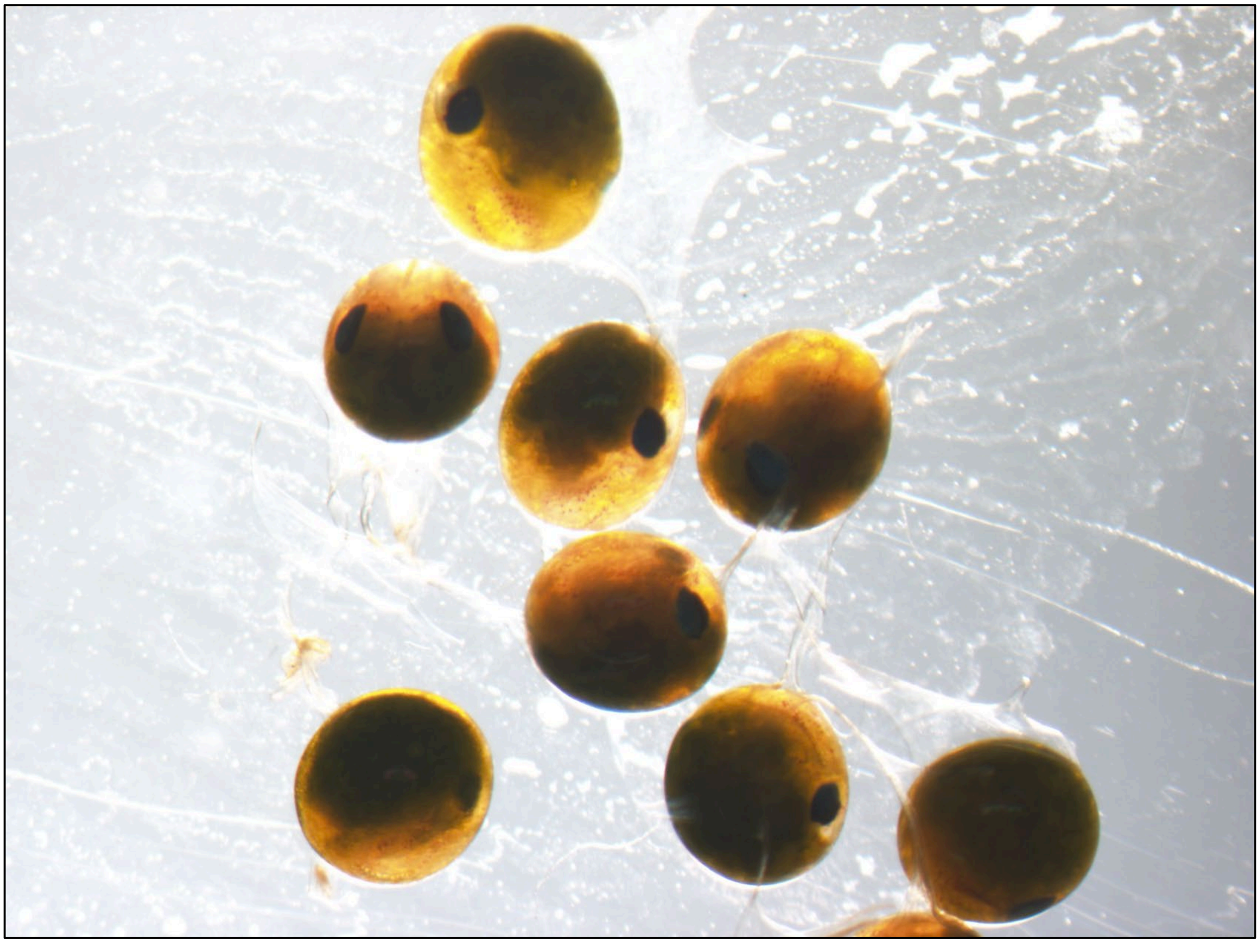


Image Credit:
Jeffery Shields

VI. March

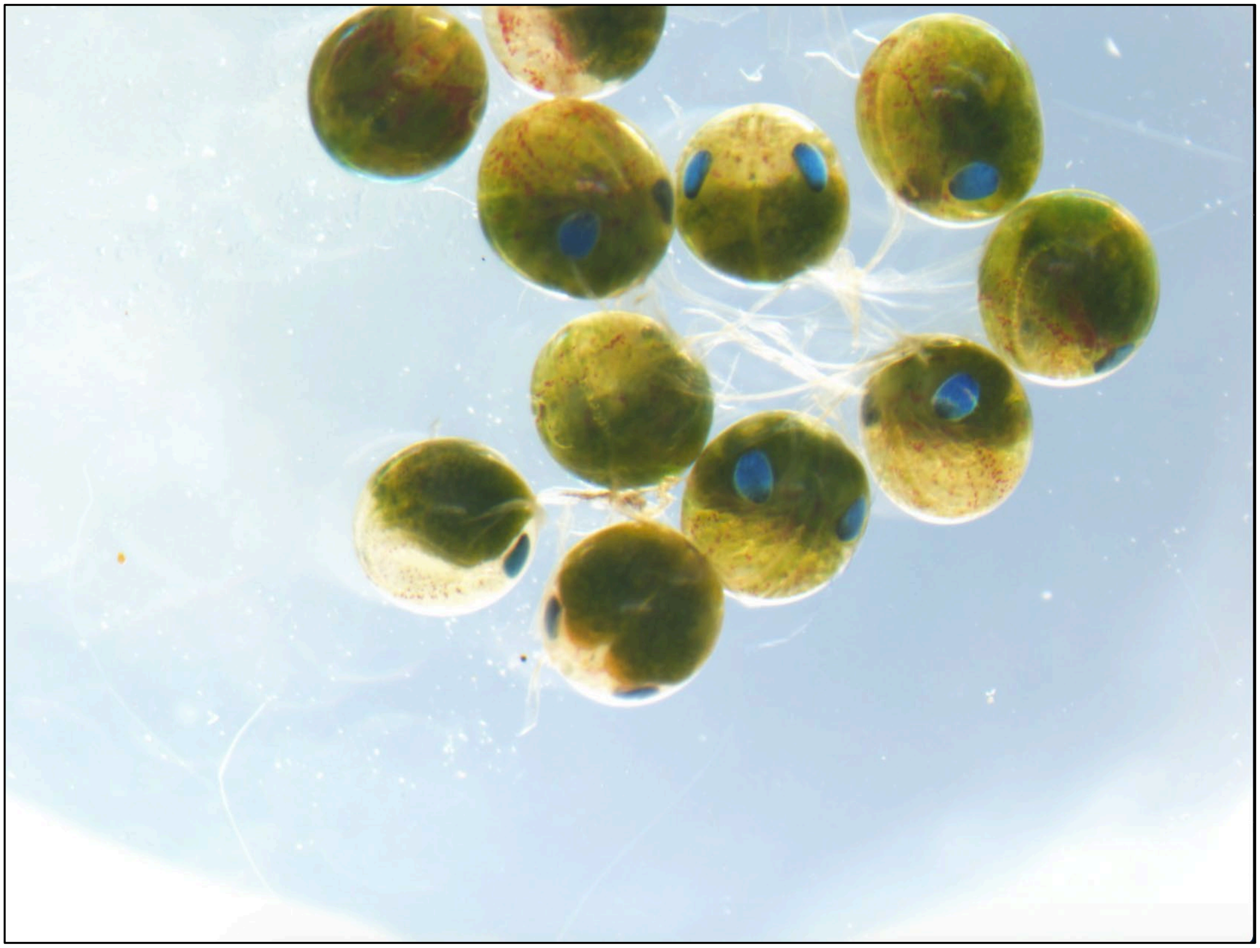


Image Credit:
Jeffery Shields