TEACHERS AND RESEARCHERS EXPLORING AND COLLABORATING

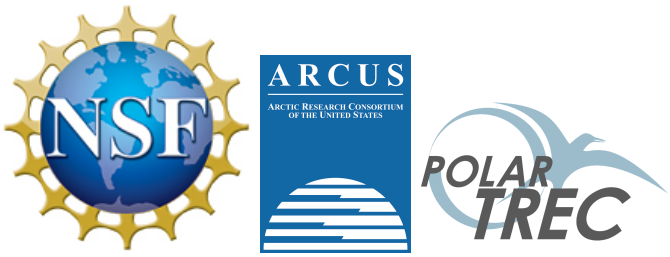
PolarTREC Lesson Resource

Don't Clam Up - The Effects of Warming Seas on Respiration and Biomass

Piper Bartlett-Browne

Northern Chukchi Integrated Study

PolarTREC Expedition Page
https://www.polartrec.com/expeditions/northern-chukchi-integrated-study



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Overview

This lesson plan is designed to teach students about the importance of the benthic community in the shallow portions of the Arctic and how climate change may affect their respiration. One of the dominant benthic animals in the Arctic, the bivalve Macoma sp., is an important food source for higher trophic level organisms such as walrus and Spectacled Eiders. Understanding how warming waters can affect these mollusks can help predict what may happen to other animals in the Arctic. Students will generate respiration rate data for bivalves in varying water temperatures and draw conclusions about the relationship between their data and biomass.

Objectives

1. Students will be able to care for bivalves in a lab setting by understanding their physiology
2. Students will use oxygen sensors, graphing software, and other lab equipment to collect data
3. Students will understand the importance of benthic organisms in the Arctic and how bivalves in particular play an important role in upper trophic levels
4. Students will be able to identify relationships between respiration rate and temperature
5. Students will be able to predict how warming waters will have an overall effect on the biomass of benthic organisms using respiration data and the idea of carrying capacity
6. Students will draw conclusions about bivalve biomass and its effect on species such as walrus and Spectacled Eiders

Lesson Preparation

The Distributed Biological Observatory (DBO) is an international scientific effort to observe changes over a latitudinal gradient in the Bering and Chukchi Seas in the Pacific Arctic. The sampling sites have been chosen for their high productivity, biomass, and rates of change of biological components (https://www.pmel.noaa.gov/dbo/about). The benthic organisms at these sites are varied and can provide information about the health of the ecosystem. The benthos is dominated by bivalves, worms, crabs, sea stars, and many other invertebrates and in many cases provides a food source for higher trophic levels. For example, bivalves provide food for walruses in the Arctic. Understanding the location and biomass of bivalves can give information about walrus foraging. Understanding the relationship between the benthic organisms and their environment can help scientists learn more about the Arctic ecosystem and predict what may happen in the future.

Resource Details

Region

Arctic

Completion Time

About a week

Grade

High school and Up

Permission

Download and Share

Location

Northern Bering and Chukchi Seas

Expeditions

Northern Chukchi Integrated Study

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Materials

3 dissolved O2 sensors per student group

Computer with data collection software and graphing software

Climate Change in the Arctic
NOAA's Arctic Report Card reports on the health of the Arctic and the effects of climate change on the ecosystem. In 2019, the August mean sea surface temperatures (SSTs) were about 1-7 °C warmer in the Chukchi Sea than previous years and indicated a statistically significant warming trend. The end of summer sea ice extent was tied with 2007 as the second-lowest in satellite record. Higher than normal SSTs are related to increases in air temperature due to greenhouse gases and, more significantly, the melting of sea ice, which lowers albedo and absorption of more shortwave radiation from the Sun. The reduction in sea ice and higher sea surface temperatures will affect the ecosystem, including benthic organisms.

Cellular Respiration
Aerobic cellular respiration is the process by which organisms break down sugars (food!) using oxygen. Arctic bivalves, humans, and many other species undertake cellular respiration to break down food and generate energy for survival. The general equation for cellular respiration is as follows:

$C_6H_{12}O_6$(sugar) + $6O_2$(oxygen) -----> $6CO_2$(carbon dioxide) + $6H_2O$(water) + ~38 ATP(energy)

There are several factors that can affect the rate of respiration. In this lab activity, students will be examining how temperature and mass can affect respiration. An increase in temperature will increase the rate of respiration. A higher biomass will also increase the rate of respiration. Students will observe more oxygen being consumed by larger bivalves and those individuals in warmer water.

Live Bivalves

3 Beakers per student group

Internet

Parafilm

Thermometers

Digital Scale (in grams)

3 refrigeration units

Fish tank

Air pump

Extension cords (if necessary)

Topic

Tools and Methods

Ecology

Organisms and Their Environments

Regulation and Behavior

Climate Change

Carrying Capacity
As Arctic sea temperatures increase, so will the consumption of oxygen by benthic organisms. Oxygen is an essential resource and the more animals that use it, the less available oxygen there is for other individuals. Carrying capacity for an environment is the maximum population size of a species that can be sustained given availability of resources like food, habitat, oxygen and other needs. Generally, we expect that more oxygen will be consumed as temperature increases resulting in an overall reduction of individuals for any given ecosystem space. As a result, a reasonable hypothesis would be that with increasing temperature, the biomass of the dominant bivalves in the Arctic will decrease and provide less food for walrus, Spectacled Eider, and other higher trophic level consumers.

Procedure

Day 1

1. Students will be collecting data on respiration rates of bivalves using two variables: body mass and temperature. You can have each lab group of students complete a data set for each or assign lab groups to different variables.
2. For each group, have students hypothesize what will happen to the respiration rate of the bivalves and how it will change as a result of temperature and body mass variations.
3. In their groups, students will research bivalve anatomy and watch video clips of footage of benthic organisms taken in the Bering and Chukchi Seas. Have students include notes about

their observations in their lab notebook. You will find the video here.
4. Temperature Variable Group: Set the three refrigerators to three different temperatures within the bivalve's range of survival. Have students choose a high, mid-range, and low temperature. Put a large container of water in each refrigerator to adjust to the temperature overnight. Put an air pump in each to keep water circulating for oxygenation.
5. Set up any tables or extension cords needed for the computers or sensors. Students will be collecting data for 24 hours and equipment will need to be plugged in.

Day 2

6. Each group will get three beakers, three dissolved O2 sensors, and parafilm. Have students set up their O2 sensors to collect data continuously during the experiment using the sensor software. You can have them do a test run to ensure that the data will be collected.
7. Temperature Variable Group will receive three bivalves of approximately the same mass. Use the digital scale and record each bivalve's mass. Students will put water from each of the three different temperature refrigerators in each labeled beaker. Have students take the temperature of the water and record it on their data table. Body Mass Variable Group will receive three bivalves of three different sizes. Use the digital scale to measure and record each bivalve's mass. Students in the body mass variable group will be using the mid-range water temperature. Students will put this water in each of their three labeled beakers and record the temperature of each. They should be about the same.
8. All groups will then place one bivalve in each of the beakers and cover the top of the beaker with stretched parafilm to form a good air-tight. Push the O2 sensor probe through the parafilm so that it is in the water. You can have students tape around any large hole that is made – to seal the experiment. Depending on the data collection program you are using, have students start the data collection for a 24-hour period.

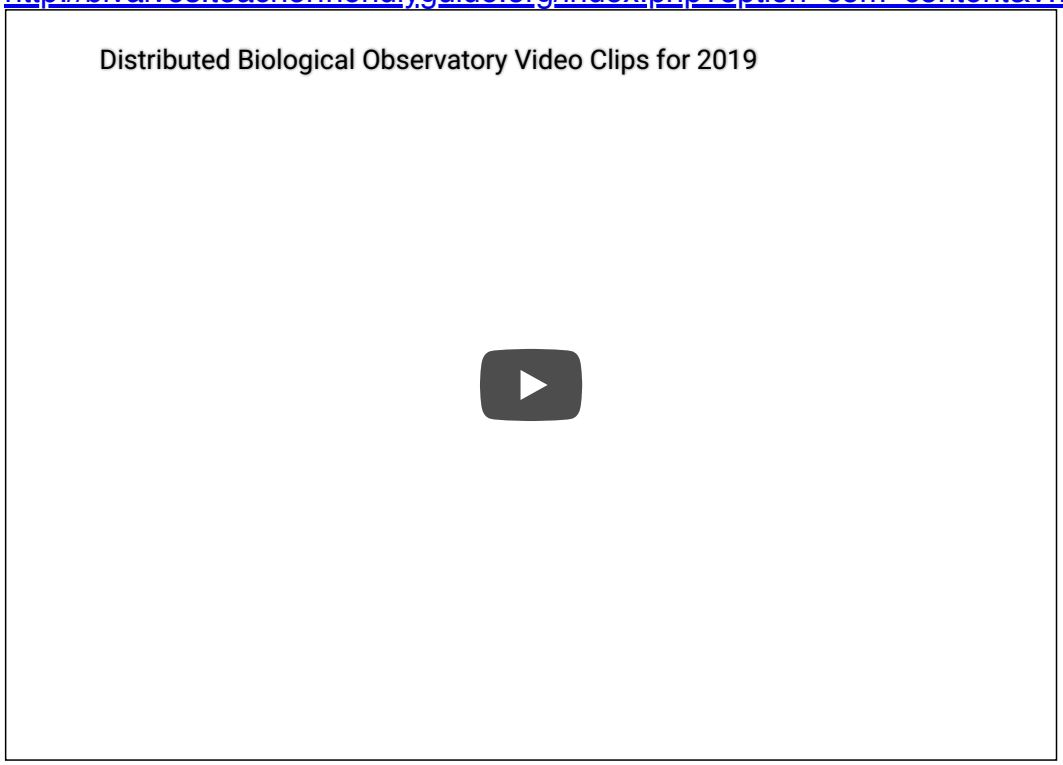
Day 3

9. After 24 hours, students should have collected a large amount of data. Using Excel or other graphing programs, students should graph their variable against dissolved O2 consumption.
10. Using their data, students will calculate the rate of respiration for their variable and draw conclusions.
11. Have students explore the most recent NOAA's Arctic Report Card to learn more about what is happening with ocean temperatures in the Arctic.
12. Once students have completed the above tasks, you can have them discuss the following questions in their lab groups and then have a class discussion:
    a. How are respiration, body mass, and temperature related?
    b. How will climate change in the Arctic affect the respiration of the dominant bivalves that live there?
    c. What could potentially happen to individual bivalve body mass and overall bivalve biomass with an increase in ocean temperature? (Hint: think carrying capacity!)
    d. How will the change in biomass from question c affect animals like walruses and Spectacled Eiders?

Extension

Cellular respiration can also be measured using CO2 sensors. Students can collect this data and include it in their graphs. They can also measure the pH of the water at the beginning and the end of the experiment to draw conclusions about CO2 and acidity. Students can discuss ocean acidification and how respiration products and absorption of carbon dioxide from the atmosphere can result in this phenomenon. How will ocean acidification affect benthic organisms in the Arctic?

Resources

- https://www.pmel.noaa.gov/dbo/
- https://arctic.noaa.gov/Report-Card/Report-Card-2019
- http://bivalves.teacherfriendlyguide.org/index.php?option=com_content&v…
- 

- https://arcticdata.io/catalog/portals/DBO

Assessment

Students will be assessed by the data that they collect and graph for their variable(s) for the respiration rate. They will submit:

- Data Excel Sheet
- Graphs comparing temperate and/or body mass with oxygen consumption
- A calculated rate of respiration based on their data
- Explanations about how increased sea temperatures will affect the body mass of individual bivalves and their overall biomass availability for higher trophic levels.

Author/Credits

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Don't Clam Up – Lab Activity Data Sheet

Hypothesis:

Temperature Variable Group

	Beaker 1	Beaker 2	Beaker 3
Temperature (°C)			
Mass of Clam (g)			
Rate of Respiration (mL of O_2)			

Body Mass Variable Group

	Beaker 1	Beaker 2	Beaker 3
Temperature (°C)			
Mass of Clam (g)			
Rate of Respiration (mL of O_2)			

Conclusion Questions:

1. How are respiration, body mass, and temperature related?
2. How will climate change in the Arctic affect the respiration of the dominant bivalves that live there?
3. What could potentially happen to individual bivalve body mass and overall bivalve biomass with an increase in ocean temperature? (Hint: think carrying capacity!)
4. How will the change in biomass from question c affect animals like walrus and Spectacled Eiders?