Cuckoo for Copepods

How can we use copepods as a model to learn about how marine organisms can tolerate extreme hypoxia?

Overview

Ocean and freshwater environments can experience hypoxia, which is a condition of low or depleted levels of oxygen in the water. In this unit, students will learn what hypoxia is, different ways hypoxia can be caused in our oceans, and what some organisms do to survive in hypoxic conditions. Researchers can use model organisms to better understand physiologic reponses to hypoxia, and through genetics, the knowledge gained from studies of model organisms can help scientists understand the effects of hypoxia on other species. Students will learn how intertidal copepods are used as a model organism, and how their unique and varied physiological responses to hypoxia can be investigated to explore questions about extreme tolerance to hypoxia.

Essential Questions

- *Why is dissolved oxygen important?*
- *How is upwelling and hypoxia affecting the Pacific Northwest?*
- *Why are copepods model organisms?*
- *How can we use computers to analyze and present data?*

Learning Goals

Students will learn the following:

- *Dissolved oxygen is essential for supporting respiration-based life in water.*
- *Climate change is causing oceanographic changes in upwelling that are leading to periods of more frequent and more extreme hypoxia.*
- *Copepods are genetically related to commercially important crustaceans, and are good lab specimens.*
- *Computers can be used to analyze datasets from researchers using software such as Microsoft Excel or Google Sheets.*

Intertidal copepod Tigriopus californicus
Photos: Dan Schneck

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Grade Level

9-12

Time

1 – 2 weeks

Anchoring Phenomenon

Cuckoo for Copepods

Driving Question

How can we use copepods as a model to learn about how marine organisms can tolerate extreme hypoxia?

Standards

Next Generation Science Standards

LS4.C – Adaptation

Common Core Math Standards

HS.DR.A.2
HS.DR.A.3
HS.DR.B.6
HS.DR.C.8

Learning Objectives

Students will be able to:

- *make generalizations about a population from a random sampling of the population.*
- *describe the importance of dissolved oxygen in water.*
- *identify locations that have different dissolved oxygen levels.*
- *Identify species that have different dissolved oxygen needs.*
- *Describe hypoxia.*
- *Explain how ocean upwelling can lead to hypoxia.*
- *Describe why copepods are good model species to study hypoxia on the Pacific coast.*

Describe some of the research that is currently occurring with copepods and hypoxia.

Introduction

Climate change is a complex phenomenon that includes changes to terrestrial environments as well as our oceans. Ocean change, or climate change occurring in the ocean, refers to all the changes that oceans are experiencing due to rising greenhouse gas emissions. This lesson focuses on one effect of ocean change, hypoxia, where dissolved oxygen concentrations in water bodies become so low that it is harmful to aquatic life.

Hypoxia naturally occurs in some marine environments, such as tide pools. However, hypoxia is becoming more common throughout our oceans due to changes in wind patterns and ocean upwelling. If oxygen concentrations in our oceans get too low, animals such as fish and crab will not be able to breathe through their gills which leads to impacts on our ecosystems, fisheries, and coastal economies.

By studying the animals that survive in frequently hypoxic tide pools, we can better understand what specific adaptations exist to survive hypoxic stress. Scientists at Oregon State University are studying copepods, a zooplankton that is a member of the crustacean family, that live in frequently hypoxic tide pools to model important Oregon fishery organisms like crab and shrimp. Using the genetic information from copepods, scientists will better understand how to help our fisheries adapt to a changing climate.

Formative and Summative Assessment

Collect student questions and answers throughout the unit to create a Jeopardy game at the end. See page 5 for details.

LESSON RESOURCES

Key Definitions

Anoxia *– a complete lack of oxygen.*

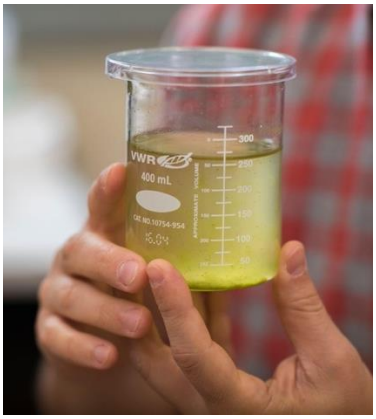
Hypoxia *- low or depleted oxygen in a body of water.*

Normoxia *– normal, air-saturated water.*

Upwelling *- Upwelling is an oceanographic phenomenon that involves wind-driven motion of dense, cooler, and usually nutrient-rich water from deep water towards the ocean surface. It replaces the warmer and usually nutrient-depleted surface water.*

Model Organism *- A model organism is a species that has been widely studied, usually because it is easy to maintain and breed in a laboratory setting and has particular experimental advantages.*

Dissolved Oxygen *- how much oxygen gas is in water.*



Beaker of copepods, artificial saltwater
Photo: Barreto Lab, OSU

Lesson Procedure

ENGAGE

Activity: The Hook

Begin the unit by showing students a set of two short unnarrated Engage videos and ask them what they observe. Make sure the video is set to 1080p HD so observers can see the small organisms moving (or not) in the petri dish. It may take students a few replays to be able to come up with answers to the prompts. Before moving on to the day's lecture, explain that the organisms in the video are small zooplankton known as copepods, and in one video the copepods are in normal water conditions, and in another they are in anoxic conditions. Over the course of this unit, students will discover more about research on copepods and why researchers are interested in their tolerances to low oxygen conditions.

Activity: Dissolved Oxygen (D.O.)

Use the Dissolved Oxygen slides to introduce the unit. Present the information on your own following the instructor guidance in the Notes section of the slides, and/or show students the Video Lecture. To help students take notes, provide them with the Dissolved Oxygen Cornell Notes worksheet, and distribute the Dissolved Oxygen Handouts as needed.

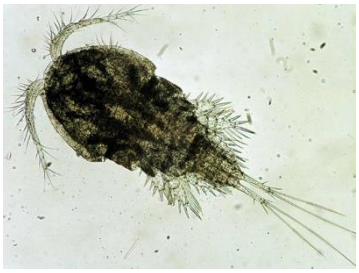
EXPLORE

Activity: Breath Lab

How long can animals survive without oxygen? To answer that question, use the Breath Lab slides and Breath Lab worksheet to have students see how long they can hold their own breath, and speculate on how long other species can go without breathing. Students can check their guesses through the video How long can different animals hold their breath?

Activity: Water Sampling Lab (optional)

In this lab, students bring water samples from home and analyze the characteristics of those samples in the lab. They record data on a Water Quality Datasheet to explore how D.O. and other water quality parameters vary and change over time. They discuss the characteristics of the water in those samples and what might make them different from other water samples. If possible, have the class acquire multiple water samples during a field trip to analyze back in the lab. Compare the different samples and discuss the similarities and the differences.



Copepod, Wikimedia

***Copepods** are small planktonic crustaceans that are the most abundant multicellular organism on Earth!*

The Hook
- *Video: Engage [0:51]*

Day 1: Dissolved Oxygen (D.O.)
- *Dissolved Oxygen slides (ppt)(pdf)*
- *Video: Dissolved Oxygen Lecture [20:16]*
- *D.O. Cornell Notes (pdf)(doc)*
- *D.O. Handouts (pdf)*

Day 2: Breath Lab
- *Breath Lab slides (ppt)(pdf)*
- *Breath Lab worksheet (pdf)(doc)*
- *Video: How long can different animals hold their breath? [2:00]*

Optional: Water Sampling
- *Water Quality Datasheet (pdf)(doc)*

Sampling water quality
Photo: Oregon Sea Grant

EXPLAIN

Activity: Upwelling and Hypoxia

In this section, students learn about oceanographic conditions that lead to dangerously low-oxygen levels known as hypoxia. Use the Upwelling and Hypoxia slides to present the information to students, either on your own or by showing the Video Lecture. The presentation includes two videos, Understanding Hypoxia from Oregon State University, and What is Upwelling from Hakai. Students can use the Upwelling and Hypoxia Cornell Notes worksheet to take notes during the presentation.

Activity: Career Connections

Use the Career Connections handout to introduce students to some of the scientists involved in research on ocean hypoxia and its impacts on marine organisms. Two of the featured scientists helped create this lesson: Jenny Koester, who is the Ocean Acidification Policy Assistant Project Leader for the Oregon Coordinating Council on Ocean Acidification and Hypoxia (OAH Council), and Marine Andriot, a graduate student researcher in the Barreto Lab at Oregon State University. In the next section, students will learn more about Marine's research studying intertidal copepods.

ELABORATE

In this section, students learn about model organisms, and how intertidal copepods are used as model organism to study genetic tolerances to hypoxia.

Barreto Lab researchers collecting copepods. Photo: Dan Schneck

Activity: Model Organisms

Use Model Organism slides 1 through 22 to present the information to students, either on your own or by showing the Video Lecture, Part One. Students will learn why model organisms are used in research, and the the characterstics that make a species a good model organism. Through images and short videos, students learn about *Tigriopus californicus*, an intertidal copepod that researchers use as a model organism to study responses to hypoxia. Students can use the Model Organism Cornell Notes worksheet to take notes during the presentation.

Day 3: Upwelling and Hypoxia

- *Upwelling and Hypoxia slides (ppt)(pdf)*
- *Video: Upwelling and Hypoxia Lecture [14:33]*
- *Video: Understanding Hypoxia [14:17]*
- *Video: What is Upwelling [0:50]*
- *Upwelling and Hypoxia Cornell Notes (pdf)(doc)*

Career Connections

- *Career Connections (pdf)*
- *OAH Council*
- *Barreto Lab, OSU*

Jenny Koester

Marine Andriot

Day 4: Model Organisms

- *Model Organisms slides (ppt)(pdf)*
- *Video: Model Organisms Lecture, Part One [16:17]*
- *Model Organisms Cornell Notes (pdf)(doc)*

Readings: OSU Research

For more information about hypoxia tolerant copepod research at OSU, see this 2019 article which describes research published in the *Proceedings of the National Academy of Sciences* (Graham & Barreto, 2019).

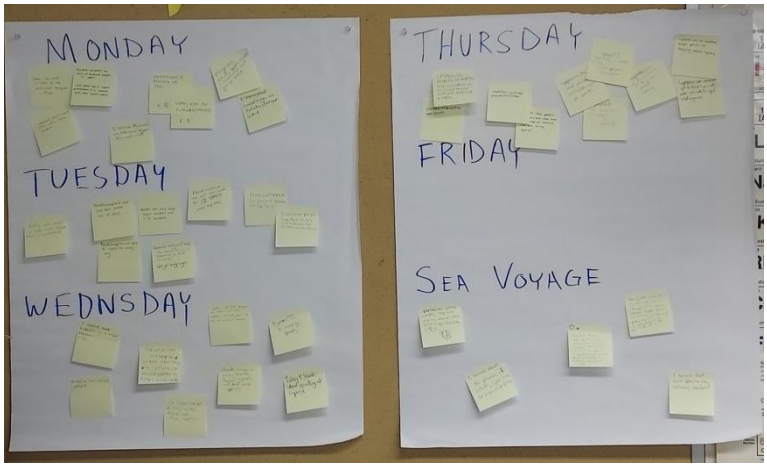
Activity: Copepod Graphing

Beginning with slide 23, continue with the Model Organism slides presentation and lecture video to share descriptions and short videos that illustrate the methods Marine uses to collect and sort copepods into treatment groups.

Now it is time for the students to use a dataset from one of Marine's experiments to make their own calculations and graph the results. Using the Anoxia Survivorship Worksheet, students will calculate the percentage of survivors in three different groups of copepods that have been subjected to anoxic environments. They will then calculate the percentage of survivors in normoxic conditions. Using the Anoxia Graphing Datasheet, they will use Excel to create a chart that describes the results of the experiment, and answer four questions to explain the results. An answer key is provided.

EVALUATE

Use the game "Jeopardy" to assess student learning gained from this unit. The Jeopardy Teacher Guide provides instructions for formative and summative assessments, and example Jeopardy questions that have been prepared using jeopardylabs.com.



Daily Exit Questions. Photo: Bryan Coyle

Readings: OSU Research

- *Lundeburg, S. 2019 article (link)(pdf)*
- *Graham & Barreto, 2019 (link)(pdf)*

Day 4: Copepod Graphing

- *Model Organisms slides (ppt)(pdf)*
- *Video: Model Organisms Lecture, Part Two [15:55]*
- *Anoxia Survivorship worksheet (pdf)(doc)*
- *Anoxia Graphing datasheet (xls)*
- *Answer Keys: (pdf)(xls)*

Graphing Questions

1. *Which group of copepods had the highest survivorship?*
2. *Which group of copepods had the lowerst survivorship?*
3. *Which group would survive the best if the amount of dissolved oxygen decreased?*
4. *Why do you think this group would survive the best?*

Marine Jeopardy Assessment

- *Jeopardy Teacher Guide (pdf)*
- *Example Jeopardy questions (pdf)(link)*

Next Generation Science Standards

Performance Expectation:
HS-LS4-5: Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

Science & Engineering Practices:
Engaging in Argument from Evidence

Disciplinary Core Ideas:
LS4.C: Adaptation

Crosscutting Concepts:
Cause and Effect

Common Core Math Standards

Math Practices:
MP4. Model with mathematics
MP7. Look for and make use of structure

Common Core Math Standards:
HS.DR.A.2 - Formulate summative, comparative, and associative statistical investigative questions for surveys, observational studies, and experiments using primary or secondary data.
HS.DR.A.3 - Formulate inferential statistical investigative questions regarding causality and prediction from correlation.
HS.DR.B.6 - Distinguish and choose between surveys, observational studies, and experiments to design an appropriate data collection that answers an investigative question of interest.
HS.DR.C.8 - Identify appropriate ways to summarize and then represent the distribution of univariate and bivariate data multiple ways with graphs and/or tables. Use technology to present data that supports interpretation of tabular and graphical representations.

Data

The data for this project came from preliminary research conducted in the Barreto Lab at OSU.

Acknowledgments

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See more lessons on the ORSEA webpage: oregoncoaststem.oregonstate.edu/orsea