Coastal Hypoxia

How do environmental and ecological factors affect ocean deoxygenation off the Oregon Coast?

Overview
In this lesson, students explore the causes and effects of hypoxia in the coastal ocean through a case study based on real-world events. Students take on the role of scientist, policy maker, or fisherperson on the Oregon Coast. As they explore a mystery involving crabbing, microbes, circulation, and upwelling, students begin to see the effects of climate change and what they can do to help.

Essential Questions
- *What role do microbes play in ocean ecosystems?*
- *What is coastal upwelling and how does it contribute to deoxygenation on the Oregon Coast?*
- *How does climate change contribute to coastal deoxygenation and impact communities?*

Learning Goals
Students will learn the following:
- *Phytoplankton and bacteria impact ocean food webs.*
- *Physical circulation and wind patterns influence upwelling.*
- *Coastal deoxygenation is driven by natural phenomena and worsened by human impacts.*

Learning Objectives
Students will be able to:
- *define ocean deoxygenation and understand its impacts on an Oregon coastal ecosystem.*
- *analyze real data to form hypotheses related to ocean circulation, temperature, and dissolved oxygen levels.*
- *apply their understanding of coastal hypoxia to a mystery relating to Dungeness crab deaths, and propose solutions to the ongoing problem.*

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Grade Level

6-7

Time

4-5 days, or can be used modularly

Anchoring Phenomenon
Coastal Hypoxia

Driving Question
How do environmental and ecological factors affect ocean deoxygenation off the Oregon Coast?

Standards

Next Generation Science Standards
LS2.A – Interdependent Relationships in Ecosystems
LS2.C – Ecosystem Dynamics, Functioning, and Resilience
LS1.C – Organization for Matter and Energy Flow in Organisms

Oregon 2021 Math Standard
6.DR.D.4

<<Marine microbes play a role in coastal hypoxia. This microscopic photo is of the bacterium *Pelagibacter ubique*. *Photo: Gulf of Alaska Seamounts 2019 Expedition - NOAA: Ocean Exploration and Research, Public Domain*

Introduction

With the looming threat of climate change, students worry about the future of our planet and often feel powerless to make change. Climate change is driven by multiple factors, which vary from place to place. Here, we present a case study where students can take on the role of stakeholders on the Oregon Coast, an area with one of the largest Dungeness crab fisheries on the west coast. Students will study the biological, chemical, and physical factors that drive climate change and explore how those changes directly impact coastal fishing communities.

This unit will familiarize students with concepts of coastal hypoxia by exploring a critical component of marine food webs, marine microbes. In groups, students will navigate through a role play simulation (inspired by a true story) to read, answer questions, solve puzzles, and based on their chosen role: design experiments (scientist), create a public service announcement (policymaker), or brainstorm a community engagement project (fisherperson). Breaking down climate change into digestible pieces from the global to local scale will allow students to engage in problem solving conversations with their classmates.

This interactive webquest includes checkpoints with a scoring rubric to make grading straightforward for teachers. At the end of the lesson, students will have a better understanding of climate change from the science to application.

Lesson Procedure

ENGAGE

Students will use prior knowledge regarding the ocean and climate change to begin to process the phenomenon and impacts of acidification and hypoxia in certain parts of the ocean along the Oregon Coast. Students will be presented with a problem and assume the roles of different stakeholder to find out what may be happening. Descriptive videos, demonstrations, and interactive simulations keep students engaged during the learning process.

Station 1A – Introduction

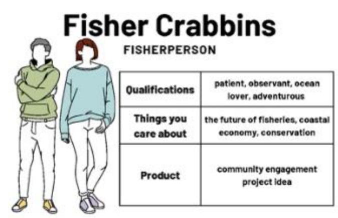
Begin with the outline of the unit described in the *Introduction* station. Students choose or are assigned to take on one of three stakeholder roles: Dr. Seeksalot, Fisher Crabbins, or Representative Wordsmith. Provided *Role cards* describe each stakeholder's qualifications, interests and the products they will provide by the end of the unit.

LESSON RESOURCES

Interdisciplinary Coastal Simulation
- *Station 1A – Introduction*
- *Station 1B – Crab Fisheries*
- *Station 2 – Marine Microbes*
- *Station 3 – Coastal Dynamics*
- *Station 4 – Oxygen*
- *Station 5 – Hypotheses*
- *Station 6 – Solutions*

The full packet is available for Students (pdf) and online at https://www.sarahwolf.online

For Teachers - Unit Resources
- *Teaching Strategies and Assessments (pdf)*



Station 1A - Introduction
- *Introduction (pdf)*
- *Role cards (pdf)*

Station 1B – What's Going On?
Students use the What's Going On *Station 1B worksheet* to learn about an observable phenomenon: Large amounts of crabs and sea life in a certain areas are mysteriously dead. What's going on? They also observe video of *Dungeness crabs underwater*, learn about Dungeness crab biology, and calculate the economic impact of crab landings on the Oregon coast over the past 20 years. Students may use a *Crab Landings student spreadsheet* to make their calculations and graphs, and a *Teacher Key* is provided.

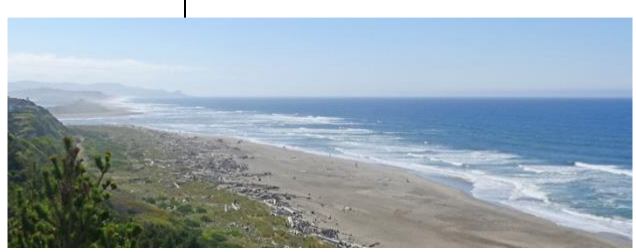
EXPLORE

Next, students take time to explore ideas. Activities are designed so all students have common, concrete experiences which can be used later when formally introducing and discussing scientific and technological concepts and explanations.

In this section, students conduct research regarding crab life cycles, ocean currents, upwelling, and ocean chemistry. They apply principles to conduct simulations and process data collection of variables that influence economic and environmental impacts on Oregon coastal communities.

Station 2 – Marine Microbes
To help students form a hypotheses about what's happening to the crabs, they use the Marine Microbes *Station 2 worksheet* to learn about microbes. Students watch the Ocean Portal video *The Microbial Loop* to learn how microbes are involved in ocean food webs. Then through the article *Understanding Marine Microbes* they learn about methods marine microbiologists use to make new discoveries. The station ends with a short quiz, and a *Teacher Key* is provided.

Station 3 – Coastal Dynamics
Using the Coastal Dynamics *Station 3 worksheet*, students learn about the physical factors that affect the Oregon Coast. In the TED-Ed video *How do ocean currents work?* students learn how "Friendly Floatees" have helped oceanographers understand ocean currents, and they explore currents in real time using the interactive *Earth Nullschool* online platform. In a short clip from OSU's *Ocean Acidification video*, they learn how wind patterns affect currents and ocean chemistry. As the Ted-ED video *Climate Change: Earth's giant game of Tetris* describes, ocean temperature is rising. Furthermore, they see that the ocean has layers, and mixing of these layers is driven by currents. The station ends with a short quiz, and a *Teacher Key* is provided.



Station 1B – What's Going On?
- *Station 1B worksheet (pdf)*
- *Video: Dungeness crabs underwater [1:42]*
- *Crab Landings student spreadsheet (xls)*
- *Crab Landings Teacher Key (xls)*

Marine bacteria growing on an agar plate. Image courtesy of Lophelia II 2012 Expedition, NOAA-OER/BOEM.

Station 2 – Marine Microbes
- *Station 2 worksheet (pdf)*
- *Video: The Microbial Loop [2:18}*
- *Article: Understanding Marine Microbes*
- *Marine Microbes Teacher Key (pdf)*

Station 3 – Coastal Dynamics
- *Station 3 worksheet (pdf)*
- *Video: How do ocean currents work? [4:33]*
- *Earth Nullschool*
- *Video: Ocean Acidification clip [1:08]*
- *Video: Climate Change – Earth's giant game of Tetris [2:48]*
- *Coastal Dynamics Teacher Key (pdf)*

Using the Ocean Oxygen *Station 4 worksheet*, students explore the role oxygen may play in the dead crab mystery. In this section, students learn about the dissolved oxygen in the ocean affects organisms, how marine microbes use oxygen, and how oxygen is measured. In the *What is Upwelling?* video from the Hakai Institute, students learn how upwelling changes oxygen concentrations, and then they explore the relationship between ocean temperature and oxygen levels. The station ends with a crossword puzzle, and a *Teacher Key* is provided.

EXPLAIN

This phase consists of two parts. Students can share the what they learned from the readings in the EXPLORE section, and review key vocabulary and concepts.

Station 5 – Forming Hypotheses

Then, using their initial models and, students follow the Forming Hypotheses *Station 5 worksheet* to come up with a testable hypothesis that could explain their observations. Assuming their assigned stakeholder roles, students will identify next steps and create products to address the problem.

ELABORATE

Like Dr. Seeksalot, marine researchers continue to study coastal hypoxia. In the *Researcher Bio*, students learn about the work and career pathway of Sarah Wolf, a graduate student at Oregon State University who studies the role that microbes play in coastal hypoxia.

Station 6 – Solutions

In this secton, students use the Solutions *Station 6 worksheet* to locate and read news articles to learn more about about the real life story of coastal hypoxia on the Oregon coast. Then they engage in role plays of stakeholders and policy makers to come up with new proposals for funding to help further research for the impacting problems of the Oregon Coast due to hypoxia and acidification. Students extend their learning by creating a policy briefing that could be presented to government and non-government agencies for awareness and action plans. In addition, students will investigate possible career connections to marine and environmental sciences.

Station 4 – Ocean Oxygen
- *Station 4 worksheet (pdf)*
- *Video: What is Upwelling? [0:50]*
- *Ocean Oxygen Teacher Key (pdf)*

Key Vocabulary & Concepts

Microbes
Dissolved Oxygen (DO)
Apoxia
Hypoxia
Deoxygenation
Dead Zone
Respiration
Heterotroph
Autotroph
Upwelling

Station 5 – Forming Hypotheses
- *Station 5 worksheet (pdf)*

Sarah Wolf, OSU

Career Connections
- *Researcher Bio: Sarah Wolf (pdf)(link)*

Station 6 – Solutions
- *Station 6 worksheet (pdf)*

EVALUATE

Students to assess their understanding and abilities and teachers evaluate individual student progress toward achieving learning goals and outcomes. The provided *Teaching Strategies and Assessments* include rubrics and guiding questions for the unit. Opportunities to assess learning throughout the unit include station comprehension questions, data analysis, and role-playing activities intended to help students create their own understanding about the need for future research and funding for marine and environmental sciences.

Next Generation Science Standards

Performance Expectations:

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

MS-LS2-1: Analyze and interpret data to provide evidence for the effect of resource availability on organisms and populations of organisms in an ecosystem.

MS-LS1-6: Construct a scientific explanations based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.

Science & Engineering Practices:

Engaging in Argument from Evidence, Analyzing and Interpreting Data, Constructing Explanations and Designing Solutions

Disciplinary Core Ideas:

LS2.A – Interdependent Relationships in Ecosystems
LS2.C – Ecosystem Dynamics, Functioning, and Resilience
LS1.C – Organization for Matter and Energy Flow in Organisms

Crosscutting Concepts:

Stability and Change, Cause and Effect, Energy and Matter

Common Core Math Standards

Math Practices:

Construct viable arguments and critique the reasoning of others

Math Standards:

6.DR.D.4 – Interpret quantitative measures of center to describe differences between groups from data collected to answer investigative questions.

For Teachers - Unit Resources

- *Teaching Strategies and Assessments (pdf)*

Acknowledgments

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