Seafloor Graveyard

What is causing episodes of dead animals on the seafloor?

Overview
When researchers in Oregon began to see mass graveyards of animals dead on the seafloor, they had a mystery on their hands. Students will investigate the cause of these hypoxia events, how they are measured, and their connection to climate change. They will also explore the impact on the ecosystem and challenges researchers face.

Essential Questions
- *Why does Oregon have hypoxia events during the summer?*
- *Were hypoxia events always occurring off the Oregon coast? Why are they happening now more than before?*
- *What role do hypoxia events play in an ecosystem?*
- *What connection can be made between climate change and these hypoxia events?*
- *How are hypoxia events measured?*

Learning Goals
Students will learn the following:
- *Upwelling and climate change can contribute to low oxygen levels offshore.*
- *A change in environment (hypoxia) impacts ecosystems*
- *Researchers with the Ocean Observing Initiative (OOI) monitor ocean conditions and use data to make predictions.*

Learning Objectives
Students will be able to:
- *Connect causes and effects of hypoxia events to environmental impacts.*
- *Describe and model how changes to the environment, both natural (upwelling) and human generated (climate change) may affect an ecosystem.*
- *Understand the types of research equipment used to monitor ocean conditions, and the engineering considerations associated with the equipment.*

Image: Dead crabs observed on the seafloor, 2006. Credit: ODFW ROV

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Grade Level

9-10

Time

1-2 weeks

Anchoring Phenomenon
Seafloor Graveyard

Driving Question
What is causing episodes of dead animals on the seafloor?

Standards

Next Generation Science Standards
LS2.A – Interdependent Relationships in Ecosystems
LS2.B – Cycles of Matter and Energy Transfer in Ecosystems
LS2.C – Ecosystem Dynamics, Functioning, and Resilience

Common Core Math Standards
HS.ID.A.1 - HS.ID.A.4
HS.ID.B.5 – HS.ID.B.6
HS.ID.C.7 – HS.ID.C.9

Introduction

What is causing all the dead animals on the seafloor on the Oregon coast? In 2006 scientists discovered a graveyard on the seafloor whereas in 2000 they had witnessed thriving ecosystems. It was a mystery that only time and data could solve. Scientists now constantly monitor ocean conditions through the Ocean Observatories Initiative to help understand and predict environmental impacts. Hypoxia (low oxygen) events are now happening with greater frequency and are caused by a combination of upwelling phenomena as well as climate change. In order to understand the reasons, scientists must collect and analyze data using a variety of equipment.

Optional: Prior to beginning the lesson, administer a *pre-survey* to gauge student knowledge and understanding.

Lesson Procedure

ENGAGE

To introduce students to the anchoring phenomena, show students the Oregon Department of Fish and Wildlife *2000 vs 2006* video that compares underwater footage taken from a Remotely Operated Vehicle (ROV) in 2000 and then again at the same location in 2006.

Student Worksheet #1 – Cause and Effect

1. Play the video until 3:47 then pause it and have students free write for 2-3 minutes on *Worksheet #1*, answering the first question.
2. Play the rest of the video and have the students finish the remaining questions on the worksheet.
3. Have students either discuss what they saw in small groups, or have a whole group discussion. Alternatively, have a brief discussion between the first and second segments of the video then ask students to describe changes.

Image: Swimming fish observed in 2000. Credit: ODFW ROV

LESSON RESOURCES

Definitions

- *Hypoxia – Low oxygen environment*
- *Upwelling – A process in which currents bring deep, cold water to the surface of the ocean due to the direction of the wind*

Resources

- *Ocean Observatories Initiative* — *A science-driven ocean observing network that delivers real-time data from more than 800 instruments to address critical science questions regarding the world's oceans*
- *Partnership for Interdisciplinary Studies of Coastal Oceans* — *An academic consortium that conducts research to advance understanding of the coastal ocean within the California Current Large Marine Ecosystem and inform management and policy.*

OCEAN OBSERVATORIES INITIATIVE

Pre Assessment

- *Pre-survey (pdf)*

Cause and Effect

- *Video: 2000 vs 2006 (link)*
- *Worksheet #1 (pdf)(doc)*

EXPLORE

Student Worksheet #2 – Measuring Ocean Conditions

1. In small groups, have students brainstorm ideas about measurements and have them complete questions 1 and 2 on *Worksheet #2.*
2. The rest of the worksheet will walk students through an exploration of a web page that details information about the Ocean Observatories Initiative (OOI), a reading on dissolved oxygen, energy transfer in living things, and observations about specific data.

Student Worksheet #3 – Engineering Considerations for Monitoring Equipment

1. The worksheet is designed as a jigsaw. Please hand out the worksheet, grouping your students how you see fit for the jigsaw. The handout contains five different versions, one for each equipment type.
2. Show students the *Engineering Considerations* slides featuring *Photos and Data* associated with different types of equipment and have them begin to think about the different challenges researchers face. Have them answer question 1 based on the images then have a group discussion about their answers, making sure students have an understanding of each problem - waves, biofouling, power, and deployability.
3. Have the students use the Platform *Descriptions and Challenges* slides to become an expert in their equipment type, answering the questions in Worksheet #3 based on the platform they were assigned. They will share this information with their group with the expectation the other students will record information as the students share. (Alternatively, all students for one particular type of equipment could put a short presentation/informational poster together for their group/class to share information and then either have the students present or do a gallery walk.) Students will have access to the pictures and information for all equipment types that were shown, so they can use them for a deeper understanding.
4. Once students have shared they can work together to determine which type(s) of equipment may work best for each scenario presented. Have each group share about one or two of the scenarios, explaining their choices.

Extension: Have students debate pros and cons, discuss other constraints around equipment such as funding, telemetry (how the data is transmitted for the researchers), and maintenance, or tally how often each equipment type is mentioned as being useful for the scenarios and compare it to how many of that equipment type are shown to be in use on the OOI website.

LESSON RESOURCES

Measuring Ocean Conditions
- *Worksheet #2 (pdf)(doc)*
- *Ocean Observatories Initiative*
- *Indicator: Dissolved Oxygen*

Engineering Considerations for Monitoring Equipment
- *Worksheet #3 (pdf)(doc)*
- *Photos and Data (pdf)*
- *Descriptions and Challenges (pdf)*

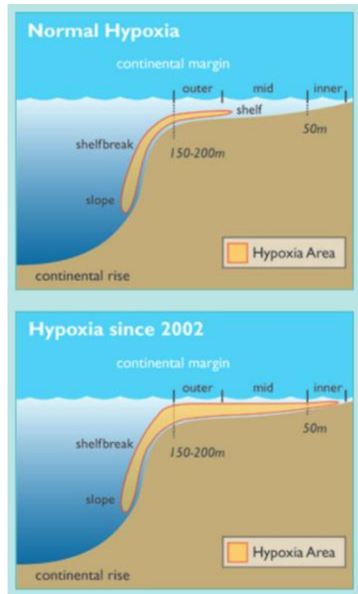


Image from PISCO's "Hypoxia off the Pacific Northwest Coast"

"Lower oxygen content of seawater, changes in ocean circulation, and changes in wind patterns are all expected under a changing climate, and all are happening."

- student explanation

EXPLAIN

Student Worksheet #4 – Effects on the Ecosystem

1. Have students answer question 1 on *Worksheet #4.*. Remind them about what a food web shows and how it models the transfer of energy in the ecosystem.
2. Students will watch the video *Hypoxia: Dead Zone* and then answer questions 2 & 3.
3. To answer question 4, students should read the *Science of Hypoxia* off the Pacific Northwest Coast summary prepared by PISCO (Partnership for Interdisciplinary Studies of Coastal Oceans).
4. Finally, students will demonstrate their learning by drawing a scene depicting the concepts.

ELABORATE

In this section, students use the scenarios on *Worksheet #3* and the scene they create on *Worksheet #4* to ELABORATE on their learning. Students create a linear regression model of data to visualize the relationship between temperature and oxygen near the Oregon shore.

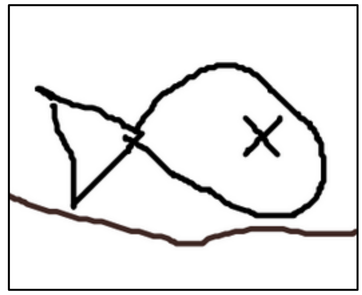
Student Worksheet #5 – Temperature and Dissolved Oxygen

1. Have students use Desmos (or another graphing calculator) to plot points related to temperature and oxygen near the Oregon shore ("inshore" data). They will run a "linear regression" to determine the "line of best fit" and the equation of that line in slope-intercept form, and to make predictions about temperature and oxygen.
2. Students will then compare and contrast the "real graphs" of inshore data and offshore data to determine similarities and differences, and how this information might be useful to scientists studying these hypoxia events.
3. [Optional] Students will determine whether the "offshore" data could be modeled by a "piecewise" function in the form of two or three linear functions.
4. Students will use this information to explain what "upwelling" is, why it leads to low oxygen levels inshore, and why scientists think it has been occurring over the last several decades

Independent Extension Activity: Students follow an *Tutorial* in which Jonathan Fram walks through how to use the *Data Explorer* on the OOI website. Students apply their knowledge gained of upwelling and hypoxia using the information provided.

Effects on the Ecosystem

- *Worksheet #4 (pdf) (doc)*
- *Video: Hypoxia: Dead Zone*
- *Summary: Hypoxia off the Pacific Northwest Coast*



[During hypoxic events] the things that are too slow to get away in time suffocate and die." – student explanation

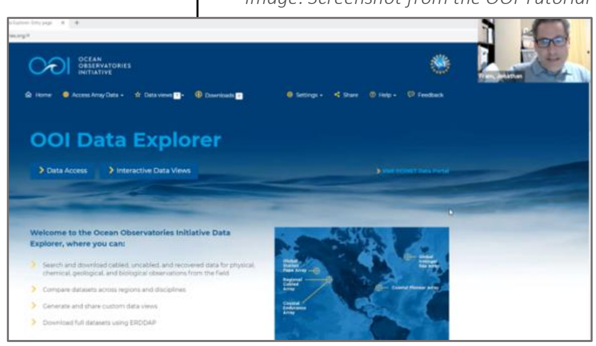
Concepts/Vocabulary Developed

hypoxia, upwelling, climate change, dead zone, ecosystem, abiotic, biotic, dissolved oxygen, glider, inshore surface mooring, coastal surface mooring, surface piercing profilers, wire following profilers

Temperature and Dissolved Oxygen

- *OOI Data Explorer*
- *Worksheet #5 (pdf) (doc)*
- *Worksheet #5 Key (pdf)*
- *Extension Activity (pdf)(doc)*
- *OOI Tutorial with Dr. Fram*

Image: Screenshot from the OOI Tutorial



Career Connections
What does it take to work on a project like the Ocean Observatories Initiative? Students can use the *OOI Project Careers* handout to learn about the different kinds of jobs needed to build, maintain, deploy, retrieve, engineer, and analyze equipment and data. Use this resource and the Sea Grant *Marine Careers* summary to help connect students with their interests. Consider contacting a researcher to be a guest speaker for your classroom.

EVALUATE

In this section, have students create a poster or slide presentation to demonstrate their learning. Students share what they have learned about hypoxia, how it's measured, what causes it, how climate change is connected, and the effects on the ecosystem. Students should include at least one graph from the OOI website and two additional images to enhance the project.

Assess student work using the *Rubric.*

Optional: At the conclusion of the Seafloor Graveyard lesson, administer a *post-survey* to gauge changes student knowledge and understanding.

Next Generation Science Standards

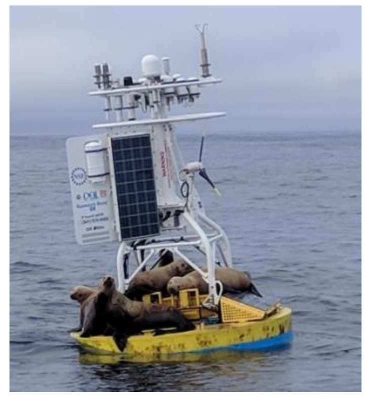
Performance Expectations:
HS-LS2-1: Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
HS-LS2-2: Plan and conduct an investigation that uses mathematical representations to support explanations about factors affecting biodiversity and populations in ecosystems of different scales.
HS-LS2-3
HS-LS2-6

Science & Engineering Practices:
Developing and Using Models
Engaging in Arguments from Evidence
Constructing Explanations and Designing Solutions
Using Mathematics and Computational Thinking

Disciplinary Core Ideas:
LS2.A – Interdependent Relationships in Ecosystems
LS2.B – Cycles of Matter and Energy Transfer in Ecosystems
LS2.C – Ecosystem Dynamics, Functioning, and Resilience

Career Connections
- *OOI Project Careers handout (pdf)(doc)*
- *Marine Careers*

Evaluate
- *Poster Instructions and Rubric (pdf)(doc)*
- *Post-Survey (pdf)*



Sealions enjoy resting on a Coastal Endurance Array mooring. This image is from work supported by the National Science Foundation's (NSF) Ocean Observatories Initiative, a major facility fully funded by the NSF.

Crosscutting Concepts:
Stability and Change
Energy and Matter
Scale, Proportion and Quantity

Common Core Math Standards

Math Standards:
HD.MP4 – Model with mathematics
HS.MP.2 – Reason abstractly and quantitatively

HS.ID.A.1 – Represent data with plots on the number line
HS.ID.A.2 – Use statistics appropriate to the shape of the data distribution to compare center and spread of two or more datasets
HS.ID.A.3 - Interpret differences in shape, canter and spread in the context of the data sets, accounting for possible effects of outliers
HS.ID.A.4 – Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages
HS.ID.B.5 – Summarize categorical data for two categories in two-way frequency tables.
HS.ID.B.6 – Represent data on two quantitative variable on a scatter plot, and describe how the variables are related
HS.ID.C.7 – Interpret the slot and the intercept of a linear model in the context of the data
HS.ID.C.8 – Compute and interpret the correlation coefficient of a linear fit
HS.ID.C.9 – Distinguish between correlation and causation

Math Practices:
1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

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