Forams as Storytellers

What can tiny plankton tell us about past and present ocean climate?

Overview

As ocean temperatures change, entire ecosystems are impacted. During marine heatwaves, tropical species are more frequently found in areas outside their normal range. When a massive marine heatwave known as ‘The Blob’ occurred off the Oregon coast, researchers recorded impacts to tiny plankton called foraminifera (or ‘forams’). Forams have been called the ocean’s ‘living thermometers’ because they can be used to understand ancient climate, and they can also be used to tell us what’s happening with current phenomena like the Blob. In this lesson, students learn about marine heatwaves, explore how heatwaves impact forams and other organisms, and learn how the distribution of foraminifera species in the fossil record and in deep sea sediment cores helps researchers understand changes in ocean climate.

Essential Questions

- *How could large scale ocean temperature variation affect the distribution of tiny drifting plankton?*
- *How are foraminifera and marine heatwaves related?*
- *How are bioprovinces defined for forams?*
- *What is an anomaly from an average?*
- *What makes forams useful for studying climate?*

Learning Goals

Students will learn the following:

- *Researchers use biological ocean data to understand a changing ocean and climate change.*
- *Changing ocean temperatures affect an area’s biodiversity and ecosystems.*
- *Forams are distributed in the world ocean by bioprovince, defined by ocean temperatures.*
- *Forams are climate proxies that help us understand past ocean conditions.*

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Grade Level
9-12

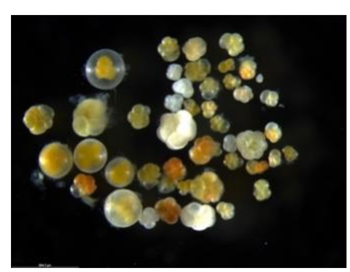
Time
5 days

Anchoring Phenomenon
Forams as Storytellers

Driving Question
What can tiny plankton tell us about past and present ocean climate?

Standards
Next Generation Science Standards
LS2.A – Interdependent Relationship in Ecosystems
LS2. C – Ecosystem Dynamics, Functioning, and Resilience

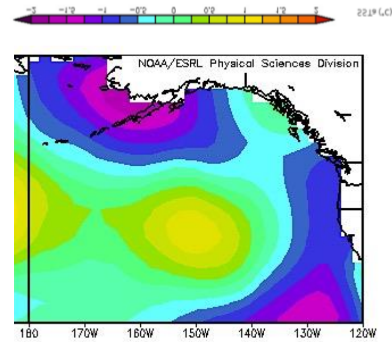
Oregon Math Standards
HS.AFN.A.3


Foraminifera. Photo: M.Kelsey Lane

Learning Objectives

Students will be able to:

- *interpret sea surface temperature anomaly (SSTa) maps.*
- *identify forams typical of their bioprovinces.*
- *define and identify a marine heatwave.*
- *make observations about foram distributions.*
- *identify correlations between SST anomalies and foram distribution.*
- *relate sediment core records to past climates.*

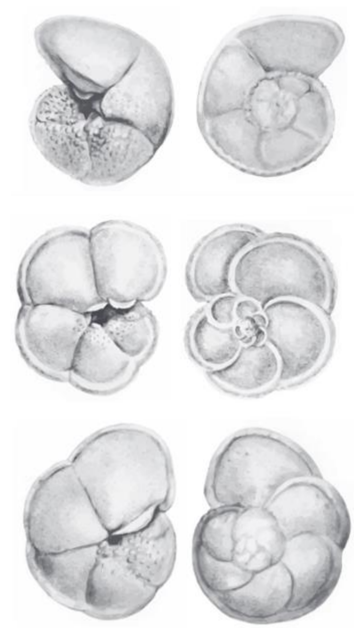


Fal 2012 Sea Surface Temperature (SST) map. Image credit: NOAA/ESRL

Introduction

Foraminifera, or forams, are microscopic, shelled protists found throughout the global oceans. Distribution of foraminifera species is dependent on water temperature and other measurable, environmental factors. By collecting and analyzing foram species annually off the Oregon coast, researchers have correlated changes in water temperature with species frequency and distribution. Additionally, the study of foraminifera can be applied to deep sea sediment cores to help us understand ancient climate. Distribution of foram species is one of our best tools for understanding the ocean climate in the past, before we had an instrument record.

In this lesson, students will learn about marine heatwaves and sea surface temperature anomalies, study how foraminifera distributions changed between years along a long-term time series, and then predict how distributions changed during marine heatwaves. Students can also make and analyze model sediment cores to look for evidence of past ocean warming, and/or apply pre-calculus concepts to contour maps.



Foraminifera
Image credit: Theresa Fritz-Endres

Lesson Procedure

ENGAGE

This unit begins with a short video hook that introduces the idea of a marine heat wave to get students thinking about how oceans have their own extreme weather events.

Activity – Introducing The Blob

Show any one of the three provided news video clips about a "Warm Blob" event in the Pacific. After sharing the video, ask students what they learned from the news about the cause of a marine heat wave, any effects, and where this specific Warm Blob is located. Gather students' initial ideas about what's going on.

LESSON RESOURCES

Introducing The Blob

- Video: *NBC local weather clip [3:36]*
- Video: *NBC The return of 'The Blob' [1:35]*
- Video: *CNN Pacific ocean blob [1:26]*

EXPLORE

This section of the unit provides students with more information about the Blob, and expands student understanding of Sea Surface Temperature Anomalies and maps. Students will predict possible effects of cold and warm anomalies. A *Key Vocabulary* list provides teacher background and can also be used to support ELD, SPED, and students for whom these concepts are new.

Activity – Exploring SSTa Maps (45 min)
Use the *Exploring SSTa Maps presentation* to guide students through a group investigation of a Sea Surface Temperature anomaly (SSTa) map. The presentation includes short video clips designed to help students identify marine life that might be affected by marine heat anomalies.

Divide the class into groups and provide each student with one copy of *Student worksheet #1,* and each student group with one *SSTa Map*. Groups will look at their map together and determine the location and extent of temperature anomalies, using longitude and U.S. West Coast states as references. They also predict how specific marine organisms could be affected by the anomaly depicted on their map. Finally, have groups present their map and findings to the rest of the class.

EXPLAIN

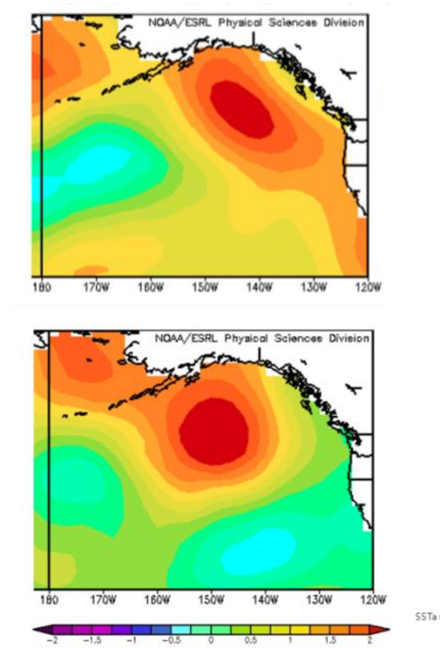
This section of the lesson introduces forams, the Newport Hydrographic Line, bioprovinces, and OSU foraminifera researchers. It also focuses on the question: ***How do ocean conditions affect foram abundances?***

Activity: Forams as Storytellers (45-60 min)
Use the *Forams as Storytellers presentation* to introduce foraminifera and their importance as storytellers of ocean conditions. Students then use *Student worksheet #2* and selected data in a *Student Graph set* to identify abundances of forams and their bioprovinces, and explain why two sets of data may differ.

Activity: Bioprovince Table Station (optional)
In the *Studying Climate of the Past* activity designed by OSU researcher Theresa Fritz-Endres, students match planktic foraminfera with their locations on a distribution graph. Designed as a short tabling station, the activity can be adapted for in the use classroom, or serve as an outreach or assessment tool through which students can share their knowledge. If you have access to 3D printing, you can find files to make *3D printed foram models* on the *Forminarium* website.

Vocabulary and Definitions
- *Key Vocabulary (pdf)(doc)*

Exploring SSTa Maps
- *Presentation (ppt)(pdf)*
- *Student worksheet #1 (pdf)(doc)*
- *Student SSTa map set (pdf)*



SST maps from Fall 2014 (a) and Fall 2016 (b). Data from NOAA/ESRL and maps made by K. Lane

Forams as Storytellers
- *Presentation (ppt)(pdf)*
- *Video: Foraminifera [7:57]*
- *Video: Foram researcher clip [1:25]*
- *Video: How do we collect plankton? [0:40]*
- *Student worksheet #2 (pdf)(doc)*
- *Student Graph set (pdf)*

Bioprovince Table Station
- *Studying Climate of the Past (pdf)*
- *3D printed foram models (pdf)*
- *Foraminarium website*

Career Connections
Introduce students to formanifera researcher Kelsey Lane from Oregon State University. Her *Researcher Bio* describes how she and other sea-going oceanographers collect data from research vessels and how they use sediment cores and fossil foraminifera to understand past changing climates.

ELABORATE

This section of the lesson gives students the opportunity to find patterns in the data and match ocean conditions to foram abundances.

Activity: Data from the Newport Hydrographic Line (45-60 min)
Use the *Data from the NHL presentation* to give students the task of matching the full set of ocean SSTAs with foram abundances. Provide students with the *SSTa maps* from the EXPLORE section that are keyed by letter, not year, and a full set of foram *Relative Abundance graphs*, keyed by year and bioprovince. Remind them they have a key for bioprovinces. Have the groups record their predictions and reasoning on their *Group Student worksheet*. After student work time, groups share their findings and reasoning and record their predictions on the *Class Prediction table*. To help make connections between marine heatwaves and continental conditions, Included in the slides is a 13 minute video *How I Learned to Love The Blob* presented by scientist Philippe Tortell. At the end of this activity, students use an *Individual Student worksheet* to reflect about how forams can help us understand present and past ocean conditions. NOTE: The final slide of the presentation includes an answer key for matching the maps and years.

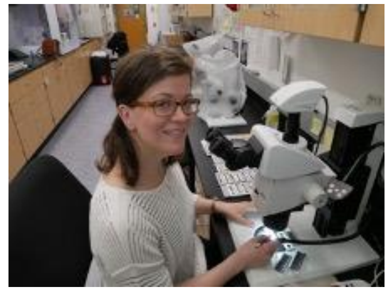
EVALUATE

Use one or more of the following extension activities to extend and assess student learning.

Activity: Make a Sediment Core
This activity gives students an opportunity to apply their learning by making a sediment core and interpreting the core of another group. Options include making an edible core or drawing one.

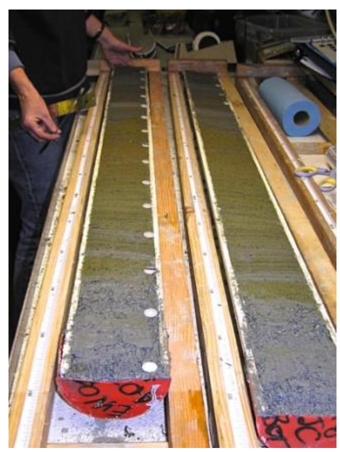
Provide students with background using the *Make a Sediment Core presentation* which includes a *What's a Core For?* storymap. Then have students follow the instructions in the *Student worksheet* where they use their knowledge of how foraminifera species change with ocean temperatures to make predictions about local climate change and marine heatwaves.

Career Connections
- *Researcher Bio: Kelsey Lane (pdf)*



Researcher Kelsey Lane picking foraminifera under a microscope

Data from the Newport Hydrographic Line
- *Presentation (ppt)(pdf)*
- *SSTa maps (pdf)*
- *Relative Abundance graphs (pdf)*
- *Group Student worksheet (pdf)(doc)*
- *Class Predication table (pdf)(doc)*
- *Video: How I learned to love The Blob [13:16]*
- *Individual Student worksheet (pdf)(doc)*



Marine sediment core – Photo: OSU

Make a Sediment Core
- *Presentation (ppt)(pdf)*
- *Storymap: What's a Core For?*
- *Student worksheet (pdf)(doc)*

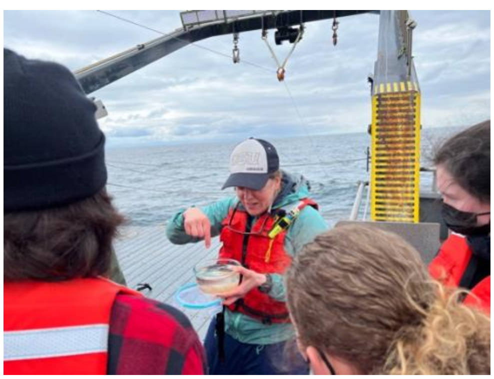
Activity: Evaluating Derivatives Using Contour Lines
In this activity, students use multivariable calculus to explore contour lines extracted from SSTa data. After using the traditional topographical maps, this lesson can be used to introduce the concept of multivariable derivatives. This can also be used as a first introduction or to build a relevant application for contour lines.

Guidance is provided in the *Presentation* and the *Teacher Notes*. After orienting students to the maps and contour lines, the instructor first demonstrates the process, and then students get to choose what part of the graph that they wish to analyze. They will use their math skills to gain a deeper understanding of mathematics as well as an awareness of the change in ocean temperatures annually.

Activity: Student Reflection
Another way to assess student learning is to have students submit a reflection in a form of their choosing:

- Formal paper
- Science Journal
- Video reflection
- Slideshow
- Poster board/collage

Teachers may use the provided *Rubric* to assess or grade student work.

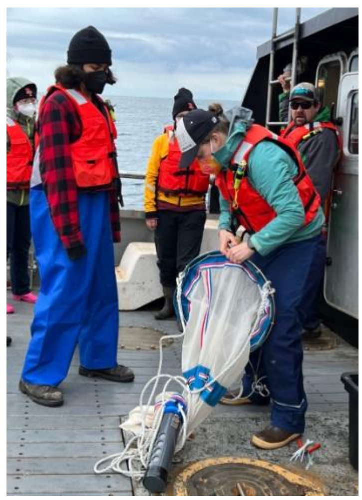


Evaluating Derivatives Using Contour Lines
- *Presentation (pdf)*
- *Teacher Notes (pdf)*

Find the value in 'x' direction using f' x(x,y) = Δz/Δx

Find the value in 'y' direction using f' y(x,y) = Δz/Δy

Student Reflection
- *Rubric (pdf)*



Teachers and students joined Kelsey Lane at sea on board the R/V Pacific Storm to collect plankton.

Next Generation Science Standards

Performance Expectations:

HS-LS2-2: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
HS-LS2-6: Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

Science & Engineering Practices:

Using Mathematics and Computational Thinking
Engaging in Argument from Evidence

Disciplinary Core Ideas:

LS2.A – Interdependent Relationships in Ecosystems
LS2.C – Ecosystem Dynamics, Functioning, and Resilience

Crosscutting Concepts:

Stability and Change

Common Core Math Standards

Math Practices:

MP. 3 – Construct viable arguments and critique the reasoning of others.

Oregon Math Standards:

HS.AFN.A.3 – Calculate and interpret the average rate of change of a function over a specified interval.

Acknowledgments

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

ORSEA Team Foram-able Observations