Stuff people said…

“I really enjoyed the Ocean Science lessons! It totally changed the way I look at the ocean. It has always been important to me, I live close to the beach and I love going to the beach, but after learning all about ocean currents and the power of the ocean to control so many things on Earth I will never look at the ocean the same way. Now I want to learn more about the deep ocean.” – 6th grade student Adelante Charter School
Stuff people said...

“I found the OSS curriculum to be rigorous, engaging and extremely relevant. The investigations uncovered and pushed individual student thinking in areas that were new to the students, leaving them hungry for more. The students had already been learning about the importance of the ocean, the beauty of its complex ecosystems and the responsibility we as informed citizens have in protecting and preserving its beauty, but this curriculum took their learning to a whole new level. They really began to understand the connection all life on Earth has to the ocean, regardless of where you live. They were able to articulate how the ocean influences climate and weather — really complex ideas! Because of the carefully crafted investigations, all students were able to access this content.”

-6th grade teacher, Title 1 2-way immersion school

Stuff people said...

“The investigations are well supported with additional computer simulations or animations that really helped the students gain a deeper understanding of the concepts. This was particularly helpful for the ELs who were able to pinpoint a misconception on the screen and correct it rather than having to re-do the investigation.”
Stuff people said...

“I was so impressed with the questions and observations the students made all throughout the unit. They were applying what they learned to other situations and it was fascinating to watch. I was especially impressed with the way the students developed their own understanding of density as it relates to ocean currents. They were able to write about their new understanding clearly and accurately. I taught middle school science for many years and always found density to be a very difficult concept for students to really understand. The OSS curriculum does a phenomenal job of developing this difficult concept in the students over time. These 6th graders were carrying on academic discussions using the new vocabulary and writing complex conclusions and arguments in a way that I haven’t seen in many middle school classrooms.”

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Stuff people said...

“This curriculum aligns not only with NGSS, but supports CCSS literacy standards so well. There is a huge emphasis on developing argumentation skills and providing explanations grounded in evidence. This provided an excellent opportunity to address these standards in a meaningful engaging way. Students were actively engaged in advanced levels of thinking about content that really interested them.”

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Structure of the Units

“First Ideas” assess prior conceptual understanding.

Evidence is gathered that relates to questions.

Students engage in discourse.

More evidence is gathered that relates to discourse and questions.

Students add more information to “First Ideas” to gauge learning.

Learning Cycle

Invitation

Reflection

Exploration

Application

Concept Invention

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## Learning Cycle in action:

<table>
<thead>
<tr>
<th></th>
<th>Climate Change &amp; Ocean Currents Activity (3.7 &amp; 3.8)</th>
<th>Today’s Workshop</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Invitation</strong></td>
<td>Near Earth’s poles, what direction do you think ocean water moves? Why do you think that?</td>
<td>What are the positive aspects and challenges of engaging your students in discussions?</td>
</tr>
<tr>
<td>Exploration</td>
<td>Explore video of the Great Ocean Conveyor Belt.</td>
<td>Observing a classroom engaged in argumentation. What do you notice?</td>
</tr>
<tr>
<td>Concept Invention</td>
<td>Can climate change affect ocean currents? Demonstrate ocean currents in a model ocean. Use simulation of changing ocean current. Learners predict, make explanations &amp; gather evidence to support ideas. Teacher explains as necessary.</td>
<td>Argumentation discussion – what is it &amp; why do it? Learning Cycle in the design of OSS and discussion of how it supports learning through experiences and discussions.</td>
</tr>
<tr>
<td>Application</td>
<td>Connecting climate and ocean currents through reading and discussing an article. Students (3.8)</td>
<td>How will you support a culture of talk in your classroom? What will you incorporate into your teaching?</td>
</tr>
<tr>
<td>Reflection</td>
<td>Reflection prompts – How might Earth’s climate be affected by changes in ocean currents?</td>
<td>How confident do you feel to address the questions you came in with &amp; what do you still need?</td>
</tr>
</tbody>
</table>

---

**Structure of the Teachers Guide**

- **Session Overview**
- **Key Concepts**
- **Other concepts**
- **Time Frame**
- **Unit Learning Goals**
- **Ocean Literacy Correlations**

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Structure of the Teachers Guide

Notebook pages, student sheets, and transparencies

Step-by-Step Instructions with suggested language

Support for ELL and Differentiation

Providing More Experience

Focused Opportunities to Learn Essential Concepts

- Essential not exhaustive
- Represents strategic knowledge that will prepare students for future learning in ocean sciences, and for responsible citizenry
- Addresses commonly held alternative conceptions and/or uncommonly taught concepts
- Assists teachers in meeting new NGSS

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Pedagogically Current

- Reflects the rigor of new research-based approaches:
  - More opportunity for reflection
  - More opportunity for discourse

Pedagogically Current

- Provides opportunities for students to learn to think like scientists:
  - Evidence-based reasoning
  - Building increasingly accurate models of the natural world
- Adequate time spent on each concept
Student Readings

- Engaging accounts of historical and current scientific activities
- Second-hand sources of evidence for making explanations and forming concepts
- Many shorter readings embedded in the activities
- Compliments and enhances your literacy goals (practice with expository text in context—supports CCSS)

Features Designed to Maximize Ease of Use, Helpful Guidance & Flexibility

Left-hand pages
—Step-by-step procedure for getting ready and presenting the lessons
—First line introduction and summary of each step in bold

Right-hand pages
—Science Notes: science content as you need it
—Class management suggestions
—Critical Junctures: assessing and reinforcing key concepts
—Alternative and additional activities
—Pedagogically educative material

DVD
—PowerPoint slides
—Animations and simulations (also on web resources page)
—Archive of all printed student material
OSS 6-8 Online Resources

- [http://mare.lawrencehallofscience.org/curriculum/ocean-science-sequence/oss68](http://mare.lawrencehallofscience.org/curriculum/ocean-science-sequence/oss68)

Session Resources

**Session 1.1: Heat Energy and Moving Molecules**
- Simulation: Rising Temperatures (Mac)
- Simulation: Rising Temperatures (PC)
- Simulation: States of Matter

**Session 1.2: Water vs. Air**
- Simulation: Heat Reservoirs (Mac)
- Simulation: Heat Reservoirs (PC)

**Session 1.3: The Ocean as a Heat Reservoir**
- Video: Oceans of Climate Change

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Revised Ideas

Describe what you know about the carbon cycle. Then describe how human industry has affected the flow of carbon on Earth. Be sure to include examples of some reservoirs and four different flows, and also discuss what you know about the total amount of carbon on Earth.

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Word Bank
- photosynthesis
- respiration
- carbon cycle
- carbon dioxide
- carbon reservoirs
- industry
- increase
- decrease

Science Standards
- Analyze and interpret data to answer questions about the carbon cycle. (Science and Engineering Practice: Develop and use models)

Human Impact on the Carbon Cycle
- Increased carbon dioxide
- Increased temperature
- Increased plants
- Increased respiration

Graphic Organizer for Writing Revised Ideas
Unit 3: What are the Causes and Effects of Climate Change?

- Over the course of Earth’s history, how have Earth’s ocean and atmosphere changed?
- What does carbon dioxide have to do with temperature?
- What is climate change?
- What evidence shows that climate change is happening?
- What are some effects of climate change?
- What are some possible solutions to climate change?

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Session 3.1
Introducing Earth's History

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Session 3.2

Tracking Earth's CO₂ through Time

Carbon Reservoirs

Ocean Surface Water

Deep Ocean Water

Atmosphere

Plants

Soil

Animals

Fossil Fuels: Natural Gas, Crude Oil, Coal

Limestone & Other Rocks

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Session 3.2

Tracking Earth's CO$_2$ through Time

- Small groups of 6
- Pairs read and discuss one of the 3 sections
- Pairs share what they have learned with the rest of the small group and any questions they still have
- Each small group shares out 2 ah ha’s, questions, or things you found particularly interesting with whole group

Atmospheric CO$_2$: 550 Million Years Ago to Present

[Graph showing atmospheric CO$_2$ levels over millions of years]
One Million Dots

100 Squares of 10,000 dots = 1,000,000 dots

Three Graphs about CO₂

1. CO₂ Levels in Atmosphere Measured at Mauna Loa Observatory: 1960–2010

2. CO₂ Levels in Atmosphere: 400,000 Years Ago to Present

3. Atmospheric CO₂: 550 Million Years Ago to Present
Since 1960, the level of CO$_2$ in the atmosphere has increased faster than at any time in the last 10,000 years of Earth’s history.

Reflection Prompt

- Why do you think changing the residence time of carbon in the fossil fuel reservoir might have a large effect on the carbon cycle?
Determining the Source of the Atmosphere’s Extra CO₂

It is widely believed that the increase in atmospheric CO₂ is caused by human activities, particularly the burning of fossil fuels and deforestation. However, there is evidence that other factors, such as volcanic activity and ocean acidification, may also contribute to the increase in CO₂ levels. To determine the source of the extra CO₂, we will conduct an experiment that involves monitoring the CO₂ concentration in two different environments: a laboratory setting and a natural setting.

Materials:
- CO₂ detector
- Tapes
- Labels
- Electrolytes
- Small containers
- Baseline (initial) CO₂ measurements

Procedure:
1. Establish a baseline measurement of CO₂ concentration in a laboratory setting, where the atmosphere is controlled and CO₂ emissions are minimized.
2. Establish a baseline measurement of CO₂ concentration in a natural setting, such as a forest, where CO₂ emissions are naturally occurring.
3. Place the containers in each environment and record the CO₂ concentration over time.
4. Analyze the data to determine which environment is contributing more to the increase in CO₂ levels.

Results:
- In the laboratory setting, the CO₂ concentration remains relatively constant.
- In the natural setting, the CO₂ concentration increases over time.

Conclusion:
- The increase in CO₂ concentration is primarily due to human activities, such as burning fossil fuels and deforestation.

Experiment continued...

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Determining the Source of the Atmosphere’s Extra CO₂ (continued)

In addition to the laboratory experiment, we will conduct another experiment to determine the source of the extra CO₂ in the natural environment. This experiment involves measuring the CO₂ concentration in different parts of the forest, such as the canopy, the understory, and the soil.

Materials:
- CO₂ detector
- Tapes
- Labels
- Electrolytes
- Small containers
- Baseline (initial) CO₂ measurements

Procedure:
1. Establish a baseline measurement of CO₂ concentration in the canopy, understory, and soil.
2. Place the containers in each environment and record the CO₂ concentration over time.
3. Analyze the data to determine which part of the forest is contributing more to the increase in CO₂ levels.

Results:
- In the canopy, the CO₂ concentration is relatively low.
- In the understory, the CO₂ concentration is moderate.
- In the soil, the CO₂ concentration is high.

Conclusion:
- The increase in CO₂ concentration is primarily due to the contribution of the soil, which contains a significant amount of organic material that decomposes and releases CO₂.

Further experiments will be conducted to determine the contribution of other factors, such as volcanic activity and ocean acidification, to the increase in CO₂ levels.
**Key Concepts**

- CO$_2$ is a heat-trapping gas. As CO$_2$ levels increase in the atmosphere, Earth's temperature rises.

- Scientific evidence suggests the main cause of rising CO$_2$ levels in the atmosphere over the last 200 years has been people burning fossil fuels.

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Revised Ideas, Part 1

- What is the cause of the rapid change in CO₂ levels since 1960? Explain using evidence.
- How do you think the recent increase in levels of CO₂ in the atmosphere affects temperatures on Earth? Use evidence to explain your answer.

Guiding Questions:

- What evidence shows that climate change is happening?
- What are some effects of climate change?
Session 3.6
Demonstrating Cause and Effect
Guiding Question:
What evidence shows that climate change is happening?

Make a Flow Chart
How could you make a cause and effect flow chart with these cards?

- Fossil fuels are burned.
- Fossil fuels are taken from underground.
- CO₂ levels in the atmosphere increase.
- People invent industrial tools, such as engines and factory machines.
- More energy from sunlight is absorbed by the atmosphere.
Directions for flow charts

- Cut apart cards.
- Discuss and create cause and effect chain.
- Glue cards and draw arrows.
- Write evidence along arrows.

Increased CO₂ in the atmosphere, a result of human industry, is the main cause of changing sea ice, rising sea level, and melting glaciers.
Sample Student Work

- Look at 2-4 examples of student work
- What do each of these examples tell you about student understanding?
Session 3.10
Solutions to Climate Change, Part 1

Store Carbon in Rocks

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Capture CO$_2$ from the Atmosphere

Capture CO$_2$ from Factories
BEFORE
It Reaches the Atmosphere...

in Microscopic Cages!
Reduce Cow Gas

Clover (far left) and bales of alfalfa.

Paint Roofs White
Build Houseboats

Scientists and engineers are working to slow or stop climate change and to lessen the effects of climate change.

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Session 3.11
Solutions to Climate Change, Part 2

24 Solutions

1. Preserve Forests
2. Recycle and Use Less Paper
3. Turn Lights Off
4. Adjust Your Thermostat
5. Plant a Tree or Garden
6. Walk or Roll to School
7. Recycle Plastic
8. Buy in Bulk (or less packaging)
9. Bring a Shopping Bag
10. Use Rechargeable Batteries
11. Eat Less Meat
12. Buy Used Instead Of New
13. Eat Locally Grown Food
14. Recycle E-Waste
15. Unplug Electronics You're Not Using
16. Replace Incandescent Lightbulbs
17. Use Wind and Solar Power
18. Use Trash to Produce Energy
19. Turn Off Your Vehicle
20. Make an Action Plan For Sea Level Rise
21. Improve Fuel Efficiency
22. Improve Public Transportation Options
23. Reduce the Release of Heat-Trapping Gases
24. Support NPS's Climate-Friendly Parks Program
3.12: Thinking Critically about Climate Change

- 3.1 Introducing Earth’s History
- 3.2 Tracking Earth’s CO2 through Time
- 3.3 What Does CO2 Have to Do with Temperature?
- 3.4 Reflecting on Carbon and Climate Change
- 3.5 Investigating Climate Change Evidence Stations
- 3.6 Demonstrating Cause and Effect
- 3.7 Investigating Climate Change: Ocean Currents
- 3.8 Connecting Climate and Ocean Currents
- 3.9 Investigating Climate Change: Organisms
- 3.10-3.11 Solutions to Climate Change

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Directions for flow charts

1. State the action.
2. Add results or effects (include evidence).
3. Complete the flow chart.
Student work, first and revised ideas

- What can you say about each of these students’ understanding of climate change at the end of the Unit?
- What about how their understanding changed from what they wrote in the first ideas?

Break
Post-assessment

Using pre- and post-assessments to gauge student understanding

- In partners, look at questions 8 and 11.
- Read each of the multiple choice options for the question.
- What might you be able to say about a student’s partial/mis-/naïve/complete understanding of that concept if the student selected A? B? C? D?
- How would you address this student’s understanding? (Questions correlate to sessions 3.2-3.6)
Pre- and Post-assessment System

NGSS Alignment
Reflection

- As a professional learning experience for you, what did you find most interesting and useful about this workshop?
- What do you hope your students will get out of engaging in this curriculum?
- As a teacher preparing to implement this curriculum: what are your next steps & what questions do you still have?