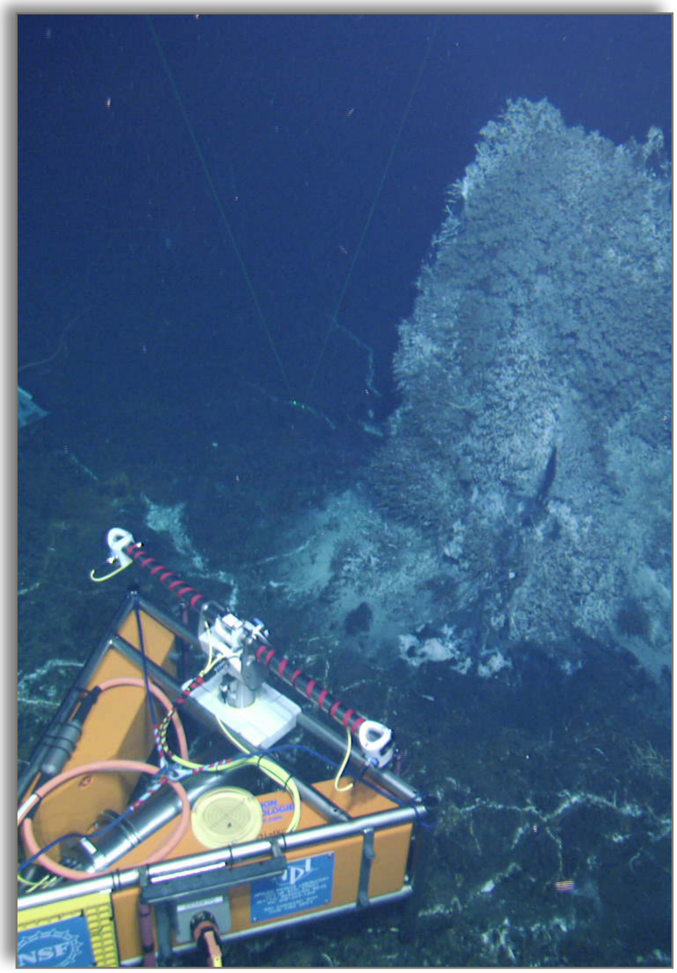

Building an Ocean Data Lab

A workbook for the

OOI Ocean Data Labs Workshop

March 8-13, 2019, Princeton, NJ
Hosted by Rutgers University

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Introduction

This workbook is designed to help you think through the stages of development of your OOI Ocean Data Lab. Please use it as a guideline to help you in the development process and as a way to collect your thoughts over our five-day workshop.

The steps in this workbook were adapted from *Understanding by Design* by Grant Wiggins and Jay McTighe.

What is Backwards Design?

Backward Design is a model process for designing instructional materials where the instructor or designer begins the design process with a focus on the desired results (i.e., the outcome) of instruction. It is an alignment exercise where learning objectives are tightly matched to activities.

Rather than beginning the planning process with a focus on supporting exercises, resources or long-used textbooks, the designer focuses on the learners and begins the design process by asking ***what learners should be able to understand and do after the provided instruction***.

The designer then identifies what types of evidence is sufficient proof of the desired end result. The designer works "backwards" from that end goal and intentionally plans and develops supporting instruction and learning experiences around the desired outcomes and evidence.

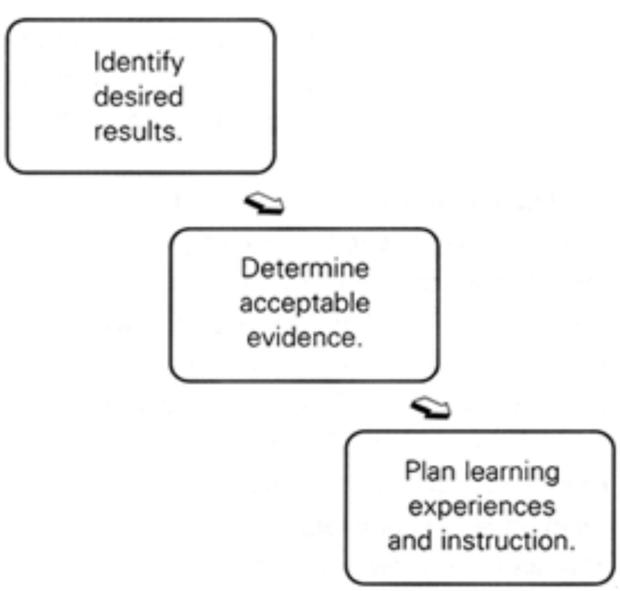


Figure from: https://en.wikipedia.org/wiki/Backward_design#/media/File:Backward_Design_Model.gif

Backward Design can be summarized in a three-step process:

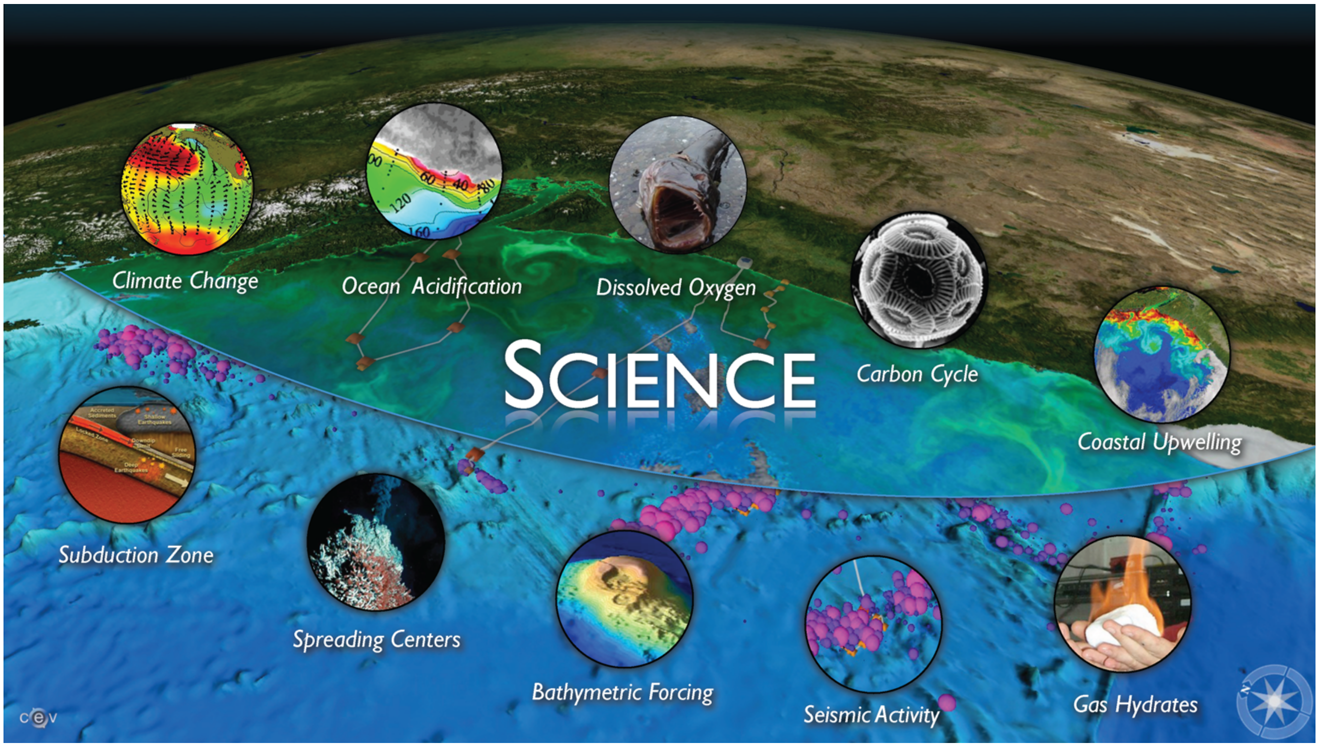
Step #1: Identify Desired Outcomes
Articulate what learners should be able to understand and do after provided instruction.

Step #2: Identify Metrics for Success
Determine what types of assessments and measures would clarify when and whether students can perform the desired outcome.

Step #3: Plan Learning Experiences and Instruction
Develop exercises, materials and instruction around the desired outcomes and evidence.

Step 1: Identify Desired Outcomes

Articulate what learners should be able to understand and do after provided instruction.



Graphic courtesy of UW CEV

The OOI infrastructure is designed to make scientific observations of short-term, energetic processes and long-term subtle changes in the ocean. These observations inform scientists and our broader society on changes in the ocean and atmosphere that might trigger "tipping points" in planetary phenomena.

Task A: Review the OOI Science Themes and Prospectus

Review the OOI Science Themes or the OOI Science Prospectus. Think about which of these themes or concepts would enhance your Introduction to Oceanography program or syllabus.

Here is a selection of interesting science questions the OOI was designed to help address:

- How can we improve storm forecasting and our understanding of climate change models using OOI observations? (ocean-atmosphere exchange)
- How will climate variability impact ocean circulation patterns? The marine ecosystem? (Climate variability, ocean circulation, and ecosystems)
- How does ocean mixing influence primary production? Carbon sequestration (and other biogeochemical processes)? (Turbulent Mixing and Biophysical Interactions)
- How can we understand the variability of the coastal ocean? What are the impacts of low dissolved oxygen conditions (hypoxia) on marine organisms? (Coastal Dynamics and Ecosystems)
- What are the geological processes that form and age the ocean floor? What is the impact of perturbation events such as magmatic intrusion and earthquakes on geological, chemical and biological processes in the seafloor and within the overlying ocean? (Fluid-Rock Interactions and the Sub-seafloor Biosphere)
- How do active plate boundaries influence the ocean from a physical, chemical, and biological perspective? (Plate scale Geodynamics)

What OOI science theme is most interesting to you?

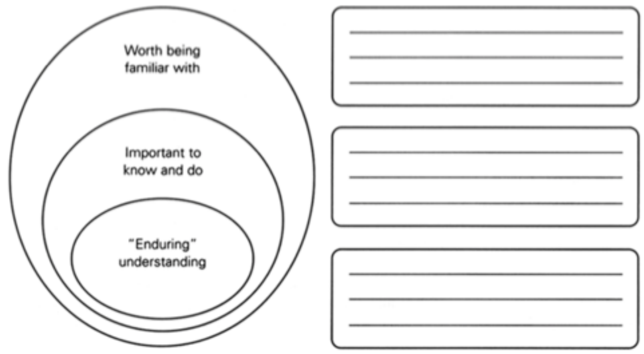
Task B: Compare Oceanography Textbook Content with OOI Themes

Review the OOI/Essentials of Oceanography crosswalk document. This document was created to help place the OOI science themes in the context of a typical introductory oceanography textbook (in this case, Trujillo & Thurman's *Essentials of Oceanography* 12th edition, 2017).

Which of these OOI questions/themes is important for your students to understand?

Task C: Find the big idea and identify what is worth knowing

How do we determine what is worth understanding amid a range of content ideas and topics? You can find the big idea for your Data Lab by separating what it is important for your students to know or do and what is worth being familiar with.



The diagram on the right provides a framework for thinking about these multiple levels of understanding.

- **Enduring understandings** go beyond discrete facts or skills to focus on larger concepts, principles, or processes. As such, they are applicable to new situations within or beyond the subject. **A big idea** can be described as a linchpin idea. The linchpin is the pin that keeps the wheel in place on an axle. Thus, a linchpin idea is one that is essential for understanding. Without a focus on linchpin ideas that have lasting value, learners may be left with easily forgotten fragments of knowledge.
- **Important to Know and Do** refers to the key knowledge students will acquire from the lesson and course. What students will do refers to the key skills students will acquire from the lesson and the course. These skills and knowledge are essential (prerequisite knowledge) for the enduring understanding.
- **Worth Being Familiar with** refers to what students should be familiar with in the course of the lesson or course. It can be interpreted as the contextual knowledge, the big picture, or the broad strokes, familiarity with which forms a foundation for more targeted investigation of the concepts and understandings that reside within the innermost circle.

Example: Investigating Primary Production with OOI Data

From Dr. Anna Pfeiffer-Herbert, Stockton University

In 2016, Stockton University Professor and Data Lab team member Anna Pfeiffer-Herbert developed a Data Lab lesson for her class on primary productivity. Below we provide an example to help guide you through Step 1 of the Backwards Design process.

Learning Objectives

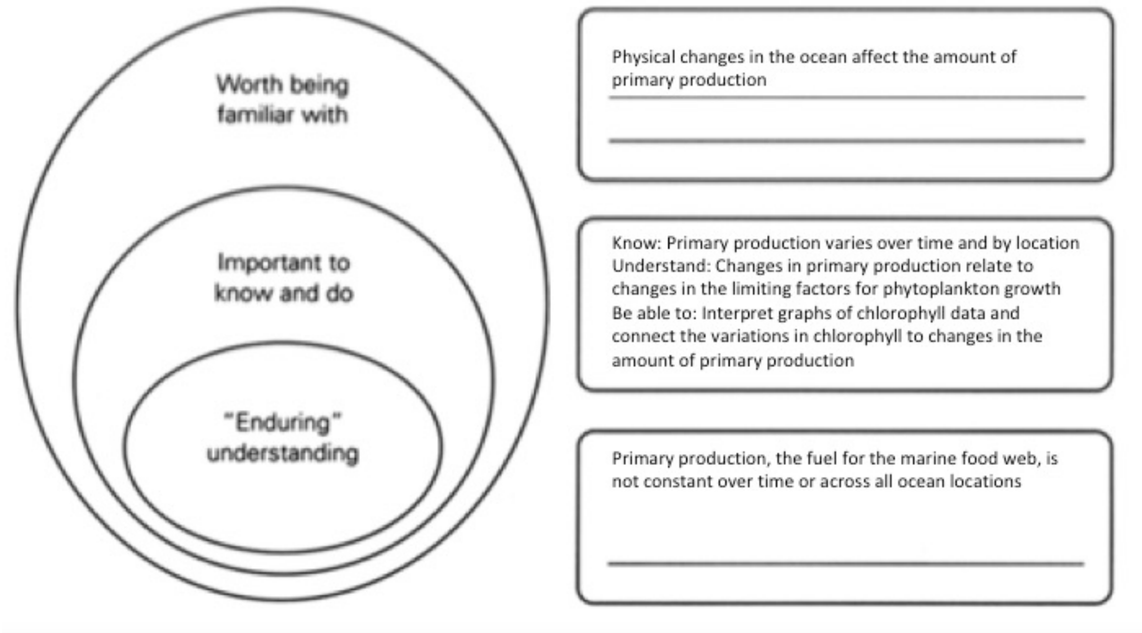
Anna's *student learning objectives* involved getting her students to understand seasonal cycles of primary production and an understanding of the factors that limit production in the ocean.

Students should be able to:

- Describe geographic and seasonal variation in primary production
- Identify patterns in realistic chlorophyll data that relate to primary production cycles
- Apply knowledge of limiting factors (nutrients, light, stratification) and evidence from data to develop hypotheses about primary production in different regions of the ocean

Enduring Understanding

We asked Anna to describe: What should students know, understand, and be able to do? What big ideas are worthy of understanding? What "enduring" understandings are desired? What questions are worth pursuing to guide student inquiry into these big ideas? Below is the breakdown of ideas:



Applying Filters

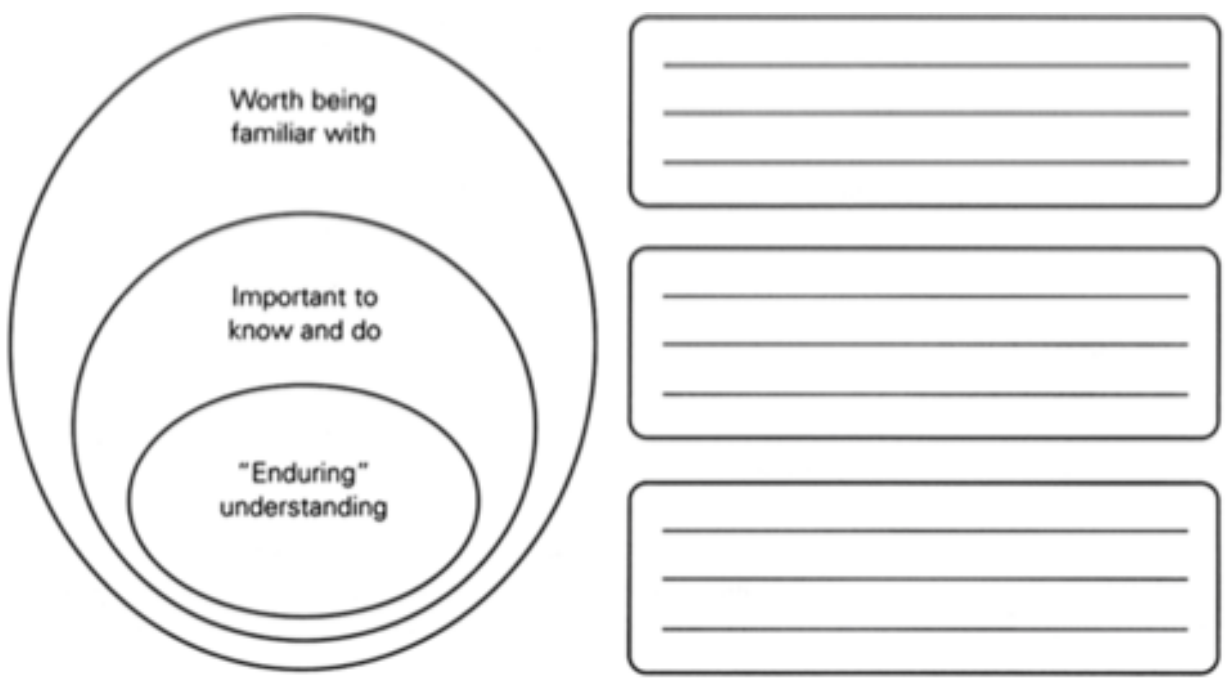
Next Anna applied filters to hone in on the big ideas for she wanted her students to understand.   There are four filters to consider including: 1) to what extent does the topic or process represent a "big idea" having enduring value beyond the course?; 2) How can this knowledge be generated tested or used?; 3) What will students often have difficulty grasping? What do they typically struggle with? Which big ideas are they likely to have a misconception about?; and 4) To what extent does the topic, or process offer potential for engaging students?

Filter 1: To what extent does the topic, or process represent a "big idea" having enduring value beyond the course?	Primary production responds to changes in available sunlight, nutrients and surface mixed layer depth
Filter 2: How can this knowledge be generated, tested, or used?	Use limiting factors concept to evaluate changes in PP by season and by latitude; Assess students' ability to apply limiting factors concept to changes in chlorophyll in time series from different locations

Filter 3: What will students often have difficulty grasping? What do they typically struggle with? Which big ideas are they likely to have a misconception about?	Common misconception: Temperature causes changes in primary production, and so PP peaks in the summer; Graph reading difficulty: Keeping track of changing physical factors while viewing chlorophyll data; Scientific method difficulty: Meaning of observation, evidence, hypothesis
Filter 4: To what extent does the topic, or process offer potential for engaging students?	Students interested in marine species and ecosystems connect to the concept of primary producers as the base of the food web, especially for short food chains found in high primary production coastal areas (Plankton - Zooplankton - whales)

Your Turn: What is your Data Lab's desired outcomes?

Use this space to record your ideas:



What is worth being familiar with?

What is important to Know?

What is important to do?

What is the enduring understanding you want to achieve?

Applying Filters: There are four criteria, or filters, to use in selecting ideas and processes to teach for understanding. Jot some ideas you have for your Data Lab in each of the spaces below:

Filter 1: To what extent does the topic, or process represent a "big idea" having enduring value beyond the course?	
Filter 2: How can this knowledge be generated, tested, or used?	
Filter 3: What will students often have difficulty grasping? What do they typically struggle with? Which big ideas are they likely to have a misconception about?	
Filter 4: To what extent does the topic, or process offer potential for engaging students?	

By having the students encounter big ideas in ways that provoke and connect to their interests (as questions, issues, or problems), we increase the likelihood of student engagement and sustained inquiry.

Developing Learning Objectives

A Student Learning Objective is an academic goal set at the start of a course that is specific, measurable, based on available prior student learning data, and aligned to your syllabus. Objectives are:

- **Specific:** Describes an action, behavior, outcome, or achievement that is observable.
- **Measurable:** Details quantifiable indicator(s) of progress towards meeting the goal
- **Audience:** Describes outcomes from the perspective of the student (i.e., what the student will be able to do).
- **Relevant:** Is meaningful, realistic, and ambitious; the student can (given the appropriate tools, knowledge, skills, authority, resources) accomplish the task or make the specified impact.
- **Time Bound:** Delineates a specific time frame (e.g., six months after participating in the course, at the conclusion of the course).

Your Turn: Write your SMART Objectives

In this activity, students will:

Step 2: Determining Success

Determine what types of assessments and measures would clarify when and whether students can perform the desired outcome.

The Backward Design approach encourages us to think about our work in terms of the collected evidence needed to document and validate that the desired learning has been achieved, so that the course is not just content to be covered or a series of activities or worse yet – just information we give them.

- How will you know your students are on the right path?
- How do you know your students understand the concept?
- How do you know they are making progress?
- How would the students themselves know they are understanding the concept?

Your Turn: Write your ideas for assessment

Jot down your ideas here...

Through what authentic performance tasks will students demonstrate their understanding? Will you for example use conversations and dialogue (reflective self report information from audio/video/written); observations; student projects (short or long-term); and/or prompts or open ended questions?

How will students reflect upon and self-assess their own learning?

What additional information do you need to complete Step 2?

Step 3: Planning Learning Experiences & Instruction

Develop exercises, materials and instruction around the desired outcomes and evidence.

With clearly identified results (enduring understandings and assessment strategy), we can now plan instructional activities. Several key questions must be considered at this stage of design:

- What enabling knowledge (facts, concepts, and principles) and skills (procedures) will students need to perform effectively and achieve desired results?
- What activities will equip students with the needed knowledge and skills?
- What will need to be taught and how should it best be taught, in light of performance goals?
- What materials and resources are best suited to accomplish these goals?
- Is the overall design coherent and effective?

Creating a Data Lab

What additional information do you need to determine the best way to deliver the content?

Step 3A: Identify an OOI dataset to Explore

The first step in creating a Data Lab is to identify what data you want to use to develop an instructional strategy for your learning objectives. In this part of the lesson, students view the dataset(s) you have selected and consider the questions you have proposed. Analyzing individual datasets and other pieces of evidence should help students address the Challenge you have posed.

Example: Ocean Atmosphere Interactions During Storms

From Dr. Silke Severmann, Rutgers University

In 2016, Silke developed a lesson focused on Hurricanes and Super storms using data from a Rutgers glider deployment and buoy data from the NOAA.

Students were instructed to form a group of 3-5 people and read a short introduction. They then received a worksheet (right) where they could record their analysis of some online data that were collected during recent hurricane Irene and Superstorm Sandy.

Introduction to Oceanography, Spring 2015
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Exercise 7 – Hurricanes and Superstorms

Date: 16 April 2015 **Name:**___________________

Find yourself a group of 3-5 people. To begin the exercise, go to the following webpage: http://education.oceanobservatories.org/node/300/detail. First, you will read a short introduction and then analyze some online data that were collected during recent hurricane Irene and Superstorm Sandy.

The goal of this investigation is to write up a description and analysis of the provided datasets. As you work through the exercise, complete the tables below, this will help you to answer the five questions at the end of this exercise.

Glider data	**Hurricane Irene**		**Superstorm Sandy**	
	Before	*During/after*	*Before*	*During/after*
Date of storm impact				
Maximum wind speed (km/h)				
Mixed layer depth (m)				
Mixed layer water temperature (°C)				
Deep water temperature (°C)				
Mixed layer backscatter (m^{-1})				

Buoy data	**Hurricane Irene**			**Superstorm Sandy**		
	Before	*Peak*	*After*	*Before*	*Peak*	*After*
Air pressure (hPa)						
Date of minimum air pressure						
Wind speed (m/s)						
Wave height (m)						
Sea surface temperature (°C)						

Instructions
Using the datasets provided, describe the impact that Hurricane Irene and Superstorm Sandy had on the ocean. Include an analysis of how the oceanic response varied between the two storms.

The goal of the investigation is to support the students in writing up a description and analysis of the provided datasets. Students answer 5 questions at the end of the lesson that help them synthesis the data to form ideas about the differences between the two storm systems.

Step 3A: Your Turn - Identify an OOI data set

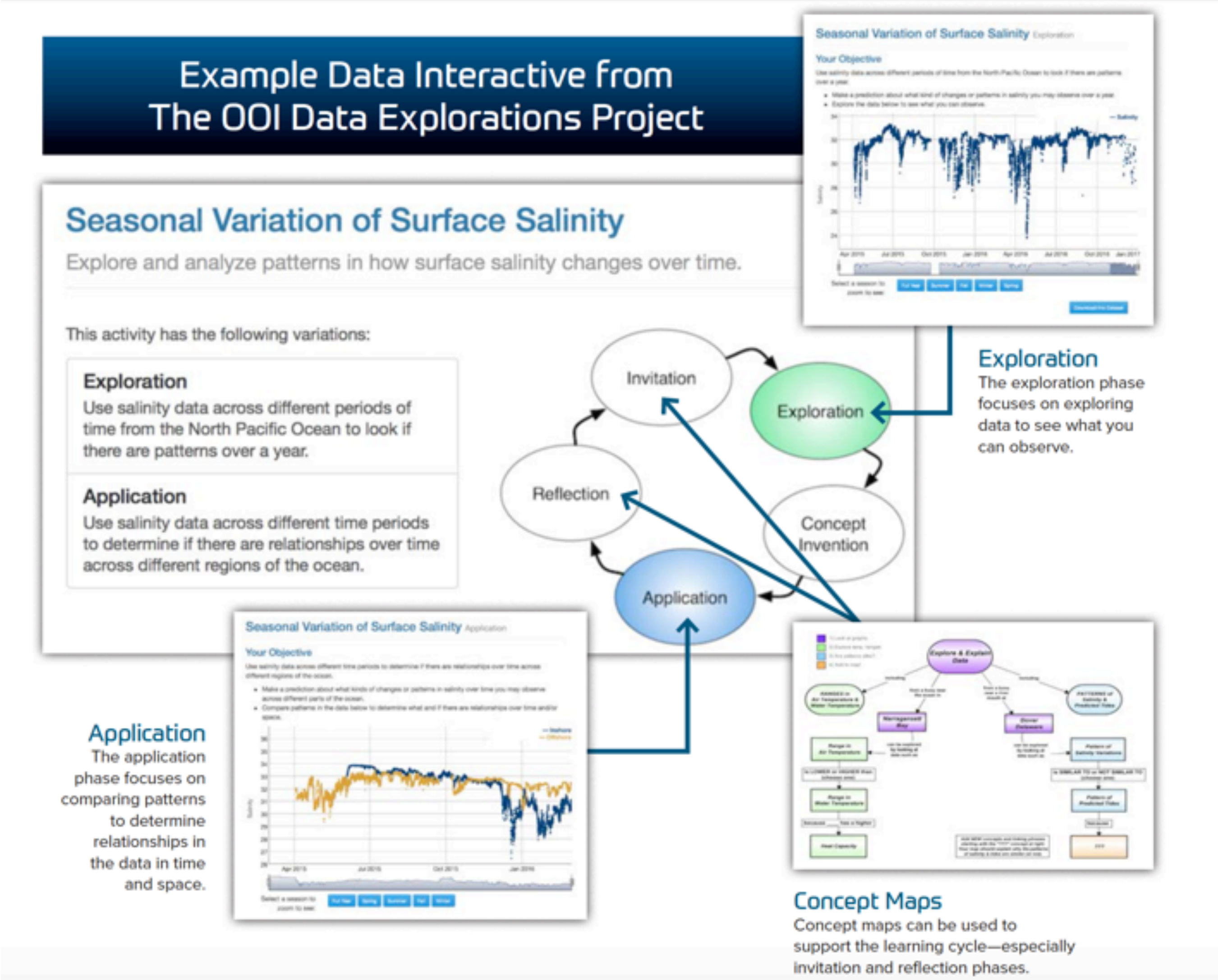
- Review the list of **Educational Data Nuggets**. Please review the new data sets being identified by data evaluators working on the OOI program. Find a data nugget that you think can be developed into a data lab and can support your learning goals and objectives. or….
- Find a **Data Exploration** that you think can be tweaked/improved for your learning goals and objectives.

What instruments/datasets do you initially plan to use?

What should I do before this?	What do I do on this page?	What should I do next?
Drafting a learning objective will help you decide which dataset(s) to include in your investigation.	This is the heart of your Data Lab. Here students view the dataset(s) you have selected and consider the questions you have proposed. Analyzing individual datasets and other pieces of evidence should help students address the Challenge you have posed.	After identifying the dataset, you should develop the Challenge question your students should address. This process is iterative – you may need to come back to this page to edit the descriptions and questions for each dataset(s).

Step 3B: Develop your Challenge Question/Objective

Before this step, you should draft your learning objectives and identify some key dataset(s) you would like students to use in this Data Lab. With those ideas in mind, you can now identify the objective you want your students to pursue. In Silke's lesson example in the previous step, the challenge was for the students to use the glider and buoy data to identify physical features of the ocean that changed during Hurricanes Irene and Sandy.



Look through the existing Data Labs and notice the range of objectives that support either the Exploration or Application phase of the Learning Cycle. For example, in a lesson on the Seasonal Variation of Surface Salinity, professors can chose to focus on the Exploration phase of the Learning Cycle - where the focus is on student observation or the Application phase where the student focus is on analyzing the relationship in time and space (geographic regions).

Step 3B: Your Turn - Develop a Challenge Question

Take some time to think about what your objective/change question is for your Data Lab. Review the stages of the Learning Cycle and think about what purpose you want your Data Lab to serve for your students. You might consider having your students:

- Develop a conceptual model to explain…
- Analyze data from …to identify or explain or look for a pattern…
- Construct an explanation using the data provided that describes….
- Investigate data from…and develop your own question about the dataset, and explain

Add your notes here:

What should I do before this?	What do I do on this page?	What should I do next?
Before writing your research challenge, you should identify the potential dataset(s) you would like students to explore	Develop a research goal that you want your students to investigate. You will also relate this to the desired outcome, or assessment you planned earlier in the workshop (Steps 1 and 2) on days one and two.	After establishing your research Challenge, you should revise your descriptions and add specific investigation questions to each dataset.

Step 3C: Develop Data Tips & Investigation Questions

In this section of the Data Lab, your students receive instructions and orientation to the data activity. You should draft 2-3 sentences that help students orient to the task and begin to ask questions of the data. In our previous example from Silke, students review six different data interactive and are asked to write up a description and analysis of the datasets. Students use the datasets provided to describe the impact that Hurricane Irene and Superstorm Sandy had on the ocean. They include an analysis of how the oceanic response varied between the two storms. Students are given guiding questions such as:

- As Hurricane Irene moved closer to shore, what changes did you notice in the ocean?
- As Superstorm Sandy moved closer to shore, what changes did you notice in the ocean?
- Based on your observations, what is the relationship between storms and the ocean?
- Explain the differences in mixed layer depths between the two storms as they moved closer to land. Why are they different?
- If Hurricane Sandy had occurred a few weeks earlier in the season when atmospheric temperatures were warmer, how do you think he storm would have been different?

In the Seasonal Salinity example, students are asked to orient and interpret the data.

Data Tips

When the site loads, you are able to see the full dataset of salinity data from the Coastal Endurance's Near Shelf Surface Mooring. You can interact with the data by:

- Selecting a different time period (season or full year) to explore the data in ways that interest you.
- Zooming in and out of the data to look at different time scales that interest you by changing the width of the highlighted section of the bottom graph (it loads with all of the data highlighted).

Questions for Thought

Orientation Questions

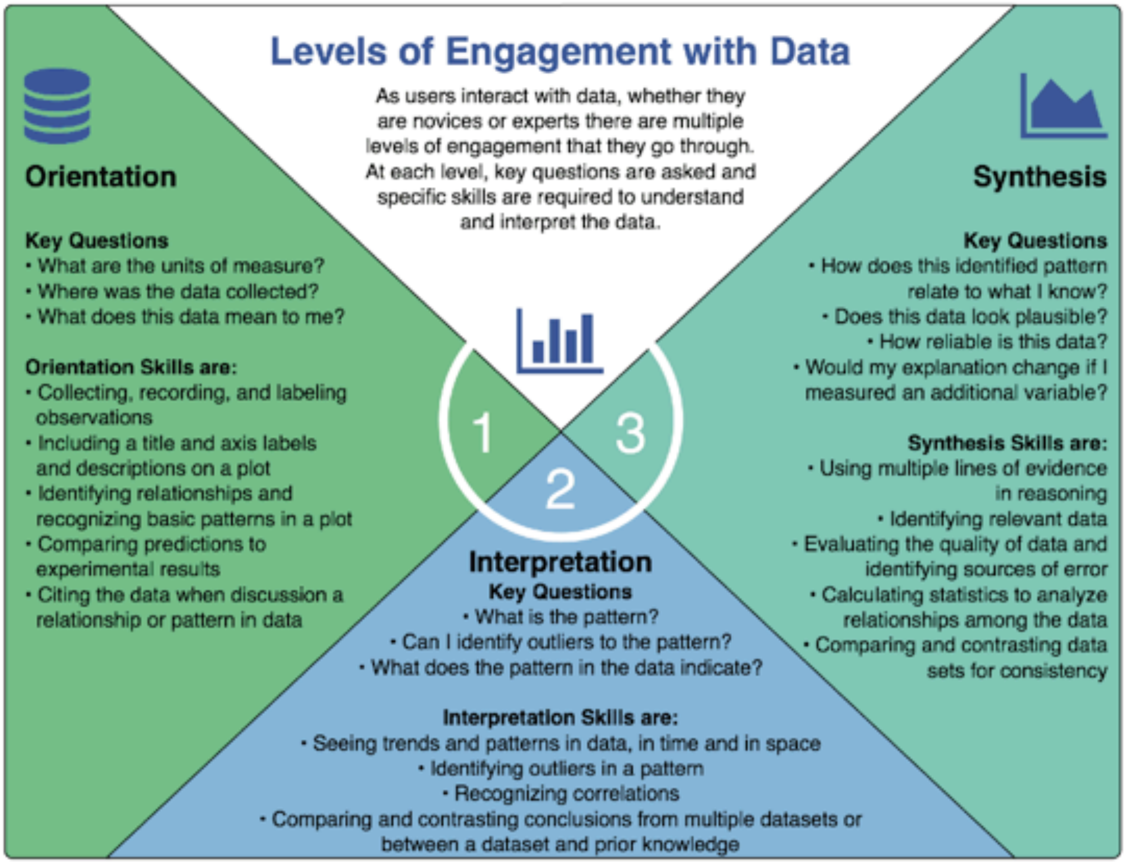
- Across what time periods are you able to observe salinity data in this graph?
- What is the first month and year there are data?
- What is the last month and year there are data?

Interpretation Questions

- What changes or patterns did you observe in salinity over this time period in the Northern Pacific Ocean?
- When did you see these changes or patterns?
- What questions do you still have about why salinity changes over time?

Step 3C: Your Turn - Student Data Tips and Questions

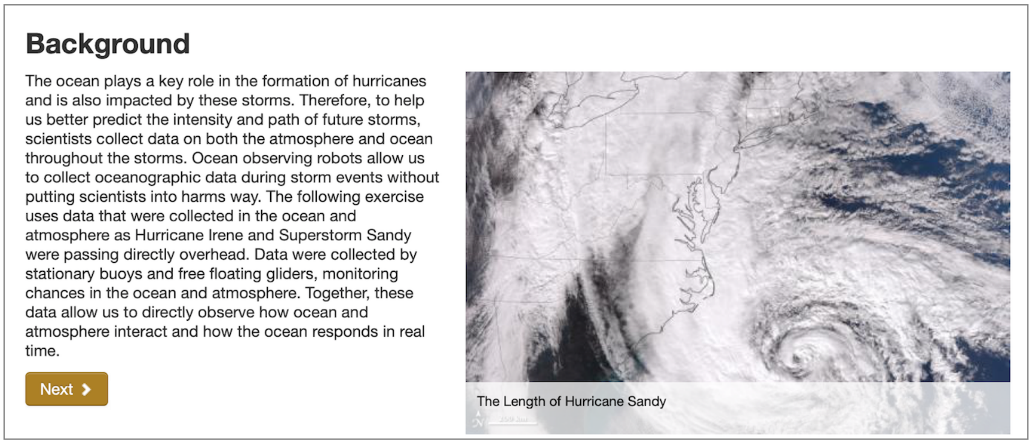
Take some time now to work out your Data Tips and Investigation questions. Think about what your data skills goals are for your students and relate back to your student learning objectives.



What should I do before this?	What do I do on this page?	What should I do next?
Develop a research goal that you want your students to investigate. You will also relate this to the desired outcome, or assessment you planned earlier in the workshop (Steps 1 and 2) on days one and two.	After establishing your research Challenge, you should revise your descriptions and add specific investigation questions to each dataset.	In the next step you will develop background information to help your students orient to the content and lesson goals.

Step 3D: Assemble Background information

In this section, students learn about where and how the data was collected. In Silke's Hurricane lesson, students learned more about how hurricanes form.



In the Seasonal Salinity lesson, students learn about the Coastal Endurance array and about CTDs. This is largely context setting for your students. You should be thinking about how you will integrate this material into your existing class structure. Do you have materials that can be integrated and supportive of your student learning goals? This is also a good time to revisit the **Crosswalk document** and see if there are other connections you can make in your course syllabus.

Step 3D: You Turn - Background Information

Add your notes here:

What should I do before this?	What do I do on this page?	What should I do next?
In the previous step, you should have revised your descriptions and added specific investigation questions to each dataset.	Here you will develop background information to help your students orient to the content and lesson goals.	The final step is providing Instructor notes for how you will deliver the lesson to your students.

Step 3E: Final Step - Develop Instructor Notes

In this final step, you should document your data sources, provide a summary of the lesson, list your learning objectives, and any teaching instructions. In the seasonal Salinity Variation lessons, the developers provided key information on the data sources and the goals for both the Exploration and Application phase of the Learning Cycle.

Seasonal Salinity Variation

Students look at timeseries of single-point salinity over space and time to explore the data for changes and patterns. The students can:

- **Exploration:** Explore salinity data across different time periods to see what you can observe. The data are from the northern Pacific Ocean (Coastal Endurance Array) from April 2015 to March 2017.
- **Application:** Compare patterns in salinity data across different time periods to determine if there are relationships over time across different regions of the ocean. The data are from the northern Pacific Ocean (Coastal Endurance Array), northern near polar Atlantic Ocean (Irminger Sea Array), northern Atlantic Ocean (Coastal Pioneer Array), and southern near polar Atlantic Ocean (Argentine Basin Array) from April 2015 to March 2016.

Step 3E: Your Turn - Instructor Notes

Add your notes here: