OOI Data Lab Lesson Plan: Chlorophyll-a in Temperate Zones of the Ocean

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Time required: This lab requires a minimum of 1 hour. With additional optional discussions and demonstrations, this lab could take up to 1.5 hours.

Assumed prior knowledge: This lesson is appropriate for 100-level undergraduate students or advanced high school students who are taking or have completed an introductory oceanography course. Students should be familiar with the concepts of primary productivity, phytoplankton, trophic levels, and coastal upwelling.

Equipment required: Access to computers with internet connection, preferably one computer per student or per pair of students.

Pre-class prep: Print out the Chlorophyll-a Data Lab Worksheets.

Pre-class assignment:
Have students read this short online article about global fisheries and answer the questions below.

1. Approximately how many million metric tons of fish were harvested from the ocean in 2010?
   About 100 million metric tons

2. What two categories of fish are caught the most? What types of fish are included in each of these two categories?
   Small pelagic fish, such as anchovies and sardines, and demersal fish, such as cod and other fish that live on the ocean floor.

3. Where are fish caught the most often – in coastal waters or in the open ocean? Brainstorm a reason why this might be the case.
   More fish are caught in coastal areas. Reasons might include ease of access to fisheries, better habitat, better water quality, more food, etc.

Lesson Overview:
Part 1: Introduction

- Hand out Page 1 of the data lab worksheet.
- Have students pair up and answer Questions 1 and 2

- Optional: If your students are not familiar with phytoplankton you can show a short video, like this one.
- Discuss reasons measuring phytoplankton is important: basis of the marine food web, supports world's fisheries, indicator of environmental problems
- In pairs, have students answer Question 3 using this map of chlorophyll in the ocean.
- Discuss answers as a class to make sure everyone got the right answers.

Part 2: OOI Data Lab

- If students are not familiar with OOI, give some background information and watch this video.
- Hand out page 3 of the data lab worksheet.
- Give students about 5 minutes to explore the OOI Chlorophyll-a in Temperate Zones of the Ocean data lab.
- In pairs, have students answer questions 4 – 11.
- Briefly go through Questions 4 – 10 as a class to make sure everyone got the right answers.
    - Optional: Discuss outliers in the datasets
- Discuss Question 11 as a class. Make a list and guide students to the two most likely answers: sunlight and nutrients.

Part 4: Tying it together

- Hand out page 4 of the data lab worksheet.
- In pairs, have students answer Questions 12 and 13 using this Global Solar Alas.
- Briefly discuss Questions 12-13 as a class to make sure everyone got the right answers.
- In pairs, have students answer Question 14.
    - If students have previous knowledge of upwelling some may come to this as the correct answer.
    - If students do not have knowledge of upwelling, tell them briefly about upwelling, but have them research the connection between upwelling, nutrients, and the Pacific coast themselves.
- Discuss the answer to Question 14 as a class.
    - For students with little oceanography background and/or with minimal class time, simply explain that the North Pacific coast has more upwelling than the North Atlantic and South Atlantic coasts.
    - For more advanced students and/or with more available class time, discuss why the North Pacific coast has more upwelling, going into Ekman transport.
- Optional: End class with this video connecting upwelling, phytoplankton, and the marine food web.

Part 5: Homework

Students will read an article exploring marine productivity and salmon survival. They may either write a short summary of the article or answer the multiple-choice questions below.

Chittenden, C., J. Jensen, D. Ewart, S. Anderson, S. Balfry, E. Downey, A. Eaves, S. Saksida, B. Smith, S. Vincent, D. Welch, and R. McKinley. 2010. Recent salmon declines: A result of lost feeding opportunities due to bad timing? PLOS ONE [online serial] 5(8): e12423. DOI: 10.1371/journal.pone.0012423.

1. Why were hatchery salmon not migrating to the ocean in time for the phytoplankton bloom?
    a. **They are released from the hatchery too late**
    b. They did not grow fast enough in the river system
    c. They have altered olfactory imprinting and take longer to migrate
    d. Low snowpack creates low spring river flows and difficulty out migrating
2. Why are estuaries a risky place for salmon?
    a. **Large number of predators**
    b. Poor water quality
    c. High flows require higher energy expenditure
    d. Smolts cannot tolerate brackish water for long periods
3. What do the results of this study suggest?
    a. **Hatchery salmon should be released a week before the phytoplankton bloom**
    b. Supplementing hatchery salmon with additional feed before release offsets lost feeding opportunities in the ocean
    c. Releasing hatchery salmon after the wild salmon have migrated to the ocean decreases competition and increases survival
    d. It is not possible to improve hatchery salmon marine survival because of the shifting phytoplankton blooms