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Phytoplankton Responses During an Upwelling Cycle

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Summary

PUPCYCLE (**P**hytoplankton response to the **UP**welling **Cycle**) is a research project to measure the physiological responses of phytoplankton to upwelling. Upwelling tends to generate regions of high productivity in the oceans that can fuel phytoplankton blooms. Locating the microscopic phytoplankton that create these blooms can be quite challenging and scientists use a variety of methods, including satellite data and in situ (in place) data to assist them in locating regions with high productivity. This activity allows students to incorporate data visualization skills to explore the data used to identify these highly productive regions. Students will analyze shipboard (including CTD data) and satellite data (e.g., temperature, chlorophyll, nitrates, silicates) collected during the PUPCYCLE II Research Cruise. *[TAGS: phytoplankton; upwelling; primary productivity; real data; PUPCYCLE]*

Key Concepts: Ocean Productivity/Primary Productivity; Ocean Exploration Technology; Remote Sensing/Satellite Data vs. In Situ Data; Ocean Upwelling Cycle; Biogeochemical Cycle

Objectives

Students will:

- Ask questions pertaining to upwelling cycles, biogeochemical cycles, and the responses of phytoplankton to the changing ocean environment.
- Use real scientific data to carry out and investigation into the responses of phytoplankton during an upwelling cycle.
- Use mathematics and computational skills to generate two graphs from the provided data set and illustrate the responses of phytoplankton during an upwelling cycle.
- Analyze and interpret real scientific data to observe phytoplankton responses during an upwelling cycle.
- Obtain, evaluate, and communicate information that describes the responses of phytoplankton during an upwelling cycle.

Materials

- Include any additional resources that educators would need to teach the lesson
    - Background Information (Use the PowerPoint presentation provided to introduce this lesson and to guide students through the lab investigation.)
    - Student Lab Sheet (**Phytoplankton Responses During an Upwelling Cycle**)
    - Data Set (included in the PowerPoint presentation)
    - (Additional Application) Sea Surface Temperature and Chlorophyl Satellite Maps (included in the PowerPoint presentation)

Suggested Procedure

I. Background Information - Use Phytoplankton Responses to Ocean Upwelling PowerPoint presentation (Slides 1 – 7) to introduce to ocean research, the aquatic food web, and ocean upwelling.

a. Slides #1 - 3: PUPCYCLE II Research Vessel and Research Institutions investigating the Responses of Phytoplankton to Upwelling Cycles in the Ocean
b. Slide #4: Aquatic Food Web, including microscopic plankton.
c. Slide #5: Size reference for plankton and other aquatic organisms
d. Slide #6: How upwelling currents form in the ocean
e. Slide #7: A brief overview of the Biogeochemical Cycle used by microbes for survival and reproduction

II. Introduction to the Lab - Use Phytoplankton Responses to Ocean Upwelling PowerPoint presentation (Slides 8 – 12) to introduce students to the lab investigation.

a. Slide #8: Image showing scientists collecting their water samples from the CTD. Each niskin bottle (long cylinder grey tubes) is programmed to collect water at a specific depth, as requested by the scientists. Seawater and microbes from the specified depth are collected inside the tube when a signal to close the bottles is "fired" from a computer on the ship. Once the CTD is retrieved (using cranes and cables) and secured on the ship's deck, the scientists use their containers to siphon the seawater from the niskin bottles.
b. Slides #9 – 10: A scientist demonstrates the lab processes used to filter the seawater samples and collect the microbes onto filters. The filters come in various sizes designed to collect a specific size microbe (see Slide #5 for reference).
c. Slide #11: A scientist demonstrates the lab processes used to filter the seawater samples and collect chlorophyl data.
d. The seawater and microbe data received further analysis when researchers left the ship and returned to the university. The final analyses of these samples provided the scientist with the data shown in the data table.

III. LAB: Phytoplankton Responses During an Upwelling Cycle: Distribute the lab sheet (Student version attached at the end of the lesson. Teacher KEY available upon request.)

a. Facilitate a class discussion using satellite images to observe primary productivity on Earth throughout various seasons. (See link to "Primary Productivity in Earth's Oceans".)
b. Provide students time to construct their hypothesis based on the question posed on the lab sheet.
c. Use Slides #13 and #14 to introduce students to the data (Slide #13) and to assist students in generating the 2 graphs (Slide #14) needed for the data analysis.
d. Slides #15 and #16 illustrate the Nutrient and Chlorophyl graphs completed.
e. Use Slide #17 to assist students in analyzing the graphs and constructing a summary of the findings and conclusions.

IV. Additional Application of Knowledge – This section allows students to identify Stations 1, 2, and 3 on the Satellite maps used to assist the researchers in locating the ocean upwelling cycle.

a. Distribute the Satellite maps for each Station (Slide #19 – May 29; Slide #21 – **May 31**; and Slide #23 – **June 01**) and use the Latitude/Longitude data (on the data table, Slide 13) to assist students in plotting each of the following:
    i. Station 1 on the SST/CHLA page dated May 29.
    ii. Stations 1 and 2 on the SST/CHLA page dated May 31.
    iii. Stations 1, 2, and on the SST/CHLA page dated June 01.
b. Facilitate a class discussion on the location of the upwelling cycle observed by the scientists and the direction in which the upwelling current was moving (e.g., north, south, east, or west).

Additional Resources

Websites, publications, or other resources that would be helpful for teachers or students preparing for this lesson.

- Good description of how satellites detect and measure chlorophyll-a concentration in the ocean (include video clips of CHLA changes in Equatorial and Polar Zones: https://chlorophyll-esrioceans.hub.arcgis.com/pages/ocean-color
- Website for CHLA historical and current maps (animated) showing global changes in CHLA. Also includes Basic, Intermediate, and Advanced Information about Ocean Productivity: https://neo.gsfc.nasa.gov/view.php?datasetId=MY1DMW_CHLORA&date=2020-12-01
- Good video on eutrophication, including N, P, and Si and Diatoms: https://chlorophyll-esrioceans.hub.arcgis.com/pages/eutrophication
- Periodic Table of Ocean Chemistry: https://www.mbari.org/know-your-ocean/periodic-table-of-elements-in-the-ocean/

LAB: Phytoplankton Responses During an Upwelling Cycle *(Student)*

QUESTION: How Does Phytoplankton Respond During an Upwelling Cycle?

HYPOTHESIS: _____

_____

PROCEDURES:

Open the Data Sheet and use the directions (provided in the PowerPoint presentation) to generate graphs illustrating the changes in Nutrient data and Chlorophyl data across the 3 Stations.

DATA COLLECTION: (Copy and paste your data table and graphs below.)

DATA ANALYSIS: Analyze your data set and graphs to respond to the following analyses questions.

1. At what depth are Silicates at their highest concentration?

2. Is there an observable trend in the Silicates data set? If so, describe the observed trend in Silicates across the 3 stations.

3. At what depth are Nitrates at the highest concentration?

4. Is there an observable trend in the Nitrates data set? If so, describe the observed trend in Nitrates across the 3 stations.

5. At what depth did we observe the highest concentration of Chlorophyl A?

6. Is there an observable trend in the Chlorophyl A data set? If so, describe the observed trend in Chlorophyl A across the 3 stations.

7. The phytoplankton's response to upwelling is:
   A. Immediately observed in the data set.
   B. More apparent on Day 2 of the upwelling event.
   C. Identical to the abundance of nutrients available during the upwelling event.

8. At what depths of the ocean does most primary productivity occur? Why?

9. At what depth of the ocean are most of the nutrients found?

10. How does ocean upwelling support primary production?

11. Describe the relationship between primary productivity responses to the upwelling of nutrients in the ocean.

Summary of Findings/Conclusion: Use these key words in the Summary Statement: aquatic food web, biogeochemical cycle, nutrients, photosynthesis, primary productivity, upwelling, and upwelling cycle. Be sure to include data to support your findings.