



Virtual Research Cruise

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Summary

“Virtual Research Cruise” is designed to guide students (middle grades/high school/college) and general audiences through the scientific methods and technologies incorporated during a 2-week investigation focused on microbial oceanography. Students can work independently or in teams to complete the activity as a stand-alone lesson or within a marine science curriculum. Photo-journals, videos, and live feeds will engage students as they explore the relationship between phytoplankton blooms and ocean upwelling cycles. Students will explore physical and biological concepts, aligned with science standards, and observe the collaboration skills needed for researchers to complete investigations at sea. Students will be able to describe the responses of phytoplankton during various phases of coastal ocean upwelling. A certificate of completion is available for download after completion of the activity.

[TAGS: phytoplankton, ocean upwelling, biogeochemical cycle, genomics, & microbiology]

Key Concepts

- Ocean Upwelling Cycles; Global and Coastal Ocean Currents; Biogeochemical Cycles; Phytoplankton Physiology

Objectives

Students will:

- Develop cognitive learning skills to synthesize the scientific concepts explored during the 2-week cruise including the relationship between:
 - Ocean dynamics and ocean upwelling; and
 - Ocean upwelling cycles and phytoplankton blooms
- Analyze and interpret graphics to identify:
 - Remote sensing technologies used to locate upwelling zones;
 - Various parameters that impact ocean upwelling and the importance of upwelling to the aquatic food web;
 - Various sizes of microbes that support aquatic food webs; and
 - Nutritional requirements for single-celled organisms.
- Engage in discussions compare and contrast the different ecosystems explored in the video log.
- Obtain, evaluate, and communicate information to describe the physiological process carried out in microscopic trophic levels and analyze how changes in their aquatic ecosystem drive changes in the aquatic food web.
- Experience life at sea and describe the need for collaboration in a limited and challenging environment.
- Define challenges of and protocols for conducting scientific research on microscopic organisms while at sea.

Materials

- The following materials are used in this activity:
 - Background Information on R/V Oceanus: <https://ceoas.oregonstate.edu/oceanus/>
 - YouTube video tour of R/V Oceanus: <https://ceoas.oregonstate.edu/ships/rcrv/>
 - PUPCYCLE¹ Photo-journal (available online at [Science by the Sea](#)[®] and as pdf files, listed below):
 - [Days 1 - 8](#);
 - [Days 9 - 14](#)
 - [PUPCYCLE Video Log](#)
 - [PUPCYCLE Challenge Question Table](#): (OPTION: Use the PUPCYCLE Challenge Question document to assess the learning levels of your students to determine if additional support may be needed to facilitate their understanding of new terms or concepts presented in the activity.)
 - PUPCYCLE Certificate Answer Key (Available upon request [HERE](#))
- ¹PUPCYCLE is an acronym used throughout the 2-week cruise and stands for *Phytoplankton response to the UPwelling conveyor belt CYCLE*

Procedure

1. **Investigation Overview** – Students will follow the 2-week expedition using the PUPCYCLE Photo-journal: [Days 1-8](#) and [Days 9-14](#) and the PUPCYCLE [Video Log](#) to explore the scientific methods, technologies, and concepts related to the responses of phytoplankton to ocean upwelling. Days 1-8 focus on the procedures and processes followed for data collection and introduce many of the scientific concepts explored by the scientists. Days 9-14 explore the scientific concepts in more depth and may be challenging for some learning levels. Students will also complete the Challenge Questions using the [PUPCYCLE Certification Google Form](#). The Google Form questions are published in multiple-choice format and students must accurately complete each question in succession before the form will move forward to the next question. After completing the PUPCYCLE Certificate, students will be directed to print a certificate verifying their successful completion. Providing students with the [PUPCYCLE Challenge Questions](#) in document form will assist them in note taking during the activity. This document may also be referenced when students complete the PUPCYCLE Certificate Google Form.

(The outline provided for this activity is not intended as a timeline. Pacing for the activity should be adjusted based on individual student learning levels and time constraints for the activity. The Video Log includes the length of each video to assist in planning.)

2. Introduction

- a. Introduce the activity with the YouTube video tour of R/V Oceanus: <https://ceoas.oregonstate.edu/ships/rcrv/>. This will provide students an overview of the layout of the ship and assist them as they view photos and videos within the activity.

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2



- b. Locating the **Hatfield Marine Science Center** at Oregon State University in Newport, Oregon is also suggested to orient students to the global location of the research vessel and the Pacific Northwest coast of the United States:
<https://hmsc.oregonstate.edu/>.
- c. Use **Video #14: Live Feed Friday from Newport, Oregon – West Coast Intertidal** to demonstrate how student will access the videos in the PUPCYCLE Video Log during the activity. Encourage students to compare and contrast the topography and ecology of this region of the country to ecosystems where they live. (Webcams are also available on the site, though time zone and weather differences may affect visibility: <http://webcam.oregonstate.edu/hmsc>.)
- d. A general understanding of coast upwelling processes, phytoplankton, and biogeochemical cycles will also assist students in the successful completion of the activity. (Each of these concepts will be explored through the activity.)

3. Virtual Research Cruise: Days 1 – 7 Aboard the R/V Oceanus

- a. View **Video #1: Live from the R/V Oceanus!** for a glimpse into life onboard a research vessel before heading out to sea.
- b. Read **PUPCYCLE Log Day 1: Heading to the California Upwelling Zone - CUZ that's where the plankton are!**. Explore the location of the research cruise and the parameters affecting the ocean currents in this region. Answer the Challenge Question based on the information and images provided in the log.
- c. View **Video #2: Live Feed Friday from Newport, Oregon. Bon voyage, Y'all!** Observe some of the challenges researchers might face during the 2-week expedition at sea.
- d. (Optional) View **Video #4: Live Feed from the R/V Oceanus – Bringing another scientist onboard**. This video provides a 2nd look at Yaquina Bay, Newport, OR as the R/V Oceanus returns to port and boards another scientist for the expedition.
- e. Read **PUPCYCLE Log Day 2: Phytoplankton Chillin' with the UBCB** to learn more about the Upwelling Conveyor Belt Cycle (UCBC) and the equipment being used on the ship. Answer the Challenge Question based on the information and images provided in the log.
- f. View **Video #3: PUPCYCLE 2019 1st CTD cast/retrieval for samples; Video #5: Live Feed from the R/V Oceanus; Video #6: Live Feed (Round 2: CTD Retrieval) from the R/V Oceanus and Video #7: Live Feed from the R/V Oceanus (Round 3: Sample collection from the CTD)**. Observe the procedures and safety precautions followed by the researchers to collect their study samples.
- g. Read **PUPCYCLE Log Day 3: The Phytoplankton Players** to explore the various types of phytoplankton being investigated during the cruise. Answer the Challenge Question based on the information and images provided in the log.
- h. View **Video #8: Live Feed from the R/V Oceanus (Round 4: Sample collection from the GoFlo)** to observe another method used to collect water samples.
- i. Read **PUPCYCLE Log Day 4: Express Yourself, Bacteria; PUPCYCLE Log Day 5: Insights into PUPCYCLE 2019; and PUPCYCLE Log Day 6: On the**



Cutting Edge of Metabolomics. Explore and discuss the various topics being researched by each of the scientists highlighted in the logs. Answer the Challenge Questions for each day's log based on the information and images provided.

- j. View **Video #11: PUPCYCLE 2019 Live Feed Update: What happens to the water once it reaches the lab?** Observe the pathways the water samples follow from the CTD to the various labs set up on the ship by the different research teams.
 - k. Read **PUPCYCLE Log Day 7: The Bubble Lab** to discover how scientists “inside the bubble” address the unique challenges presented by their research topic. Answer the Challenge Question based on the information and images provided in the log.
4. **Virtual Research Cruise: Days 8 Aboard the R/V Oceanus (Progress Assessment)**
- a. Read **PUPCYCLE Log Day 8: Halftime at PUPCYCLE 2019**. Review the knowledge you have gained and assessed your progress by completing the Halftime Assessment posted in the log.
 - b. View **Video #9: PUPCYCLE Log Update – Cellular service returns to the R/V Oceanus**. Observe and discuss some of the lifestyle challenges that face scientists who research at sea.
5. **Virtual Research Cruise: Days 9 - 14 Aboard the R/V Oceanus**
- a. View **Video #10: R/V Oceanus takes on the heavy seas near Cape Mendocino, CA**. Observe and discuss some of the environmental challenges that face scientists who research at sea.
 - b. Read **PUPCYCLE Log Day 9: Micrometers, Nanometers, Picometers, Oh My** to gain a better perspective on the size of the organisms being investigated by the scientists. Answer the Challenge Question based on the information and images provided in the log.
 - c. Read **PUPCYCLE Log Day 10: Game of Iron**. Explore the relationship between iron (Fe) and diatoms. Answer the Challenge Question based on the information and images provided in the log.
 - d. Read **PUPCYCLE Log Day 11: Heavy Seas, Anyone?** Observe the technology used to photograph microscopic plankton. Answer the Challenge Question based on the information and images provided in the log.
 - e. View **Video #12: This is the visible “line” in the ocean where today’s active upwelling was occurring** to observe the changes formed on the ocean’s surface by an active upwelling zone. Compare and contrast the ocean’s surface in this video with the ocean action displayed in Video #10.
 - f. Read **PUPCYCLE Log Day 12: Building Glass Houses** and explore how researchers are using the diatoms’ physiology to track their reproductive cycles under various environmental conditions. Answer the Challenge Question based on the information and images provided in the log.

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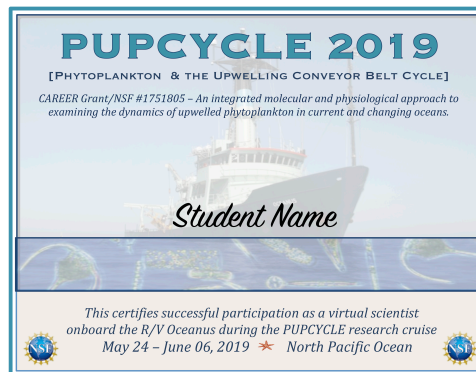
- g. Read **PUPCYCLE Log Day 13: *Going with the Flow*** and review the importance of upwelling to the phytoplankton and the aquatic food web. Answer the Challenge Question based on the information and images provided in the log.
 - h. Read **PUPCYCLE Log Day 14: *PUPCYCLE 2019 Returns to Port*** and discuss the various skills and collaborative efforts required to conduct scientific research at sea.
6. **PUPCYCLE Certification** - Follow the link to the [PUPCYCLE Certification Google Form](#) and complete the form to receive your certificate.

Assessment

- **Formative assessments**—The Halftime Assessment on Day 8 can be used to monitor student progress and understanding of the key concepts presented in Days 1 – 8 of the expedition. Conduct a class discussion to address misconceptions and concerns that may affect student success before they continue with the completion of the activity.
- **Summative assessments**—The PUPCYCLE 2019 Certificate may be used to assess student success in achieving the desired learning outcomes for the activity.

PUPCYCLE 2019 Certificate (SAMPLE): The directions for printing the certificate are provided at the end of the Activity Assessment as noted here:

YOUR OFFICIAL PUPCYCLE 2019 CERTIFICATE IS SHOWN BELOW. Thanks for participating in the research cruise. [Capture the certificate image shown below to print your certificate prior to leaving this page.]



(Sample Certificate Shown Above)

Additional Resources

- [PUPCYCLE Fact Sheet](#)

VIDEOS:

- Coriolis Effect: <https://youtu.be/mPsLanVS1Q8> (3 minutes): Demonstrates Coriolis Effect with people tossing a ball on a merry-go-round. [*Coriolis Effect*. National Geographic. April 14, 2014. <https://www.youtube.com/watch?v=mPsLanVS1Q8>.]

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- Upwelling and Nutrients: https://youtu.be/60_y6-CiUMA (1-minute+ video) [*Caught on Camera: Upwelling Off the Oregon Coast*. Oregon Division of Fisheries and Wildlife. Oregon Marine Reserves. June 08, 2016. https://youtu.be/60_y6-CiUMA]

WEBSITE RESOURCES:

- Coriolis Effect: <https://scijinks.gov/coriolis/> (Historical and Description Information) [*What is the Coriolis Effect? SciJinks: It's All About Weather*. NOAA. Jet Propulsion Laboratory, Pasadena, CA. May 08, 2019. <https://scijinks.gov/coriolis/>.]
- *Ocean Currents: Types of Upwelling*. Science Education through Earth Observation for High Schools (SEOS). European Association of Remote Sensing Laboratories (EARSeL). 2019. https://www.ssec.wisc.edu/sose/cu_activity.html
- Marine Snow: <https://www.whoi.edu/oceanus/feature/marine-snow-and-fecal-pellets/?id=2387&archives=true&sortBy=printed> [Honjo, Susumu. *Marine Snow and Fecal Pellets: The Spring Rain and Food to the Abyss*. Oceanus US Magazine. Woods Hole Oceanographic Institution. Woods Hole, MA. December 1, 1997.]
- J-SCOPE Animation of SST off Pacific Northwest: <http://www.nanoos.org/products/j-scope/forecasts.php> (4 Animations: Bottom O₂, Chl-a, SST, and Bottom pH)
- Upwelling graphic and info: <https://oceanexplorer.noaa.gov/facts/upwelling.html>
- Archived info on seasonal and climatic/El Nino phytoplankton responses : <https://earthobservatory.nasa.gov/features/Phytoplankton/page4.php>
- Wind Drive Surface Currents: Upwelling & Downwelling Background: <http://oceanmotion.org/html/background/upwelling-and-downwelling.htm>
- Upwelling: <https://oceanexplorer.noaa.gov/explorations/02quest/background/upwelling/upwelling.html> (Dr. Steve Gaines, UC-Santa Barbara; Dr. Satie Airame, Channel Island NMS; Graphics and Info specific to California Current)
- Article: Nutrient supply, surface currents, and plankton dynamics predict zooplankton hotspots in coastal upwelling systems: <https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1002/2017GL074322>
- Article: *Upwelling and the California Current*: <http://oceantracks.org/library/the-north-pacific-ocean/upwelling-and-the-california-current>

Extensions or adaptations

- This activity is designed to allow access using Internet technology or as downloadable files. The activity can be completed independently, in small teams, or as whole group discussion.
- *Diatom Adventures*[®] is a board game activity that can be used with introductory or review material for microbiology, ecosystems, or nutrition standards. Students complete the board game in teams of four as they discover the nutritional requirements needed by microbes (e.g. diatoms) for survival and reproduction. Trophic levels are also explored, in addition to predator/prey relationships occurring within the aquatic food web.

