Office of National Marine Sanctuaries
National Oceanic and Atmospheric Administration
in collaboration with Oikonos Ecosystem Knowledge

Education

WINGED AMBASSADORS
OCEAN LITERACY THROUGH THE EYES OF ALBATROSS

Lesson 3: Protecting Ocean Hotspots

Grade Level

- 6-8, with options for 9-12.

Timeframe

- Three 45-minute class periods

Materials

- Student worksheets
- Albatross and bathymetry maps
- Lesson 3 Presentation
- Use of Google Maps (optional)

Key Words

- Bathymetry
- Photosynthesis
- Upwelling
- Decomposition
- Albatross Hotspots
- Marine Protected Area

Activity Summary

Just as on land, the ocean's floor has many diverse features, including mountains, hills, canyons, and plains. The prevailing wind patterns and the underlying seafloor features influence horizontal and vertical water movements, which in turn affect ocean productivity (how much organic matter is created by primary producers through photosynthesis). In this lesson, students will review common bathymetric features in the ocean and will examine the movements of albatross with respect to water depth and seafloor contours.

Learning Objectives

Students will be able to:

- Identify common seafloor features.
- Interpret contour maps.
- Analyze albatross movements in relation to seafloor features.
- Explain the concept of a hotspot of animal activity.
- Discuss protections for North Pacific Ocean hotspots.

Outline

Engage – Imagining the Seafloor
Explore – Identifying Seafloor Features
Explain – Upwelling and Phytoplankton
Elaborate – National Marine Sanctuaries
Evaluate – Seafloor Features and Upwelling

Background Information

The ocean floor is home to earth's highest mountains, widest plains, and other diverse features. Along the edge of the continents is a flat shallow area known as the continental shelf. Hills on the continental shelf are known as banks. The shelf "breaks" at a steep decline known as the continental slope, which extends down to the seafloor, also known as the abyssal plain. Mid-ocean ridges are underwater mountain ranges where tectonic plates are diverging. At trenches, the plates are converging, creating the deepest areas of the ocean. Volcanic activity on the seafloor results in the formation of seamounts (underwater mountains) and islands, (reaching above the ocean's surface). The study of depth and seafloor features is known as **bathymetry**.

Much of the ocean is essentially a desert; the abundance of living things is very sparse. Ocean productivity is limited by light and nutrient availability, and sunlight can only reach the top 250 meters of the water column. The ocean's major primary producers are photosynthesizing microbes known as **phytoplankton**.

Phytoplankton have short life cycles and reproduce quickly when enough nutrients, such as nitrate and iron, are available. Nutrients are made available to ecosystems by the work of decomposers. In the ocean, however, living organisms sink when they die, and decompose at great depths (over 250 m). Therefore, these precious nutrients are not always available near the surface.

Ocean water is constantly in motion, due to the action of tides and currents. The water circulates among ocean basins and its movement is influenced by wind patterns and bathymetry. For instance, when steady winds moves surface water away from the coast, it is replaced by water from down below that is cold and nutrient-rich, a process known as **upwelling**. Upwelling also occurs along abrupt bathymetric features, such as continental shelves and slopes and at seamounts, which interrupt and redirect the flow towards the surface and cause mixing. Areas of upwelling fuel phytoplankton growth, providing more energy to the ecosystem. Therefore, upwelling zones tend to be incredibly productive, supporting rich food webs. Albatross, for instance, are known to travel thousands of miles to feed in productive upwelling areas along the coast of Alaska and California.

If you have not completed Lessons 1 & 2, consider reviewing some of the background information on seabirds and their movements with your students.

Vocabulary

BATHYMETRY – the study of ocean depth and underwater topography

SEAMOUNT – a mountain on the seafloor

BANK – undersea hill on the continental shelf

CONTINENTAL SHELF – shallow area found on the edges of continents

CONTINENTAL SLOPE – steep land area between the shallow continental shelf and the deep abyssal plain

SEAFLOOR – the ocean floor

ATOLL – a ring-shaped area of coral around an island or seamount

HOTSPOT – an area where organisms are observed very often

UPWELLING – the movement of nutrient-rich water from depth to the surface

PRODUCTIVITY – the amount of organic matter produced by primary produces using nutrients and light

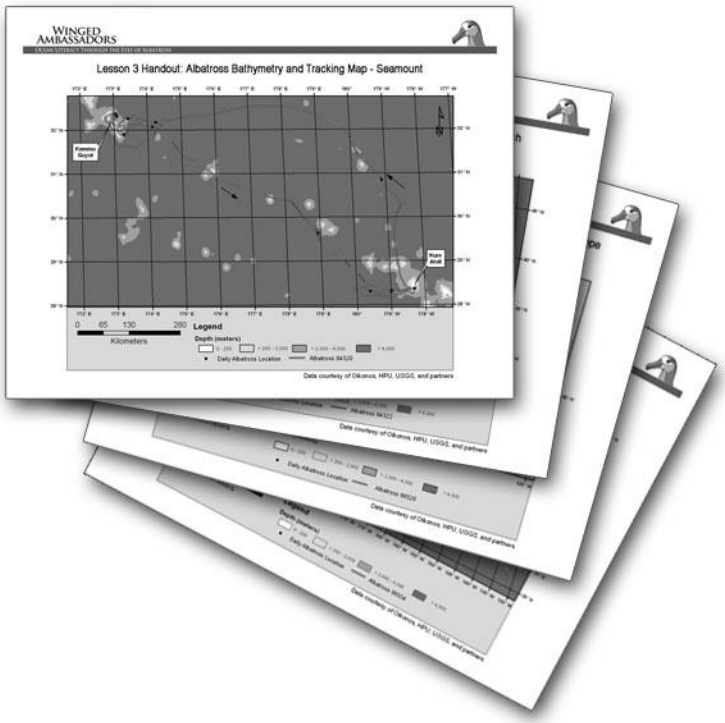
PHYTOPLANKTON – photosynthesizing microbes

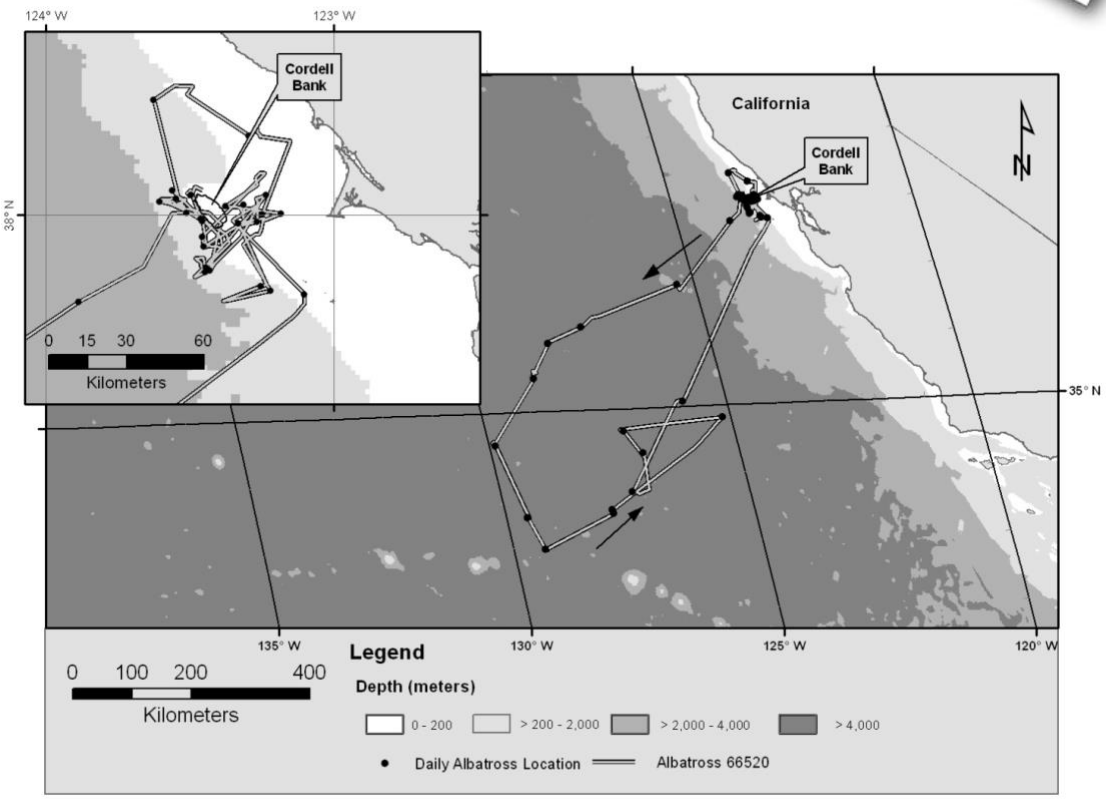
DECOMPOSITION – the breakdown of dead organisms into simpler elements by the action of bacteria

Preparation

Make a copy of the handouts “Albatross Bathymetry Tracking Maps” for each pair of students. There are four bathymetric maps highlighting a seamount, Japan trench, Alaska shelf/slope, and California shelf/slope. Divide these maps evenly among groups of students. (See example below.)

Lesson 2 is highly recommended if mapping or wildlife satellite tracking are unfamiliar topics.





Data courtesy of Oikonos, HPU, USGS, and partners

Example:

Learning Procedure

Engage

Direct students to answer Question 1 on their student worksheet.

Have several students share their ideas with the class. Be aware that it is a common misconception that the seafloor is flat. Do not correct student ideas at this time.

Explore

(65 minutes)

Show slides of the Pacific Ocean and other ocean basins provided in the presentation. Alternatively, use Google Maps (www.maps.google.com), click on "satellite" view in the upper right, and then scroll so that the map is centered on the Pacific Ocean or other ocean basin of interest. Explain to students that they are looking at the seafloor, which is covered by up to 6 miles of water.

As you show students the images, point out specific places, (e.g., Alaska, Baja California, Hawai'i), to help students orient themselves.

Give students a few minutes to observe the seafloor and to record their observations in Question 2 of the Student Worksheet.

Have students share their ideas. If using Google Maps, zoom in on specific features to observe them more closely. In addition, the presentation shows zoomed-in images of several features, including the Hawaiian Islands and associated seamounts, the continental shelf off of California and Alaska, etc.

Discuss some of these features with students.

? Describe the features that you see. Do any of them look like features you see on land?
The seafloor is not flat. There are mountains, hills, valleys, and plains, very similar to features that we see on land.

? What does the majority of the seafloor looks like?
Much of the seafloor is flat, but there are lots of bumps.

As a class, read the short paragraph on the student worksheet.

Moving forward in the presentation, show students the labeled pictures of different seafloor features. Remind students that the depths given are the vertical distances *from the ocean surface.*

a) **seamount** – volcanic mountains rising over 1,000 m above the deep seafloor, but under the waves
b) **bank** – an undersea hill on the continental shelf
c) **continental shelf** – shallow areas on the edges of continents (0 – 200 m deep)
d) **continental slope** – steep "drop off" between the continental shelf and the abyssal plain (200 – 2,000 m deep)
e) **seafloor/abyssal plain** – the flat base of the ocean basin (2,000 m and deeper)

Extension

Students should draw a sketch and write a description of each seafloor feature in Question 3 on their worksheet.

Discuss:

? Identify local or well known land features for scale – what hill or mountain nearby is 200 m or 1000 m high?

? What do you think seafloor features have to do with albatross movements?
Accept all answers at this point. Many students will likely believe that since albatross are seabirds that fly above the water, that bathymetry will not affect them.

Divide students into pairs or groups of three. Provide each pair with one of the photocopied albatross tracking maps.

They should follow instructions on the student worksheet in order to analyze albatross movements with respect to bathymetry.

Assist students in identifying areas of shallow and deep water on the shaded contour maps, and making calculations, as directed on the student worksheet.

Differentiation: To reduce the difficulty, do the calculations as a class.

Explain

(25 minutes)

Ask groups to share their findings, as well as their hypotheses as to why the animals might spend more time in certain areas.

Share some of the albatross **hotspots** as a class. Use the slides of the maps and invite students to come to the board to point to areas that they found.

Read the Ocean Productivity and Food passage as a class and discuss it as you go. If you have not completed Lesson 1, provide students with some background information on albatross.

Differentiation: Have students illustrate each paragraph to build understanding of the content.

Discuss:

? How would you describe upwelling in your own words?
The vertical movement of water from depth to more shallow depths. The deep water contains lots of nutrients. Upwelling makes these nutrients available to primary producers living in the sunlit waters close to the ocean surface.

? Why is upwelling important?
Upwelling makes nutrients available to primary producers, which use sunlight to produce the organic matter that supports the entire ecosystem.

? Why do phytoplankton matter to albatross, which do not eat them directly?
Phytoplankton (primary producers) produce organic matter via photosynthesis, which is eaten by zooplankton (grazers). These organisms are then eaten by other predators (fish, whales, birds). This way, the energy contained in the organic matter is passed on and used through the food web. Thus, albatross eat the squid that ate the zooplankton that ate the phytoplankton.

Direct students to answer the questions with a partner. Then, review the answers as a class, referring back to the hotspots identified near seamounts and / or continental slopes.

Elaborate (20 minutes)

Show the slide that highlights some of the U.S. National Marine Sanctuaries and Monuments in the Pacific Ocean basin.

Discuss what students are seeing:

? How do the areas of protection compare to the size of the whole ocean?
Very little of the ocean is protected area.

? Which NMS is closest to us?
Answers will vary.

? Why might oceanic areas need protection?
Many human activities can have negative impacts on marine life.

? What are some human activities that could affect seabirds?
Accept all answers at this time. They may include fishing, pollution, egg poaching, etc.

Direct students to read the passages "Protecting Ocean Habitats" and "National Marine Sanctuaries near the West Coast" on the student worksheet, and to complete the data table and answer the questions that follow. Assign each student or small group 1-2 NMS and then to share their findings with other groups.

> **Differentiation:** To reduce difficulty, read the passages aloud as a class. Have advanced students read the entire passage and complete the data table.

Review the questions as a class. Invite groups to share their suggested areas for creation of national marine sanctuaries with the class. If applicable, explain that students will learn more about threats to albatross in future lessons.

Because many people use and rely on our ocean, *kai*, for many reasons, conflicts may arise amongst different users accessing the same resources.

Be sure that students understand the competing priorities of different users and interest groups. For instance, oil and gas companies would likely oppose the creation of a marine protected area in a location where they planned to drill. Fishers would oppose a no-fishing marine protected area in a productive fishing ground. On the other hand, conservationists would support their creation.

Evaluate (Homework)

Direct students to complete the Evaluate section of the student worksheet.

Extension

View NOAA's video lesson about seamounts.

https://oceanexplorer.noaa.gov/edu/themes/seamounts/welcome.html

Resources

- Animation of growing phytoplankton: https://oceanservice.noaa.gov/education/kits/estuaries/media/supp_estuar10h_clorophyll.html
- Online land and ocean topography zoom tool: http://www.oceanmotion.org/html/resources/etopo.htm
- Learn to pronounce Papahānaumokuākea: http://www.papahanaumokuakea.gov/about/name.html

Credits and More Information

This lesson was developed for NOAA's Cordell Bank National Marine Sanctuary and Papahānaumokuākea Marine National Monument, by Meghan Marrero of Mercy College and Oikonos - Ecosystem Knowledge. This lesson cannot be used for commercial purposes. Permission is hereby granted for the reproduction, without alteration, of this lesson for educational use only on the condition its source is acknowledged. When reproducing this lesson, please cite NOAA's Office of National Marine Sanctuaries and Oikonos - Ecosystem Knowledge as the source, and provide the websites below.

Data integrated into these lessons were provided courtesy of Michelle Hester (Oikonos), David Hyrenbach (Hawai'i Pacific University), Josh Adams (USGS), and David Anderson (Wake Forest University). Data from Tern Island, Kure Atoll and Cordell Bank were obtained in partnership with USFWS, State of Hawaii, and Cordell Bank NMS.

Special contributions of paintings and photography donated by Sophie Webb and high resolution images of albatross bolus contents donated by David Liittschwager.

Content created and reviewed by Meghan Marrero, David Hyrenbach, Michelle Hester, Carol Keiper, Jennifer Stock, and Andy Collins. Tracking and bathymetry maps were created by Pam Michael (Oikonos).

Graphics and design by NOAA, Tara Alvarez, and Greg Hester. We thank the many people who donated photographs, illustrations and video.

Some content was adapted from Oikonos' Albatross and Plastic Pollution Activities for the California Coastal Commission Science Activity Guide: Waves, Wetlands, and Watersheds.

Please contact Oikonos or NOAA to request further use of any images, art, videos, data or text included in the Winged Ambassadors activities.

We appreciate feedback, corrections and questions. Please email WingedAmbassadors@oikonos.org

Lessons and resources available at:

http://cordellbank.noaa/gov/education/teachers.html

http://papahanaumokuakea.gov/education/wa.html

http://oikonos.org/education

Education Standards

National Education Standards	NSES Grades 6-8: • Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models. • Technology used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations. • Populations of organisms can be categorized by the function they serve in an ecosystem. Plants and some microorganisms are producers—they make their own food. All animals, including humans, are consumers, which obtain food by eating other organisms. Decomposers, primarily bacteria and fungi, are consumers that use waste materials and dead organisms for food. Food webs identify the relationships among producers, consumers, and decomposers in an ecosystem. • For ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis. That energy then passes from organism to organism in food webs. • The number of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition. Given adequate biotic and abiotic resources and no disease or predators, populations (including humans) increase at rapid rates. Lack of resources and other factors, such as predation and climate, limit the growth of populations in specific niches in the ecosystem. • Water, which covers the majority of the earth's surface, circulates through the crust, oceans, and atmosphere in what is known as the "water cycle." Water evaporates from the earth's surface, rises and cools as it moves to higher elevations, condenses as rain or snow, and falls to the surface where it collects in lakes, oceans, soil, and in rocks underground.
Ocean Literacy Principles	• 1a. The ocean is the dominant physical feature on our planet Earth—covering approximately 70% of the planet's surface. There is one ocean with many ocean basins, such as the North Pacific, South Pacific, North Atlantic, South Atlantic, Indian and Arctic. • 1b. An ocean basin's size, shape and features (such as islands, trenches, mid-ocean ridges, rift valleys) vary due to the movement of Earth' lithospheric plates. Earth's highest peaks, deepest valleys and flattest vast plains are all in the ocean. • 1c. Throughout the ocean there is one interconnected circulation system powered by wind, tides, the force of the Earth's rotation (Coriolis Effect), the Sun, and water density differences. The shape of ocean basins and adjacent land masses influence the path of circulation. • 5b. Most life in the ocean exists as microbes. Microbes are the most important primary producers in the ocean. Not only are they the most abundant life form in the ocean, they have extremely fast growth rates and life cycles. • 5e. The ocean is three-dimensional, offering vast living space and diverse habitats from the surface through the water column to the seafloor. Most of the living space on earth is in the ocean. • 5f. Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate and circulation, ocean life is not evenly distributed temporally or spatially, i.e., it is "patchy". Some regions of the ocean support more diverse and abundant life than anywhere on Earth, while much of the ocean is considered a desert. • 6e. Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (such as point source, non-point source, and noise pollution) and physical modifications (such as changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean. • 6g. Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.
California	Grade 6: • 4c. Students know the sun is the major source of energy for phenomena on Earth's surface; it powers winds, ocean currents, and the water cycle. • 5a. Students know energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis and then from organism to organism through food webs. • 5c. Students know matter is transferred over time from one organism to others in the food web and between organisms and the physical environment. • 7b. Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data. Grade 7: • 7a. Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.

Education Standards (continued)

Hawai'i	Grades 6-8: 1. Collect, organize, analyze and display data/ information, using tools, equipment, and techniques that will help in data collection, analysis, and interpretation. • Develop conclusions and explanations showing the relationship between evidence and results drawn. • Communicate and defend scientific procedure used and conclusion and explanation drawn from evidence. • Give examples where scientists used mathematics and technology to gather, quantify, and analyze results of an investigation. 2. Give an example of the interdependence of science, technology, and society and how it changed the course of history. • Describe and exemplify how information and communication technologies affect research and work done in the field of science. 3. Explain how methods for obtaining and using resources such as water, minerals, and fossil fuel have consequences on the environment. 5. Illustrate and explain the relationships among producers, consumers, and decomposers in a food web. 6. Explain how plants use the energy from sunlight and matter from the atmosphere to make food that can be used for fuel or building materials. 7. Relate how changes in the environment can affect the survival of individual organisms and entire species.