Unit 3

Oceans

Background

Introduction

The increase in world population and the continued rise of industrialization have resulted in a need to further understand the world's oceans. One of the most important factors that impact the biosphere is the condition of the world's oceans. A basic understanding of the structure and composition of the ocean and knowledge of how life in the ocean affects life on land can increase the extent to which we are able to protect this important natural resource and the life that depends on it.

Essential Questions

What have we learned about the oceans over the course of Earth's history?

How does today's increased population and industrial use impact the oceans?

What does the future hold in terms of ocean quality, use, and preservation?

Content

Unit 3 seeks to create a general understanding of the world's oceans. In the past, the exploration of the oceans has been limited due to their size and depth, and so there is still much to be learned. The unit begins with the basic structure and composition of the ocean and discusses the basic principles of oceanic pressure and temperature. Oceans content relates to Unit 8, "Water Resources," and Unit 9, "Biodiversity Decline," leading to a contextual understanding of preserving this important natural resource. In the video for Unit 3, you will be introduced to Mark Cane and Steve Ziebiac, who have developed a model that attempts to predict the occurrence of El Niño. By making the model public, they have enabled people to prepare for this event, saving many lives. The second part of the video discusses the ocean system "biological pump," where nutrients from the upper layers of the ocean are forced downward to nourish the life below. Penny Chisholm, professor at MIT, explains the essential role of phytoplankton in maintaining life on Earth. The recent discovery of a species of phytoplankton, Prochlorococcus, which is the most efficient light-absorber of all phytoplankton, has enabled scientists to understand nutrient sources in the ocean to a much greater extent.

Background

Learning Goals

During this session, you will have an opportunity to build understandings of the following.

a. Knowledge

i. The specific structure and composition of the ocean is based on temperature, salinity, and increasing pressure with depth.

ii. The thermohaline circulation of the ocean has an impact on global weather and climate.

iii. The ocean supports a great diversity of life and ecosystems, all of which are directly or indirectly nourished by plankton.

b. Skills

i. Science is a process that is both descriptive and experimental, and it helps explain current events.

ii. Oceanographic science is an interdisciplinary study because of the complex interactions with other Earth systems.

c. Dispositions

i. Change in the oceans has a direct impact on life in the ocean as well as life on land.

ii. Oceanic research provides new knowledge that improves life and enhances our understanding of oceanic processes.

iii. When studying the ocean, a spatial approach is important because of the dynamic, circulating nature of the ocean.

Key Concepts

Oceanic zones	Ocean currents	Ocean floor characteristics
Forces	Circulation	El Niño southern oscillation (ENSO)
Temperature	Salinity	Climate
Biological pump	Buoyancy	Oceanic ecosystems
Algal blooms	Gyre	Compensation zone
Coriolis force	Ekman spiral	Marine snow
Phytoplankton	Zooplankton	Specific heat capacity
Thermocline	Upwelling	Thermohaline circulation

FACILITATOR: These concepts correspond roughly to the sections of the unit. There are a number of other concepts that could be included. It is best to start with the author's major ideas and then ask for input from the study group for other concepts they would include.

Background

Misconceptions and Oceans

As the public becomes more educated about our natural resources, it is important that educators address common misconceptions that their participants hold about the world's oceans. The root causes of misunderstanding seem to stem from the misinterpretation of terms that are currently used, world maps, and participants' own observations and experiences.

The general understanding is that the ocean surface has no actual relief of its own and therefore is flat. This understanding leaves out changes due to waves, tides, surges, etc. In reality the ocean surface has "hills" as well as "depressions" with a maximum variation of approximately eight feet. This is the direct result of the circular pattern of surface currents, or gyres, that produce areas of water convergence (high areas) and divergence (low areas).

Another misunderstanding that people often have is that tides are caused by the action of the wind. Actually, tides are not caused by the wind, but by the gravitational pull of the moon and sun on the Earth. Quite often, people think that waves are caused by the moon. However, tides are caused by the moon, and breaking waves are caused by the wind and the slope of the shoreline. Other misconceptions include the understanding of currents and the influence of specific currents on land climate and the commonly held beliefs that the ocean depths are devoid of life and that the seafloor is flat and the same age as the continents.

Getting Ready (45 minutes)

Activity One: Assessing Prior Knowledge, Questions, and Related Experiences

FACILITATOR: Distribute index cards to the group. On the first card, ask participants to indicate something they know about oceans. On the second, they should write one question they have about oceans. And on the third card, they should describe a direct experience that they have had that relates to oceans. For example an individual might write:

The different oceans are connected somehow.

What type of life lives in the ocean?

The ocean has a high and low tide.

The oceans influence weather patterns.

Getting Ready

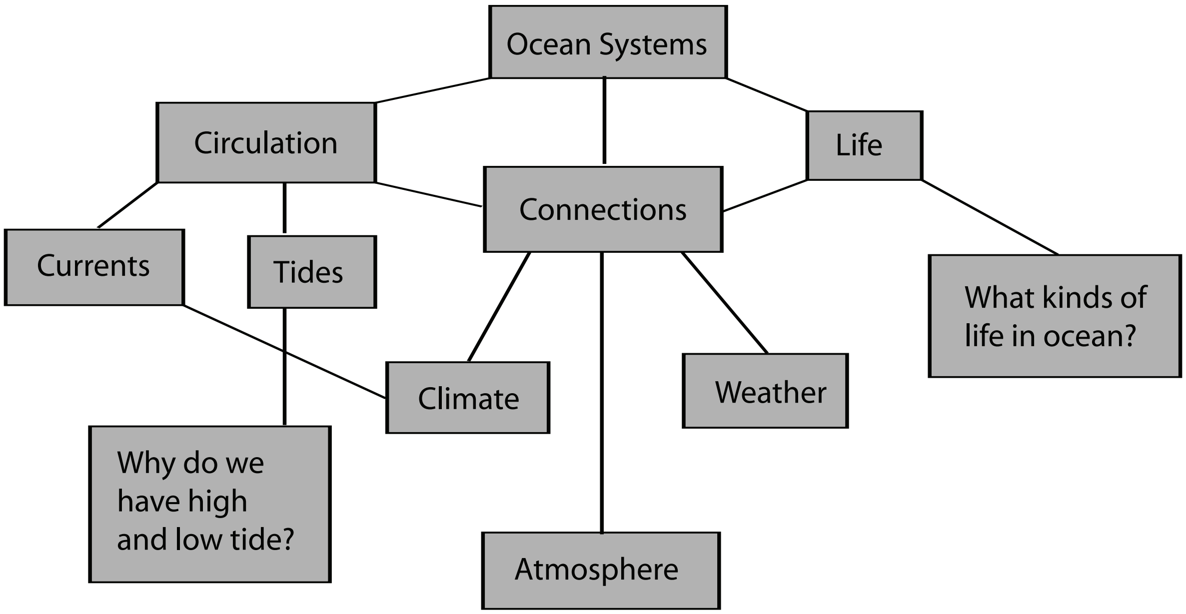

Figure 3.1 An example of a study groups' idea collection, with major subjects identified and the addition of the major focus ideas of the video. This activity links individual pre-existing knowledge with that of other members of the group and the unit content.

Activity Two: Current Events & Editorial Cartoons

Participants will share an article that they have found that relates to the week's topic. All members of the group will share their headlines for the articles. The leader should ask a few people to summarize their articles and ask for comments from others with related articles. As the group discusses the articles, a participant should record key concepts and make a list. (Participants may choose to bring in a cartoon or an editorial related to the week's topic instead of an article.)

Activity Three: Ocean Currents Demonstration

This activity addresses surface circulation and the movement of ocean waves. It is also an introduction to teaching about the Ekman spiral.

Materials

Large, shallow watertight container

Food coloring

Fan

Water

Stopwatch

Getting Ready

Setup

1. Prepare a shallow container with water and place it near a fan.
2. Ask participants to make observations about what will happen when the fan is turned on.
3. Turn the fan on low.
4. Ask participants to make observations and draw pictures about what they think is happening to the water.
5. Participants should then write a hypothesis about what is occurring.

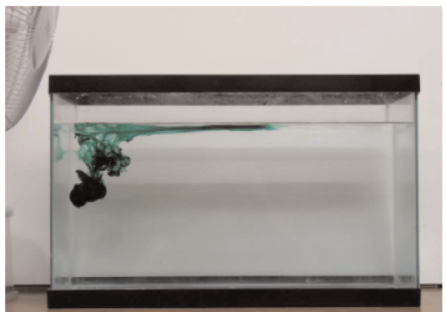

Figure 3.2 Current Demonstration time = 4 seconds

(this figure can be a simple line diagram)

Procedure

Participants will test their hypotheses using food coloring to more easily track the circulation of the water. They should draw a diagram about what is happening after the food coloring is dropped into the water. Repeat this experiment with the fan turned on at progressively faster speeds. (A stopwatch may be useful to time the dispersion of food coloring in the tank.)

Discussion

1. Compare and contrast the various hypotheses formulated by participants.
2. Discuss how ocean surface circulation affects distribution of temperature and associated organisms.
3. How can human activities affect ocean circulation and what are the consequences?

Video (45 minutes)

Activity Four: Watch the Video

As you watch the video, think about the following focus questions.

1. What conditions allowed the crew on board the RV Conrad to realize that an El Niño event was occurring?
2. How do we use the information derived from the retrospective forecast models of Cane and Zebiak to predict and prepare for an El Niño?
3. What role does Prochlorococcus play in the ocean ecosystem?
4. Why did it take so long for marine scientists to realize the presence of and identify Prochlorococcus?
5. What factors appear to regulate the population of Prochlorococcus?
6. What is the relationship between the simplicity of the structure of Prochlorococcus and its ability to survive in a "biological desert"?

Activity Five: Discuss the Video

Discuss the following questions about the video.

1. What are the conditions that allow oceanographers to predict an El Niño event?
2. Discuss the overall ocean-atmosphere interaction during an El Niño event.
3. What is the impact of the complex, co-evolved system in maintaining the balance of carbon dioxide in the oceans?
4. Why do the researchers consider Prochlorococcus a model to apply to systems biology?
5. Discuss the methods that oceanographers use to conduct research. How are these different or similar to other science research?

FACILITATOR: Refer back to the misconception section and Activity One: Assessing Prior Knowledge. Has the video contributed to the participants' new understanding of concepts? Are there any changes the participants would make about the arrangement of their cards from Activity One?

Going Further (60 minutes)

Activity Six: Stratification of a Water Column

This demonstration encourages participants to start thinking about density differences in the ocean and introduces the idea of thermohaline circulation and ocean layer stratification.

Materials

Watertight column (such as settling tubes, clear PVC, or a very large graduated cylinder)

4 small glass vials with screw-lids

Fine sand

Food coloring (optional)

Water

Going Further

Setup

Using three buckets, fill one with cold salty water, the second with cold tap water, and the third with warm tap water. To insure that the cold salty water has a distinct high density, dissolve as much salt as possible into warm/hot water and then cool the solution in a refrigerator over night.

Prepare 4 small vials. Carefully add sand to one vial (marked "1") until it sinks in the cold salt water. Continue with the next vial (marked "2") until it sinks in the cold fresh water and floats in the cold salt water. Fill the next vial (marked "3") until it sinks in the warm fresh water but floats in the cold fresh water. The last vial (marked "4") will need to float in the warm fresh water. Getting the vials to sink and float is a matter of trial and error, adding and removing sand as needed. The lids on these vials must be tight before you use them in the water column to prevent water from entering and changing the density of the vials. One option is to create two of each of the four vials. Each pair will be similar but float at slightly different levels. Two vials at each level will add more complexity to the demo.

After you prepare the vials, transfer the water from the buckets to the large clear cylinder with as little mixing of layers as possible. Tilt the column and slowly add the water for the next layer. Again tilt the column and slowly slide the vials into the water. It is possible to construct a device using a funnel and rubber tubing to easily fill the column and minimize mixing. It is important to construct the water column and add vials quickly. As the water mixes and cools to room temperature, the composition of the column and the location of the layers will change. Since this demonstration takes some skill to construct, be sure to have extra prepared water on hand in case you need it.

Procedure

Participants will observe the water column and diagram the demonstration, take notes, and try to explain what is happening.

Participants will develop a hypothesis to explain what they are seeing.

Participants should consider these questions:

What do you think is in the water column?

What do you think is in the vials?

Why do you think the vials float at different levels?

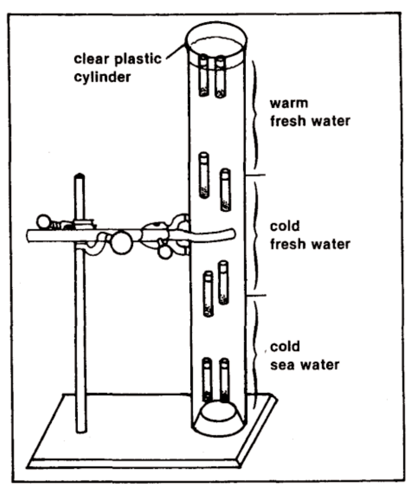

Figure 3.4 Diagram of water column

Going Further

Discussion

What will happen when the water eventually mixes and has the same temperature and salinity throughout?

What does this example imply about oceans, seas, and estuaries? Where is the salinity greater or less in the marine environment? Why?

What does this example imply about freshwater habitats? Where is the temperature greater or less in a large lake or pond? Why? When and how can it change?

In the ocean, what would cause the different temperature or salinity layers to mix? Does this happen naturally? If so, why and when does it happen?

Why are layers based on temperature and salinity a critical part of marine and freshwater systems? How do temperature and salinity gradients affect aquatic and marine life?

How does thermohaline stratification affect the distribution of nutrients?

Extension

Place colored ice cubes in the top of the column and observe. Predict what will happen. Are there equivalent phenomena in nature?

Color each bucket of water with food coloring to make the layers distinct.

Let the water column sit until your next meeting. What will happen to the layers over time? Predict how long it will take for the layers to mix completely.

Activity Seven: Return to Essential Questions

The facilitator should draw the attention of the participants back to the essential questions posed in the Background Section of this unit guide. Discuss how the participants' ideas may have changed in regard to the questions. Discuss the most logical and complete answers to the questions.

Activity Eight: Discuss Supplementary Classroom Activities

If the participants in the study group are teachers, the facilitator should draw the participants' attention to supplementary classroom activities located at the end of this guide. Discuss how teachers would implement these activities in their classrooms and how they would relate them to the topics in this unit.

Between Sessions

Next Week's Topic Overview

In Unit 4, the emphasis is on ecosystems. Sub-topics will each examine a different area of concern, and examples are given. All of the sub-topics are linked to projections of the future, and the uncertainties with predicting the future will be a key part of the discussion.

Read for Next Session

Read the Unit 4 Professional Development Guide background section. Consider the essential questions as you read the text. The misconceptions section will give you some insight into what misunderstandings people may have about ecosystems. Consider discussing the topic with your friends or students and discussing common misconceptions.

Current Events

Bring in a current event article or cartoon related to human impact on ecosystems.

Supplementary Classroom Activity 1

Ocean Currents and Circulation

A Model Area: Gulf of Maine Ocean Observing System (GoMOOS)

In this activity, students will become familiar with the type of on-going research that physical oceanographers are carrying out in the Gulf of Maine. Examples of other monitoring regions are available, such as the Monterey Bay, CA system.

www.GoMOOS.org

www.mbari.org

Go the Gulf of Maine website and search for oceanographic information from the menu in the left column or the thematic sections.

Participants should answer these questions:

1) What is GoMOOS? What is the rationale or purpose of this research effort?
2) Sketch a map of the GoM.
3) Draw in the major surface currents for the GoM.
4) Select an ocean buoy and record the data for that station.
5) What are the current atmospheric conditions?
6) Check out the remote sensing data for SSTs, color, and winds. Record.
7) Read the section About the GoM. Enlarge the maps to see some details of the area.

Supplementary Classroom Activity 2

Biogenic Ooze

This activity explains to participants what happens to phytoplankton after they die. It also informs participants of the many types of zooplankton and phytoplankton.

Materials

Access to the Internet

Setup

The teacher should explain to students that phytoplankton (plants) and zooplankton (animals) are the major food source for life in the ocean. Biogenic ooze on the ocean floor consists of 70 percent inorganic mud and 30 percent skeletal debris of microscopic organisms, such as phytoplankton or zooplankton.

Procedure

Students will conduct research on the Internet to complete the chart below:

	Zooplankton or Phytoplankton?	Made of Calcite or Silica?	Picture
Foraminifera			
Pteropods			
Radiolarians			
Coccoliths			
Diatoms			

Results

Students will present their findings and discuss the role of these organisms.