THE BLUE PLANET
Seas of Life

Until now, we've only touched the surface...

Dear Educator:

The Blue Planet: Seas of Life reveals the seas at their most fearsome and alluring. This series chronicles the mysterious and awe-inspiring creatures of the deep, as well as coastline populations, sea mammals, tidal and climatic influences, and the complete biological system that relies on and revolves around the world's oceans. *The Wall Street Journal* suggests, "If there were a Nobel Prize for wildlife filmmaking, these producers would get it." *Newsday* calls *The Blue Planet: Seas of Life* "a masterpiece...the finest documentary on the world's oceans that any human being has ever seen."

Youth Media International and BBC Video are pleased to provide you with this teacher's guide to *The Blue Planet: Seas of Life*. Narrated by David Attenborough, this ground-breaking documentary took five years to film, cost $10 million, and was filmed in more than 200 locations around the world. The first four episodes were recently broadcast on the Discovery Channel and are currently available on DVD and VHS from BBC Video. Four more episodes will be broadcast on May 5, 2002, and will be available on DVD and VHS beginning May 7, 2002.

The spectrum of life captured in *The Blue Planet: Seas of Life* is extraordinary–from microscopic krill and phytoplankton to the blue whale, the largest animal on the planet. In every ecosystem, behavioral and structural adaptations allow animals to survive, whether in the sun-drenched coral reef or in the cold, hostile deep sea where water around geothermal vents can be as hot as molten lead. This series reveals behaviors, habitats and species never seen before, explores the interplay between life on land and life in the sea, and shows how the moon and the sun influence and control both.

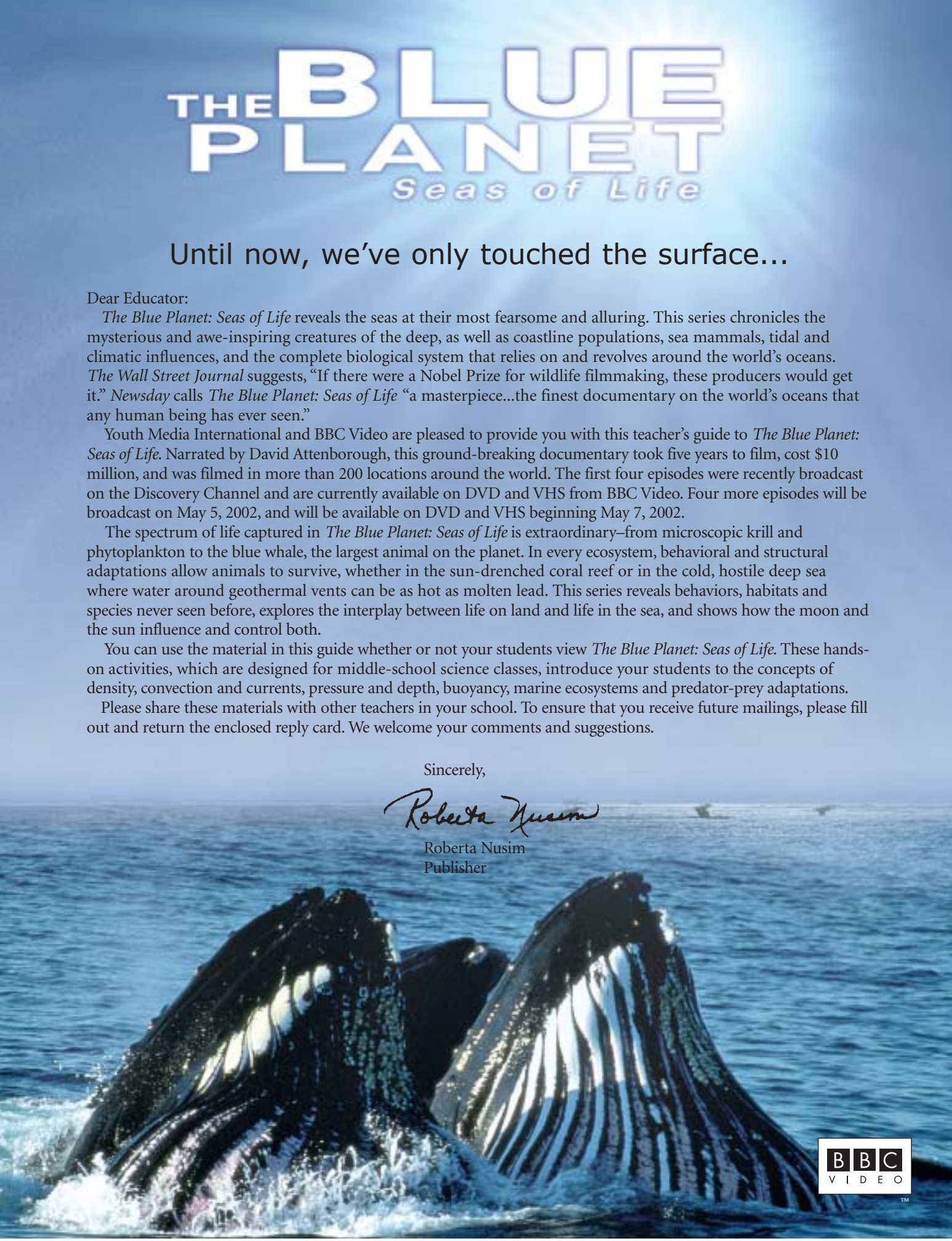
You can use the material in this guide whether or not your students view *The Blue Planet: Seas of Life*. These hands-on activities, which are designed for middle-school science classes, introduce your students to the concepts of density, convection and currents, pressure and depth, buoyancy, marine ecosystems and predator-prey adaptations.

Please share these materials with other teachers in your school. To ensure that you receive future mailings, please fill out and return the enclosed reply card. We welcome your comments and suggestions.

Sincerely,

Roberta Nusim

Roberta Nusim
Publisher



Target Audience

The activities in this program have been designed for middle-school students in grades 6 to 8.

Program Components

1. This teacher's resource guide
2. Three reproducible student activity sheets
3. A teacher response card

Program Objectives

1. To explore relationships between heat, density, convection and ocean circulation
2. To understand how currents impact life in and around the oceans
3. To investigate Archimedes' Principle to see how it applies to submarines and submersibles
4. To understand the relationship between pressure and depth and how pressure limits exploration
5. To identify producers and consumers in various marine ecosystems
6. To construct food chains to see the interdependence of organisms and the flow of energy

How To Use This Guide

- If necessary, modify activities to suit the interests and abilities of your students.
- It is not necessary to see *The Blue Planet: Seas of Life* to complete these activities, but viewing the series will enhance the learning experience.
- If there are not enough materials for all groups to complete an activity at the same time, arrange the materials into a lab station and have groups rotate.
- Each experiment should take one class period. Allow extra time for data analysis.

Overview

Water covers more than two-thirds of our planet, yet we know less about the deep oceans than we do about the surface of the moon. Episode One, **Ocean World**, demonstrates the amazing size, power and complexity of this enormous blue expanse. In Episode Two, **Frozen Seas**, we explore the polar regions and the adaptations that allow animals to survive there. Episode Three, **Open Ocean**, reveals the secrets of the isolated open seas where the nearest island is 500 kilometers away. In Episode Four, **The Deep**, we go on a dangerous and exciting journey of extreme temperatures and pressures to see some of the weirdest life forms on our planet. Life in the oceans is dramatically dependent on the changing sun, as whole ecosystems rise and fall in Episode Five, **Seasonal Seas**. In Episode Six, **Coral Seas**, incredible time-lapse photography unfolds the complexity of life in "the rainforest of the sea". Episode Seven, **Tidal Seas**, explores the power and influence of tides on the ocean's waters and organisms. Episode Eight, **Coasts**, ends the series on the edge of land and sea—where animals are in a constant state of transition and change.

Convection, Currents and Circulation

ACTIVITY ONE

Materials Needed: hot water, cold water, clear rectangular container, large clear container, food coloring, small narrow-necked bottle, plastic sheet, world map

Concepts: temperature, density, convection, heat transfer, expansion, contraction, currents, inferring, predicting, discerning patterns

Part A. Divide the class into groups of at least 3 students each. The ideal container is a clear, rectangular box, but you can use clear salad-bar containers. First, cut a flexible plastic material or a laminated manila folder to make a divider the width of the container. It will hold back the bulk of the water as it is being poured. Use food coloring to make different colors for the hot and cold tap water.

One group member should hold the divider tightly against the bottom and sides of the container. Another person should pour the specified amount of hot water into one compartment at the same time as the third person pours an equal amount of cold water into the other compartment. Tell your students to remove the divider carefully.

Two distinct layers will form—with warm water on top and cold water on the bottom. Students can infer that the warm water is less dense than the cold water. Heating causes the water to expand, thus the same mass of water takes up a slightly larger volume. Cold water contracts and takes up a slightly smaller volume. Expansion decreases density and contraction increases it.

The bottom layer of ocean is called the deep zone and is comprised of very cold, dense water—around 4°C. The temperature of the water warms as you move upward. Many organisms move from one layer to another, as we see in *The Blue Planet: Seas of Life*, but the border between layers can be a barrier to smaller creatures.

Part B. Convective movement sets up a global system of density currents as colder, denser water sinks below warmer, lighter water and moves laterally toward the equator. As cold water moves away from the poles, it warms and rises, creating a circular pattern. These deep, moving ocean currents are climate regulators and global movers of nutrients.

In the open ocean, currents collide with landforms such as islands and seamounts, forcing the waters upward, bringing nutrients and hordes of feeding animals. In *The Blue Planet: Seas of Life*, we see these great concentrations of life around seamounts in the Pacific Ocean.

Seasonal convection occurs when winter temperatures make surface waters colder than the waters beneath them. When the colder surface water sinks and the warmer water rises, the result brings life-giving nutrients that trigger plankton blooms and the feeding frenzy of larger organisms we see in *The Blue Planet: Seas of Life*.

When your students put a bottle of colored, hot water into a large container of cold water, they will discover that the hot water flows out and rises in a plume. When it reaches the top, it spreads over the surface and sinks in delicate patterns as it cools. When they put a bottle of cold water into a container of very warm water, the cold water flows out and sinks to the lowest point, where it can remain for hours.

The container must be large enough for students to insert their hands (2-liter soda bottles with top and bottom collars removed work well). Sample bottles of shampoo, flavoring or pills usually have narrow necks. Use the hottest and coldest tap water tolerable. Make sure students use tap water to avoid getting scalded.

Extended Activity

- The Agulhas Current, the Falklands Current, the Gulf Stream, and the Brazil Current are important in *The Blue Planet: Seas of Life*. Ask students to research this and other ocean currents to find out if they are warm or cold and whether they flow near the surface or deep in the ocean. They can also research where the currents are and which way they flow.

The Pressure is On!

ACTIVITY TWO

Materials Needed: 2-liter soda bottles with lids, glass medicine droppers, water, glass, tape, calculator

Concepts: buoyancy, water pressure, submarines, Archimedes' Principle, displacement, density, conversions

Part A. Place the empty dropper into a glass of water. Squeeze the bulb of the dropper so enough water comes in to allow the dropper to just barely float upright. Now fill the soda bottle completely with water. Place the dropper (with its water inside) into the bottle and screw the cap on tightly, making sure there is very little air inside the bottle.

Archimedes' Principle states that the buoyant force on a body has the same magnitude as

the weight of the fluid displaced by the body. The property of buoyancy is demonstrated by this submarine (dropper) activity. An object will float when it pushes aside an amount of water that weighs more than the weight of the object. Likewise, it will sink when the weight of the object is greater than the weight of the displaced water. When the bottle is squeezed, the water is forced into the dropper bulb and compresses the air in it. As the bubble gets smaller the dropper becomes less buoyant and sinks. Releasing the squeeze on the bottle causes the water to flow out of the bulb, and the dropper rises to the top again.

Submarines work on this same principle. By controlling the amount of water in their ballast tanks, they can rise and sink just like this dropper.

Part B. Make holes in a large, plastic container several inches apart, starting at the top and working downward. Have students place the container over a sink and cover the holes with tape before filling the container with water. When the holes are uncovered, water will squirt a greater distance from the bottom hole, showing that pressure increases with depth.

Part C.

Answers to pressure calculations from Activity Two.

Dive record	feet	atm	psi
ALVIN (3-person submersible)	14,763	399	5,865
Titanic final resting place	12,500	380	5,586
Jason (robotic submarine)	19,685	598	8,791
Sperm whale dive record	3,773	115	1,691
Northern elephant seal dive record	4,921	150	2,205
Mariana Trench dive record	35,802	1,086	15,964

Extended Activity

- Have students research the animals and equipment listed above, and place pictures and information about each on a chart showing the depth of each dive.

Energy for Life

ACTIVITY THREE

Concepts: food chains, adaptations, photosynthesis, chemosynthesis

Part A. Assign ecosystems from *The Blue Planet: Seas of Life* for further research. Suggest the Arctic, Antarctic, shallow coastal waters, open ocean, deep ocean floor, coral reefs, tropical seas, tidal marshes, kelp forests, hydrothermal vents, cold vents, and temperate seas. Other locations include: Sable Island, Nova Scotia, Alaska, Bahamas, Florida, Mexico, Galapagos, Cape of South Africa, Queensland, Vancouver Island, Azores, and the California coast. Have each group do an oral report accompanied by a poster.

Part B. If your students view *The Blue Planet: Seas of Life*, they can complete this chart after each episode. Otherwise, have them do research to determine the benefit of each adaptation.

Animal	Adaptation	Benefit of Adaptation
Puffin, ring seal, polar bear	Hide young in caves, burrows	Young hard to find by predators
Harp seal, hooded seal	Short nursing period	Quick nutrition in unstable environment
Polar bear, gray whale	Long period of maternal care	Better nutrition, better survival
Deep-sea jellyfish	Protective coloration	Becomes "invisible" to predators
Octopus	Sense organs detect movement	Easier detection of prey
Emperor penguin	Male protects single egg for 115 days	Greater chance for survival
Herring	Excessive numbers of eggs	Greater chance for survival
Ridley turtle	Synchronized egg lay	Overwhelms predators, greater survival rate
Angler fish	Bioluminescence	Attracts prey to light
Hatchet fish	Flat body, mirrored underbody	Reflects light, makes it seem to disappear from below
Sail fish	Changes color	Confuses prey

Part C. Have students research photosynthesis and chemosynthesis and create a Venn diagram.

In photosynthesis circle only:
- Converts solar energy
- Producers—phytoplankton and green plants
- Needs presence of sunlight—usually top few meters of the ocean
- Depends on seasonal sunlight

In overlap area:
- Converts energy into usable simple nutrients
- Carbon dioxide is fixed into organic compounds
- Producers—base of food chain

In chemosynthesis circle only:
- Converts chemical energy from hydrogen sulfide in hot vents and from methane in cold seeps
- Producers—bacteria
- Does not rely on solar energy
- Takes place thousands of feet down
- Takes place constantly if there is hydrogen sulfide

Resources

The Blue Planet: Seas of Life DVD and VHS from BBC Video

The Blue Planet: Seas of Life, by Andrew Byatt, Alastair Fothergill, Martha Holmes, DK Publishing, 2002

Discovery Channel *The Blue Planet: Seas of Life* Web site: http://dsc.discovery.com/convergence/blueplanet/blueplanet.html

Smithsonian Institution: http://seawifs.gsfc.nasa.gov/OCEAN_PLANET/HTML/education_ diving_records.html

Office of Naval Research: http://www.onr.navy.mil/focus/ocean/water/pressure1.htm

Los Alamos National Laboratory: http://www.acl.lanl.gov/GrandChal/GCM/currents.html

American Geophysical Union: http://www.agu.org/sci_soc/eosdksmith. html

http://www.youthmedia.com for online *The Blue Planet: Seas of Life* guide

The Blue Planet: Seas of Life is available on DVD and VHS wherever videos are sold. Volumes 1 and 2 are currently available. Volumes 3 and 4 will be available May 7, 2002. Each volume contains two episodes from the series and retails for $19.98 (DVD) or $14.95 (VHS). DVD extras include hours of behind-the-scenes features, interviews, photo galleries and fact files.

Youth Media International
P. O. Box 305, Easton, CT 06612
(203) 459-1562
www.youthmedia.com

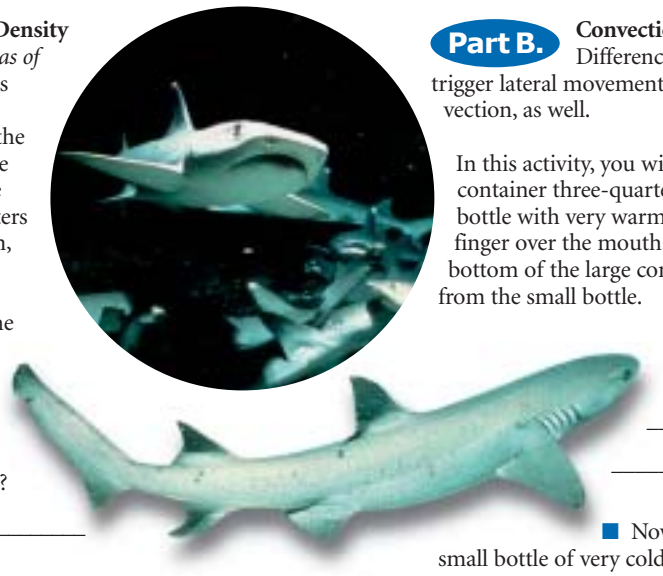
BBC VIDEO ™

2000-01 EdPress Member

Convection, Currents and Circulation

ACTIVITY ONE

Until now, we've only touched the surface...



Part A. Temperature and Density

The Blue Planet: Seas of Life reveals that life in the oceans is regulated by the path of nutrient-carrying currents. Density affects the generation and maintenance of the currents, and in turn, temperature influences density. Cold, polar waters have a different density than warm, tropical waters.

In this activity, you'll investigate the behaviors of different temperatures and densities of water. Follow your teacher's directions.

- What happened to the water when you removed the divider?

_____

_____

_____

- If you know that materials denser than water sink and less dense materials float, what can you infer about the densities of water at each temperature?

_____

_____

- Heating makes water expand. With expansion, the same mass of water takes up a slightly larger space (or volume). Density is mass divided by volume. How will the density of water be affected when it expands? (Remember, you will be dividing the same mass of water by a slightly **larger** volume.)

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- What does cooling do to the water?

_____

- How does this affect the density?

_____

- What would have happened if the water in both compartments had been the SAME temperature?

_____

- Where on Earth would there be cool water throughout the year?

_____

- Where would there be warm, heated water?

_____

Part B. Convection Currents

Differences in density due to temperature not only trigger lateral movements of water but vertical movements, or convection, as well.

In this activity, you will see a model of convection currents. Fill the container three-quarters full with very cold water. Fill the small bottle with very warm water and add food coloring. Hold your finger over the mouth of the small bottle and gently lower it to the bottom of the large container of cold water. Remove your finger from the small bottle.

- Describe what happens to the hot water from the small bottle.

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- Now reverse the above procedure and place a small bottle of very cold water inside a large container of very warm water. Describe what happens to the cold water from the small bottle.

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- What could cause the warm water to behave this way? Hint: Think of **Part A**.

_____

_____

- What could cause the cold water to behave this way?

_____

_____

- What do you think happens to the temperature of surface water after it has been exposed to continued winter cooling?

_____

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- What would happen to the deeper water if it became slightly warmer than the surface water?

_____

- If density currents flow like rivers in the deep ocean, what do you think would happen to their waters if they collide with a large body of land such as an island or underwater island?

_____

_____

- How could this benefit marine animals?

_____

The Pressure is On!

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ACTIVITY TWO

Launching one of the submarines used to film *The Blue Planet: Seas of Life.*

The BBC crew discovered this octopus and nicknamed it Dumbo!

Part A. Although the majority of Earth is covered by water, researchers from *The Blue Planet: Seas of Life* estimate that less than one percent of the deep ocean has been explored. The only way to go there is by submersible, such as ALVIN, the one we see in *The Blue Planet: Seas of Life.*

In this activity, you will observe how a dropper (acting like a submarine) in a bottle filled with water can model the way actual submarines ascend and descend. Place the bottle on a flat surface and squeeze it in the middle and then hold the squeeze. Release the squeeze slowly. Observe what happens to the dropper (submarine). Repeat this procedure several times.

- What happens to the submarine when you squeeze the bottle and hold the squeeze?

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_____

- How do you get the submarine to hover in one spot?

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_____

- Since the volume of the submarine cannot change, what property varies as you squeeze and release the bottle?

_____

_____

- When you release the squeeze, what happens to the submarine?

_____

_____

- What determines if the submarine floats or sinks?

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_____

- When it is floating, how dense must the submarine be in comparison to water?

_____

_____

- When it sinks?

_____

Part B. In *The Blue Planet: Seas of Life*, we learn that 60 percent of the ocean is a mile or more deep. At that depth, there is no sunlight, and the pressure is 160 times greater than on the surface of the earth. On the deepest ocean floor, pressure is equal to a person supporting the weight of 50 jumbo jets. It's no wonder humans need the protection of submersibles!

The record dive using an untethered, pressurized diving suit is 1,968 feet, and the record for a scuba air dive is 475 feet. In comparison, ALVIN is rated safe for 20,000 feet with a normal operating depth of 13,124 feet. While filming *The Blue Planet: Seas of Life*, ALVIN made dives of 4,500 meters or 13,765 feet. Its dive record is 14,763 feet.

To determine the relationship between water pressure and depth, place tape over the holes in the bottle your teacher gives you. Fill the container with water and stand it up with the holes facing into a sink. Remove the tape from each hole. Measure the lengths the water squirts from each of the holes.

- How did the streams differ from each other?

_____

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- What does this demonstration tell you about the relationship between pressure and depth?

_____

_____

Part C. Submersibles such as ALVIN must be constructed of materials strong enough to withstand intense pressures. ALVIN is a 2-meter (6.5 ft) titanium sphere. This size and shape help prevent implosion. While there are only five submersibles capable of reaching the abyssal plain, some animals make incredibly deep dives. In Episode Two of *The Blue Planet: Seas of Life*, a sperm whale dives more than 1,000 meters (over 3,000 feet) in search of food. Pressure squeezes the animal's lungs to just one percent of their volume.

Calculate the pressure conditions in atmospheres (atm) and pounds per square inch (psi) for each of the items in the list below. To convert the feet of depth readings to atmospheres, divide by 33 because for each 33 feet of depth, the pressure changes one atmosphere. You must add 1 atm to the answers to account for the surface air pressure at sea level. To get psi, multiply the number of atmospheres by 14.7—the pressure of one atmosphere.

Dive record	feet	atm	psi
ALVIN (3-person submersible)	14,763	399	5,865
Titanic final resting place	12,500		
Jason (robotic submarine)	19,685		
Sperm whale dive record	3,773		
North elephant seal dive record	4,921		
Mariana Trench dive record	35,802		

Energy for Life

Until now, we've only touched the surface...

ACTIVITY THREE

The hairy angler fish was not known to science until the BBC crew discovered it.

Part A. Every organism has its unique place in the food chain—the route by which energy flows from *producers* (organisms that manufacture their own food) to *consumers* (organisms that get energy by feeding on other organisms). Consumers that feed directly on producers are called *primary consumers*. Organisms that eat the decaying remains of others are called *scavengers*.

In *The Blue Planet: Seas of Life*, we see that food chains often rely on tides, seasons, weather, storms, and migrations. Humans often harm the balance. After your teacher assigns a marine ecosystem to your group, do some research to make a poster displaying the information listed below:

1. Where this ecosystem can be found
2. A flow chart of one possible food chain within this ecosystem—identifying producers, primary consumers, intermediate/secondary consumers, top consumers, scavengers/decomposers
3. Forces, factors, phenomena this food chain depends upon
4. Factors, actions that can damage this food chain
5. Problems within the ecosystem that affect the food chain
6. What you think will happen to this ecosystem in the future

Part B. *In The Blue Planet: Seas of Life*, we see adaptations within marine predator-prey relationships. *The Blue Planet: Seas of Life* refers to this as "an evolutionary arms race" in which "one device for escape is countered by another for attack."

Look at this list of animals and adaptations. Explain how the adaptation is beneficial.

Part C. Plants convert the sun's energy to food energy through *photosynthesis*. In *The Blue Planet: Seas of Life*, we see that plankton is responsible for photosynthesis in the seas. We also see striking examples of organisms thriving in environments completely devoid of sunlight. These strange creatures rely on host bacteria to convert the chemical energy in hydrogen sulfide and methane found in deep thermal vents. This process of conversion of chemical energy to food energy is called *chemosynthesis*.

Research photosynthesis and chemosynthesis. On the back of this sheet, construct a Venn diagram to compare and contrast these processes. List the names of some organisms that carry on each process.

Animal	Adaptation	Benefit of Adaptation
Puffin, ring seal, polar bear	Hide young in caves, burrows	Young hard to find by predators
Harp seal, hooded seal	Short nursing period	
Polar bear, gray whale	Long period of maternal care	
Deep-sea jellyfish	Protective coloration	
Octopus	Sense organs detect movement	
Emperor penguin	Male protects single egg for 115 days	
Herring	Excessive numbers of eggs	
Ridley turtle	Synchronized egg lay	
Angler fish	Bioluminescence	
Hatchet fish	Flat body, mirrored underbody	
Sail fish	Changes color	