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2007: Exploring the Inner Space of the Celebes Sea

Ocean Drifters

Focus
Ocean plankton

Grade Level
5-6 (Life Science)

Focus Question
What are plankton, and how are they adapted to life in the open ocean?

Learning Objectives
Students will define plankton, phytoplankton, and zooplankton.

Students will compare and contrast phytoplankton and zooplankton.

Students will identify at least three ways in which plankton are adapted for life in the open ocean.

Materials
- ❒ Drawing materials and/or materials for constructing models (e.g., pieces of styrofoam, pipe cleaners, toothpicks, rubber bands, water-resistant clay, duct tape; see Learning Procedure, Step 3)
- ❒ (Optional) 10-gal or larger aquarium filled with water (see Learning Procedure, Step 4)

Audio/Visual Materials
- ❒ Overhead projector with transparencies and markers or marker board
- ❒ (Optional) Images of planktonic organisms (see Learning Procedure, Step 1)

Teaching Time
Two 45-minute class periods

Seating Arrangement
Classroom style or groups of 2-3 students

Maximum Number of Students
30

Key Words
Plankton
Phytoplankton
Zooplankton
Adaptation
Midwater
Celebes Sea
Drawing/model

Background Information
Indonesia is well-known as one of Earth's major centers of biodiversity. Although Indonesia covers only 1.3 percent of Earth's land surface, it includes:
- 10 percent of the world's flowering plant species;
- 12 percent of the world's mammal species;
- 16 percent of all reptile and amphibian species; and
- 17 percent of the world's bird species.

In addition, together with the Philippines and Great Barrier Reef, this region has more species of fishes, corals, mollusks, and crustaceans than any other location on Earth.

What, exactly, is meant by biodiversity, and why is it important? The term "biodiversity" is usually understood to include variety at several levels:

- variety of ecosystems: high biodiversity suggests many different ecosystems in a given area;
- variety of species: high biodiversity suggests many different species in a given area;
- variety of interactions between species; and
- variety within species (genetic diversity): high biodiversity suggests a relatively high level of genetic variety among individuals of the same species.

A simple definition of biodiversity could be "The variety of all forms of life, ranging in scale from genes to species to ecosystems."

Biodiversity is important to humans because our survival depends upon many other species and ecosystems. Some examples of our dependence on biodiversity include:

- fresh air containing oxygen;
- clean water;
- productive soils;
- food, medicines and natural products;
- natural resources that provide the basis for human economies; and
- natural beauty that improves our quality of life.

(adapted from the Biodiversity Project, http://www.biodiversityproject.org/bdimportant.htm)

Quite a lot is known about Indonesia's terrestrial and shallow-water ecosystems. But scientific knowledge and understanding of midwater ocean communities is generally sketchy, and many midwater animals have not been studied at all—even though the midwater ocean environment is our planet's largest ecosystem. Midwater animals range from microscopic zooplankton to the largest animals on Earth, provide a major source of nutrition for benthic (bottom) communities, and are an important link in the transfer of energy and materials from the top to the bottom of the ocean.

"Plankton" (from a Greek word meaning "drifters") is a general term for organisms that drift or swim weakly in midwater environments, and includes plants (phytoplankton) as well as animals (zooplankton). Individual planktonic organisms are sometimes referred to as "plankters." Phytoplankton include major primary producers in aquatic food webs, and produce most of the oxygen in Earth's atmosphere. Because they require sunlight for photosynthesis, phytoplankton need to stay relatively close to the ocean surface. Most phytoplankton are very small, and their body composition makes them nearly neutrally buoyant, so the viscosity ("stickiness") of seawater is often enough to counteract any tendency to sink. Some phytoplankton have flagella which are tail-like appendages that give the cells a limited ability to move themselves. Another adaptation to avoid sinking is the production of low-density oils that increase the cells' buoyancy.

Zooplankton include animals that are planktonic for their entire lives, as well as larvae for whom the planktonic existence is temporary. Many marine animals produce planktonic larvae, regardless of whether the adults are swimmers, bottom-dwellers, or completely immobile as adults. Because they come from many different kinds of animals, zooplankton have many different forms and may resemble jellyfish, worms, shrimps, or extremely bizarre fishes. Many zooplankton are quite small (less than a millimeter long), but the "gelatinous zooplankton" are much larger (1 cm long to as large as 2,000 cm) and include organisms such as jellyfish, shell-less swimming snails, arrow worms, and salps. Many zooplankton (particularly larger ones) move up and down in the water column, migrating to shallower water at night to feed and returning to the safety of deeper waters during the day to avoid predators.

Zooplankton includes many primary consumers that are a key link in transferring energy to other consumers in ocean food webs. Despite their importance, many types of zooplankton are not well-understood. This is partially because many species are fragile, jelly-like creatures that are easily damaged by nets and other devices that are traditionally used to collect midwater animals for study. Scientists participating in the 2007: Exploring the Inner Space of the Celebes Sea Expedition plan to use techniques known as "blue-water diving" to observe and collect fragile midwater animals, some of which will probably be new to science.

In this lesson, students will hypothesize some of the adaptations needed by plankton to live as drifters in the open ocean, and will design a model plankter exhibiting some of these adaptations.

Learning Procedure

1. To prepare for this lesson, review the introductory essays for the 2007: Exploring the Inner Space of the Celebes Sea Expedition at http://oceanexplorer.noaa.gov/explorations/07philippines/. You can view many images of planktonic organisms at http://www.imagequest3d.com/catalogue/larvalforms/, but be aware of copyright restrictions posted on the Web site.

   You may also want to review one or more of the following educational activity packages about plankton:
   - http://www.msc.ucla.edu/oceanglobe/pdf/PlanktonPDFs/PlanktonEntirePackage.pdf – Plankton lesson plans from the University of California, Los Angeles Marine Science Center
   - http://www.msc.ucla.edu/oceanglobe/pdf/guide_plankton1.pdf – "A Guide to the Marine Plankton of Southern California" by Robert Perry
   - http://www.marine.usf.edu/pjocean/packets/f01/f01u6p2.pdf – Plankton unit from UCLA's Project Oceanography Science Standards with Integrative Marine Science (SSWIMS)
   - http://sealevel.jpl.nasa.gov/education/activities/ts3ssac3.pdf – plankton identification activity from NASA's "Visit to an Ocean Planet" CD-ROM
   - http://www.oceanexplorer.noaa.gov/explorations/02sab/background/edu/media/sab_drifting.pdf – "Drifting Downward," lesson plan from the Ocean Explorer 2002 Islands in the Stream Expedition

2. Briefly introduce the 2007: Exploring the Inner Space of the Celebes Sea Expedition, highlighting the Expedition's emphasis on midwater communities and the fact that these communities have not been well-explored, even though they are part of Earth's largest ecosystem. Discuss the role of plankton in ocean ecosystems (you may want to tell students that "plankton" comes from a Greek word meaning "drifters"). Be sure students understand the distinction between phytoplankton (plant plankton) and zooplankton (animal plankton), and that zooplankton may be planktonic for all of their lives or only part of their lives (as is the case with larvae of many marine animals). Point out that phytoplankton are responsible for the majority of primary production in the ocean, and produce at least half of the oxygen we breathe. Show students some images of phyto- and zooplankton (from sources referenced in Step 1), lead a "brainstorming" discussion of the kinds of biological adaptations that might be needed by a planktonic organism, and list students' ideas on an overhead transparency or marker board. The list might include:
   - adaptations for staying afloat (particularly important for phytoplankton that require sunlight for photosynthesis);
   - adaptations for capturing food (zooplankton), or making their own food (phytoplankton);
   - adaptations for avoiding predators; and
   - adaptations for movement, either passively (such as being carried by currents) or by active swimming.

   Note that while it is generally accurate to describe plankton as "weak swimmers" compared to other midwater organisms such as squid or fish, many plankton species are capable of significant movement, often enough to avoid being captured collecting devices (which is another obstacle to scientific studies).

3. Tell students that their assignment is to design a planktonic organism. This could be a drawn design, or a three-dimensional model made from pieces of styrofoam, water resistant clay, pipe cleaners, toothpicks, rubber bands, duct tape, and other materials. If students are making models, you may want to add a requirement that the models have a slightly negative buoyancy so that they will remain suspended in water for a specified period of time (e.g., one minute or more). Students should also prepare a written description of their drawing or model stating how their organism obtains nutrition and describing at least three adaptations exhibited by their creation.

4. (Optional) If students have made three-dimensional models with a buoyancy requirement, have each student or student group test their model's buoyancy in an aquarium filled with water. Ask students what would happen to their model's buoyancy if seawater were used instead of fresh water. Students should predict that their model would be more buoyant in seawater, because seawater is more dense than freshwater (so the weight of displaced seawater will be greater than the weight of displaced freshwater, and as a result the buoyant force acting on the model will also be greater).

The Bridge Connection

www.vims.edu/bridge/ – In the "Site Navigation" menu on the left, click on "Ocean Science Topics," then "Biology," then "Plankton" for information and activities involving phytoplankton, zooplankton, and bioluminescence.

The "Me" Connection

Have students write a short essay in which they imagine themselves as a planktonic organism, describing how they spend a typical day, and whether they would prefer to be a phytoplankter, permanent zooplankter, or temporary zooplankter (i.e., the larva of an animal that might be a swimmer or bottom-dweller as an adult).

Connections to Other Subjects

Art, Language Arts, Physical Science

Assessment

Models or diagrams and written descriptions provide opportunities for assessment.

Extensions

1. Visit oceanexplorer.noaa.gov to keep up to date with the latest 2007: Exploring the Inner Space of the Celebes Sea Expedition discoveries, and to find out what researchers are learning.

2. See activity packages referenced in Step 1 for additional activity ideas involving plankton.

Multimedia Learning Objects

http://www.learningdemo.com/noaa/ – Click on the links to Lessons 8 and 12 for interactive multimedia presentations and Learning Activities on Ocean Currents and Food, Water, and Medicine from the Sea.

Other Relevant Lesson Plans from the Ocean Exploration Program

Journey to the Unknown & Why Do We Explore [http://www.oceanexplorer.noaa.gov/explorations/02galapagos/background/education/media/gal_gr5_6_l1.pdf] (10 pages, 596k) (from the 2002 Galapagos Rift Expedition)

Focus: Ocean Exploration

In this activity, students will experience the excitement of discovery and problem-solving to learn about organisms that live in extreme environments in the deep ocean and come to understand the importance of ocean exploration.

Cool Lights [http://www.oceanexplorer.noaa.gov/explorations/04deepscope/background/edu/media/CoolLights.pdf]
(PDF, 220Kb) (from the 2004 Operation Deep Scope Expedition)

Focus: Light-producing processes and organisms in deep-sea environments (Life Science and Physical Science)

In this activity, students compare and contrast chemiluminescence, bioluminescence, fluorescence, and phosphorescence. Given observations on materials that emit light under certain conditions, students infer whether the light-producing process is chemiluminescence, fluorescence, or phosphorescence. Students explain three ways in which the ability to produce light may be useful to deep-sea organisms and explain how scientists may be able to use light-producing processes in deep-sea organisms to obtain new observations of these organisms.

Jelly Critters [http://www.oceanexplorer.noaa.gov/explorations/05arctic/background/edu/media/arctic05_jellycritters.pdf]
(5 pages, 269k) (from the Hidden Ocean, Arctic 2005 Expedition)

Focus: Gelatinous zooplankton in the Canada Basin (Life Science)

In this activity, students will be able to compare and contrast at least three different groups of organisms that are included in gelatinous zooplankton, describe how gelatinous zooplankton fit into marine food webs, and explain how inadequate information about an organism may lead to that organism being perceived as insignificant.

Now You See Me, Now You Don't [http://www.oceanexplorer.noaa.gov/explorations/05deepscope/background/edu/media/now_u_see_me.pdf]
(5 pages, 281Kb) (from the Operation Deep Scope 2005 Expedition)

Focus: Light, color, and camouflage in the deep ocean. (Life Science)

In this activity, students will be able to explain light in terms of electromagnetic waves, and explain the relationship between color and wavelength; compare and contrast color related to wavelength with color perceived by biological vision systems; and explain how color and light may be important to deep-sea organisms, even under conditions of near-total darkness. Students will also be able to predict the perceived color of objects when illuminated by light of certain wavelengths.

Twisted Vision [http://www.oceanexplorer.noaa.gov/explorations/05deepscope/background/edu/media/twisted.pdf]
(7 pages, 303Kb) (from the Operation Deep Scope 2005 Expedition)

Focus: Polarization vision. (Life Science/Physical Science)

In this activity, students will be able to explain the meaning of polarized light, and will be able to identify three ways in which unpolarized light can become polarized; explain why some animals have polarization vision, and why humans do not have this ability; and discuss three ways in which polarization vision may be useful to marine organisms.

Other Links and Resources

The Web links below are provided for informational purposes only. Links outside of Ocean Explorer have been checked at the time of this page's publication, but the linking sites may become outdated or non-operational over time.

http://oceanexplorer.noaa.gov – Web site for NOAA's Ocean Exploration program

http://oceanexplorer.noaa.gov/gallery/livingocean/livingocean_coral.html – Ocean Explorer photograph gallery http://www.st.nmfs.gov/plankton/ – NOAA's Coastal & Oceanic Plankton Ecology, Production & Observation Database (COPEPOD)

http://www.oceanexplorer.noaa.gov/explorations/02sab/background/edu/media/sab_drifting.pdf – "Drifting Downward," lesson plan from the Ocean Explorer 2002 Islands in the Stream Expedition

http://www.msc.ucla.edu/oceanglobe/pdf/PlanktonPDFs/PlanktonEntirePackage.pdf – Plankton lesson plans from the University of California, Los Angeles Marine Science Center

http://www.msc.ucla.edu/oceanglobe/pdf/guide_plankton1.pdf – "A Guide to the Marine Plankton of Southern California" by Robert Perry

http://www.marine.usf.edu/pjocean/packets/f01/f01u6p2.pdf – Plankton unit from UCLA's Project Oceanography Science Standards with Integrative Marine Science (SSWIMS)

http://sealevel.jpl.nasa.gov/education/activities/ts3ssac3.pdf – Plankton identification activity from NASA's "Visit to an Ocean Planet" CD-ROM

http://www.imagequest3d.com/catalogue/larvalforms/ – Image Quest 3-D Web site, featuring images of numerous marine organisms; all images are copyrighted, but are still great to look at

National Science Education Standards

Content Standard A: Science As Inquiry
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard B: Physical Science
- Motions and forces

Content Standard C: Life Science
- Structure and function in living systems
- Populations and ecosystems
- Diversity and adaptations of organisms

Content Standard F: Science in Personal and Social Perspectives
- Populations, resources, and environments

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 4.
The ocean makes Earth habitable.
Fundamental Concept a. Most of the oxygen in the atmosphere originally came from the activities of photosynthetic organisms in the ocean.

Essential Principle 5.
The ocean supports a great diversity of life and ecosystems.
Fundamental Concept a. Ocean life ranges in size from the smallest virus to the largest animal that has lived on Earth, the blue whale.
Fundamental Concept b. 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.
Fundamental Concept d. Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (such as symbiosis, predator-prey dynamics and energy transfer) that do not occur on land.
Fundamental Concept e. 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.

Essential Principle 6.
The ocean and humans are inextricably interconnected.
Fundamental Concept a. The ocean affects every human life. It supplies freshwater (most rain comes from the ocean) and nearly all Earth's oxygen. It moderates the Earth's climate, influences our weather, and affects human health.

Essential Principle 7.
The ocean is largely unexplored.
Fundamental Concept a. The ocean is the last

and largest unexplored place on Earth—less than 5% of it has been explored. This is the great frontier for the next generation's explorers and researchers, where they will find great opportunities for inquiry and investigation.

Fundamental Concept d. New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.

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oceanexeducation@noaa.gov

For More Information

Paula Keener-Chavis, Director, Education Programs
NOAA Ocean Exploration Program
Hollings Marine Laboratory
331 Fort Johnson Road, Charleston SC 29412
843.762.8818
843.762.8737 (fax)
paula.keener-chavis@noaa.gov

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