Light in the Deep Sea

Topics
Light, Adaptations, Camouflage

Grades
6-12

Site
Indoors

Duration
30-45 minutes

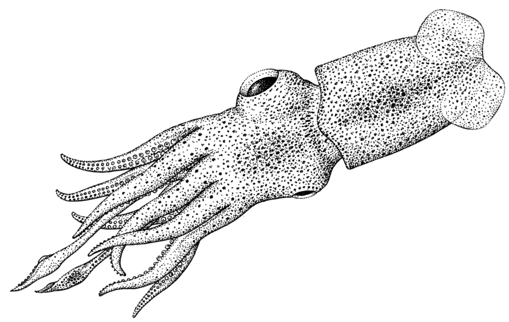
Materials
For each group:
- Deep Sea Photos
- Deep Sea Data Sheets #1, #2, #3
- Colored felt (black, red, orange, yellow, green, blue , purple)
- Deep Sea Glasses (Deep Sea Glasses template, blue plastic film, file folders, tape, scissors, binder clips or staples)
- Colored pencils

Vocabulary
camouflage, midwater, visible light, wavelength

National Science Education Standards
Science as Inquiry
(5-8) (9-12)
Abilities necessary to do scientific inquiry

Life Science (5-8)
Diversity and adaptations of organisms

Physical Science (9-12)
Interactions of energy and matter



Overview

Why are so many deep sea organisms red? Students explore one camouflage strategy of deep sea animals through an in-depth examination of light properties in ocean waters.

Objectives

Students will be able to:
- Define visible light as being made of many different colors and wavelengths.
- Describe how the wavelength of light determines its ability to penetrate seawater.
- Investigate how deep sea organisms use properties of light to help them survive.

Background

The Deep Sea Habitat

The deep sea is the largest and least understood habitat on Earth. It begins approximately 200 meters (or 660 feet) below the surface of the ocean and reaches down, on average, 3,800 meters (12,500 feet) to the ocean floor. The deepest part of the ocean, in the Marianas Trench, is 11,033 meters (36,201 feet) deep. Darkness is one of the defining characteristics of the deep sea because sunlight is absorbed and scattered by the ocean water. In clear water, some sunlight can penetrate into the **midwater**, or "twilight," zone between approximately 200 to 1,000 meters (660 to 3,300 feet). Light intensity is low but does allow for some animals to see. Sunlight cannot reach below 1,000 meters (3,300 feet) making this area eternally dark. Despite the darkness, deep sea organisms in these zones possess many **camouflage** strategies that help them both find food and avoid becoming someone else's meal. One camouflage technique utilized by deep sea organisms is red coloration. The red wavelength of the light spectrum is unable to penetrate into deep ocean waters, effectively camouflaging those red organisms into the deep sea darkness.

The Light Spectrum

In order to understand camouflage in the deep sea, one must have a basic understanding of the **visible light** spectrum and how it penetrates ocean waters. Visible light represents a narrow band of electromagnetic radiation that appears white when all colors are present. The colors of the spectrum (red, orange, yellow, green, blue, indigo and violet) can be remembered using the mnemonic device: ROY G BIV, which uses the first letter of each color. Light travels in waves at a very rapid speed. Each color of the spectrum has specific **wavelength** ranges.

The colors at the middle of the visible spectrum (yellow, green and blue) penetrate seawater to the greatest depth, while colors of longer (violet) and shorter (red and orange) wavelengths are absorbed and scattered more rapidly. This property of light influences the coloration patterns and distribution of marine organisms.

During this activity, students use blue filters in order to simulate the behavior of light at varying ocean depths. A colored filter allows only one color of light to pass through the filter; all other colors are absorbed and therefore blocked from the eyes of the viewer. In the case of the blue plastic filter, all colors except blue are absorbed and the only color that can pass through is blue light. This simulates blue light being the only light that penetrates into deeper water. On land, an item will appear a specific color because it is absorbing all other colors and reflecting back its "color" to our eye.

Deep Sea Camouflage

The wavelengths of light that can penetrate into the depths of the ocean are yellow, green and blue. Because other wavelengths are not present in the deep sea, they cannot be seen. A color must be present in the surrounding environment in order to be seen by the eye. Several organisms living in ocean depths have red coloration. Their red color effectively makes them "disappear" in the inky darkness, because no red wavelengths are present.

Red coloration is not the only camouflage strategy used by deep sea organisms. Many deep sea organisms are able to produce their own light, called bioluminescence. Some animals, like the viperfish, possess bioluminescent organs on their bellies. As they migrate upwards to find food in shallower depths, where some visible light does penetrate, the bioluminescent organs on their bellies brighten. This matches the downwelling light making the fish disappear into the background. Some deep sea animals are transparent which allows them to blend into their surroundings. Many of these transparent animals also utilize the color red for camouflage, especially around digestive organs. These red guts hide bioluminescent prey, effectively camouflaging the predator from becoming prey itself!

Teacher Preparation

1. Make color copies of **Deep Sea Photos** for each student group. You may choose to source additional animal photographs found in the Animal Guide on the Monterey Bay Aquarium website: www.montereybayaquarium.org.

2. Make deep sea glasses, enough for every group of students to have at least one pair with four layers of blue film. (You may have students construct their own glasses.) Directions for glasses construction:
   - Print out the **Deep Sea Glasses Template** found on page 8. Use this template to cut out glasses from recycled file folders.

VOCABULARY

Camouflage: a behavior, shape, color and/or pattern that helps an organism blend in with its surroundings

Midwater Zone: an ocean zone 200 - 1,000 meters (660 - 3,300 feet) in depth

Visible Light: the section of electromagnetic radiation that can be seen by the human eye

Wavelength: the distance between successive crests of a wave

TEACHER TIP

Save paper (and time copying!) by having students record their observations in a notebook rather than printing out the attached data sheets.

- Source blue film and cut into strips, approximately 5.5 inches long by 1.5 inches wide. Either blue plastic report folders or gels used for stage lights from theater supply companies will work.
- Tape one blue film strip onto each pair of glasses covering the eye holes. Attach one side of the three additional layers of film together with tape. DO NOT tape down all sides of the additional film layers, as students will need to utilize them separately during the activity.

3. Prepare sets of felt pieces for student groups. Each set should contain one black felt background (12-inch square) and at least one felt piece (cut into one-inch squares) of each of the following colors: red, orange, yellow, green, blue and purple. Note: The color indigo is left out of the experiment due to its close proximity to blue and violet, as well as the difficulty in obtaining indigo felt pieces.

Procedure

1. In small groups, have students examine colors of deep sea organisms.
Pass out copies of **Deep Sea Data Sheets #1** and **#2** (or project the data sheets so students record observations in a notebook). Distribute a set of **Deep Sea Photos** to students or allow students to search for images of deep sea organisms on the internet.

2. Pass out Deep Sea Glasses and sets of felt pieces to each student group.
If you haven't already constructed one pair of glasses per student group, have students do so. Then make sure each group has one large black background and one square of red, orange, yellow, green, blue and purple felt.

3. Students experiment with colors in the "deep sea" using their glasses.
Have student groups use the two data sheets to record changes in their ability to see the colors of felt through the Deep Sea Glasses as they add layers of blue film (representing increasing ocean depth). Students should observe that the red, orange and yellow felt pieces become harder to see. (Students may also notice that the black background becomes difficult to see.) Next students observe the **Deep Sea Photos** using their glasses and record their ability to see the organisms as they add layers of blue film.

4. Introduce the light spectrum and explore the properties of light in water.
Explain that light travels in wavelengths and we see objects because light wavelengths reflect off of them and enter our eyes. Visible light contains a range of colors, including red, orange, yellow, green, blue, indigo and violet (ROY G BIV). Each of those colors has a different size wavelength. Have students complete **Deep Sea Data Sheet #3.** You may go into greater detail by discussing light penetration in shallow versus deep ocean waters. There is a **Spectrum of Light in the Ocean** chart on page 9 that you may share with students.

5. Lead a class discussion of their findings about camouflage in the deep sea.
Why is red a good color to be if you live in the deep sea? How does the color of deep sea organisms compare to the colors of shallower ocean organisms? What other camouflage adaptations might deep sea organisms have?

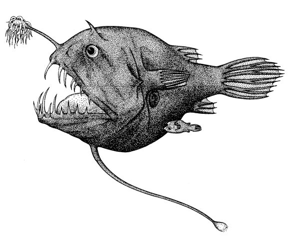
CONSERVATION TIPS

As far away as the deep sea seems, our actions on land have a direct impact on the health of this ecosystem. Some ways you can help care for the deep sea are:
- Reduce the amount of trash you generate.
- Be energy efficient.
- Recycle as much of your trash as possible.

ELL TIPS

Visual scaffolding is helpful for English Language Learners. Demonstrate that all colors are present in white light by shining a light through a prism in a darkened room. A rainbow should appear.

THE MISSION OF THE MONTEREY BAY AQUARIUM IS TO INSPIRE CONSERVATION OF THE OCEANS.



Extensions

- Try using different colored filters, such as red and green. What colors are easy to see? Which colors do not pass through the filter?
- Have students view images of transparent deep sea animals and discuss the advantages of this camouflage strategy.

Resources

Websites

Monterey Bay Aquarium. www.montereybayaquarium.org

Learn more about red, bioluminescent and/or transparent deep sea organisms in the Animal Guide on Monterey Bay Aquarium's website.

Monterey Bay Aquarium Research Institute. www.mbari.org

View pictures and videos of deep sea organisms and read current research projects and findings from a cutting-edge research and engineering organization.

Books

The Deep Sea. Robison, Bruce and Judith Connor. Monterey Bay Aquarium Foundation, 1999.

The Silent Deep. Koslow, Tony. The University of Chicago Press, 2007.

The Deep. Nouvian, Claire. The University of Chicago Press, 2007.

References

Learning Ocean Science Through Ocean Exploration. Edited by Chase, Valerie. National Oceanic and Atmospheric Administration (NOAA), 2006.

The Marine Biology Coloring Book. Niesen, Thomas M. Coloring Concepts, Inc., 2000.

Standards

California Science Standards

Grade 6: 3a; 4b; 5e, 7e

Grade 7: 5a; 6a, b, e; 7c

Grades 9-12: Physics 4a, c, e
Biology/Life Sciences 6a
Investigation and Experimentation 1d, g

Acknowledgements

Adapted from "All that Glitters" in NOAA's *Learning Ocean Science Through Ocean Exploration.*

Name:

Deep Sea Data Sheet
#1

Look at the photographs of deep sea organisms and answer the questions below.

- What do you notice about each organism's coloration?

- How might their coloration help these organisms survive?

- What do you wonder about them?

Now use the **Deep Sea Glasses** to observe how colors appear in the ocean. Record what happens to your ability to see the colored felt pieces with varying layers of blue film in the chart below. Each layer of blue film represents a deeper depth in the ocean.

# of blue film layers	Red	Orange	Yellow	Green	Blue	Violet
1						
2						
3						
4						

Summarize your results in the space below.

How might your results relate to the coloration of deep sea organisms?

Deep Sea Data Sheet
#2

Name:

Use the **Deep Sea Glasses** to look at the photographs of deep sea organisms. Record what happens to your ability to see the deep sea organisms with varying layers of blue film in the chart below. Use blank columns for any additional photographs of deep sea organisms you have found.

# of blue film layers	Midwater shrimp	Johnson's sea cucumber	Bloodybelly comb jelly	Red sea fan		
1						
2						
3						
4						

Summarize your results below.

Why do you think you had these results?

What implications do your results have for red coloration of deep sea organisms? How might red coloration help them survive?

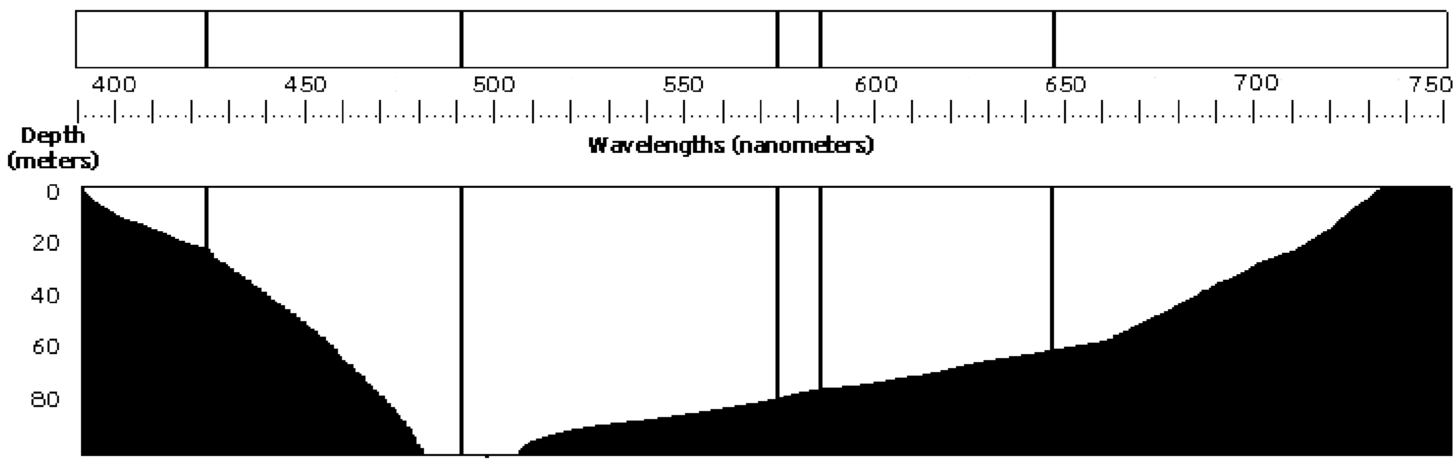
Deep Sea Data Sheet
#3

Name:

Look at the table and diagram below. The table shows light radiation and their wavelengths. The diagram depicts a cross-section of the ocean.

Use your colored pencils to color the sections in the diagram so that they correspond to the wavelength ranges listed in the table. Notice that some colors of light penetrate deeper than others.

Type of radiation	Wavelength in nanometers
violet	380-424
blue	424-491
green	491-575
yellow	575-585
orange	585-647
red	647-750



Which color wavelength penetrates deepest into ocean waters?

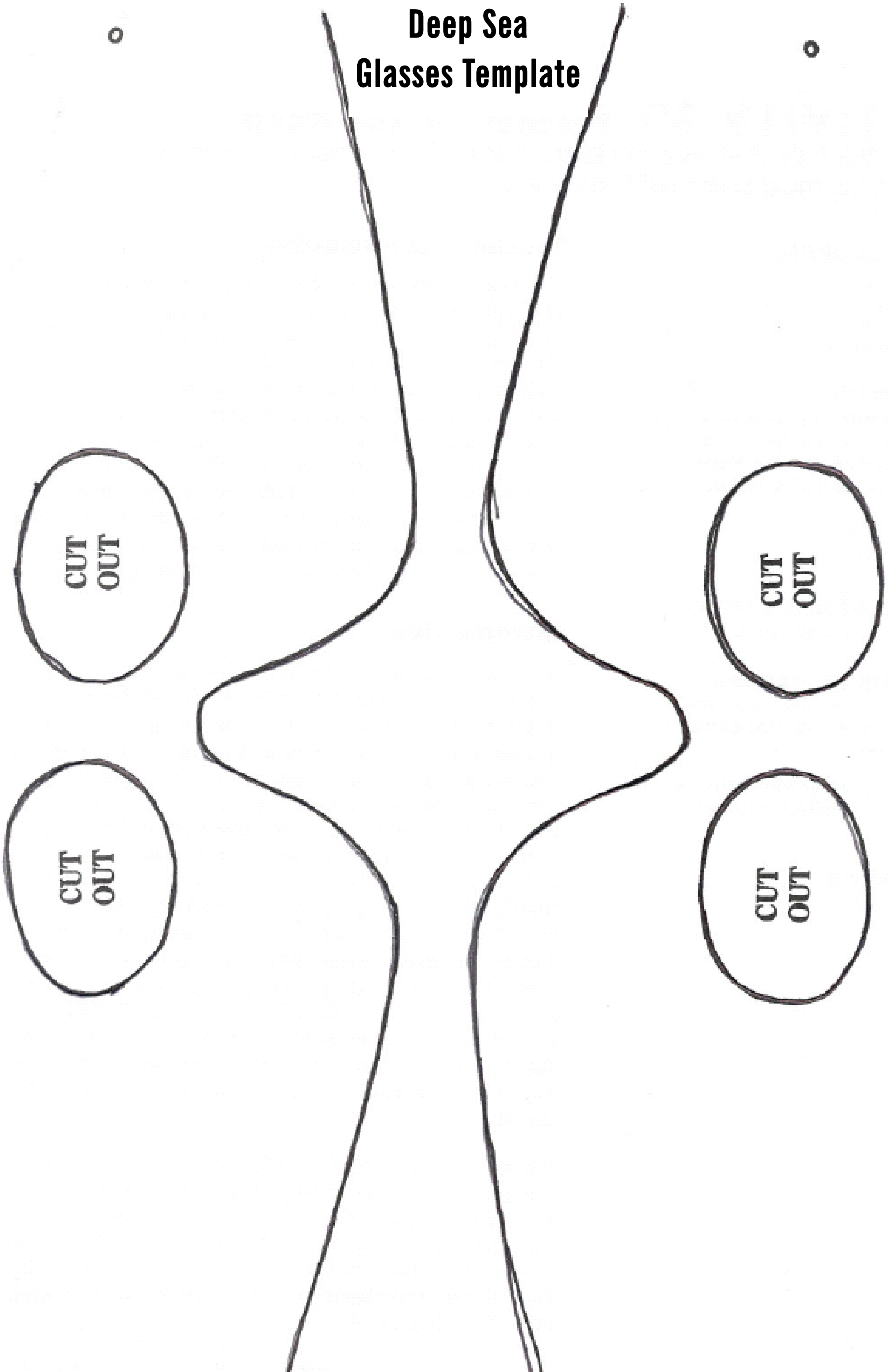
What is happening to the other wavelengths of light as they penetrate the water?

Does this diagram support your observations on the other data sheets? Why or why not?

Describe the relationship between depth and an organism's coloration.

BONUS: On land when the entire light spectrum is visible, what is making a red apple appear red?

Deep Sea Glasses Template



Spectrum of Light in the Ocean

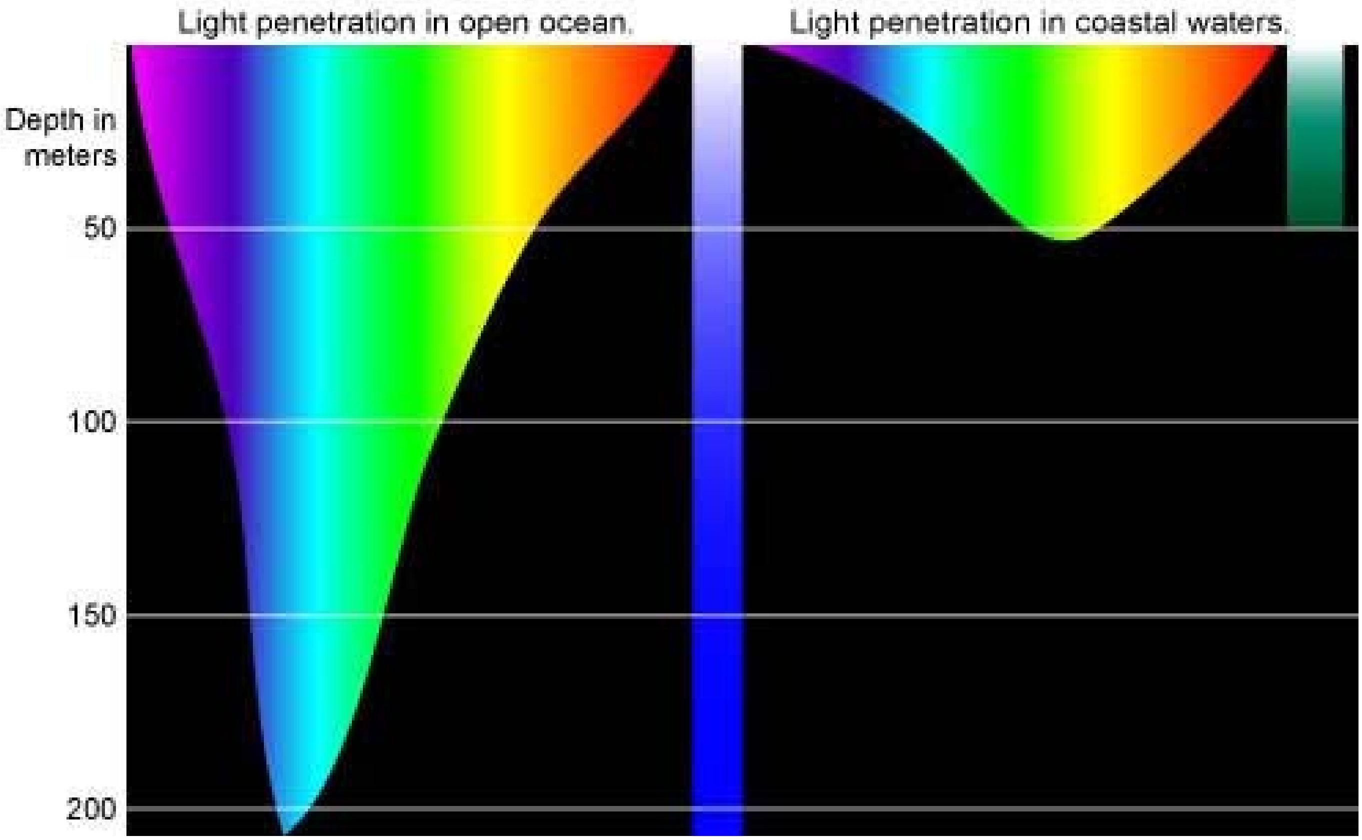
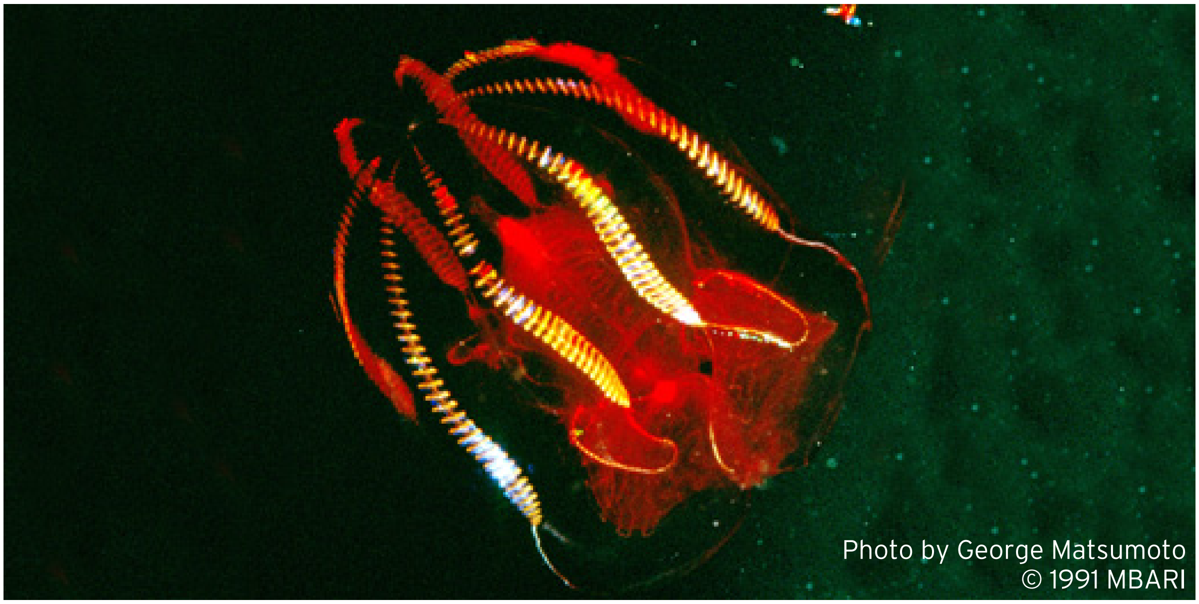


Image courtesy of Kyle Carothers, NOAA-OE

Midwater shrimp
Sergestes similis

Johnson's sea cucumber
Parastichopus johnsoni



Bloodybelly comb jelly
Lampocteis cruentiventer

Red sea fan
Swiftia kofoidi