6: WAVES AND LIGHT IN THE OCEAN

Grade Level: 9-12
Time: 30-45 min

SUMMARY:

In this activity, students will complete a short research assignment on the behavior of light in the ocean, and use this information to make a visual representation of the different light zones in the ocean, and learn which wavelengths of light are able to penetrate to each depth.

OBJECTIVE(S):

Students will:

- Identify the characteristics of the different zones of light in the ocean.
- Understand the relationship between water depth and light zones.
- Model and discuss the behavior of sunlight in the ocean and the degree of penetration of different wavelengths.

STEM APPLICATIONS:

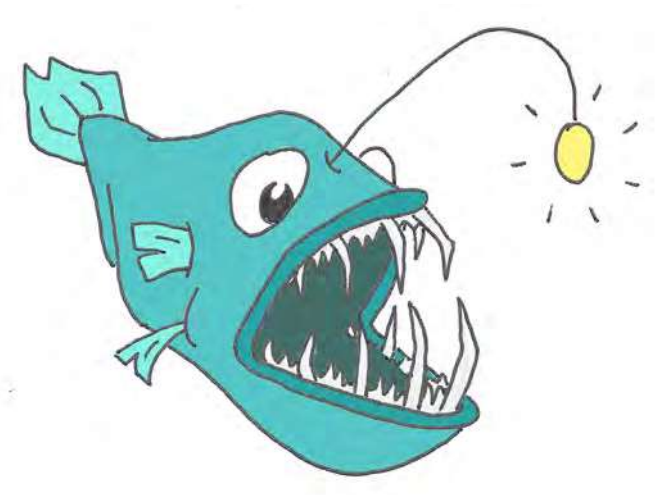
- **Science (physics, biology)** - Students will understand the laws of physics that govern the behavior of light in water, and how it differs from its behavior on land. Light is a major determiner of the assemblage of animals that can live in each zone of the ocean, and students will study this biological relationship.
- **Technology** - Students will conduct research on the interaction of light in the ocean using a computer.
- **Engineering** - Students will use their knowledge of light zones to construct a model of color-depth penetration in the ocean.

NGSS ALIGNMENT:

- **Practice 2.** Developing and Using Models
  - **9-12 –** Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.
- **Practice 4.** Analyzing and Interpreting Data
  - **9-12 –** Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.
- **Practice 8.** Obtaining, Evaluating and Communicating Information
  - **9-12 –** Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.
  - **9-12 –** Gather, read and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.
  - **9-12 –** Communicate scientific and/or technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

VOCABULARY:

Optical Oceanography – The study of how light behaves in the ocean.
Wavelength – A measure of the distance between two crests of a wave. Different colors in the color spectrum have different wavelengths – violet is the shortest, and red is the longest.
Amplitude – The maximum "height" of a wave, or the distance it travels away from the midline in either direction.
Spectrum – All of the colors that make up visible light.
Frequency –The number of wavelengths that pass a certain point in a given period of time. The unit of measure is Hertz (Hz), which reports wavelengths per second.
Speed of Light - = wavelength x frequency.
Photic or Epipelagic Zone – The upper layer of water on the surface of the ocean in which light penetrates sufficiently to allow photosynthesis.
Dysphotic or Mesopelagic Zone – Also known as the "twilight zone," this layer of the ocean is in between the photic and the aphotic zone. Only certain colors on the spectrum penetrate to this depth, and light is too limited for photosynthesis to occur.
Aphotic or Bathypelagic Zone – The bottom-most layer of the ocean, in which there is no light at all. About 90% of the ocean is in this completely dark zone!



MATERIALS:

- Access to computers or textbooks on physical oceanography
- Poster board
- Glue
- Colored construction paper (red, orange, yellow, green, blue, navy blue, violet)
- Markers

BACKGROUND:

Light travels in waves at the fastest known speed in the physical universe. What appears to us as white light is actually light made up of many different colors, or wavelengths, which is the reason why we see the world in the many colors that we do. These waves are imperceptible to us, but if visible, we would notice that there are many similarities between light waves and physical waves in the ocean. In fact, many of the same measurements are used to describe the size, shape, and speed of waves for light and waves in the ocean, including wavelength and frequency.

The degree and depth to which sunlight penetrates in the ocean determines the extent of primary productivity and divides the ocean into distinct zones of life. When sunlight hits the water, about 5% is reflected back into the atmosphere, while the other 95% gets absorbed. Plankton and photosynthetic organisms live exclusively in the photic zone, the uppermost layer of the ocean where sunlight is available. These creatures absorb the usable light to produce energy, and in turn sustain all life in the ocean through the food web! As you travel further into the ocean's depths, light slowly disappears – color by color. The first color to vanish is ultraviolet, followed by red (at the extent of the photic zone), then yellow, green, and finally blue before the ocean fades into darkness.

ACTIVITY:

1. Engage/Elicit

Begin this activity with a discussion on the behavior of light. How and why do we see colors as they are? A blue shirt, for an example, is blue because it absorbs all colors with the exception of blue. Instead, it reflects it. The wavelength reflected is the color that our eyes perceive. This is true for all objects, which absorb or reflect certain parts of the spectrum of light. The color of an object is based on the wavelength of light that is reflected, not absorbed. This explains why black objects become much warmer than white objects when in the sun – black absorbs all of the colors while white reflects them.

Review the color spectrum and use the provided diagram (Fig. 1) of the different wavelengths of colored light. Go over the vocabulary words in this section to help students describe how waves are measured including: wavelength, amplitude, spectrum and frequency. Help students visualize this concept by drawing or printing a labeled wave diagram and/or color spectrum. Refer to Figures 1 and 2 for this activity.

2. Explore

Allow the students about 20 minutes to research the interaction of light and the ocean in groups. Ask the students to take notes on what they find and direct them to the following informative websites:

- www.marinebio.org/oceans/light-and-color.asp
- www.oceanexplorer.noaa.gov/edu/curriculum/section5.pdf
- www.oceanexplorer.noaa.gov/facts/light-distributed.html
- www.oceana.org/en/explore/marine-science/light-and-sound

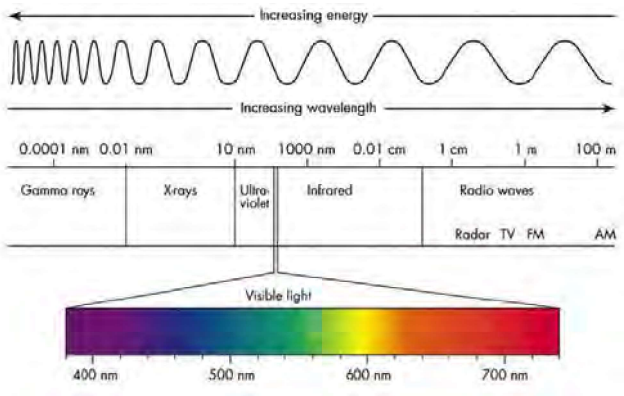


Figure 1. Wave length of increasing light

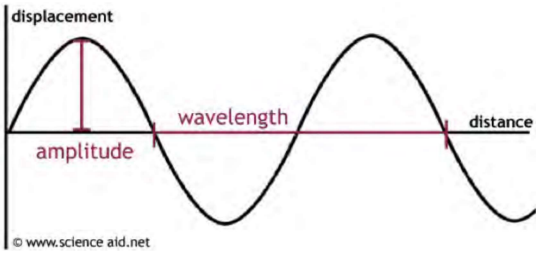


Figure 2. How waves are measured

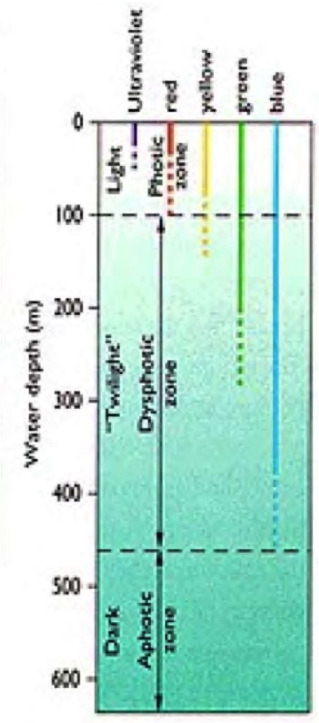
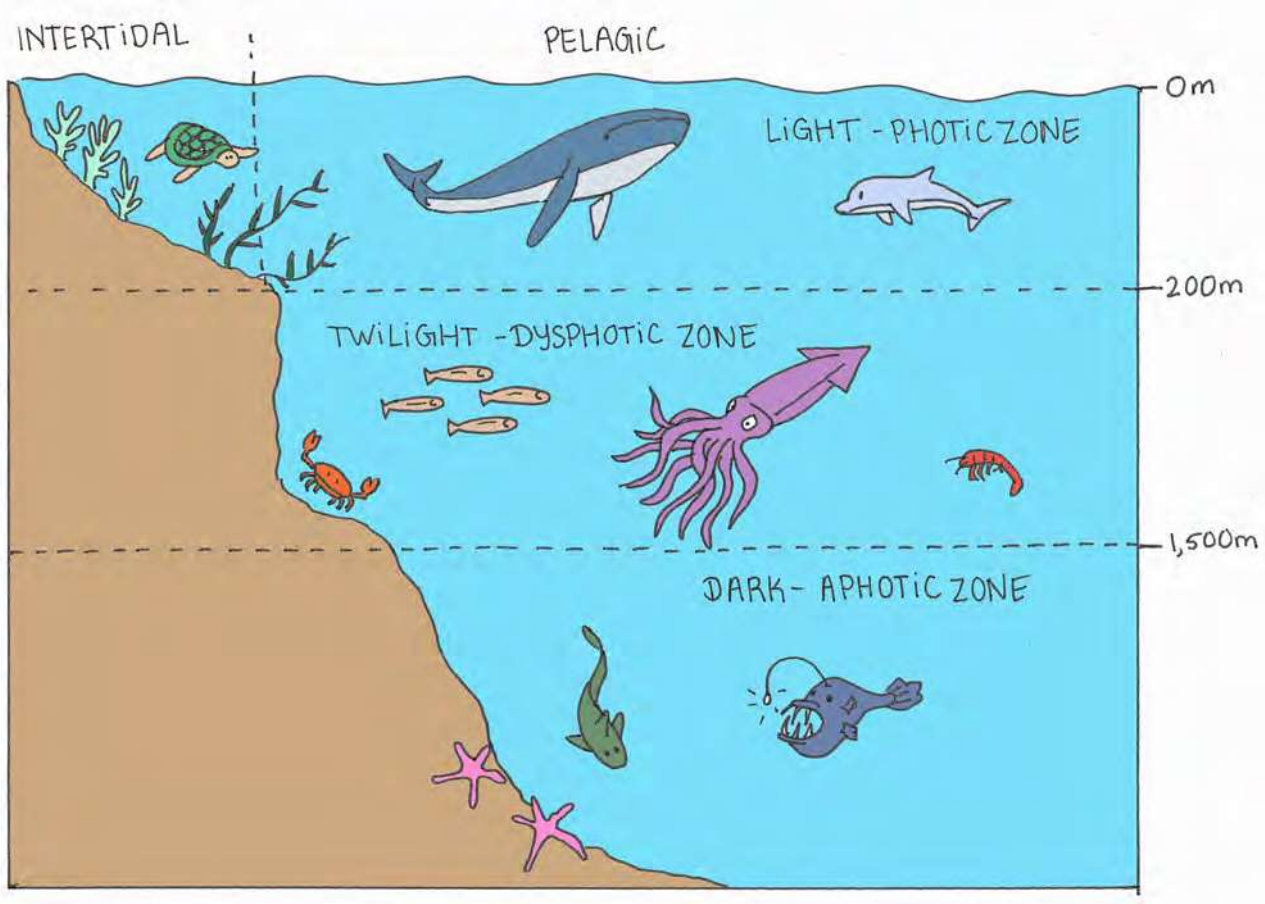


Figure 3. Lightzones

Figure 1 SOURCE: Fordham University; Figure 3 SOURCE: marinebio.org



After the students gather information, ask them to use their notes to create a poster of the light zones in the ocean using colored construction paper and glue. Make sure the students include the different wavelengths of light and their respective depths.

Creativity should be encouraged during this process! For example, the depth of the photic zone, is highly variable. In productive, coastal waters, it may only be a few meters deep, but in the open ocean (which can be devoid of planktonic life), light could penetrate all the way down to 150 meters. See Figure 3 for a reference – this is roughly the result that students should replicate. This image can be found at one of the links above, on www.marinebio.org.

Ask the students to label everything clearly, including the three zones of light/life (Photic/Epipelagic, Dysphotic/Mesopelagic and Aphotic/Benthopelagic) and use the respective color of paper to show approximately how deep in the water column each wavelength of light will travel.

3. Explain

Discuss the impact of colored light and sunlight penetration to life in the world's oceans. Ask the students why ultraviolet, red, and yellow light get absorbed mostly in the photic zone, while green and blue continue to penetrate in the water column.

The answer is that chlorophyll, the sunlight-capturing compound produced by all plants (including phytoplankton) is green! Because of what we know about light absorption and reflection, we can infer that plankton cannot absorb the color green, and therefore it gets reflected from their bodies and travels deeper into the sea. They can, however, absorb contrasting colors like red, ultraviolet, and yellow (to some extent) and use this part of the color spectrum to make energy.

4. Evaluate/ Wrap-up

After each group has finished creating their diagram of light in the oceans, ask the students to present what they have created. Check for understanding by ensuring that all parts of the diagrams, including the ocean light and biological zones, are labeled, and that the colors are in the right order and travel to the right depth. Ask students to employ the vocabulary words in this section when they are talking about their diagrams, particularly when they describe how light moves and is used by life in the ocean.

5. Dive Deeper

Take a dive 11,000m down into the depths of an ocean trench at www.bbc.com/news/science-environment-17013285. See how the pressure and light level changes with depth, and learn about why we do science in these hard-to-reach locations on earth.

For more information on ocean exploration, please visit www.namepa.net/education.