Section 2: Telepresence

Pen-Yuan Hsing works diligently in the ROV Control Room to maximize the scientific benefits of the dives. Image courtesy of the NOAA *Okeanos Explorer* Program.
http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/logs/hires/apr5-4-hires.jpg

A representative group of mission personnel who were on board NOAA Ship *Okeanos Explorer* during the third and final cruise leg of the 2012 Gulf of Mexico Expedition. Image courtesy of the NOAA *Okeanos Explorer* Program.
http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/logs/hires/apr29_update_hires.jpg

Engineers fabricate parts for the ship's infrastructure. Image courtesy of NOAA *Okeanos Explorer* Program, INDEX-SATAL 2010.
http://oceanexplorer.noaa.gov/okeanos/explorations/10index/logs/hires/engineers_hires.jpg

Lesson 2: A Day in the Life of an Ocean Explorer

Focus
Telepresence and communications for ocean exploration

Grade Level
7-8 (Physical Science) Adaptations to grades 5-6 and 9-12 can be found on page 46.

Focus Question
What strategies are used aboard the NOAA Ship *Okeanos Explorer* to investigate unknown areas in Earth's ocean and how are human communication and telepresence involved with these strategies?

Learning Objectives
- Students will discover the many methods of communication used aboard an exploration vessel and understand how telepresence technologies aboard the NOAA Ship *Okeanos Explorer* increase the pace, efficiency, and scope of ocean exploration.
- Students will explore how patterns in the basic properties of simple waves contribute to processes of obtaining, evaluating, and communicating information in ocean exploration.

Materials
- Copies of
  - "A Day in the Life of an Explorer" by Colleen Peters (*http://oceanexplorer.noaa.gov/okeanos/explorations/10index/logs/july29/july29.html*).
  - "Implementing Telepresence: Technology Knows No Bounds" by Webb Pinner and Kelley Elliott (*http://oceanexplorer.noaa.gov/okeanos/explorations/10index/logs/july09/july09.html*); and
  - "Executing Telepresence: The Seattle ECC Comes Online!" by Kelley Elliott and David Butterfield (*http://oceanexplorer.noaa.gov/okeanos/explorations/10index/logs/june29/june29.html*)

    or have students reference these online.
- Access to the *Ocean Explorer* video playlist *http://oceanexplorer.noaa.gov/okeanos/media/exstream/exstream_playlist.html*
- 1 rope, at least 3/8-inch diameter x 8 ft; braided nylon or other flexible material (preferably in a bright color for good visibility)

Audiovisual Materials
- Optional – Images of exploration technologies (see Learning Procedure, Step 1d)

Teaching Time
Three to six 45-minute class periods (see Learning Procedure, Note b)

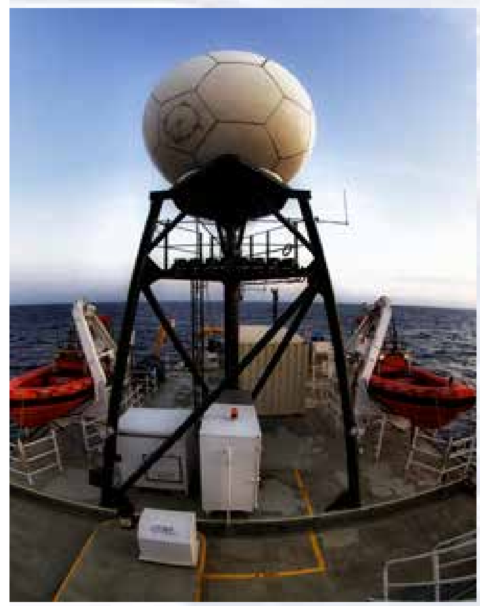
Seating Arrangement
Groups of two to four students

Maximum Number of Students
30

Key Words and Concepts
Ocean Exploration
Okeanos Explorer
Telepresence
Satellite communication
Wireless communication
Electromagnetic wave
Frequency
Wavelength
Modulation

Background
Telepresence is the key to the *Okeanos Explorer*'s exploration strategy. This technology allows people to observe and interact with events at a remote location. The *Okeanos Explorer*'s telepresence capability is based on advanced broadband satellite communication through which live images can be transmitted from the seafloor to scientists ashore, classrooms, newsrooms, and living rooms, providing new educational opportunities that are a major part of *Okeanos Explorer*'s mission for advancement of knowledge.

For more information about telepresence, please see the *Introduction to Telepresence* on page 33. This lesson guides an introduction to ocean exploration aboard the *Okeanos Explorer*, and how the concept of telepresence is implemented as part of the overall exploration strategy.



Early morning view from the ship. The VSAT and rescue boats are visible. Image courtesy of the NOAA *Okeanos Explorer* Program. *http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/logs/hires/mar23-1-hires.jpg*

Learning Procedure
NOTES:

a. This lesson provides an introduction to some of the fundamental concepts of communication, the foundation for wireless communication technology, and the interdependence of science, technology and engineering in ocean exploration. Depending upon curriculum mandates and the availability of time and resources, this introduction may be extended to include additional content and activities described under Extensions on page 47.

b. This lesson includes content on the process of ocean exploration aboard the *Okeanos Explorer*, basic concepts of communication, and the technological basis for telepresence. While these topics are closely related in the context of the *Okeanos Explorer* mission, several class periods will be needed to complete the entire Learning Procedure. Educators are encouraged to adapt these topics to their own curricula, and steps in the Learning Procedure have been identified with the relevant topic to assist this process.

Senior Survey Technician Colleen Peters makes an entry in the mapping watch log book. Image courtesy of NOAA *Okeanos Explorer* Program, INDEX-SATAL 2010.
http://oceanexplorer.noaa.gov/okeanos/explorations/10index/logs/hires/mapper_hires.jpg

1. To prepare for this lesson:
   a) Review:
   - "A Day in the Life of an Explorer" by Colleen Peters (*http://oceanexplorer.noaa.gov/okeanos/explorations/10index/logs/july29/july29.html*);
   - "Implementing Telepresence: Technology Knows No Bounds" by Webb Pinner and Kelley Elliott (*http://oceanexplorer.noaa.gov/okeanos/explorations/10index/logs/july09/july09.html*); and
   - "Executing Telepresence: The Seattle ECC Comes Online!" by Kelley Elliott and David Butterfield (*http://oceanexplorer.noaa.gov/okeanos/explorations/10index/logs/june29/june29.html*).

   b) Review background information about telepresence and the *Okeanos Explorer* exploration strategy and technologies.
   c) Make copies of the two telepresence essays and the daily log for July 29, 2010 by Colleen Peters, referenced above (or students can read these directly online).
   d) If desired, download images to accompany discussions in Step 4.

2. **Basic Concepts of Communication** – Instruct students to keep a "Communication Diary" for one 12 hour day and bring it to class. In their diary, ask them to list the different communication methods they used and the reasons they chose those particular forms of communication for different situations. In class, discuss students' results. How many different forms of communication were used? Were they surprised by their results? How might their results be different 10 or 20 years ago?

   Ask students to describe the requirements for human communication. In the simplest analysis, human communication requires someone to send a message, someone to receive the message, and something that can carry the message from the sender to the receiver. Discuss some of the ways that humans send messages. In addition to verbal messages, there are many forms of nonverbal communication based on various signals. Facial expressions, gestures, and body language are well-known examples. Students should realize that signals may be passive (silence can send a powerful message under some circumstances!); and that if the sender and receiver do not attach the same meaning to a given signal, communication has still occurred. Ask students which of our senses are used for communication. With a little thought, students should realize that all five senses can be involved under some circumstances.

   Point out that communication can involve different scales of time and distance. Some signals may be received long after they are sent. Pictographs created thousands of years ago can still convey messages to "receivers" who see them.

   Sometimes the meaning of a particular message seems fairly clear. In other cases, the message may contain symbols whose meaning is much less obvious. Ask students if they ever use symbols to communicate. If students do not identify "emoticons," show a few of these symbols [such as :-) or :-(]. Ask what these symbols mean, and why they are used. Students should recognize that these symbols provide a way of quickly sending a message that might otherwise require many words to express. Point out that we have inserted two more steps in the basic model of communication: an encoding step in which the sender translates a message into one or more symbols, and a decoding step in which the receiver translates the symbols back into the ideas or words they represent. Students should also recognize that a symbol is only useful if the sender and receiver attach the same meaning to the symbol. This requirement is also useful if the sender wants to conceal a message from some receivers, and is the basis for codes and encryption.

3. **Communication Aboard a Ship** – Tell students that they are about to read about a day in the life of modern ocean explorers. Provide each student or student group with copies of the daily log for July 29, 2010 by Colleen Peters, Senior Survey Technician. Instruct students to read the log and record all obvious and probable methods of communication used in this 24-hour period aboard the *Okeanos Explore*r.

   Note: There may be terms and acronyms that are unfamiliar to your students but this should not impact the lesson. However, a glossary is provided here to use as needed.

Glossary

XBT – Expendable bathythermograph; an instrument that measures the temperature of the ocean at different depths; this information is used to calculate the speed of sound in seawater, which is used to adjust the multibeam sonar mapping system

MSD book cell – A Marine Sanitation Device (MSD) is designed to keep untreated sewage out of the ocean; a book cell produces chlorine gas from the salt in seawater using electricity; chlorine gas is used to reduce the number of microorganisms in sewage

CO – Commanding Officer; the captain of the ship

VSAT – Very Small Aperture Terminal; refers to the satellite dish antenna in the large dome on the *Okeanos Explorer*'s mast

FTP – File Transfer Protocol; a type of Web site that is used to exchange very large data files (such as video)

ECC – Exploration Command Center; a location that is equipped to exchange video, voice transmissions, and other data with the *Okeanos Explorer* and other ships equipped for telepresence

Secure – On ships, this verb means to stop doing some activity or to put away equipment so that it cannot move with the motion of the ship

ROV – Remotely Operated Vehicle; an underwater robot used to obtain video images or perform other tasks; usually connected with a cable

Students should realize that communications of various kinds are involved with many of the activities described in the log entry. These include hourly science updates, recording information in various logs, reviewing reports and data, meetings (safety, mapping products, and daily operations are mentioned specifically), and communication of orders. Methods of communication include face-to-face conversations, intercom, written logs, and satellite radio (including Internet). Crew members regularly use walkie-talkies as well, though these are not mentioned in the log entry.

4. **Ocean Exploration Aboard the *Okeanos Explorer*** – If you have not already done so, briefly introduce the NOAA Ship *Okeanos Explorer*, the only U.S. ship whose sole assignment is ocean exploration. Say that the log entry students just read was written during the ship's maiden voyage in the summer of 2010. Briefly discuss why this kind of exploration is important (for background

A NOAA Corps officer writes in one of the many logs that the bridge officers must update during their watches. These include the Deck, VHF, GMDSS, Compass, Trash and Weather Logs. Image courtesy of NOAA *Okeanos Explorer* Program, INDEX-SATAL 2010.
http://oceanexplorer.noaa.gov/okeanos/explorations/10index/logs/hires/bloss_logs_hires.jpg

information, please see the lesson, *Earth's Ocean is 95% Unexplored: So What?*; *http://oceanexplorer.noaa.gov/okeanos/explorations/10index/background/edu/media/so_what.pdf*). Students should realize that ocean exploration involves many people with many different skills. Some of these people are scientists, but operating a modern ship of exploration requires many other talents as well. (See *Appendix B: Ocean Exploration Careers*).

Highlight the overall exploration strategy used by *Okeanos Explorer*, highlighting the following points:

a. The overall strategy is based on finding anomalies.
b. This strategy involves three major activities:
    - Underway reconnaissance;
    - Water column exploration; and
    - Site characterization.
c. This strategy relies on four key technologies:
    - Multibeam sonar mapping system;
    - CTD and other electronic sensors to measure chemical and physical seawater properties;
    - A Remotely Operated Vehicle (ROV) capable of obtaining high-quality imagery and samples in depths as great as 6,000 meters; and
    - Telepresence technologies that allow people to observe and interact with events at a remote location.

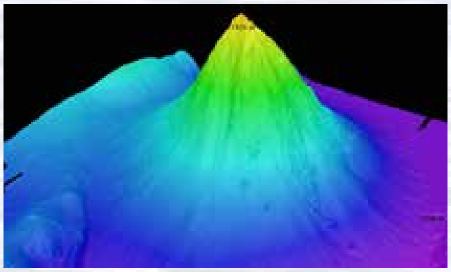
You may want to show some or all of the images in the adjacent sidebar to accompany this review.

5. **The Technological Basis for Telepresence** – Ask students how we can communicate over long distances. Point out that this almost always involves some type of technology, ranging from smoke signals to microwaves (for purposes of this discussion, we do not get into ideas about mental telepathy). Students are likely to identify various types of telecommunications (such as television, cell phones, satellites, radio, and wireless Internet) as technologies that support communication over long distances. Say that these technologies are all based on the principles of radio communication (this is explored in more detail in Step 6). Some students may consider radio to be an old-fashioned or even out-dated technology, but the basic principles of radio communication are the foundation of modern wireless communications including remote controls, cell phones, satellite television, and wireless Internet.

(a) Have students read the two essays on telepresence from the INDEX-SATAL 2010 Expedition:

- "Implementing Telepresence: Technology Knows No Bounds" by Webb Pinner and Kelley Elliott (*http://oceanexplorer.noaa.gov/okeanos/explorations/10index/logs/july09/july09.html*); and
- "Executing Telepresence: The Seattle ECC Comes Online!" by Kelley Elliott and David Butterfield (*http://oceanexplorer.noaa.gov/okeanos/explorations/10index/logs/june29/june29.html*).

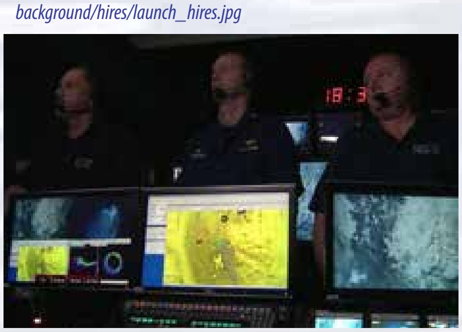
Ask students how they think telepresence benefits ocean exploration. Students should recognize that telepresence not only enables scientists at sea to communicate with scientists ashore, but also with other interested parties as well. This means that many people can be directly involved with exploration



Okeanos Explorer's EM302 multibeam sonar mapping system produced this detailed image of the Kawio Barat seamount, which rises around 3800 meters from the seafloor. Image courtesy of NOAA *Okeanos Explorer* Program, INDEX-SATAL 2010.
http://oceanexplorer.noaa.gov/okeanos/explorations/10index/logs/hires/june26fig1_hires.jpg

A CTD is attached to a metal frame called a rosette, or carousel, along with numerous water sampling bottles and when deployed, provides information about the composition of the water column. Image courtesy of NOAA.
http://oceanexplorer.noaa.gov/technology/tools/sondectd/sondectd.html

Okeanos Explorer crew launch the vehicle during test dives off Hawaii. Image courtesy of NOAA *Okeanos Explorer* Program, INDEX-SATAL 2010.
http://oceanexplorer.noaa.gov/okeanos/explorations/10index/background/hires/launch_hires.jpg



ROV Team Lead, Commanding Officer, and Science Team Lead discuss operations at the Mid-Cayman Rise with participants located at both the Silver Spring ECC, and URI's Inner Space Center. Image courtesy of NOAA *Okeanos Explorer* Program, MCR Expedition 2011.
http://oceanexplorer.noaa.gov/okeanos/explorations/ex1104/logs/hires/daily_updates_aug9_1_hires.jpg

activities and discoveries as soon as they happen, which means that ocean exploration can happen faster, more efficiently (more people involved at less cost), and cover more area; in other words, telepresence increases the pace, efficiency, and scope of ocean exploration.

(b) Have students watch the following short video clips from the 2012 Gulf of Mexico Expedition:
http://oceanexplorer.noaa.gov/okeanos/media/exstream/exstream_playlist.html
March 26, 2012
March 29, 2012
April 6, 2012

Tell them that the ROV dives from this expedition were streamed live through the internet so that anyone with an internet connection could see and hear about the discoveries as they were happening. As students are watching each video, have them record the communications they observe. Who do they think was communicating with whom? How were they communicating? You may have to review the possible "players" involved, such as ship crew members (the Bridge), scientists on board the ship, scientists on shore, ROV pilots/navigators, and ROV lead operators.

Discuss students' observations. Given their new background on telepresence technology, they should have noticed communication between the ship's bridge crew and the ROV pilot; the scientist and the ROV pilot; the scientists on the ship with scientists on shore; and one-way communication between the scientist and the public via the Internet.

Having the ability to communicate and consult at sea is one of the great benefits of telepresence. Tell students that during ROV dives, an Internet-based intercom system allows all participants, regardless of location, to easily communicate with all other participants. The real-time voice communication is supplemented by a real-time text-based collaboration tool. This text-based tool, commonly referred to as "the Eventlog", allows ship-based and shore-based participants to write their observation to a common log. The log entries made by individuals are immediately disseminated to all other users in real-time, allowing all participants, regardless of location, to see the observations made by their peers. All users on the ship and at the ECCs are encouraged to participate in the Eventlog as all observations and insights are welcome. To help with the post-cruise analysis, each log entry includes the date and time the entry was made, the author and the text observation. The date and time matches the date and time used aboard the *Okeanos Explorer*. This simplifies post-cruise data, and video searches. The Eventlog tool leverages the same technology and standards-based protocols used on the Internet for Instant Messages (IM) and chatrooms. Table 1 lists some of the abbreviations that are used in Eventlog entries to name various organisms. Figure 1 shows a sample Eventlog.

(c) Discuss the importance of communication to science. Students should realize that science is absolutely dependent upon communication, because the scientific process is based on the idea of testing hypotheses, then reporting the results to others who can verify those results or find additional information

Table 1. Some Eventlog abbreviations for various groups of animals

ACN	Actinaria
APH	Amphipod
ART	Arthropod
ASR	Asteroid
BAR	Barnacle
BIO	Biology (Unspecified)
BIV	Bivalve
BRY	Bryozoan
CHI	Chiton
CHN	Chondrichthyes
CNI	Cnidarian
COR	Coral
CRA	Crab
CRI	Crinoid
ECN	Echiuran
EGG	Egg case
FEC	Fecal matter
FSH	Fish
GAS	Gastropod
GRO	Gromiid
HOL	Holothurian
HYD	Hydroid
ISO	Isopod
JFH	Jellyfish
LOB	Lobster
MAT	Bacterial Mat
MOL	Mollusk
NUD	Nudibranch
OCT	Octopus
OPH	Ophiuroid
PAG	Pagurid (hermit)
PEN	Pennatulacean
POL	Polychaete
SCA	Scale worm
SHI	Shrimp
SPO	Sponge
SQA	Squat lobster
SQD	Squid
STY	Stylasterid
TUN	Tunicate
URC	Urchin
USO	Unidentified sessile object
WOD	Wood
WOR	Worm
XEN	Xenophyophoran
ZOA	Zoanthid

Figure 1. Excerpt from Eventlog for July 11, 2010

2010-07-11	01:56:29	jonathanrose	FSH
2010-07-11	01:56:57	okeanosexplorer	we'll try to get a few for him
2010-07-11	01:57:10	okeanosexplorer	depth is 48m, heading is 57
2010-07-11	01:57:16	okeanosexplorer	458m
2010-07-11	01:57:18	cherissedupreez	SQA
2010-07-11	01:57:40	davebutterfield	the light-colored material around the base of the rocks is primarily coral debris.
2010-07-11	01:58:14	okeanosexplorer	large stalked CRI
2010-07-11	01:58:23	okeanosexplorer	SQA
2010-07-11	01:58:25	okeanosexplorer	SHI
2010-07-11	01:58:30	okeanosexplorer	STY's
2010-07-11	01:58:35	okeanosexplorer	with OPH's
2010-07-11	01:58:49	okeanosexplorer	very neat SPO's
2010-07-11	01:58:58	jonathanrose	FSH
2010-07-11	01:59:00	okeanosexplorer	purple COR
2010-07-11	01:59:13	dustinschomagel	ROV Depth 452 Hdg 62 deg
2010-07-11	01:59:34	okeanosexplorer	URC

that builds on them. For this reason, the pace of scientific discovery and progress is highly dependent upon the rate at which communication can take place. In the case of the *Challenger* Expedition, for example, 19 years were required before all of the scientific results of the expedition were available; and until those results were published, there was no way for other scientists to build on the findings of the expedition. Ask students whether they think it is important for scientists to communicate with the public or if communicating with other scientists is enough. There are a number of reasons that public communication is also essential to science, including:

- Many scientists depend upon public funding to support their work, and if people do not understand why this work is important, funding may be difficult to obtain;
- Often, information from scientific investigations may be important to formulating public policies, but people need to understand this information before they can use it; and
- Non-scientists can be important to scientific investigations and discoveries as well as professional scientists (for example, Kathryn Aurora Gray, a ten-year-old Canadian student who discovered a supernova on New Year's Eve, 2010).

6. **It's All About Waves** – Remind students of the basic model of human communication (sender, receiver, and something to carry messages between them), and say that they are going to explore how this model applies to the way that telepresence is implemented aboard the *Okeanos Explorer*. Aboard the ship, the "sender" in our basic model is anyone who has a message or information that they wish to send to one or more "receivers" in another location including Exploration Command Centers. Telepresence, by definition, involves communicating with remote locations, and the "something to carry messages" is a modern version of radio technology.

Ask students to identify the thing that carries their message when they use a cell phone. Students should (possibly with your help) identify radio waves as the "message carrier," and should recognize that these waves are a form of electromagnetic radiation. Other familiar forms of electromagnetic radiation include light and microwaves.

Ask students to name some different kinds of waves. Answers may include sound waves, light waves, radio waves, microwaves, ocean waves, stadium waves, earthquake waves, and slinky waves (students may think of others as well).

Ask for two volunteers, and have them hold opposite ends of a piece of rope with enough slack so that a wave will form when one end of the rope is repeatedly raised and lowered. Instruct the two students to form a wave in the rope. Have other students make a sketch of the wave.

Discuss the following questions (you may choose to have students write their answers first, or just discuss each question with the entire class):

- What moved in the rope wave?
- As the wave moved along the rope, was anything moved from one location to another location?

Students should realize that portions of the rope moved in the rope wave, but that nothing ended up in a different location. Students may be puzzled by this point, because in both cases they saw "something" moving from one place to another. Encourage students to think again about exactly what they saw, and provide sufficient hints to lead them to identify a disturbance as the "thing" that moved, and that the disturbance was caused by an input of energy that moved through the system with the wave. The energy caused portions of the rope to temporarily move from their original positions, but they returned to these positions when the energy moved to adjacent portions.

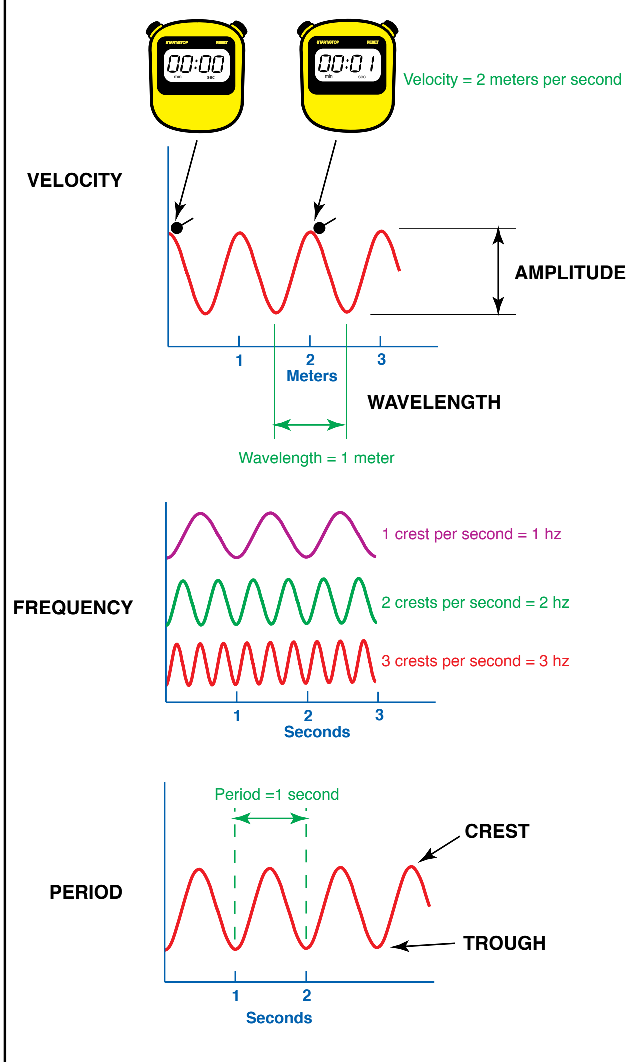
Explain to students that all waves have three features in common:

- They are energy transport phenomena. This means that they are involved in transporting energy, but do not transfer matter.
- The energy of waves moves in specific patterns.
- Waves have characteristics that include wavelength, amplitude, velocity, and sometimes frequency.

Discuss the following features of waves, and have students label them on their sketches (see Figure 2):

- Wavelength – the distance over which a wave's shape repeats (you can also think of it as the distance between successive crests or troughs of a wave)
- Amplitude – the height of a wave
- Velocity – how fast the crest of a wave is moving from a fixed point

Figure 2



- Period – the amount of time it takes for one point on a wave to complete its full range of motion and return to its original position
- Frequency – the number of crests that pass a given point in a certain amount of time
- Crest – the highest point of a wave
- Trough – the lowest point of a wave between crests

8. **Essentially, It's All About Radio Waves** – Ask students how they think the rope wave differs from a radio wave. Students (possibly with some help) should realize that rope waves require a medium (the rope) through which they can transfer energy (this type of wave is called a mechanical wave). Radio waves, on the other hand, do not require a medium. These waves are composed of an electric field and a magnetic field that are oscillating (moving back and forth) together, and are called electromagnetic waves (these waves are sometimes described as the movement of particles called photons, which are massless packets of energy that travel at the speed of light).

   Say that now we know something about the radio waves that are used to implement telepresence, and ask students how we send radio waves from one place to another. Students should identify that a device (technically called a transmitter, but students may suggest other names) is used to send radio waves, and may also identify an antenna as a necessary component of the system. Some students may have had experience with walkie-talkies, which should suggest these answers. Students may also identify satellites as a necessary component of the communications system. For telepresence as it is implemented aboard the *Okeanos Explorer*, satellites are definitely needed. Radio waves were transmitted without satellites for many years before satellites became available, and often are still transmitted this way; but satellite communications are much more reliable, particularly when the transmitting and receiving stations are thousands of miles apart. Satellites used for this kind of communication are sometimes called repeaters, because they receive signals that are transmitted to them, and then re-send these signals to receivers. So, the elements of our basic communications model have appeared again: transmitters, receivers, and things that allow messages to be exchanged between them.

   Point out that we now know that radio waves transport energy, and we know something about how those waves are sent from one place to another. Ask students, "How do we use this process to send a message?" Some students may know that in the early days of radio, messages were sent by basically turning the transmitter on and off in a pattern that formed a code, and this code was used to send messages (in fact, this is also how messages were sent on radio's predecessor: the wire telegraph). Some students also may be familiar with Morse code, which is still used to send messages this way. To send voice, music, or visual messages, though, we need an alternative approach.

   This alternative involves changing the radio waves when they are sent so that the changes incorporate the desired message, then having a receiver that can "read" the changes and reproduce the message. The process of changing the radio wave is called modulation, and the process of extracting the message from a modulated radio wave is called demodulation. A device that can modulate and demodulate is called a modulator-demodulator, or modem for short. The Modulated LED activity referenced under Extensions demonstrates this process with light; which, of course, is also an electromagnetic wave like radio waves, only with a different frequency and wavelength. Depending upon available time and resources, this activity may be done:

- by the educator as a demonstration, or
- by one or two groups of students as a demonstration, or
- by all students working in small groups with each group performing the activity independently, or
- viewed as a video demonstration (e.g., *http://www.youtube.com/watch?v=n0f7blVJIIg*)

Once students have done the activity or observed a demonstration, discuss why this works, and some of the factors that influence the effectiveness of message transfer between the sender and receiver. Be sure students understand that the output from the radio or media player is an electric current that replicates a sound that originated somewhere else. This current is added to the current from the battery, and causes the light emitting diode (LED) to flicker as the current varies. The solar cell converts light energy to an electric current. When light from the LED strikes the photocell, a current is produced that varies according to the intensity of the light. The current from the photocell is converted into sound energy by the amplified speaker.

Factors that influence the effectiveness of message transfer include the distance between the sender and receiver, the amount of interference from stray light striking the solar cell, and the strength of the signal from the radio or media player. Signal strength compared to background noise is a factor that influences many other kinds of communication; consider trying to have a conversation in a noisy room, or trying to read words on a page that is cluttered with random pictures or colors. Ask students how the message transfer system might be improved. One possibility is to focus light from the LED so that it is concentrated on the solar cell. This is the idea behind using an antenna, and is why the *Okeanos Explorer* needs a large dish to send its wireless signals to the satellite that relays these signals to receivers in Exploration Command Centers.

Technicians work to repair the satellite antenna in the VSAT dome. Image courtesy of NOAA *Okeanos Explorer* Program.
http://oceanexplorer.noaa.gov/okeanos/explorations/ex1103/logs/hires/dome_hires.jpg

Adaptations to Other Grade Levels

Grades 5 – 6: Use the guided imagery in the lesson *Journey to the Unknown* to help students visualize the communication techniques involved in telepresence and generate excitement about ocean exploration.
http://oceanexplorer.noaa.gov/okeanos/edu/collection/media/wdwe_journey.pdf
Omit the discussion of radio waves in Step 6.

Grades 9 – 12: Have students complete Extension activities 1 – 3. See Extension activities 4 and 5 for additional activities and content.

The BRIDGE Connection

www.vims.edu/bridge/ – Scroll over "Ocean Science Topics" in the menu on the left side of the page, then "Human Activities," then click on "Technology" for activities and links about satellite communications and other ocean exploration technologies.

The "Me" Connection

Have students write a short essay describing how telepresence could be of personal benefit.

Connections to Other Subjects

English Language Arts, Mathematics, Social Studies

Assessment

Class discussions provide opportunities for assessment.

Extensions

1. Listen to a beam of light – The Modulated LED demonstration from the Exploratorium® in San Francisco, California, shows how audio signals can be carried in visible light, similarly to the way signals can be carried in radio waves (both light and radio waves are forms of electromagnetic radiation). See *www.exploratorium.edu/square_wheels/modulated_led.pdf*
2. Make the simplest radio – See *http://www.midnightscience.com/oat-box-project.html*, which includes links to directions for ordering kits or a manual that explains how to make the simplest radio from parts you find yourself.
3. Mathematics - Frequency and wavelength of electromagnetic waves are related by the formula:

$$W = C \div F$$

where W is wavelength in meters, C is the velocity of the wave, and F is frequency in hertz (cycles per second). The velocity of electromagnetic waves is the velocity of light, which is 300,000,000 meters per second. Information about wavelength is used to design antennas for radio communication. From the information given in the sidebar on page 33—From the Ship to the Sky—what wavelengths correspond to the frequencies used for satellite communications on the ship?
4. Find out more about wireless communications and amateur radio: The American Radio Relay League (the national association for amateur radio) has extensive resources about wireless technology including curricula, lesson plans, free downloads, kits, and projects; see *http://www.arrl.org/etp-classroom-resources*.
5. See *Earth's Ocean is 95% Unexplored: So What?* and *Living Light* (*http://oceanexplorer.noaa.gov/okeanos/explorations/10index/background/edu/media/so_what.pdf* and *http://oceanexplorer.noaa.gov/explorations/09bioluminescence/background/edu/media/ds_09_livinglight.pdf*, respectively) for information about scientific communication using wall magazines and scientific posters.

Multimedia Discovery Missions

http://www.oceanexplorer.noaa.gov/edu/learning/welcome.html Click on the links to Lessons 5 and 6 for interactive multimedia presentations and Learning Activities on Chemosynthesis and Hydrothermal Vent Life and Deep-Sea Benthos.

Other Relevant Lesson Plans from NOAA's Ocean Exploration Program

Earth's Ocean is 95% Unexplored: So What?

(from the INDEX-SATAL 2010 Expedition)

http://oceanexplorer.noaa.gov/okeanos/explorations/10index/background/edu/media/so_what.pdf

Focus: Importance of deep-ocean exploration (Grades 5-6; Life Science/Earth Science)

Students describe at least three different deep-ocean ecosystems; explain at least three reasons for exploring Earth's deep ocean; and explain at least three ways that deep-ocean ecosystems may benefit humans; and create a wall magazine to communicate scientific ideas.

Journey to the Unknown
(from the *Okeanos Explorer Educational Materials Collection*)
http://oceanexplorer.noaa.gov/okeanos/edu/collection/media/wdwe_journey.pdf
Focus: Ocean Exploration (Grades 5-6; Life Science/EarthScience)
Using guided imagery, students experience the excitement of discovery and problem-solving to learn what organisms could live in extreme environments in the deep-ocean and understand the importance of ocean exploration. Students also posterize images and construct an ultraviolet LED poster illuminator.

Next Generation Science Standards

Lesson plans developed for Volume 2 are correlated with *Ocean Literacy Essential Principles and Fundamental Concepts* as indicated in the back of this book. Additionally, a separate online document illustrates individual lesson support for the Performance Expectations and three dimensions of the Next Generation Science Standards and associated Common Core State Standards for Mathematics and for English Language Arts & Literacy. This information is provided to educators as a context or point of departure for addressing particular standards and does not necessarily mean that any lesson fully develops a particular standard, principle or concept. Please see: *http://oceanexplorer.noaa.gov/okeanos/edu/collection/hdwe_ngss.pdf*

Send Us Your Feedback

We value your feedback on this lesson, including how you use it in your formal/informal education settings.
Please send your comments to:
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