Sound & Observation: Listening for Clues Using Real-Life Acoustic Recorders

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ABSTRACT
This article presents a classroom activity for grades 4 to 6 based on real research from the Hawai’i Institute of Marine Biology Northwestern Hawaiian Islands Research Partnership. Students learn how scientists use sound to observe and monitor marine environments. The Ecological Acoustic Monitoring tool is used to help students practice observation skills and understand biological concepts such as sound, coral reef ecosystems, scientific method, field research, and environmental monitoring, as well as marine species’ behavior. Instructions, background information, materials, and activity discussion are provided.

Key Words: Sound, observation, science activity, environmental monitoring, coral reefs.

The Hawai’i Institute of Marine Biology (HIMB) is a research facility located on an island off ‘Oahu. Coconut Island (Moku o Lo’e) is surrounded by 64 acres of protected coral reef and offers an excellent location to many scientists studying coral reef ecosystems. Through a partnership with the National Oceanic and Atmospheric Administration’s (NOAA) Office of National Marine Sanctuaries, HIMB scientists travel to the Northwestern Hawaiian Islands to conduct ecosystem-based science to help inform the management of this place. The Northwestern Hawaiian Islands were designated as the Papahānaumokuākea Marine National Monument (hereafter “Monument”) in 2006, offering the highest level of protection to roughly 140,000 square miles of low-lying islands and atolls (see Figure 1). This area is habitat for over 7000 marine species, such as the critically endangered Hawaiian monk seal, and is one of the most isolated archipelagoes in the world. One of seven research initiatives through this partnership looks at monitoring these remote coral reefs using sound. Here, we provide background, materials, procedure, and the information needed for an activity exploring how scientists use sound to monitor marine environments. Students will learn how to listen, observe, and translate what they hear to observation graphs. This classroom activity can be adapted for a variety of age groups but is targeted for grades 4 through 6.

Background
Scientists use sound to monitor environments for many things, including animals, weather, natural events, and anthropogenic phenomena. Monitoring the changing status of coral reef environments and their inhabitants is a critical management need and a considerable technological challenge, especially on reefs in remote locations, such as those in the Northwestern Hawaiian Islands. Understanding the interactions between species in coral reef communities requires long-term observation of relationships. However, although existing monitoring instruments are capable of measuring long-term physical environmental trends, they currently lack the ability to observe most biological processes.

The study of acoustics employs the sense of hearing and the science of sound. The use of acoustic tools to record biologically produced sounds in aquatic environments such as oceans is becoming a method of choice for assessing and monitoring activity in remote habitats. This is important, as conventional survey methods are often impractical or not cost effective in very distant locations. Acoustics can be used not only in distant locations but in everyday biological research. This is because many species of fish, invertebrates, and marine mammals regularly produce sounds for communication, display, and environmental sensing. In addition, acoustic monitoring is also an effective means of detecting human activities in a marine habitat, such as vessel traffic and explosives used in fishing. Acoustic monitoring can provide a cost-effective means of logging both biological activity and human presence and, thus, can help gauge biological patterns and the effectiveness of management practices (NOAA National Marine Fisheries Service, 2007).

The Story of the EAR
The Ecological Acoustic Recorder (EAR) is a digital, low-power acoustic recording system designed to sample the ambient sound field (see Figure 2). Systematic monitoring of sound-producing species on coral reefs helps to document various species, their distribution patterns, and...
changing levels of activity (Lammers et al., 2008). There are two types of EAR devices: a deep-water version that is rated to a depth of 1000 m and a shallow-water version for use to depths of 36 m or less. The deep-water EAR is recovered by activating a release that allows the recorder to float back to the surface. It can be deployed for up to 6 months. The shallow-water EAR is deployed by divers and can be left in place for a year or longer, depending on the number of batteries used and the recording schedule.

Recordings are made on a user-specified schedule and are also initiated on a start trigger set to specific acoustic-energy thresholds, such as vessel engine noise. Four EARs were deployed in the Northwestern Hawaiian Islands in September 2006. The units were set to record the ambient sound field for 30 seconds every 15 minutes and also to trigger on events. Since 2007, the recovered units have made between 25,068 and 30,099 recordings (Lammers et al., 2008).

Preliminary Findings

Preliminary results have shown that one atoll in the Northwestern Hawaiian Islands, Pearl and Hermes, had the highest noise level measured by an EAR deployed in the entire Pacific. Noise levels showed a distinct diel pattern, with nearly twice the acoustic energy at night as during the day. There was also a strong relationship between water temperature measurements and sound levels. Therefore, it is possible that the acoustic energy of this area is tied to high levels of productivity in the water (Lammers et al., 2006).

An EAR deployed in Monument waters recorded numerous instances of marine mammals. Dolphin signals were common, and the song of humpback whales (*Megaptera novaeangliae*) was frequently recorded (Lammers et al., 2009). One or more whales were recorded singing, with the greatest frequency occurring between the end of February and March. The timing and occurrence of song indicate that humpback whales use the Monument as a wintering ground in a manner similar to their use of some areas in the main Hawaiian Islands (Lammers et al., 2009).

Additionally, the EARs revealed many varying fish sounds at all locations, which can lead to important information for long-term monitoring. Some fish are acoustically active during daylight hours, whereas others produce sounds before sunrise and just after sunset. The EAR also traced a source of dominant sound on coral reefs to snapping shrimp. Pulses of sound produced by the shrimp exhibit clear trends...
with peaks of activity occurring around times of sunrise and sunset (Lammers et al., 2008).

○ **Sound Graphs**

The EAR recordings can demonstrate sound patterns when documented acoustic activity is converted to sound graphs. Sound pressure levels are contrasted against different species, locations, water temperature, dates, and times of day. The sounds of interest to researchers include those of snapping shrimp, fish, marine mammals, and vessel traffic (boats). The scientists take the acoustic waves that are generated and represent them in a visual manner using graphs for analysis. The spaces between lines on the graph demonstrate the decay in time between sound waves (see Figure 3).

○ **Activity at a Glance**

Students learn to associate sound with species identification through a listening activity and develop their own sound graphs. In the process, they gain understanding of scientific inquiry and observation using sound.

○ **Key Concepts**

- Observation through sound can tell us about our environment.
- Acoustic study examines sounds to determine various biological and human patterns of presence and activity.
- Scientific inquiry can be used to develop an understanding of ecosystems.

○ **Assessment**

- Students can explain how sound is used in science and management, why it is important to listen to and record sound in the environment, and what sound can tell us.
- Students can spend time actively observing their environment by listening to and recording sound.
- Students can produce their representation of sound through the associated sound graph outline and draw comparisons to other students’ sound graphs.
- Students can apply the knowledge they have acquired to other current events (extension activity).

○ **Vocabulary**

*Acoustics.* The study of sound.

*Ambient sound.* Sound in the surrounding environment.

*Anthropogenic noise.* Noise produced by human activities (i.e., noise produced by boat motors).

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**Figure 3.** A sound graph showing EAR recordings of snapping shrimp acoustic patterns over 10 days (RMS SPL = root-mean-square sound pressure level; graph courtesy of NOAA Coral Reef Ecosystem Division).

**Figure 4.** Sound graph handout. Have students listen to a series of EAR animal-sound recordings and write what animal they think is producing each sound. Have them draw the sound patterns to create a visual representation of the sounds on each graph.
Diel pattern. Patterns occurring through a 24-hour period, or on a regular daily cycle, as part of the physiology or behavior of an organism. 

Ecological Acoustic Recorder. A digital, low-power acoustic recording system designed to systematically sample the underwater environment for sound. There are two types of devices: a deep-water and a shallow-water EAR. Developed by Marc Lammers (HIMB) and NOAA Coral Reef Ecosystem Division.

Materials
- EAR animal-sound recordings (available at http://oceanfest.soest.hawaii.edu/links.htm)
- Sound graph template (see Figure 4)
- Writing tools
- Computer to access animal-sound recordings

Teaching Suggestions
1. Review associated material with students.
   - Discuss where the Northwestern Hawaiian Islands are located, the formation of the Papahānaumokuākea Marine National Monument, and the Hawai'i Institute of Marine Biology Research Partnership.
   - Ask students about sound. What does the ocean sound like? What sounds do they hear, etc.?
2. Ask students to observe sound.
   - Have students stop and observe for a moment. What sounds do they hear?
3. Explain acoustic recording, the EAR, and biological monitoring.
   - Ask students what sounds they think would be important in this study.
   - Pass around an EAR diagram or EAR model (if available) for students to examine.
   - Ask students to interpret preliminary findings. Why do they think Pearl and Hermes Atoll is so noisy? Would the ocean sound different in different places in the world?
4. Listen to the underwater sounds (provided online) and draft individual sound graphs.
   - Ask students to guess what they are listening to. What can this tell us?
5. Explain the use of sound graphs.
   - Ask students to listen again to the recordings, this time drawing a sound graph based on what they hear.
6. Ask students to display their graphs and compare them with others in the class.
   - How do the graphs differ? How are they the same?

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References

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