Bioacoustics

If you are doing this lesson in your classroom on your own, you can download or play sounds from: http://www.nefsc.noaa.gov/psb/acoustics/sounds.html or http://cetus.ucsd.edu/voicesinthesea_org

Background:

(excerpted/adapted from http://cetus.ucsd.edu/voicesinthesea_org/education.html lesson 4)

The ocean is a habitat where light does not penetrate very far. For whales, however, this vast 3-dimensional world is far from dark. The ocean is illuminated by sound, which travels much farther than light underwater. The sounds of waves and storms at the surface, of earthquakes and underwater landslides, of schooling fish, and of whales fill the underwater world. Whales use these natural sounds and sounds that they produce for just about every aspect of their lives. In these lessons, students will be learning about the importance of sound to marine mammals. This will provide background information on sound underwater and ways in which whales use it to navigate, to hunt for food, and to communicate with one another.

Sound energy travels as a wave. The frequency, or number of waves that travel past the ear in one second, is measured in hertz (Hz). Humans can hear sounds as low as 20Hz, or 20 waves passing the ear per second, and as high as about 20,000Hz. The intensity (loudness) of a sound is measured in decibels (dB). The softest sound a human with perfect hearing can detect is 0dB and the most intense sound a person can be exposed to without instant hearing damage is 160dB. Whales have acute hearing and can hear a much broader range of frequencies than people.

All whales produce sound. Just as no two species look or behave the same, no two species make the same set of sounds. Toothed whales, like dolphins and porpoises, make click-type sounds and most also produce whistles in the higher frequencies. Baleen whales, like right whales and fin whales, make a wide variety of lower frequency tones like upsweep or downsweep calls.

The clicks that toothed whales make are used for echolocation. This is a method of navigation underwater in which the whale produces a sharp, impulsive sound like a clapping hand and then interprets the echoes from that click off of objects in the water. These echoes returning from all directions help the whale to form a 3-dimensional picture of its environment. Like an ultrasound used to create a sonogram of an infant in the womb, high frequency clicks give a large amount of detail and can even be used to investigate the inner layers of certain objects, like fish.

Dolphins, beaked whales, and porpoises generally make high-frequency clicks. The trade-off of higher frequencies underwater is that they don't travel as far as lower frequencies. Sperm whales make clicks that are lower and much more powerful than dolphins. Although they may not provide the high resolution of higher frequency clicks, these clicks travel much farther and help the whales to find patches of food from greater distances.

In addition to clicks, most toothed whales also produce whistle-type sounds. These are used for communication between animals in a group. Bottlenose dolphins, for example, make a wide variety of

whistles to communicate with one another. Each dolphin also makes its own unique sound called a signature whistle. Scientists studying these signature whistles believe that they may be like a dolphin saying its name in order to identify itself to pod mates.

Whale researchers use sound recorded through underwater microphones, or hydrophones, as a method of detecting, tracking, and identifying whales. One way to analyze these signals from the hydrophone is to digitize them using a computer and to display them as a spectrogram. A spectrogram is a way to visualize sound like a picture. The computer draws an image of a sound over time that puts higher frequencies above lower ones, like the sheet music that musicians read. It also shows the intensity of the sounds by color or contrast. To see spectrograms of the clicks, whistles, tones, and sweeps produced by various species of marine mammals, please visit the Northeast Fisheries Science Center acoustics website: (http://www.nefsc.noaa.gov/psb/acoustics/sounds.html) or the Voices in the Sea website: (http://www.voicesinthesea.org).

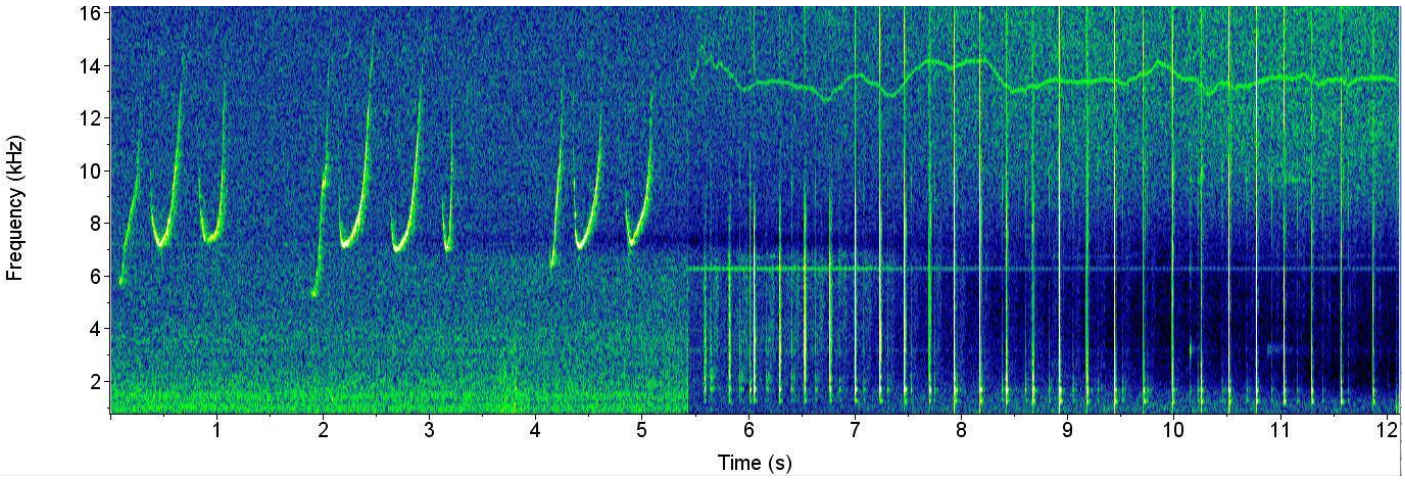

Fig.1: Spectrogram of white-beaked dolphin whistles and clicks. Frequency is displayed top to bottom while time is displayed left to right. More intense sounds are bright green.

Humans also introduce sounds into the ocean. Exploration for undersea natural resources, naval sonar, geophysical research, marine industry, fishing activities, and ships of all types produce sounds. In some areas, these man-made sounds are so loud that they may have an effect on a whale's ability to communicate or to navigate. While the effects of increasing noise pollution in the ocean are not well known, certain types of sound, like high-intensity military sonar, appears to cause injury to highly-sensitive species like the beaked whales. This is another reason that it is important to understand how whales use sound.

Lesson:

Introduce yourself as a representative of NOAA and PSB. Show students (**slide 1**) where we are located in Woods Hole.

Introduction (5 minutes):

Questions to ask while showing the slideshow intro (***Always ask the questions, generate answers on the board and THEN show the slide with information****):

(a) We'll be talking about marine mammals and sound today. What is a marine mammal? (**slide 2**)

(b) Does anyone know what the word bioacoustics means? (**slide 3**)

(c) Why do we (humans) make sounds? List their ideas on the board.

(d) Why do you think marine mammals make sound (**slide 4**)? List their ideas on the board.

(e) Why is it important that we can identify marine mammals by their sound?

Activity 1:

BLIND FIND

Goals:

- Demonstrate the large amount of information contained in sound.
- Demonstrate how sound is used to gather information.

Materials:

- Blindfold

1. Have the class form a circle facing inward.

2. Demo the activity by putting the blindfold on the teacher. Put him or her in the middle of the circle. The teacher in the middle of the circle will be trying to identify other people in the circle using sound only.

3. Spin the blindfolded person twice, then point him or her at someone in the circle. The person in the circle should say, 'Hi _____' (blindfolded person's name) in his/her normal voice.

4. The blindfolded person can say hello and ask the person in the circle any question other than one that would identify them. For example, they can ask, "What did you have for dinner last night?"

5. Using this information, the blindfolded person is to make his/her best guess at who is talking to him/her, then respond "Hi _____" (the name of who he/she thinks it is)

6. Let several students try.

7. Repeat steps 4-7 but play the ship noise from the speakers at the same time (**slide 5**).

8. Have the students sit down and discuss the following questions with the class:

   a) Were students surprised with their success in identifying people in the circle?

   b) What were some of the things that they could tell about the speaker, just in those two words? (*Male or female, age, identity, are they sick or healthy, were they smiling or laughing, are they a friend, where are they in relation to the blindfolded student*?)

   c) Why do you think marine mammals use sound more than touch/sight/etc?
      - *Using sounds of many types (clicks, whistles, songs), whales can determine many things about each other and their surroundings without having to use their eyes. 100-foot visibility underwater is extraordinarily rare. The underwater world is often too dark or murky to rely on eyesight alone. Sound also travels much farther in water than air* (**slide 6**). (excerpted from http://cetus.ucsd.edu/voicesinthesea_org/education.html, lesson 4)

   d) How did having the extra ship noise affect how well the student could gather information? How do you think ship noise affects whales in the ocean?

Activity 2:

WHOSE SOUND IS IT ANYWAY?

Goals:

- To describe how whales use vocalizations as part of their common behaviors
- Demonstrate how we can identify marine mammals by their vocalizations
- Describe how sound can be used in marine mammal conservation

Materials:

- 26 laminated pictures of a whale, 26 laminated pictures of a dolphin, 26 laminated pictures of a seal
- Slide show of spectrograms
- Sounds can be downloaded from http://www.nefsc.noaa.gov/psb/acoustics/sounds.html

1. Explain to the students that they will be an acoustician (bioacoustic scientist) trying to identify the animal sounds their hydrophones are picking up (a hydrophone is an underwater microphone).

2. First we will listen to some marine mammal sounds and look at their spectrograms. A spectrogram is a picture of the sound. As they listen to the sounds, ask them what each sound sounds like (example: the humpback whale sounds like a haunted house, the bearded seal sounds like an alien). Also ask them to compare the sounds. Does the bottlenose dolphin sound more like the Atlantic Spotted Dolphin or the Minke Whale? (**slides 7 & 8**)

3. Tell the students we are now going to play a game. Give each student a whale picture, dolphin picture, and seal picture. Tell them you are going to show them a spectrogram and play them a sound. They will have to hold up the picture of the marine mammal they think made the sound.

4. Play the first "Who am I" sound (**slide 9**), have the students hold up the picture of their guess, and write the number of students who chose whale, dolphin, and seal below the picture on **slide 10**.

5. Say you will now tell them a few facts about the marine mammal they just heard (**slide 11**). After sharing the marine mammal facts, ask them to guess which marine mammal they think they heard. Write their votes in the box (**slide 12**).

6. Show them the picture of the actual marine mammal they were hearing (**slide 13**).

7. Follows steps 4-6 twice more with the following slides (**slides 14 through 33**).

Discussion:

1. Why is it important for us to know what sounds each marine mammal makes?
   - *Sometimes we cannot see the marine mammals, but we can hear them. That allows us to know what marine mammals are in the local area when we otherwise wouldn't.*

2. How can you use whale sounds to protect them? Show them the Right Whale Listening Network (**slide 34**). Tell them that they are looking at buoys that listen for North Atlantic right whales. Fisherman can put the whale alert app on their iPads and smartphones so they know whether there are endangered right whales around and when and where they need to slow down to avoid collisions.

Activity 3:

FIND YOUR POD

Goals:

- To describe how whales use sounds to locate their podmates.
- To demonstrate how excess sound in the ocean can affect a whale's ability to use vocalizations.

Materials:

- One instrument per student.

1. Ask the students why they think different species of whales might have different vocalizations or calls (*To tell each other apart, different hunting and feeding strategies, different social patterns, etc*.)? Distinguish between vocalizations and echolocation. Echolocation is the

process by which animals emit sounds and are able to detect objects, including food, when the sound waves return to them (like a submarine's sonar). Vocalization is using sounds to communicate.

2. Ask the students why different populations within one whale species, such as orcas, might have different dialects, or types, of calls? (*E.g. feed on different prey, to tell one pod from another*.)

3. Explain to the students that each of them is an orca (**slide 35**), and they will be searching for their "pods". As orcas use squeaks to communicate and keep track of each other, the students will do the same, with musical instruments.

4. Blindfold 5 students. Give each of those students a different instrument.

5. Line the other children up in front of those blindfolded and give them each an instrument that matches one of the blindfolded students. You will have more than 1 student with matching instruments.

6. The search for the pods begins! Have each blindfolded person play their instrument for 5 seconds. Then have the other students play their instruments one at a time.

7. As each blindfolded student hears one of their podmates (a student with their same instrument), they should call them over to stand behind them. Do this until all the non-blindfolded students have joined their "pods".

8. Blindfold 5 new students (they should all keep their instruments). Have each blindfolded person play their instrument for 5 seconds. Then have 5 non-blindfolded students play their instruments at once. The blindfolded students should call over their pod mates as they hear them. Do this until all the non-blindfolded students have joined their "pods".

   Have the students return their instruments and sit down to discuss the activity.

9. Discuss with the students the difficulties of finding all their pod members, and discuss the difficulties that orcas might have when confronted with different pods coming together.

10. Review the difference between echolocation and communication. Echolocation is the process by which animals emit sounds and are able to detect objects, including food, when the sound waves return to them (like a submarine's sonar). What the students experienced today was very different: they used sounds to communicate (like marine mammals vocalize).

11. How would other sound, like ship noise, affect the ability of an orca to find their pod mates?

Conclusion:

1. Just to review, why do marine mammals make sound?

2. Why is it important to distinguish species by sound?

3. How can sound damage marine mammals, and what can you do (**slide 36, 37**)? Click on the links on **slide 37** to show video clips.

Scientist Spotlight:

Here are some of our PSB scientists (**slide 38**). Our spotlight today is on Sofie Van Parijs (**slide 39**). She is one of our scientists in Woods Hole doing bioacoustics work right now! Some of her current projects include:

1. Ocean noise (imagine looking at a map of the ocean that shows all the sounds made by whales, weather, and humans)- looking at the cumulative effects of human activities on marine life.
2. Marine mammal acoustic behavior: which species are doing what (what are they saying, and where are they saying it?).
3. Cod- how can we use acoustics to help protect a highly overfished species (North Atlantic Cod)?
4. Gliders: using technology to gain better access to surveys and to understand acoustic ecology.
5. Outreach: coming to talk to you (just like I am here) about all that she does!

She has children just like you at Mullen Hall Elementary!

Additional Activities if you have extra time:

1. Have a pair of students face each other and start talking about a subject of your choice. Then have another pair of stand directly behind each student already talking and converse with each other over the first pair. Think of how each additional pair talking makes it more difficult to hear your partner. This is what marine mammals have to deal with when trying to communicate with all the other animals and ocean noise activities surrounding them!

2. CALL MATCHING: http://cetus.ucsd.edu/voicesinthesea_org/games.html

Lesson Link to Massachusetts State Science Curriculum Standards

*All of the lessons reinforce the scientific method by asking students to observe, predict, hypothesize, participate in an experiment or activity, sort/classify, and make conclusions.

Kindergarten through 2nd grade:

(a) LS2 – Compare and contrast mammals with marine mammals and discuss how animals in these groups are more similar to each other than animals in other groups.

(b) LS6 – Recognize that marine mammals interact with their environment through their five senses with a focus on sound.