Investigation 4: Searching for Sounds in the Sea
Sounds in the Sea PowerPoint Notes

Slide	Notes
	Part One
1	Scientists track and study whales in a number of ways. 1. They conduct visual surveys from airplanes, ships, and shore and count the whales they see according to careful protocols. They then estimate the total number in the population. 2. They implant tags that can send information back. Depending on the type of tag, the information received can track an animal's location or record sound or dive information (depth, pitch, roll). Some tags, like the CritterCam, even have a video camera and light so that images are received from the viewpoint of the whale. 3. They perform "biopsies" by surgically removing a small chunk of skin, connective tissue, and blubber, about the diameter of a pencil eraser and the length of your pinky finger. The biopsied tissue is collected by shooting the animal with a special hollow dart. It hurts the whale about as much as it hurts you to have blood drawn from a pin pricking your finger. Biopsies provide incredibly valuable data about the sex and genetic background of an animal (who it's related to), as well as chemical composition of the blubber that tells us information about what the animal eats. 4. They can take pictures, then match unique features of a whale (depending on the species, these include dorsal fins, flukes, heads, and sides) with an existing "catalogue" of photographs taken at known times and locations. This photo-identification provides all kinds of information including where animals migrate, how old they are, and how many whales are in a population.
2	**Meet the Researcher** Lisa Munger received a B.A. in Ecology and Evolutionary Biology from the University of Colorado at Boulder, 1999. As an undergraduate, she conducted field work on nesting songbirds in the local foothills as well as laboratory research on fish behavior. Lisa completed a Ph.D. in oceanography at the Scripps Institution of Oceanography, University of California San Diego in 2007. Her dissertation research was on the calling behavior and habitat of North Pacific right whales in Alaska. She continues to work in the Whale Acoustics Lab at Scripps, where she now studies baleen whales off California and assists in coordinating outreach and education for the SeaTech program (seatech4teens.org) and other efforts.

	Lisa enjoys scuba diving, craft projects, gardening, and spending time with her cat and two birds.
3	Lisa Munger is working with a group of scientists who use acoustic methods because they are are extremely useful in detecting and monitoring whales & dolphins underwater, where they spend most of their time. Several technologies have been invented to use sound in the ocean. As a ship moves through the water, it can tow a cable behind it that is attached to several hydrophones (a microphone that listens underwater). This is called a towed hydrophone array. Researchers on the ship can listen and monitor the array signal in real-time to detect calling animals. Towed arrays are best for high-frequency sounds like dolphins and porpoises that are above the frequency of the engine noise. Sonobuoys are manufactured by the Navy and were developed to listen for submarines. They are a disposable device that you throw into the water and they stream a hydrophone (or several hydrophones) down to a programmed depth. They send a radio signal to the ship in real time, allowing scientists to listen and record for up to 8 hours. They work well for low-frequency sounds like baleen whales. When they are done transmitting, they sink to the bottom and the metal and cardboard parts slowly degrade (unfortunately, they also contain some plastic). Seafloor moorings contain batteries and disk drives to record sound internally. They can monitor an area for months at a time and record both low and high frequencies. This has proved to be especially useful in remote areas like the Bering Sea where it is difficult and expensive to collect data by ship.
4	No notes
5	Sound is a compression wave. When an object vibrates back-and-forth it creates the compression waves of sound. The motions of a speaker cone, a drum, and a guitar string are good examples of vibrations that cause compression waves. Compression waves have a different motion than the up-and-down motion of water waves (transverse waves) which will be shown in the next slide.
6	If sound were shown as a wave, the 'frequency' of sound would be the pitch that we hear. Pitch refers to how many wave cycles there are per second (Hertz). Human hearing is about from 20 Hz to 20,000 Hz (or lower if you've been to a lot of rock concerts). The 'amplitude' of the sound wave is the intensity, or loudness, of the sound. The wave shown in the above diagram is a perfect sine wave and we would hear it as a pure tone at constant amplitude.

	The speed of sound in water is much faster than the speed of sound in air. This is because water is much denser than air, i.e., there are more molecules per unit volume, which means there are many more particles that will vibrate as the energy of sound is transferred. The result is that sound travels about 5 times faster in water than in air. If you were to stick your head underwater and listen to a ship, or a whale, or someone shouting from across the pool (Marco Polo, anyone?), you would have a hard time telling what direction the sound is coming from. That is because it is traveling so much faster than in air that your ears are not spaced far enough apart to distinguish which ear it arrives at first.
7	In the real world, sounds that we hear are usually not perfect, pure tones (sine waves). They contain lots of different frequencies and vary in amplitude. What would the above waveform sound like to a human ear? Hard to say from this picture—that's why we need to do some analysis.
8	Scientists change the way they view the sound mathematically and produce a a spectrogram, which shows time on the x-axis, frequency on the y-axis, and intensity of the sound by a colorscale. In this picture, red sounds are loud and blue sounds are quiet. You can see some loud fin whale calls below 50 Hz, and a right whale upsweep from about 100 – 200 Hz. Spectrograms are a visual representation of sound that allow us to more easily detect whale calls and noises of interest (as opposed to looking at that jagged waveform). Also, they enable us to process data much more quickly than if we had to listen to the sound in real time.
	Part Two
1	The right whale is one of the most endangered whales in the world. Few of these whales remain in the Atlantic or the southern hemisphere and the North Pacific right whale (Eubalaena japonica) is extremely rare. There may be fewer than a hundred of these animals in the waters offshore of western Alaska and a few hundred closer to Siberia and Japan. Scientists are working hard to locate these whales and to get an accurate estimate of their population. They are developing studies to collect data on this mysterious and critically endangered whale. The data will help them to decide how they can assist in the whales' survival.
2	Commercial whaling for North Pacific right whales was highly intensive over the 1840's and 1850's, resulting in the deaths of tens of thousands of whales and devastating the population. They were the "right whale" to hunt because they are slow swimmers, close to the coast, and float when they are dead. They were prized for their oil and baleen.

3	Scientists looked at all of the sightings of right whales in the North Pacific Ocean by combining recent research focused on the whales with the detailed information in ship logs of the whaling ships which were on expeditions to hunt and kill the whales. They grouped the sightings into time periods. The story they revealed was of greatly reduced sightings and populations in both the Bering Sea and the Gulf of Alaska. With more intensive research, they were able to focus their efforts on the southeast Bering Sea used by consistently by a small number of whales.
4	In 2006, NOAA National Marine Fisheries Service used the historical information to designate critical habitat for North Pacific right whales under the Endangered Species Act. They based these areas on sighting locations since 1972. Sightings of whales were used to make the designation, but these sightings can't tell the whole story about right whales for a number of reasons. People can only go out on ships and airplanes to survey for whales when the weather permits, which only happens sometimes in summer and early fall in the Bering Sea and Gulf of Alaska.. People can only see whales during the daytime, and only when they are at the surface. Therefore, direct sightings by people can provide only a "snapshot" of whale distributions at the times surveys took place and whales were at the surface. Lisa Munger worked with other scientists to put out anchored acoustic recorders or "listening stations" throughout the right whale sighting area in the Bering Sea and near Kodiak, as well as in historically important right whale habitat along the Bering Slope. These recorders could listen for whales sounds and record them for several months at a time, through good weather and bad, day and night, summer and winter. The stations collected data from October 2000 – January 2006.
	Part Three
1	The anchored listening stations had hydrophones, the devices that listen to sound underwater, just like microphones listen to sound in air. Microphones and hydrophones work in similar ways: Microphones convert sound in air into electrical signals. The electrical signals can then be amplified, recorded, played back over loudspeakers, and transmitted over telephone lines. The electrical signals can also be used to measure the characteristics of the sound, such as amplitude and frequency. Similarly, hydrophones convert sound in water into electrical signals that can be amplified, recorded, played back over loudspeakers, and used to measure the characteristics of the sound. Hydrophones listen to sound, but do not transmit any sound. Lisa Munger and other scientists converted the sound waves into spectrograms and then used automated software, called "Ishmael" (and freely available

	online!) to detect right whale calls in the spectrogram data.
2	Lisa looked at each of the whale calls recorded at the listening stations and distinguished the right whale calls from calls made by humpback whales or sounds that were similar to whale calls , but not made by whales. She was able to tell the humpback calls which had patterned, repeated phrases from the right whale calls which were clustered into bouts of calling.
3	This shows how all of the whale call data from 2000-2005 was graphed so that Lisa could analyze it. These data provided new information about when the right whales were in the area where the stations were set up. The data showed that the whales were there from late May until mid- December, with the most activity in August, September, and December. The data also showed how many consecutive days whales called - as long as 6 days!
4	On this graph, whale call data was compiled to find out the time of day when calls were most common. One of the very important findings of the study was that the right whales called the most during the night. This finding reinforced the conclusion that the sightings of the whales during daylight hours were just a small part of whale activity that could be detected compared to using year-round acoustic technology.
5	These are the important conclusions of this study.