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The Sounds of the Ocean

Georgia Standards of Excellence:

- **S8P4.** Obtain, evaluate, and communicate information to support the claim that electromagnetic (light) waves behave differently than mechanical (sound) waves.
    - **f.** Develop and use a model (e.g., simulations, graphs, illustrations) to predict and describe the relationships between wave properties (e.g., frequency, amplitude, and wavelength) and energy.

Next Generation Science Standards:

- **MS-PS4-1.** Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.

Learning Objective:

- Students will analyze marine mammal spectrograms
- Students will graph marine mammal frequencies.

Essential Question:

- How can sound be documented and studied in a visible manner?

Key Vocabulary:

- Amplitude
- Frequencies
- Hertz (Hz)
- Spectrogram
- Hydrophones
- Soundscape
- Noise/ sound pollution

Materials:

- Frequency Data Pages
- Frequency graph worksheet
- Speakers
- Computer

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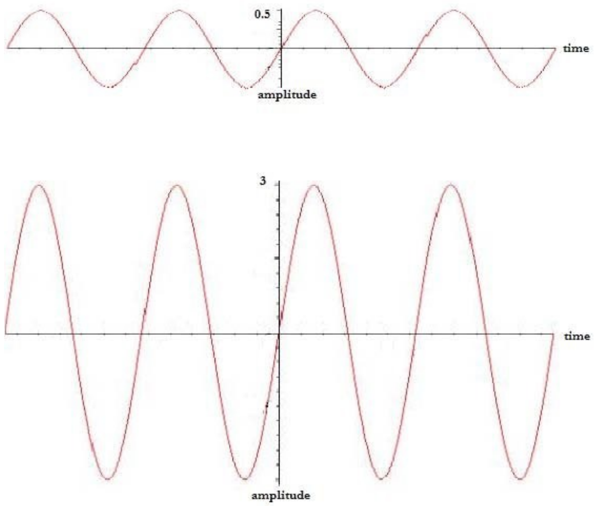
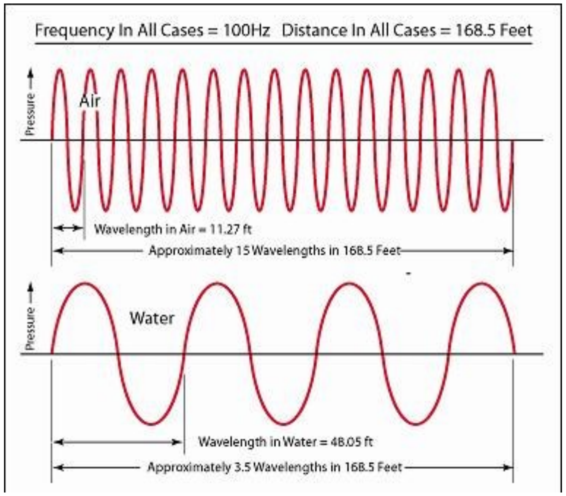
The Sounds of the Ocean

Background Information:

https://www.researchgate.net/figure/Low



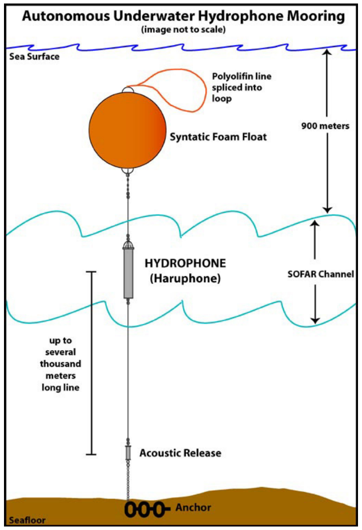
- Sound is a mechanical wave, the particles of the sound wave bump into each other as they vibrate. In air, which is a gas, the particles are generally far apart so they have to travel further to bump into each other. Since the particles are spread out from each other, there is little resistance to constrict movement. Meaning it takes little energy for sound to vibrate in air, but that low energy won't travel far.
    - Think of a whisper, it still travels in air and can be heard, but everyone has to be close by to hear it. The image on the right shows a low amplitude on top, which produces a quiet sound, and the high amplitude on bottom, which produces a loud sound. The frequency for both is the same, the only change was amplitude.



- Water allows sound to travel much further, but requires more energy, higher amplitude. The water particles are closer allowing the vibrating waves to bounce more affectively. Again, if someone was to whisper in water, it wouldn't be heard regardless of proximity do to the low energy of the vibration.
- Sound in the sea can often be "trapped" and effectively carried very long distances by the "deep sound channel " that exists in the ocean (NOAA). For example in 1997 scientist recorded a high amplitude sound from over 2,000 miles away, now referred to as the bloop. The sound was recorded on hydrophones, a key component to understanding the ocean soundscape.

The Sounds of the Ocean

Background Information:



- Hydrophones are underwater devices that detect and record ocean sounds from all directions. They measure ocean sounds with great precision. While a single hydrophone can record sounds from any direction, several hydrophones simultaneously positioned in an array, often thousands of miles apart can pick up exact locations of various sounds or to even track one animal based solely on its sounds.
- NOAA uses hydrophones to acquire long-term data sets of the global ocean acoustics environment to identify and assess acoustic impacts from both human activities and natural processes, such as underwater volcanoes, earthquakes, and icequakes on the marine environment. Understanding these various sounds and their impacts on each other is necessary for conservation and preservation efforts of ocean life.
- These sounds recorded from hydrophones all combine together to create the soundscape of the area. The ocean soundscape is a continuously changing mosaic of sounds that originate from living organisms (communication and foraging), natural processes (breaking waves, wind, rain, earthquakes), and human activities (shipping, construction, and resource extraction).
- The goal of soundscape analysis is extracting information from the recordings to identify which sources are present, the source amplitudes, how sources interact, and how animals in the environment may perceive and respond to the sounds. Marine organisms, like terrestrial organisms, have a wide range of hearing thresholds, and therefore, perceive noise in different ways.
- Laboratory and field studies have demonstrated that both invertebrates and fishes use soundscape cues for orientation and localization of appropriate settlement habitat. An increase in commercial shipping has been attributed to a steady increase in low-frequency sound (10-200 Hz). Blue, fin, sei, Brydes, right, and humpback whales all communicate in this 10- to 200-Hz frequency band; infrasound from waves crashing onshore (that marine animals likely use for orientation) is also in this band.

The Sounds of the Ocean

Background Information:

- As scientist are studying the ocean soundscape, it's becoming more and more clear humans are creating sound pollution. Humans are building further out the coasts, transporting large quantities by boat, searching for oil and gas in the sea floor by using air gun blasts, mapping the ocean floor and detecting other boats through sonar; the list goes on. Humans are increasingly adding to noise to the ocean.
- This unseen pollution is creating challenges and causing detectable problems for marine organisms. These problems are often grouped into four categories: (1) death and injury, (2) physiological effects, (3) behavioral disturbance and (4) masking of sounds. Protecting marine life from death and injury has been the focus of recent industry and government funding.
- A tractable step forward will be to better understand the hearing capabilities and variability across individuals and species and in terms of context linked to age, gender, previous noise exposure, and behavioral state. This is a lofty endeavor because there are diverse sound detection organs employed underwater, e.g., mammalian ears similar to ours, otolith organs in fish and statocyst organs in invertebrates (Miksis-Olds, J., et. all., 2018).

Activity Instructions:

1. Discuss the background information with students.
2. Play part or all of the humpback whale sounds for students from Monterey Bay Aquarium Research Institute recordings. If possible display for students to see the graph. (NOTE: The graph can be switched to a spectrogram version. Select the bar graph image in the bottom left corner of the recording.)
3. Distribute Spectrogram Data Sheets to students. Ensure students understand this is a visual representation of frequency and amplitude over time.
4. Distribute Spectrogram Data Worksheet to students.

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Evaluate:

Inquire with students…

1. Does the air gun blasts over lap with any marine animals? (yes)
2. Do you believe this will impact those animals? Why or why not?
3. What is an example of noise pollution you've experienced?

Explain humans have created so much noise pollution, for so long, scientist are beginning to recognize marine animals changing entire frequencies.

(Image courtesy of NOAA)

Extensions:

Visit Monterey Bay Aquarium Research Institute to hear live hydrophone feeds, previously recorded data and cetaceans.

https://www.mbari.org/technology/solving-challenges/persistent-presence/mars-hydrophone/

Visit NOAA for more practice with spectrograms as well as to hear what those spectrograms sound like.

https://www.fisheries.noaa.gov/national/science-data/sounds-ocean

Resources:

Jennifer L. Miksis-Olds et al. "Exploring the Ocean through Soundscapes," *Acoustics Today* 14, no. 1 (2018): 26-34; https://ccom.unh.edu/sites/default/files/publications/MiksisOlds%20et%20al_2018Exploring-the-Ocean-Through-Soundscapes_0.pdf

NOAA "Cetacean and Sound Mapping" August 2020, https://cetsound.noaa.gov/index

Cornell Lab, "Cornell Bioacoustics Research" August 2020 https://vimeo.com/user54843364

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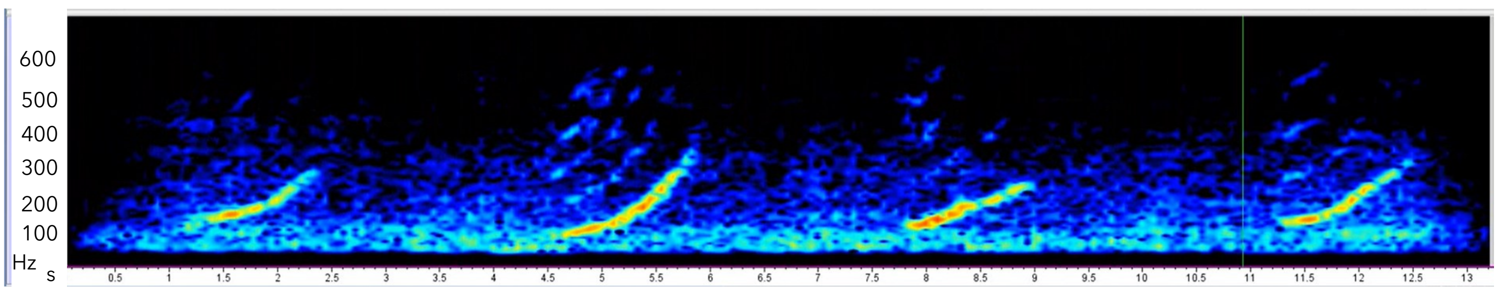
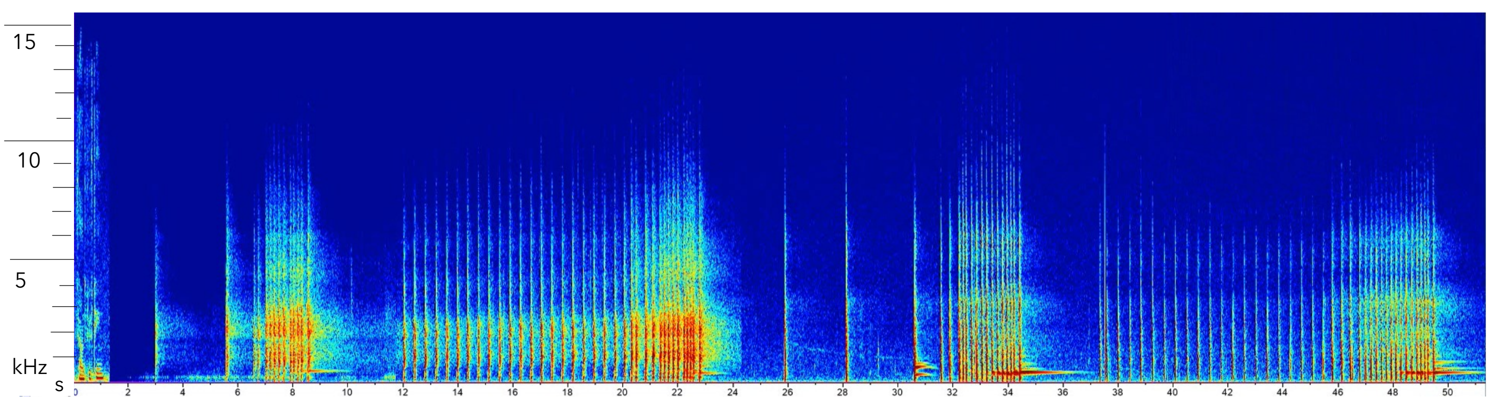
Spectrogram Data Sheets

Scientist use data collected from hydrophones to create the soundscape. Spectrograms are visual representations of sound.

North Atlantic Right Whale



Walrus



A spectrogram is a means for viewing the frequency content of a sound as it changes with time. The spectral amplitude values are converted to color with deep blues representing low values, ranging through greens and yellows to deep red for the high values.

Spectrograms taken from Cornell Lab, see reference.

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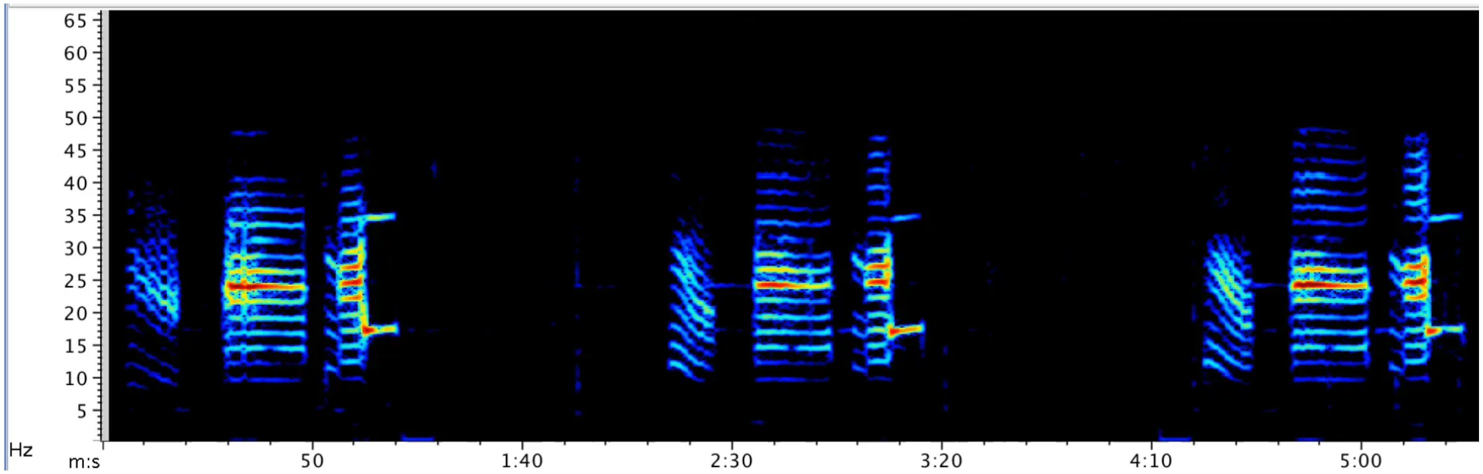
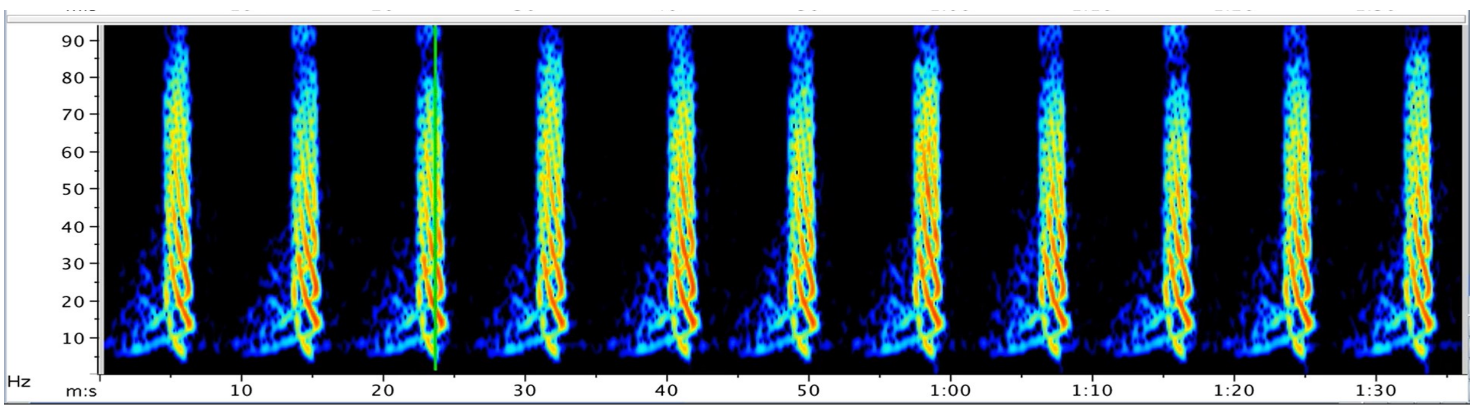
Spectrogram Data Sheets

Blue Whale



Air Gun Blast



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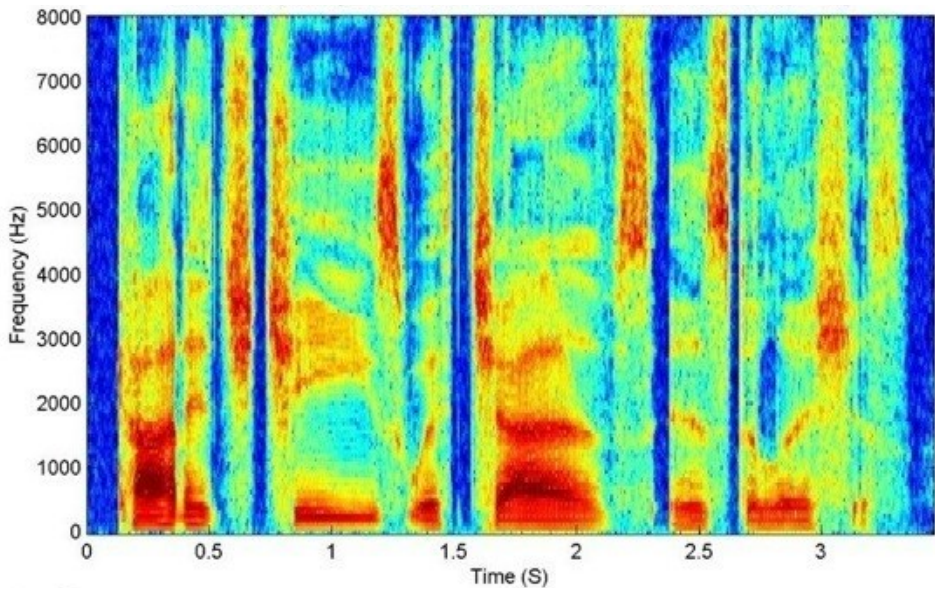
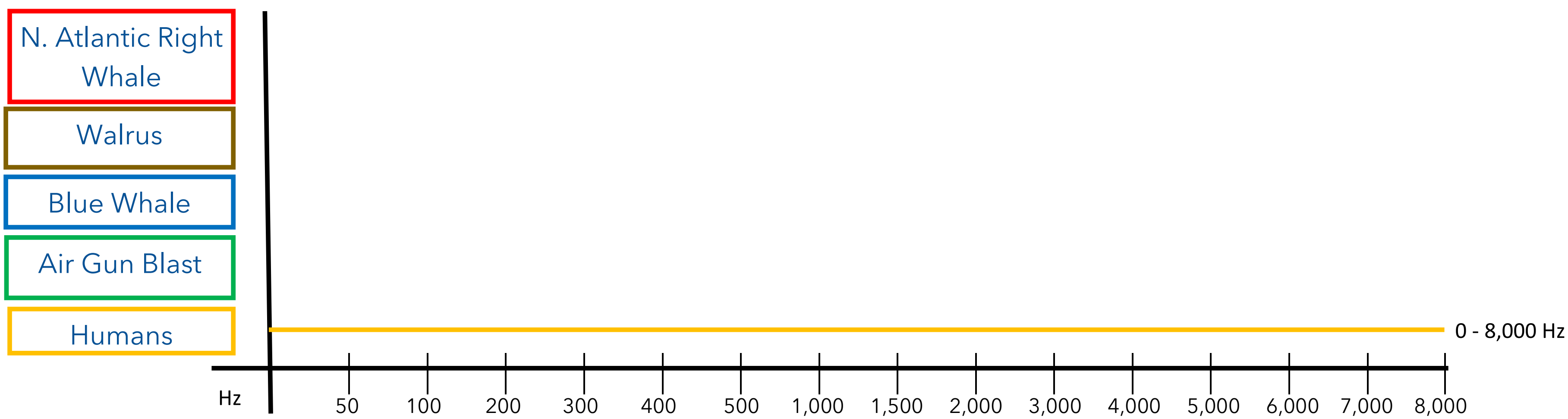
Spectrogram Data Worksheet

Human for example

http://www.columbia.edu/~djg2138/Dan_Gillespie_%40_Columbia/Assignments/Entries/2009/1/31_Assignment_1.html



Directions: Plot and label the frequency range from the spectrogram data onto the graph below. Use the highest frequency value for the upper limit. "Humans" is filled in to provide an example.



Spectrogram Data KEY Worksheet

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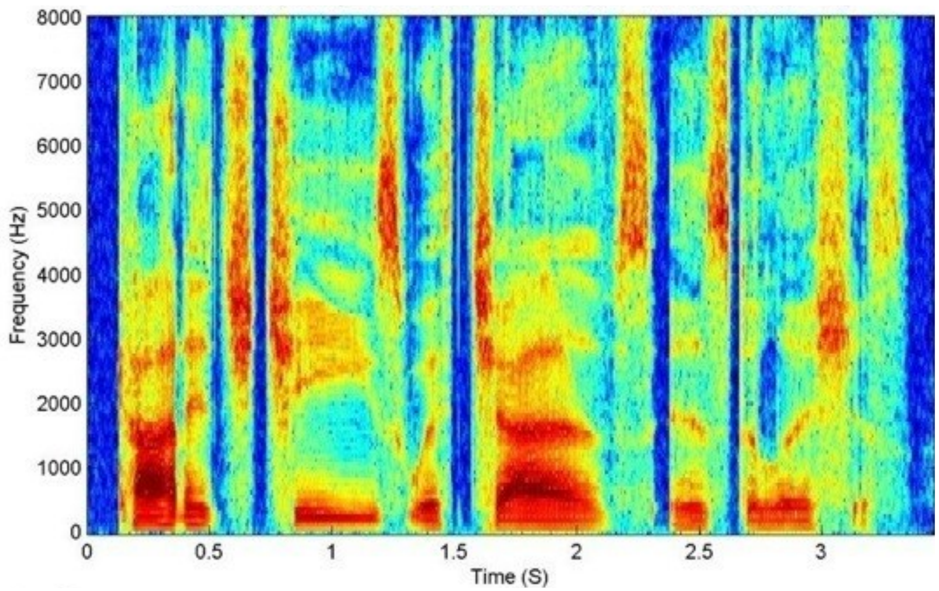

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