Can You See Sound?

Background

Have you ever you put your hand over a music speaker blasting loud music? How did it feel? It probably felt tingly. It is because the speaker is pushing the air particles around it, and these particles are tickling your hand! We cannot see the air particles because they are so small. The sound is created when the speaker wiggles or vibrates, and that vibration is transferred to the air particles near it. It causes the air particles to be squeezed, relaxed, squeezed, relaxed, etc. This pattern continues as the air moves (Figure 1). This pattern of squeezing and relaxing is what we call a "sound wave." When the sound wave hits our eardrums, our ears transform the sound waves into the sounds we hear.

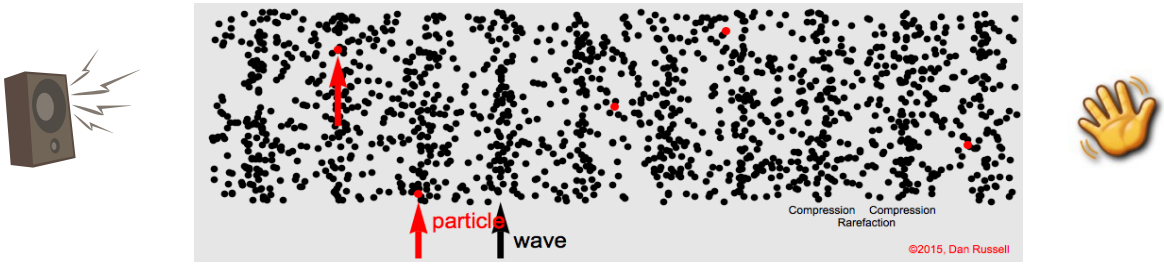
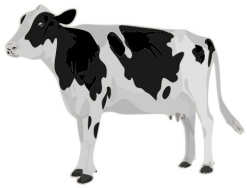


Figure 1: Between the loud sound speaker and your hand, there are air particles. The speaker wiggles or "vibrates", it causes the air particles around it to move in waves, and it tickles your hand, or your ear catches it as a sound. From: https://dosits.org/science/sound/what-is-sound/

If the particles squeeze, relax, and squeeze, and again and again really **fast**, it will sound to our ear as a **high pitch** like the chirping of a bird. If they squeeze, relax, and squeeze, etc… very **slowly**, it will sound as a **low pitch,** like a cow mooing.

High pitch



Low pitch

Sound travels through air. It also can travel through **water** and other materials. Sea animals, such as whales, dolphin, fish, etc., create sound and other animals can hear those sounds underwater. If we want to understand how ocean animals communicate with each other, it is important not only to listen to the sounds but also somehow "see" the sounds (Figure 2).

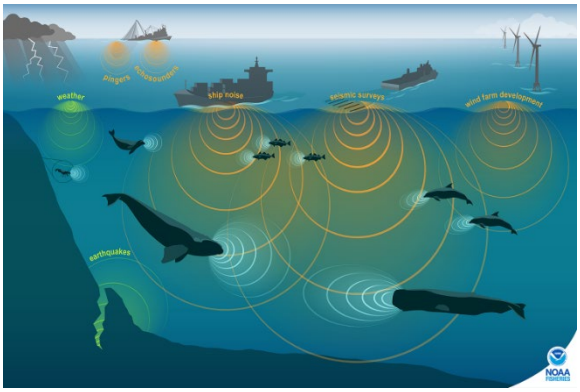


Figure 2: In the ocean, different sounds are produced by whales, dolphins, fish, boats, thunder, ocean floor movements, and other structures. https://www.fisheries.noaa.gov/national/science-data/ocean-noise

Engineers and scientists have invented a way to see sounds! Computers or phone apps can first listen to the sound and then make a diagram called **spectrogram**.

See an example of a spectrogram of a humpback whale "grunt" in Figure 3. Ask your teacher to play the sound of the humpback whale grunt and see the blue wiggle line on top of the figure.

The louder it grunts, the more the blue wiggle line goes up and down. From left to right, it shows how time passes in seconds. In the bottom of the blue wiggle line figure, it shows how low or high it grunts. The lower the grunt is, the more yellow it shows towards the bottom. The higher the grunt, the more yellow on top. How high or how low the sound is also called **frequency**. Can you find a word "frequency" in Figure 3?

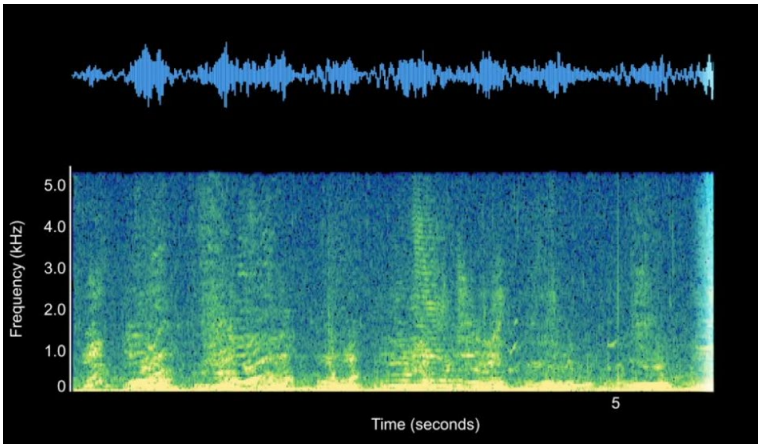


Figure 3: Humpback Whale "grunt" https://dosits.org/galleries/audio-gallery/marine-mammals/baleen-whales/humpback-whale/

Now it is YOUR turn to be a scientist or an engineer! You are going to use an app on a phone or another device to study the sounds around you! You are going to detect how loud or soft, and how high or low the sounds are.

Time to investigate!

For Teachers:

Materials

- Mobile phones or another digital device with microphone
- Any Sound analyzer apps that produces spectrogram

  Recommended apps for Android:

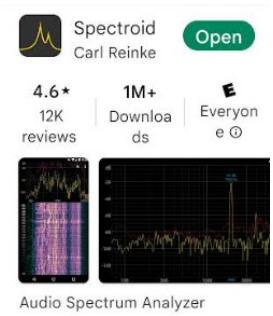
  - Spectroid: https://play.google.com/store/apps/details?id=org.intoorbit.spectrum&pli=1

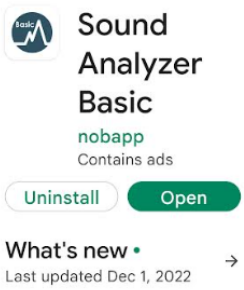
  - Sound Analyzer Basic: https://play.google.com/store/apps/details?id=jp.nokubi.nobapp.soundanalyzer.free

  Recommended apps for Apple:

  - SpectrumView: https://apps.apple.com/app/id472662922

  - Voice Spectrogram Logger: https://apps.apple.com/app/id1277134462





Procedures

1. Install one of the sound analyzer apps mentioned above or any other analyzer of your choice into a cellphone (or other digital device).
2. Play a sound from any sound source: clapping hands, singing, stomping, pounding, etc… It has to be loud enough so that you can see signals on the spectrogram responding to the variations of intensities of the sounds being produced.
3. Record various sounds and produce different spectrograms and/or spectra (graphs) of intensity of the sound versus frequencies. In some apps, intensity of the sound is labeled as "**decibel**" as the unit of loudness of the sound, or "**energy**" of the sound.
4. Allow students to produce low pitch voice and high pitch voice and let them observe how spectrogram responds.

For Students:

Data Analysis No.1

Data analysis is what scientists and engineers do to study carefully what they saw.

What was the sound you created (clapping hands, singing, stomping, video, etc.)? _____

Draw a picture of a **spectrogram** and/or **spectrum** of loudness (decibel) versus frequency as best as you can below.

How many peaks (pointy mountain tops) did you see in the **spectrogram**? _____

How many peaks (pointy mountain tops) did you see in the **spectrum**? _____

Data Analysis No.2

What was the sound you created (clapping hands, singing, stomping, video, etc.)? _____

Draw a picture of a **spectrogram** and/or **spectrum** of loudness (decibel) versus frequency as best as you can below.

How many peaks (pointy mountain tops) did you see in the **spectrogram**? _____

How many peaks (pointy mountain tops) did you see in the **spectrum**? _____

Discussions & Questions:

What happened to the spectrogram or spectrum of loudness (decibel) versus frequency when you made low pitch voice?

What happened to the spectrogram or spectrum of loudness (decibel) versus frequency when you made high pitch voice?

How many peaks did you see when you sang? Did you see just one or more?

What do you think it means when there are more than one peak in the spectrum of loudness (decibel) versus frequency?

For Teachers:

Please make as many "data analysis" sections as needed. For "Extended Activity," please allow students to compare and contrast different spectrograms and spectra.

Standards:

Next Generation Science Standards (NGSS)
K-PS2-1 Motion and Stability: Forces and Interactions
K-LS1-1 From Molecules to Organisms: Structures and Processes
1-PS4-1. Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate
3-PS2-1 Motion and Stability: Forces and Interactions
3-PS2-2 Motion and Stability: Forces and Interactions
4-PS3-2 Energy
4-PS4-1 Waves and their Applications in Technologies for Information Transfer
5-PS1-1 Matter and its Interactions

Objectives

1. Students will be able to describe that sound is produced by the disturbance in medium.
2. Students will be able to compare different sound waves.

References

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

https://dosits.org/science/sound/what-is-sound/

https://dosits.org/galleries/audio-gallery/marine-mammals/baleen-whales/humpback-whale/

Images

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