PURDUE UNIVERSITY Discovery Park

FNR-605-W

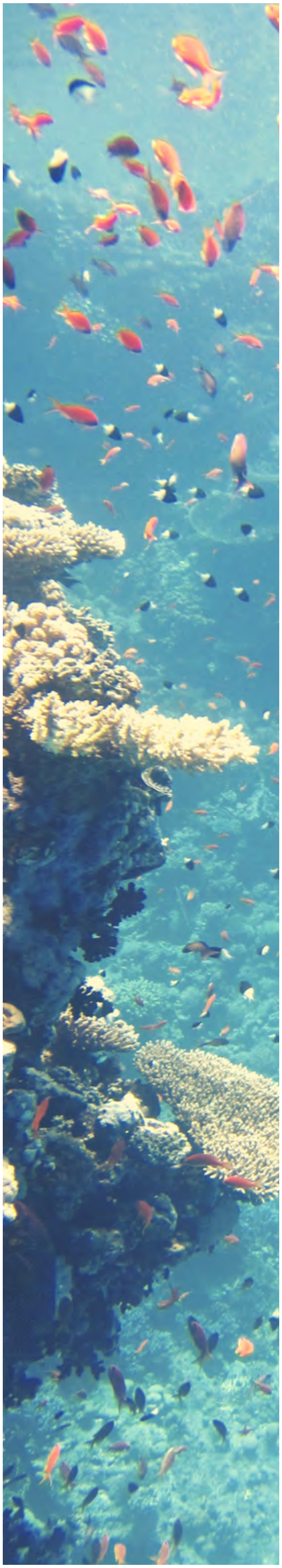
ILISTEN.ORG

SKILLS & MISSIONS

CENTER FOR GLOBAL SOUNDSCAPES

AISL-STEM TRANSMEDIA WORKSHOP JULY 2019

2ND EDITION, 2019.07



THE CENTER FOR GLOBAL SOUNDSCAPES

About Us

The Center for Global Soundscapes is home to a diverse group of researchers, scholars and educators endeavoring to better understanding nature and human-nature interactions through the lens of sound. We have training in disciplines including ecology, music, and education, and we record and analyze soundscapes in ecosystems around the world.

Our Mission

The world around us is full of amazing sounds that are often ignored by humans. Unfortunately, many of these sources of these sounds are actually in danger of being destroyed by human activities. Our mission is to study soundscapes in all of the major biomes of the world and to use this information to both understand how ecosystems are changing but also to bring nature to people through our recordings and research.

Where We Go

The work presented here is the result of dozens of studies conducted on nearly every continent and nearly every major biome. Our work spans from the tops of mountains to the depths of our oceans.

PURDUE UNIVERSITY Discovery Park

CENTER FOR GLOBAL SOUNDSCAPES

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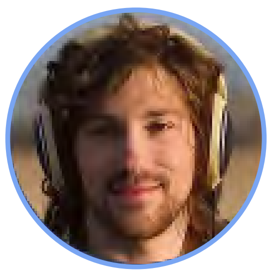

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Dear Educators,

I have a dream ... that all people listen carefully to nature and are inspired by its special song. The research and education center that I direct at Purdue University, the Center for Global Soundscapes, is on a big mission ... to record the sounds of the Earth! Why? So that we may show everyone the ways that scientists use sound to study nature. I encourage you to visit our website **www.centerforglobalsoundscapes.org** to learn more about our work. We have collected over one million recordings from some very special places on Earth and many of these are online for you to experience. We hope that our website will allow you to explore the new science called soundscape ecology. Soundscape ecology is how we learn more about what the planet has to "say". Because we are learning so much, we designed an interactive approach to learning about many aspects of including physics, biology, engineering, and math. We call this new program **iListen.org**. iListen.org provides multi-modal, media-rich learning experiences designed to stimulate and engage young minds in soundscape ecology.

This guide is a curricular companion on how to use iListen.org in your learning environment. This is just one of a suite of resources to support your students on an immersive expedition of learning to understand more about the planet we all share. Additional resources that are available to you:

- The Global Soundscapes - A Mission to Record the Earth Interactive Theater Show
- The Record the Earth Citizen Science project
- The inquiry-based curriculum "Your Ecosystem Listening Labs" (YELLs).

We want everyone to be a part of our effort to better understand this marvelous planet. Each and every one of us, as scientists and citizens, can preserve and protect the wonders it contains. The journey you are about to take is the first step!

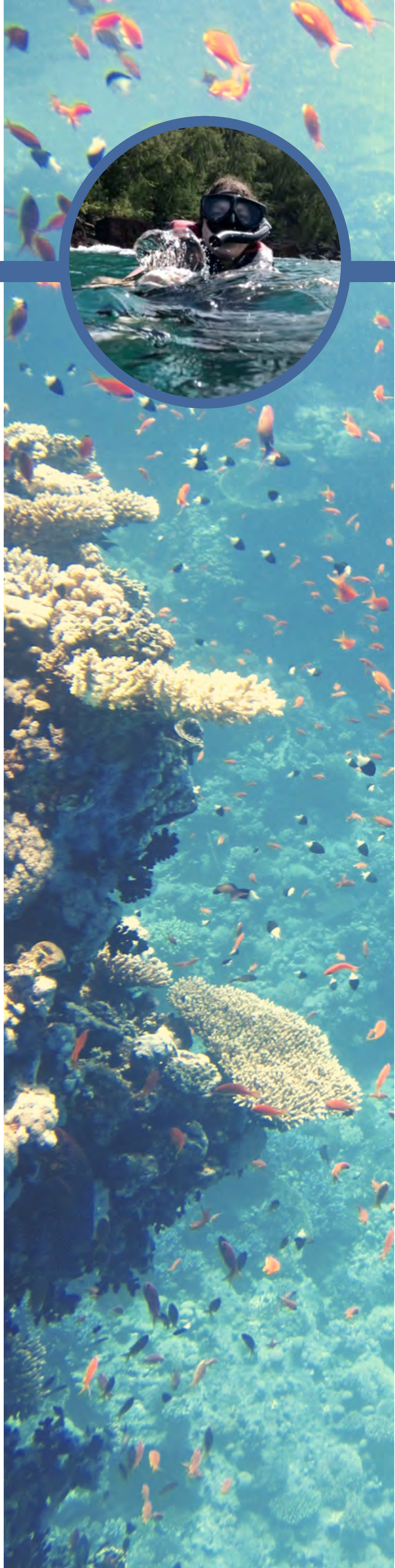
Funding for this project comes from the NSF Advancing Informal STEM Learning Program, Purdue Research Foundation, and the Department of Forestry and Natural Resources Wright Fund.

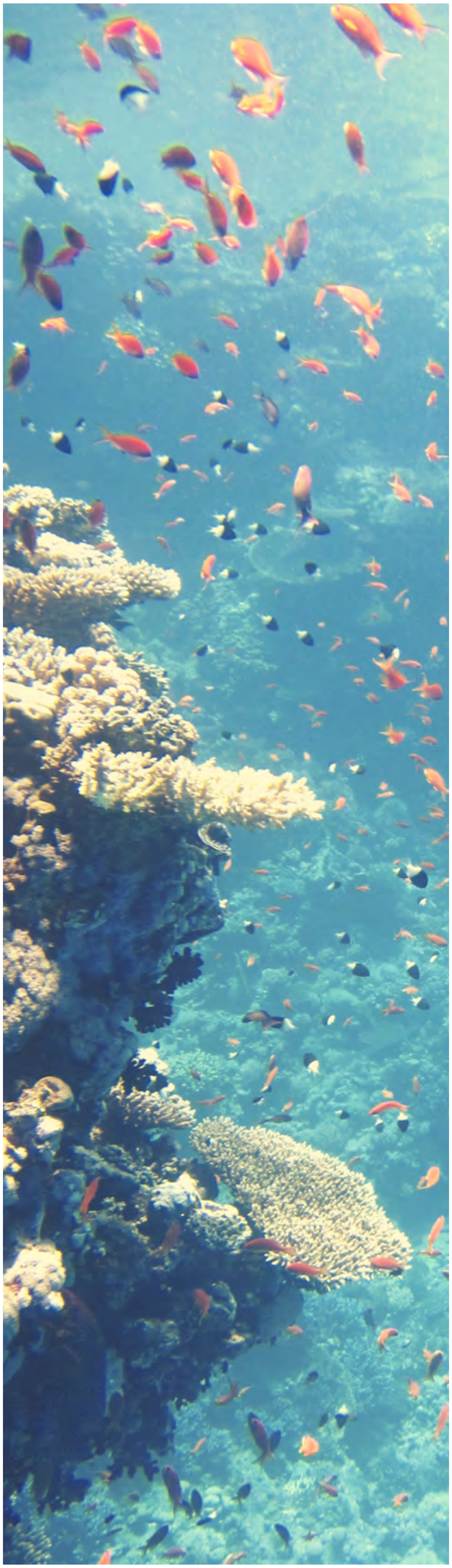
Listen Well,

Bryan Pijanowski

A GUIDE FOR

ILISTEN.ORG





How to Use the iListen.org Guide

Dear Educators,

Welcome to the **iListen.org** guide. We hope you will find this guide full of resources to help you in teaching students about sound and soundscape ecology. This listening portal is a website inspired by video games. The aim is to allow users to enter the lab and explore. There are three sections to the lab after an orientation through the main lab: **Team** (skill-building rooms), **Mission** (simulated research study), and **Explore** (extra resources).

Content in **iListen** can be conducted in any formal or informal learning environment, as the spaces in iListen include structured learning exercises, multi-day research projects, and exploratory tools. They can be used as a single learning exercise (one room's set of activities is less than one hour or as a package of scaffolded activities (several room's with a research project that could take up to 12 hours). **iListen.org** offers students in grades 5-8 the chance to step into the roles of scientists and engineers who work as a team to solve problems.

This guide is composed of four chapters. The first chapter describes the structure of iListen.org, important icons and tools that assist in accessing the rich content. The second chapter leads you through eight "skill-building" labs where students can earn a themed badge. In chapter 3, the simulated research mission allows students to visit the field, collect and analyze data, and create a science fair poster. Chapter 4 describes the bonus resources hidden throughout iListen.org.

Chapter 1

About the Project

The iListen portal provides an array of resources for the NSF-AISL project components: interactive theater show (Mission to Record the Earth giant screen show), informal learning curriculum (YELLs), and iListen portal (a website with integrated Massive Open Online Course (MOOC) material). Resources include curriculum guides, audio files from research, and printable activities.

High-level Components of iListen

Component 1: Explore & Learn. A graphically rich, explore-and-learn interface to a host of learning activities and resources that are geared toward different types of learning styles (visual, audio, interactive, textual, or conceptual/symbolic) aligned with Gardiner's work on eight pathways to learning. The design of iListen learning activities is focused on accessing the full spectrum of learning pathways using transmedia principles. The online setting organizes content in activity rooms associated with people, outdoor places, and analysis spaces. Access to this site is through the main iListen.org site.

Component 2: Educator Resources. This educational resource is in a simulated classroom environment that provides educators with context for how a student might use iListen. It organizes content and also provides an array of resources for other parts of the AISL project, e.g. YELLs documents, downloadable audio for use in teaching and analysis in any of the YELLs activities, and a list of other youth STEM resources. Access to this site is through the top menu's "Educators" section.

High-level Components of iListen

Component 3: An integrated MOOC Badging and Citizen Science Participatory Site. As they progress through the Explore and Learn components of iListen, users will obtain badges certifying that they have acquired specific knowledge or skills (See Appendix). This is currently designed to look like an online test that is described in the learning resource in Component #2.

After acquiring eight skills and the accompanying badges, users will be able to earn the "certified soundscaper" badge by taking part in a simulated research study. One example activity is to simply count the number of times a tinamou sings in one of the recordings presented to them. Users will follow the scientific method using an online notebook to write a hypothesis, collect data, and analyze it using interactive plots to create a science fair poster.

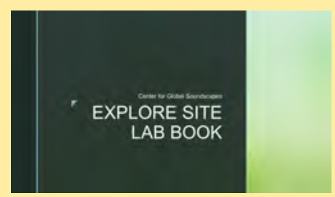
Chapter 1 Commonly used Symbols in iListen

A TABLET (iPad) is used to show where an interactive activity is available for users. They are present in many rooms in iListen.

Maria the PARROT can offer tips and tricks to users, if they are stuck or confused about what to do next.

An ALARM CLOCK can be used to start an interactive quiz to test a user's knowledge on the contents of a given room

A FLIPBOOK contains a brief set of text about a subject, with **BOLD** terms for study that can be tested with attached FLASHCARDS



A PLAY BUTTON is used to start a sound or video file.

A PLUS SIGN shows any interactive element on a lab screen.

A SONG METER is used to start a playlist of sounds that illustrate a habitat or concept.

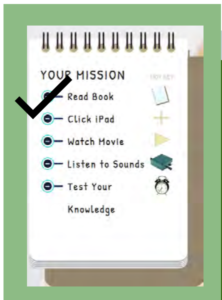
Chapter 2

Activity 1: Soundscape History

The goal of this activity is to understand the basics of soundscape ecology. Soundscape ecology is the study of the acoustic relationships between living organisms, humans, and their environment, whether the organisms are marine or terrestrial. There are five tasks to complete: 1) read book, 2) open iPad, 3) watch movie, 4) listen to sounds, and 5) take a quiz.

Chapter 2: Activity 1

Task 1: Read Book

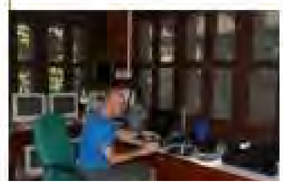


This flipbook explains the how, why, and where of soundscape ecology.

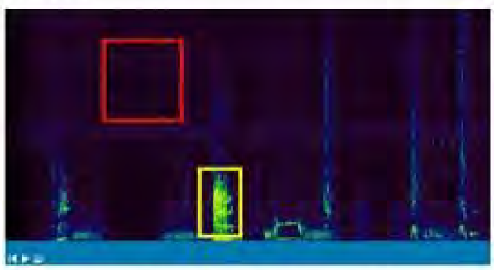
Many living organisms rely on sound for crucial ecological functions such as reproduction, feeding, and defending territories. Soundscape ecology aims to study the interaction between organisms and their environment through the analysis of acoustic composition.

Soundscape ecologists measure spatial (location) and temporal (time) variations in soundscapes and consider those variations in relation to large scale environmental disturbances such as habitat alteration, climate change, occurrence of toxins, and the spread of invasive species.

This approach represents a new perspective through which ecologists and decision-makers can work together to address a variety of environmental issues.



When the ARUs are brought back into the lab, all of these recordings are uploaded to a central computer. All of these soundscape recordings is a lot of data – this is called big data. To manage big data, scientists use different methods to analyze the data including visualizations – a way to look at sound in a picture, called a spectrogram.



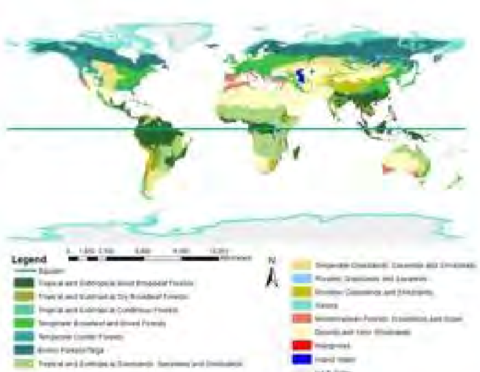
This spectrogram shows several sound sources in a soundscape.

Soundscapes are used by scientists to study changes in the environment. But, they also help Define place and time, and shape important memories for people.

This young girl is on top of a dune in the Gobi Desert in Mongolia. She is listening to the beautiful sounds that sand makes when you walk on it. Many cultures use sound as an important part of their life.

HOW DO SOUNDSCAPE ECOLOGISTS DO THEIR RESEARCH?

Scientists are collecting sounds from all over the world. They are creating an archive of recordings from different biomes. Some biomes are included below. Biomes are distinguished based on features such as how much rain, average temperature, and the types of plants that grow in the region.



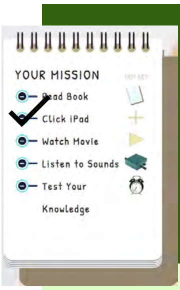
Some studies last a few days, while other studies last a long time. Scientists are using microphones to record soundscapes. Some microphones are left in the field for longer periods of times and are called acoustic recording units (ARUs).

Recording in the field.

Acoustic Recording Unit (ARU)

Chapter 2: Activity 1

Task 2: Click iPad

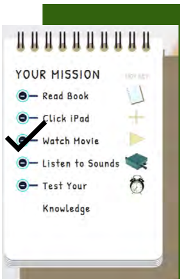


The tablet contains a movie that describes what tools and equipment a researcher needs when they go into the field.

Extension; Reflection

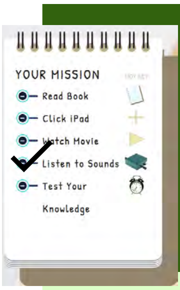
Why would you include these items? What happens if you forgot something? Would you travel alone? What place would you visit to hear a wild sound?

Task 3: Watch Movie



The movie is an interview with one of the founders of soundscape ecology, Dr. Bryan Pijanowski, "Dr. P." In this video, he describes soundscape ecology.

Task 4: Listen to Sounds



The contents of the song meter are a collection of sounds that were captured in remote places. Sounds are clickable, downlable, and shareable.

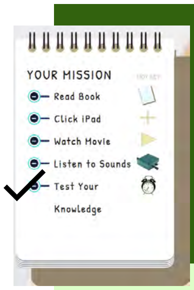
Extension: Listening

1. Listen to each recording
2. Download and share a favorite sound.

Extension: Reflection

This collection of sounds represents many biomes. How are the sounds from these biomes different? Which is your favorite?

Task 5: Test Your Knowledge



IT'S TIME TO TEST YOUR KNOWLEDGE!
An interactive quiz is opened when you click on the alarm clock.

1. What instrument is used to collect sounds?
A. acoustic sensor
B. thermometer
C. altimeter
D. barometer

2. What is a research area that interests soundscape ecologists?
A. human health
B. structure of bridges
C. animal biodiversity
D. distance of stars

3. What is a main concern of soundscape ecologists?
A. soil
B. water
C. air
D. noise

4. What tool do soundscapers use today that was also used by Charles Darwin?
A. helicopter
B. notebook
C. headphones
D. computer

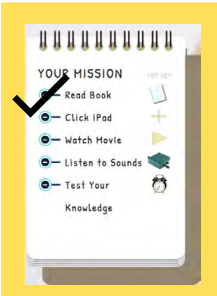
5. What do scientists call a collection of soundscape recordings that is very large?
A. spreadsheet
B. wave file
C. big data
D. little data

Chapter 2

Activity 2: Soundscape Composition

The goal of this activity is to learn about the different sound sources that contribute to a soundscape and how these sources help to describe the environment. There are five tasks to complete: 1) read book, 2) open iPad, 3) watch movie, 4) listen to sounds, and 5) take a quiz.

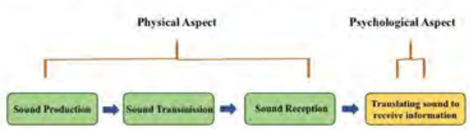
Task 1: Read Book



This flipbook explains the elements of a soundscape and animal communication.

Noise is a sound that blocks a receiver's recognition of a signal. A **receiver** is any living creature that can hear, or even a microphone. Species that live in noisy environments compete to make sounds that can be heard – this is called masking. Noise **masking** can occur in any ecosystem. Habitat change, wind, and traffic noise are some contributors to noise in an environment.

How do species react? Nightingales sing louder when it is noisy. European robins wait to sing until it is quieter. The marmoset monkey increases the length of its call when it is noisy. The Cope's gray tree frog will increase the speed of its call repetition when it is noisy.



Many animals make **sounds to intimidate** other animals and to display strength. Big cat's roars, gorillas' growls and chest beating, and hyenas' "laughter" are examples of this practice.

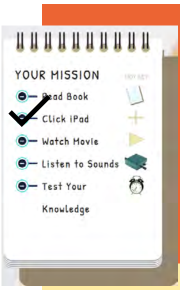
Animals also produce **sounds to warn** other members of their own species about the presence of a predator. Monkeys such as Diana monkeys and Campbell monkeys produce varied vocalizations according to the type of predator that is present. For example, their call changes if they are threatened from an animal in the sky like an eagle, or from the an animal on the ground like a leopard.

Everywhere we go, we are surrounded by diverse sounds. Some sounds are dominant, such as the sound of wind in the desert, or the sound of traffic in a large city. Some sounds are linked to specific places or times. The combination of all sounds in a specific location and at a specific time period is called a "**soundscape**." Soundscapes change over space (**spatial**) and time (**temporal**), as they are unique to different ecosystems and times of day or year.

Animals use sound for a number of different purposes. Many animals produce **sound to attract mates**. Such is the case with the singing of male frogs in the early spring, and the honking of male hammer-headed bats. Gibbons are unique because both the male and female vocalize together in an elaborate duet pattern. Penguins live in large colonies and tend to have the same mate for consecutive years. The only way penguin couples can find each other in a large crowd of visually similar individuals is through sound.

Other animals use **sound to find food**. Bats use **echolocation**, a high-frequency vocalization that bounces off objects and reflects back to the bat, revealing information about the surrounding environment. Using echolocation, bats can detect food and environmental structures like trees.

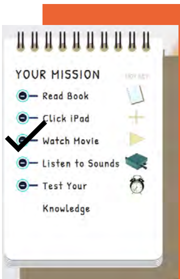
Task 2: Click iPad



The tablet contains an interactive activity with clickable photos and sounds that explores soundscape composition.

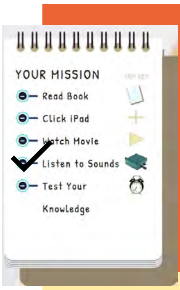
Extension: Reflection
Close your eyes. Listen to the sounds that are nearby and then to far away sounds. What types of sounds did you hear? Which soundscape composition class is your favorite?

Task 3: Watch Movie



The movie introduces the earliest sounds of Earth and how they form the basis of soundscape composition. We see natural soundscapes transform through time with the introduction of transportation and culture.

Task 4: Listen to Sounds

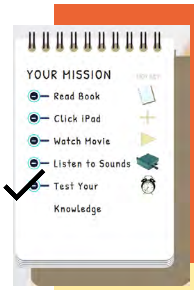


The contents of the song meter are a collection of sounds that were captured in remote places. Sounds are clickable, downlable, and shareable.

Extension: Listening
1. Listen to each recording.
2. Download your favorite.

Extension: Reflection
Soundscape composition describes sound using biophony, geophony, and anthrophony. Which sound is your favorite? Do they remind you of a particular place you visited?

Task 5: Test Your Knowledge



IT'S TIME TO TEST YOUR KNOWLEDGE!
An interactive quiz is opened when you click on the alarm clock.

1. What is the combination of all sounds in a specific location and at a specific time called?
A. diversity
B. soundscape
C. clipping
D. frequency

2. What category of sound is produced by humans?
A. geophony
B. biophony
C. anthrophony
D. monophony

3. What happens when noise interrupts animal communication?
A. stripping
B. clipping
C. masking
D. clapping

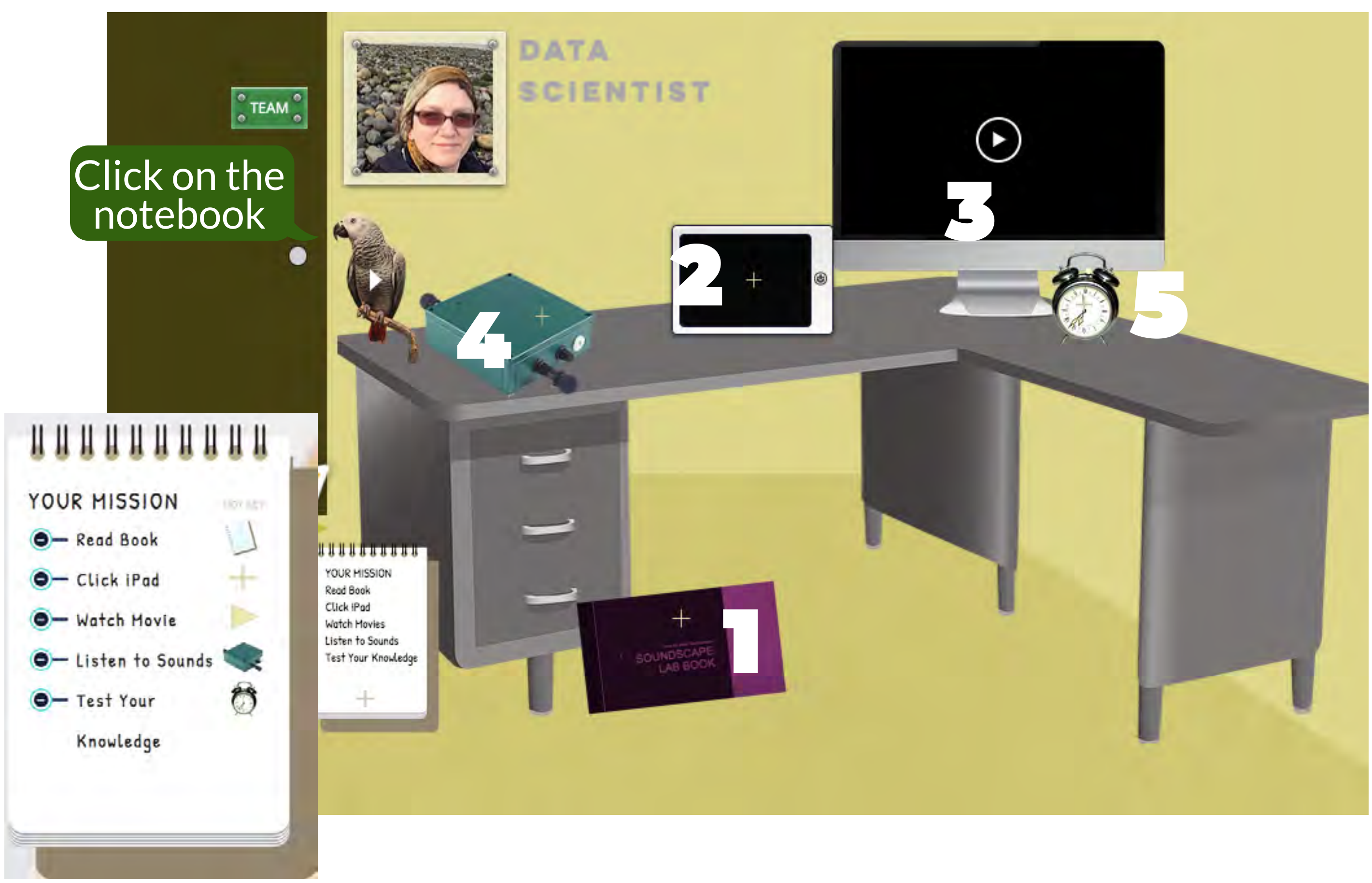
4. What is a receiver in the physical aspect of sound reception?
A. the sound producer
B. the wind
C. the listener
D. the tree

5. What type of vocalization does a bat use to find food?
A. echolocation
B. modulation
C. stridulation
D. reflection to syrinx

Chapter 2

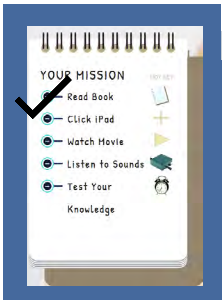
Activity 3: Physics of Sound

The goal of this activity is to learn the basics of the physics of sound and how this helps animals in the environment to communicate. There are five tasks to complete: 1) read book, 2) open iPad, 3) watch movie, 4) listen to sounds, and 5) take a quiz.



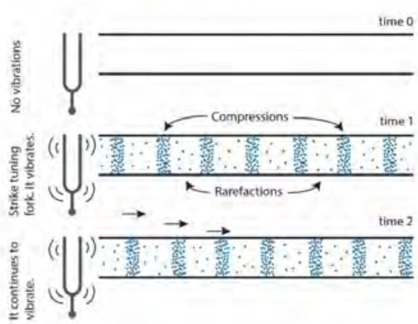
Chapter 2: Activity 3

Task 1: Read Book

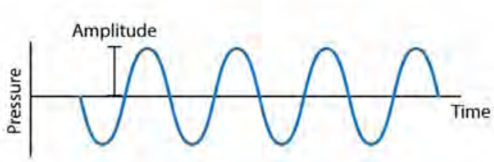


This flipbook explains the basics of physics and sound propagation.

Compressions and rarefactions refer to places of increased and decreased pressure due to the vibrations as they travel.



The distance from the source of the sound would affect how loud it would seem as well. This is called amplitude and is the amount of pressure change that is created by sound. The pressure and distance both act on the loudness of sound. If a drum is being struck very softly it will produce a lower amplitude than if it were hit hard, but if you were closer to the drum it would appear to be a higher amplitude than if you were farther away.

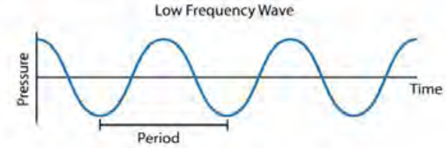


Anything that moves makes a sound. Have you ever wondered how sound travels? It must move from the sender (whatever makes the sound) to a receiver (whomever hears the sound).

When sound is produced, it must travel through a medium such as air, water or something solid like rock. When a human makes a sound with our voice, the vocal cords vibrate and produce sound. This vibration causes a transfer of energy from the sender to the medium that surrounds it. This transfer of energy changes the pressure. As these pressure changes reach the receiver (listener), the receiver's body part senses these vibrations.

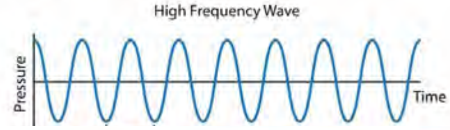
The speed that the vibrations are produced change the frequency or pitch of the sound. Frequency is measured by counting the number of peaks and valleys per second. Its unit is Hertz. Sounds with low frequency, like the grumbles that elephants make, have more energy and in turn travel longer distances.

Low Frequency Wave

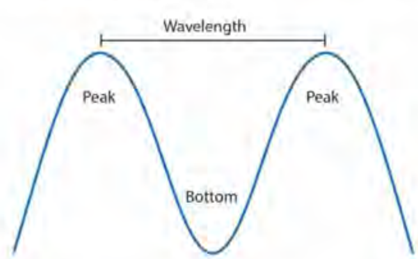


This would be the opposite of the high pitched chirp of crickets whose sound would not travel far.

High Frequency Wave



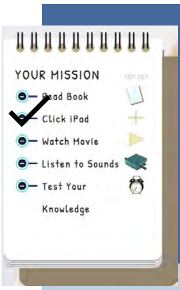
If pressure were to be drawn out it would create a pattern of peaks and valleys. A wavelength can be measured as the distance between two consecutive peaks in a cycle.



Vibrations need a receiver to understand the coded information. In the case of a mother bird who is singing to her babies, her chick must be able to understand if her song means for them to take cover or for them to come get food. This process of the chicks making sense of the information is called translation.

Chapter 2: Activity 3

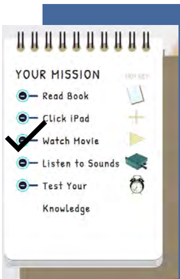
Task 2: Click iPad



The tablet contains an activity where you drag microphones to show how sound propagation changes in different landscapes.

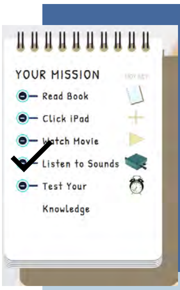
Extension: Reflection
Move the microphone icons (bottom) around the board to create a soundscape. Describe some soundscapes and the environments that they occur in. Do some places have sounds you expect?

Task 3: Watch Movie



The movie brings the viewer on a journey to Hawaii where sound propagation, mediums, and sound properties provide clues for a data scientist.

Task 4: Listen to Sounds



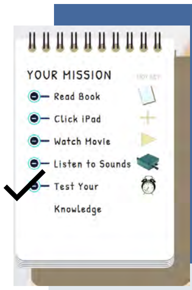
The contents of the song meter are a collection of sounds that were captured in remote places. Sounds are clickable, downlable, and shareable.

Extension: Listening
1. Listen to each recording
2. Download and share a favorite sound.

Extension: Reflection
Describe the sounds using amplitude and frequency. Describe the difference between a bird song and a call using these terms. Which do you like better?

Chapter 2: Activity 3

Task 5: Test Your Knowledge



IT'S TIME TO TEST YOUR KNOWLEDGE!
An interactive quiz is opened when you click on the alarm clock.

1. How does sound travel from the sender to receiver?
A. through a medium
B. by osmosis
C. in a vacuum
D. in deep space

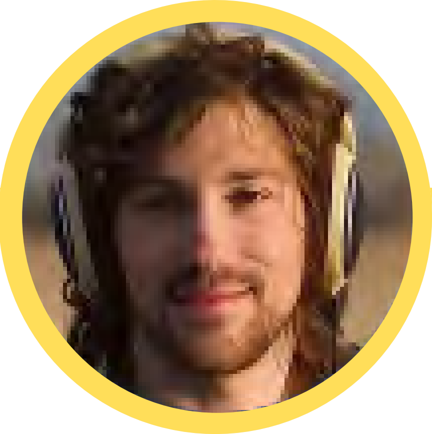
2. What is the phase of increased sound pressure called as it travels?
A. rarefaction
B. compression
C. period
D. wavelength

3. How does an elephant sound travel compared to a cricket?
A. does not travel far
B. travels at the same rate
C. does not travel
D. travels longer distances

4. What is the measurement between two consecutive peaks in a sound waveform?
A. peak
B. bottom
C. trough
D. wavelength

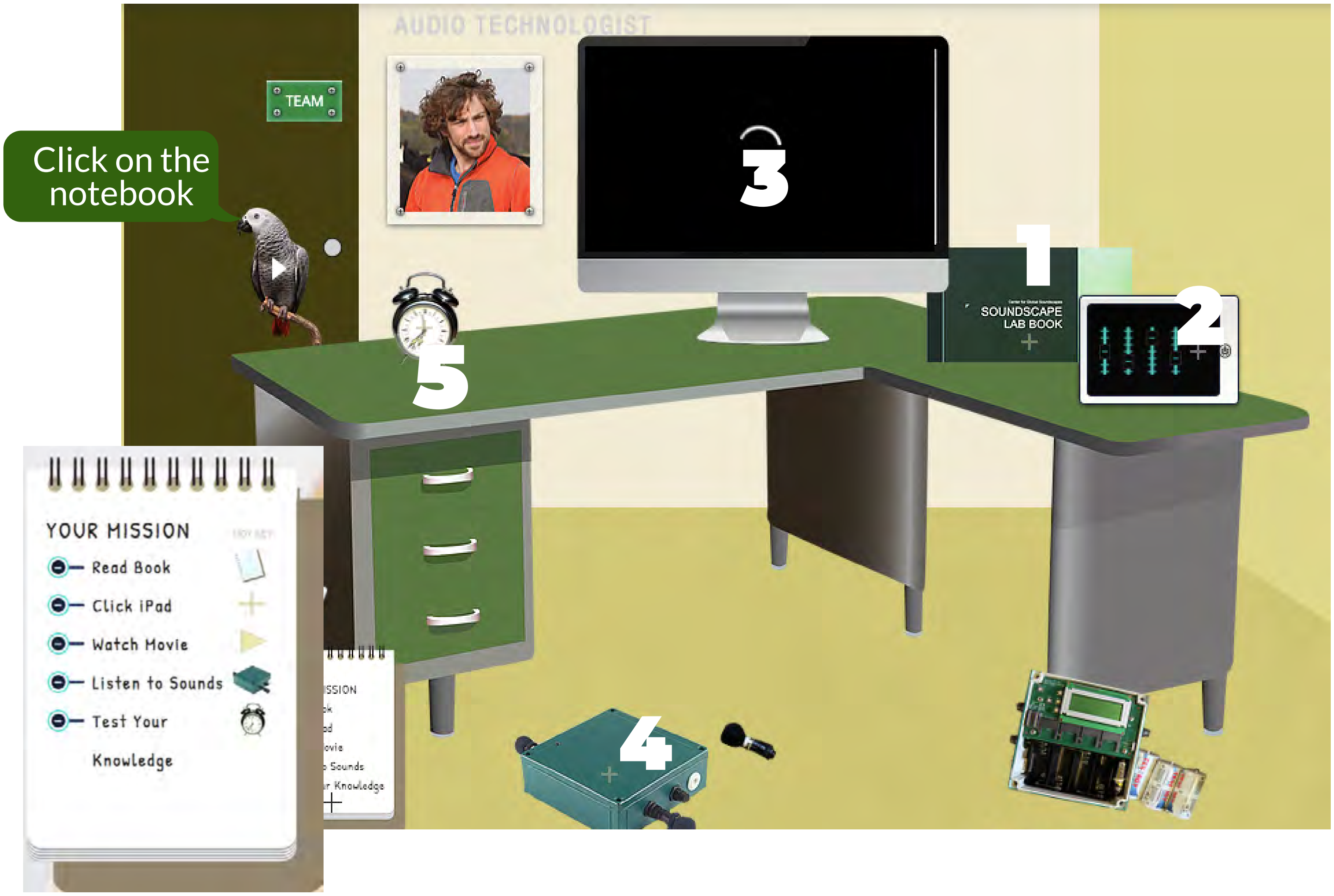
5. What is it called when a chick understands the sound from its mother?
A. translation
B. reduction
C. inspection
D. relegation

Chapter 2



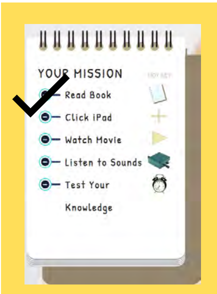
Activity 4: Recording Techniques

The goal of this activity is to learn about different methods for capturing sounds heard in nature and converting them to digitized signals. There are five tasks to complete: 1) read book, 2) open iPad, 3) watch movie, 4) listen to sounds, and 5) take a quiz.



Chapter 2: Activity 4

Task 1: Read Book



This flipbook explains techniques for listening to and record a soundscape.

Soundscape studies use data from audio recordings. The quality can be controlled by the type of equipment that is used and parameters.

Parameters include file type and sampling rate. Digital recordings are either lossless, a wave format, or lossy, an mp3 format. Scientists prefer lossless because more information is present. The sampling rate is how many points are recorded per second. The larger the number, the better the recording. For instance, 44,100 Hz is the quality of a CD recording.

The quality of field recordings is crucial for learning about soundscapes, but comes with challenges. There are a lot of questions that come up when trying to record in the field such as when and where to record.

Becoming familiar with the different sounds in a place and the animal community that is socially active in that place, can help you answer some of these questions. For example, in the early spring morning, birds can be heard singing in the **dawn chorus**. While at night, the prominent sounds will be owls, bats, and varying types of insects. Geophony, or natural sounds, can be heard changing throughout the year. During the summer you might be able to record huge thunder booms, while in the winter you could catch the soft sounds of snowfall. Anthrophony might be present as well, as airplanes and traffic noise are easily captured in recordings because of their broadband and low frequencies.

Some sounds are difficult to capture and may require a different microphone.

There are several different kinds of microphones:

Use a **Figure 8** when recording sounds from the front and back of the microphone.

Use a **shotgun** when recording a very specific sound, like a birdsong, that captures sounds in front of the microphone.

Use a **cardioid** when recording sounds in a heart shape in front of the microphone. This microphone records specific sounds clearly with a noisy background.

Use an **omnidirectional** when recording sounds at a 360 degree radius around the microphone. This is great for natural soundscapes.

How to improve recording of natural sounds

1. **Check, double- check and recheck!**
   -Make sure you have everything you will need for the day: charged recorders, microphones, batteries, cables, headphones, notebooks, and pens
   - Check the weather and dress properly
2. **Be quiet *shush***
   -Try to make as little sound as possible so you do not spook any of the animals you are trying to record
3. **Listen with your ears, NOT YOUR EYES**
   -Use your ears to find the place where you want to put your microphone.
   -Trust your ears
   -Connect your headphones to your recorder to make sure you are recording what you want

4. **Set your "gain" levels right**

- Adjust the "**gain**" which controls the strength of the signals that are being recorded

- The gain should depend on the loudness of the soundscape because loud sounds can cause the microphone to overload and miss sounds

5. **Step away from the microphone!**

- Stabilize your recorder so it will not shift position

- Hand noise can ruin a recording

- Make "voice-notes"

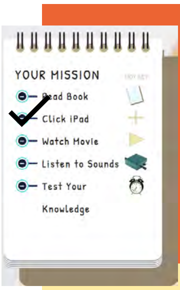
Use "voice- notes" at the beginning of each recording to tell your future self where, when, and what you are recording

6. **Have Fun & Share**

You can share your recorded sounds with other listeners using the Record the Earth app, or for your friends in your classroom.

Chapter 2: Activity 4

Task 2: Click iPad

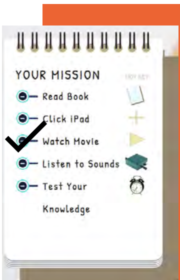


The tablet contains an activity that shows how different animals and geophysical sounds contribute to a soundscape.

Extension: Reflection

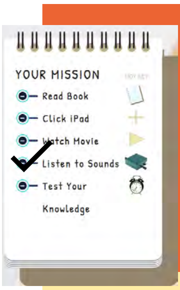
Press play and then move the faders and knobs to compose your own nature sound beat! Find the label for each track. Why do you think the recording uses a particular microphone? What is your favorite track? Why?

Task 3: Watch Movie



The movie is a story about how Pollutia tries to take all of the natural soundscapes from the world. Set in a video game level, the hero saves the sounds using different microphones.

Task 4: Listen to Sounds



The contents of the song meter are a collection of sounds that were captured in remote places. Sounds are clickable, downlable, and shareable.

Extension: Listening

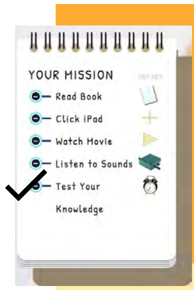
1. Listen to each recording
2. Download and share a favorite sound.

Extension: Reflection

Why do you think soundscape ecologists prefer omnidirectional microphones? Which type of microphone would you use to record your favorite sounds?

Chapter 2: Activity 4

Task 5: Test Your Knowledge



IT'S TIME TO TEST YOUR KNOWLEDGE!
An interactive quiz is opened when you click on the alarm clock.

1. What parameter is used to describe the quality of the recording?

A. file type
B. sampling rate
C. microphone
D. gain

2. What type of microphone is great for soundscape ecology recordings?

A. omnidirectional
B. shotgun
C. cardioid
D. figure 8

3. What is something you can do to improve your field recordings?

A. hold the microphone
B. eat lunch
C. talk with your friends
D. be quiet

4. What microphone setting controls the strength of the signals being recorded?

A. parameter
B. switch
C. gain
D. modulation

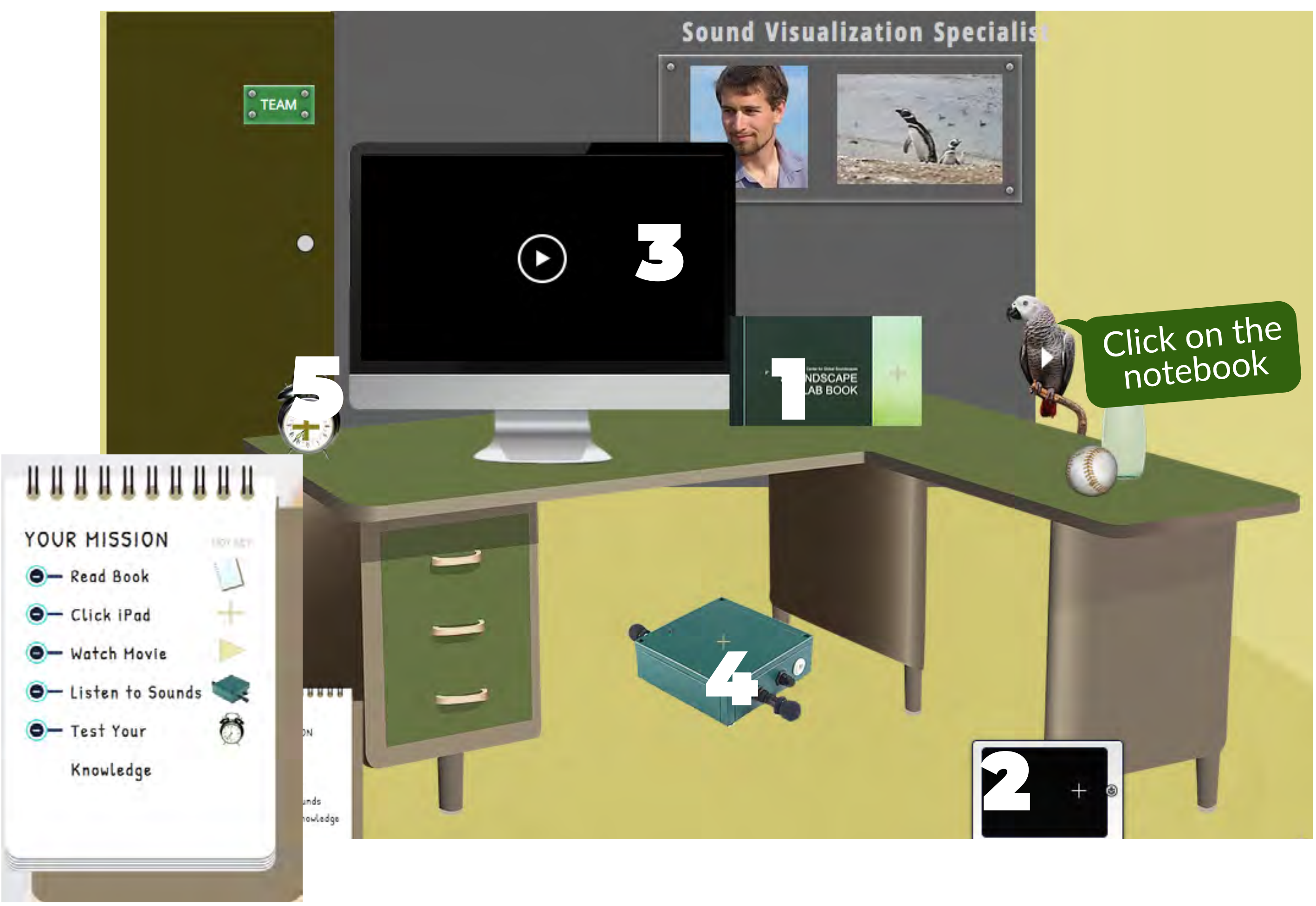
5. What is a simple way to identify a recording after you return back from the field?

A. memorize sounds
B. guess
C. listen to voice-notes

Chapter 2

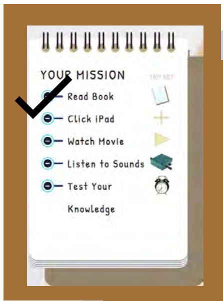
Activity 5: Spectrograms

The goal of this activity is to learn how sound can be visualized by using a mathematical function. There are five tasks to complete: 1) read book, 2) open iPad, 3) watch movie, 4) listen to sounds, and 5) take a quiz.



Chapter 2: Activity 5

Task 1: Read Book

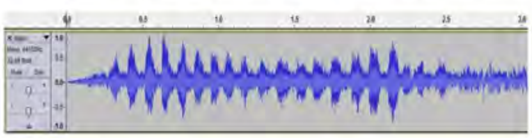


This flipbook explains how to read and create a spectrogram.

A "soundscape" is the combination of all the sounds happening at a given place over a given period of time. Natural and human-made sounds contribute to soundscapes. Soundscapes convey a wealth of information about the world around us. If you close your eyes and listen carefully, you will probably be able to guess your location, the time of day, and some events occurring nearby.

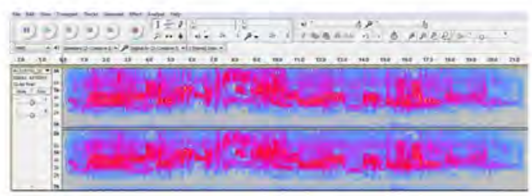
Soundscape studies record so many hours of audio that it would take too much time to listen each recording. Instead, scientists look at, or **visualize**, sound over time.

One way a scientist visualizes sound is using an oscillogram. An oscillogram is a two-dimensional graph with x and y coordinates. The x-coordinate represents time and is measured in seconds or milliseconds (s, ms). To follow the change in sound over time, you read an oscillogram from left to right.

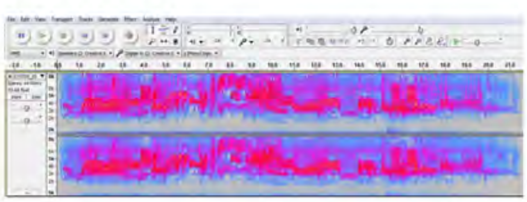


In the oscillogram view above, we can see that the recording length on the screen is 3.0 seconds. Additionally, we can see peaks that mirror across the zero-axis. These peaks, the rise and fall of the soundwave, show amplitude, or how loud the sound is at that moment in time.

Another tool for visualizing sound is a spectrogram. A spectrogram provides the same information as an oscillogram but adds a new level of information called frequency. Frequency is the pitch of a sound and is measured in Hertz (Hz).



In this spectrogram, we can see that the recording length on the screen is about 21 seconds. We can see there are two channels of sound present which means this recording is stereo. There is more information present in this view, such as the sample rate.



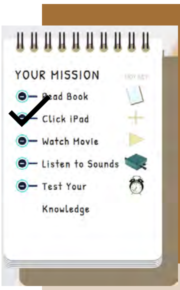
This recording was sampled at 44,100 Hz. This tells the scientist that we can see any sounds that measure up to 22,050 Hz, the upper boundary of the human hearing range. So, if an animal that makes a sound that measures above 22,050 Hz, we would not be able to see it in this spectrogram. One final piece of information is how loud parts of the signal are --- the colors tell a scientist where the amplitude measurements changes. In this view, pink means that this part of our sound recording is loudest.

Sound visualization tools are important to soundscape ecologists, acoustic scientists, and even musicians. These tools allow them to "see" sound, and with this capability, the characteristics of recordings that are minutes, hours, or even days in length can be seen at a single glance.

The occurrences of certain sonic events, like thunder, or birds singing, can be quickly located without listening to hours of audio.

Chapter 2: Activity 5

Task 2: Click iPad

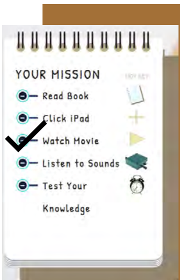


The tablet contains an interactive spectrogram generator (Chrome only) to observe common sounds and their spectrograms.

Extension: Reflection

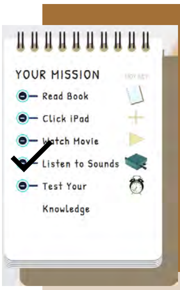
Push each button to see what the spectrogram looks like. What are some differences between the spectrograms? Draw a spectrogram of something you hear around you.

Task 3: Watch Movie



The movie is an instructional explanation of how spectrograms depict sounds that are familiar, like on a baseball field.

Task 4: Listen to Sounds



The contents of the song meter are a collection of sounds that were captured in remote places. Sounds are clickable, downlable, and shareable.

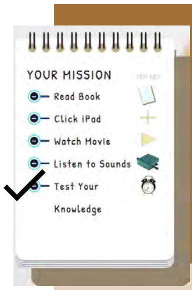
Extension: Listening

1. Listen to each recording
2. Download and share a favorite sound.

Extension: Reflection

Draw what you think the spectrogram of the sound will look like. Compare with the spectrogram picture (see icon). How does your spectrogram differ from the actual one?

Task 5: Test Your Knowledge



IT'S TIME TO TEST YOUR KNOWLEDGE!
An interactive quiz is opened when you click on the alarm clock.

1. What is the pitch measurement that is plotted on a spectrogram?
A. amplitude
B. frequency
C. magnitude
D. time

2. Why do scientists use spectrograms?
A. improves sound quality
B. helps visualize sound
C. increases sound amplitude
D. decreases sampling rate

3. What is a study that compares sounds across time?
A. contemporary
B. temporal
C. traditional
D. spatial

4. What is the benefit of using a spectrogram compared to listening to sound?
A. saves time
B. creates sound
C. developer teams
D. performs a script

.5. What does an oscillogram visualize?
A. frequency (voltage) over time
B. frequency (voltage) over space
C. amplitude over time
D. amplitude over space

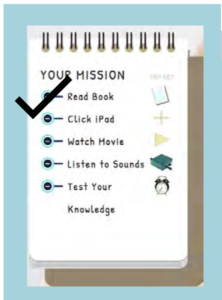
Chapter 2

Activity 6: Math in Science

The goal of this activity is to learn how mathematics and statistics are used to help scientists explain relationships in nature. There are five tasks to complete: 1) read book, 2) open iPad, 3) watch movie, 4) listen to sounds, and 5) take a quiz.

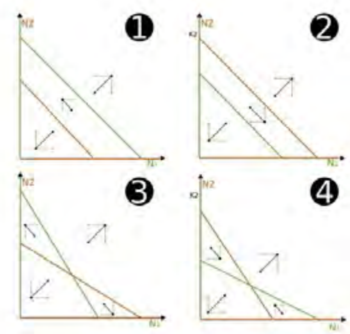
Chapter 2: Activity 6

Task 1: Read Book



This flipbook explains how mathematics is the basis for measurements in science.

Everyone has heard of math! Not only can math be a lot of fun, it is very useful for many things! Mathematics, which is the study of all things related to numbers, measurement, and space, has many applications to soundscape ecology. For example, we may want to count a number of species, measure the wavelength of a sound, or calculate the space between microphones!



Let's talk about some important parts of math that scientists use every day. Integers are whole numbers that you can count on your fingers. You can use integers to count things like books that can't be split in pieces.

1, 2, 3, ...

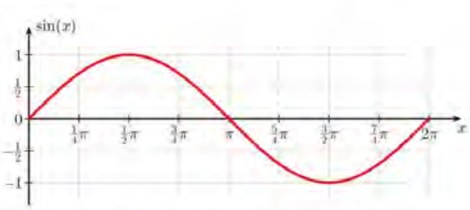
Decimals (also called real numbers) are numbers that can be used to count pieces of things. For example, 2.5 pizzas means two and a half pizzas!

2.5, 7.90, 100.3 ...

Time to kick it up a notch! We can talk about one number at a time, or we can talk about many; this is called a set. Think of coins in a bucket. If we have a penny, and two dimes this is like the set {1, 10, 10}.

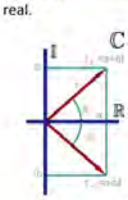
Sets are very important in mathematics and science, and are the building blocks of many parts of different types of math. One example of a type of math is algebra. Algebra, which you might have seen in school, uses letters to represent different integers and decimals, or maybe even a whole set! For instance, x = 1, y = 2: so x + y = 3.

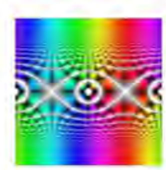
One use of algebra is to write functions. Functions are the relationship from one set to another set. One important example that soundscape ecologists use often is a sine wave function (represented as sin(x) in the plot below). It takes the decimal numbers and makes this shape out of them.



The red line above is the plot of the sine wave function and looks like a waveform. Plots are a way of looking at functions that help mathematicians and scientists understand a lot! Does the sine wave function use integers, decimals, or both?

Math doesn't stop there! There are even more kinds of numbers. One cool kind is an imaginary number, which has two parts: imaginary and real.

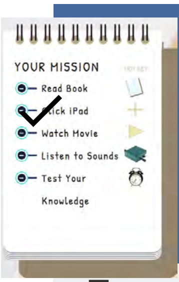




There is another type of advanced math called calculus. Calculus asks questions about sums of numbers and rates of change. Using the imaginary numbers and calculus, soundscape ecologists can do cool things to analyze sine waves and sound!

Chapter 2: Activity 6

Task 2: Click iPad

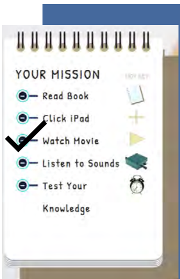


The tablet contains an activity to explore scientific notation and practice other mathematical skills.

Extension: Reflection

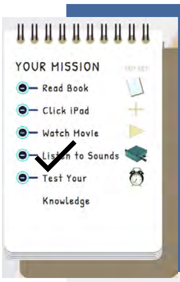
Scientific notation is important because measurements can be very small or very large. Why do you think these concepts are important? How can they help the world? What is your favorite math topic?

Task 3: Watch Movie



The movie is a story about an underdog trying to solve problems. The only solution is to use math.

Task 4: Listen to Sounds



The contents of the song meter are a collection of sounds that were captured in remote places. Sounds are clickable, downlable, and shareable.

Extension: Listening

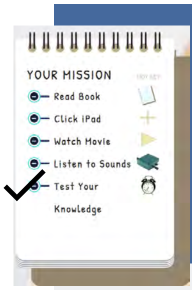
1. Listen to each recording
2. Download and share a favorite sound.

Extension: Reflection

This collection of sounds represents many biomes. How are the sounds from these biomes different? Which is your favorite?

Chapter 2: Activity 6

Task 5: Test Your Knowledge



IT'S TIME TO TEST YOUR KNOWLEDGE!
An interactive quiz is opened when you click on the alarm clock.

1. What is the study of all things related to numbers, measurement and space?
A. mathematics
B. ecology
C. soundscapes
D. statistics

2. What is a whole number?
A. rational
B. real
C. integer
D. fraction

3. What is a group of numbers, such as many coins in a bucket?
A. pieces
B. decimals
C. variable
D. set

4. What visual tool do mathematicians use to look at a function?
A. algorithms
B. plots
C. algebra
D. pairs

5. What brand of mathematics helps soundscape ecologists analyze sound?
A. calculus
B. geometry
C. imaginary
D. addition

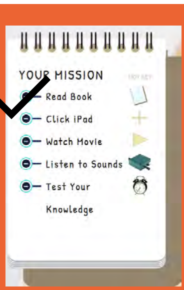
Chapter 2

Activity 7: Scientific Method

The goal of this activity is to learn about the scientific method that researchers use to study different systems and problems in the world. There are five tasks to complete: 1) read book, 2) open iPad, 3) watch movie, 4) listen to sounds, and 5) take a quiz.

Chapter 2: Activity 7

Task 1: Read Book



This flipbook explains the scientific method and describes how a scientific study works.

Scientists are interested in conducting research that other scientists and people can understand and replicate. They use the scientific method to help make this possible.

In general, the scientific method will help scientists of all ages, and even those young scientists who are participating in science fairs and contests. After a scientists has a research question – for instance, a curiosity about why something happens in nature, for instance, when are animal sounds louder?

SCIENTIFIC METHOD: STEPS

Ask a research question

Do background research

Write a hypothesis

Test with an experiment

Analyze data

Make Conclusions

Communicate Results

Scientists try to learn about the study site that pertains to their research question. They do background research about the ecosystem of the study site. They describe the habitat first and ask questions about this ecosystem.

Research Design Form

Group name:
Date:
Study area:
Biome:
Research question:
Data collection and protocol: o What type of data do you need to collect? o How many acoustic recorders do you need? o How will you distribute the recorders? o What is your recording schedule? How long will your study last, how often will you record, and how long will each recording be? o Where, when, and how will additional data be collected? o What other information will you need?

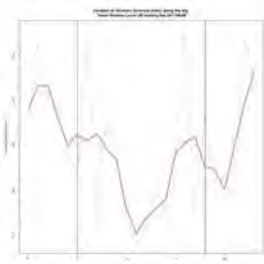
After, the scientists will write a hypothesis, a proposed explanation for why something happens. Scientists will use their hypothesis to help design an experiment. For instance, my hypothesis is that animals will be louder in the morning because the temperature is cooler at that time of the day.

Experiments are organized in very systematic ways to make sure they can be repeated and are performed without bias. The experimental design should match the goal of the research question and include measurements. For instance, soundscape ecologists might collect measurements on how loud a sound is, or what frequency is the sound source, or what time of day did the sound occur.

Conducting an experiment in the field.

Scientists will collect data according to their experimental design. Soundscape ecologists collect sound and store them on a hard drive or server. The CGS data server is called Pumilio.

Scientists will use all of the results from their analysis to accept or reject their hypothesis. Then, they will make conclusions from the analysis. For instance, if many sounds are louder in the morning, scientists can conclude that more animals sing in the morning. One reason might be because the temperature is lower in the morning, but there could be many other reasons. So, another experiment will be designed.

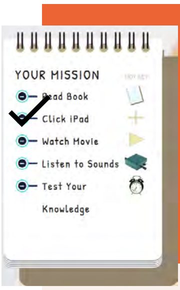


This plot shows how the acoustic activity of animals changes from morning to mid-day to late evening. The activity is highest in the morning and late evening.

Once you have finished these steps, you can organize your experiment into a science fair poster, or into a live presentation. Communicating your results is the final step in the scientific method.

Some posters are fancy, and some are made with construction paper. Your project should include all the parts of the scientific method on your poster. Include pictures and plots.

Task 2: Click iPad

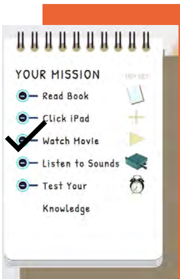


The tablet contains a slide show about how the scientific method works and how scientists use it.

Extension: Reflection

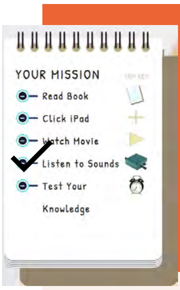
Why do scientists use the scientific method? You can practice by exploring new places and observing. Sit in the playground, park, or your backyard. Make a list of sounds. Write a question about something you observed in nature. How will you answer your question?

Task 3: Watch Movie



The movie is in the style of film noire and is a mystery about the missing amphibians. Watch how a scientist tries to answer this question using the scientific method.

Task 4: Listen to Sounds



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Extension: Listening

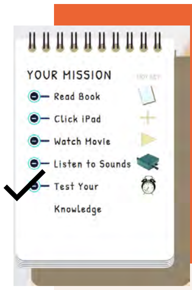
1. Listen to each recording
2. Download and share a favorite sound.

Extension: Reflection

This collection of sounds represents many biomes. How are the sounds from these biomes different? Which is your favorite?

Chapter 2: Activity 7

Task 5: Test Your Knowledge



IT'S TIME TO TEST YOUR KNOWLEDGE!
An interactive quiz is opened when you click on the alarm clock.

1. What step in the scientific method allows a scientist to predict an answer to a research question?
A. hypothesis
B. conclusion
C. results
D. analysis

2. What do scientists gather to answer a scientific question?
A. groceries
B. observations and data
C. quizzes and pencils
D. results and analysis

3. What does Dr. Gasc discover in the movie?
A. ponds are dry
B. sky is cloudy
C. frogs are missing
D. birds are migrating

4. How does Dr. Gasc solve the mystery in the movie?
A. uses sound data
B. uses cartographer
C. uses a dendrogram
D. uses a spell

5. What were Dr. Gasc's conclusion in the movie?
A. frogs may have moved
B. frogs just disappeared
C. frogs were unhappy
D. frogs decided to live in nearby homes

Chapter 3

Explore Rooms: Data Center

The data center allows students to access a wide variety of data:

1) go to the library to learn more about a variety of STEM topics, 2) access recordings in the citizen science project Record the Earth, 3) access a bonus skill about how engineers and scientists work together, 4) find more movies and sounds in the listening lab, 5) access the simulated research missions, and 6) interact with a sound collection map of several biomes.

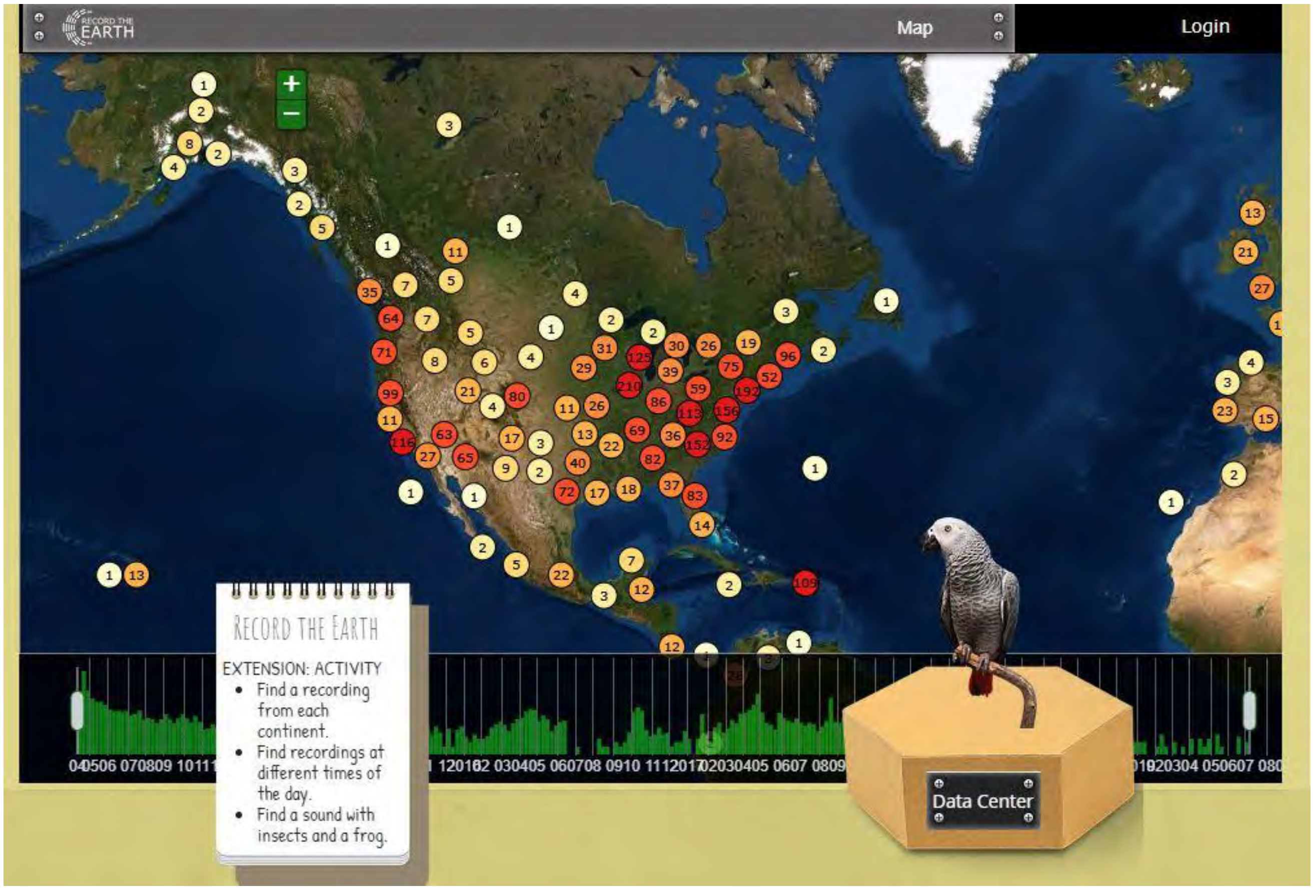
Activity 8: Visit the Library (Door 1)

The library contains resources that a student can use to study topics that interest them at their own pace. In the library a student can: 1) use the computer to find content in the iListen system, 2) read books on STEM topics, and 3) learn more about the research mission sites.

Activity 9: Visit Record the Earth (Door 2)

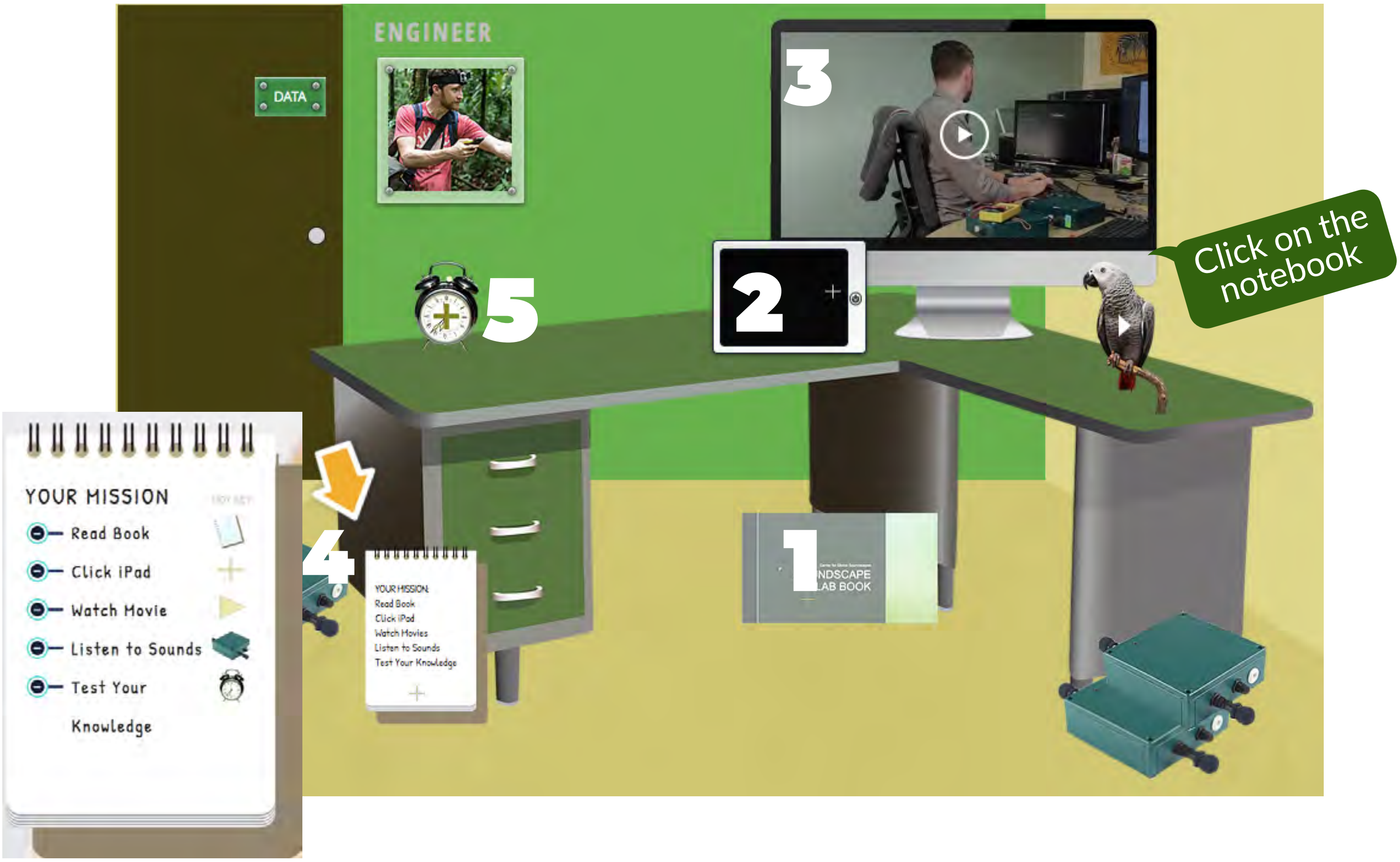
Record the Earth is a collection of sounds uploaded by soundscapers like you, with descriptions (for example, birds, rain, or crickets) and how those sounds make them feel (for example, happy, relaxed, curious, stressed). Click on a circle (number of recordings from that area) to listen to the sounds of that area. Registered users (use the "Login" button) can rate sounds and compete on a leaderboard.

Extension: Look at the notebook for extra tasks.



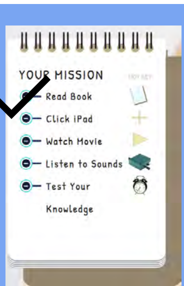
Activity 10: Engineering (Door 3)

The goal of this activity is to learn how engineers help ecologists study and solve problems that affect the environment. There are five tasks to complete: 1) read book, 2) open iPad, 3) watch movie, 4) listen to sounds, and 5) take a quiz.



Chapter 3: Activity 10

Task 1: Read Book

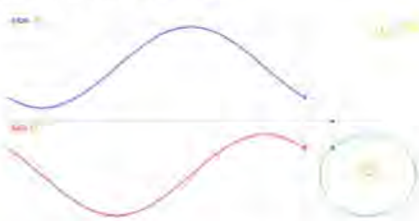


This flipbook explains a sine wave function, variables in programming, and how engineers help science.

Engineers are important in many scientific fields. In soundscape ecology, engineers help solve problems. The training for engineers includes math, science, computer programming, and requires critical thinking skills.

Engineers will help the soundscape ecology team by programming a utility program. This computer program allows a scientist to schedule the day, time and length of duration for recordings in a study site. They may also help adjust gain levels, and set up the equipment in deployment.

Engineers need advanced mathematics to solve problems that use sound. Two very important functions are cosine and sine. These two functions complement one another – just like in a color wheel where the complement to blue is orange. They are like "mirrors."



Sound doesn't look like anything in the analog world, but in the digital world, it uses cosine and sine functions to help scientists "see" sound.

A sine wave by itself sounds like a pure tone. The cosine and sine functions together, along with other functions, help to make a waveform --- or complex sound. The waveform is visualized as an oscillogram.

You can alter the qualities of a sound by changing the "t" variable in this script in the compiler window.

```
Source: y = f(w,t)
y = sin(w*t)*exp(-5*t);
```

```
Source: y = f(w,t)
y = 6.0*t*exp( -2*t )*sin( w*t );
y *= .8+.2*cos(16*t);
```

The first sound uses only a sine function and sounds like a simple synthesizer. The second sound uses both the sine and cosine functions and sounds like a flute.

You can experiment with sounds in the engineer's lab by clicking on an instrument, and copying and pasting its code into the compiler. Make sure you press the green compile button when you are finished.

Engineers enjoy spending time in the field. But after the field work, they will help scientists move the collected data to a computer (in the cloud). This important step can take hours. Engineers use computers to upload the data, to design and maintain websites, and even phone applications.

Computers perform functions using scripts. The scripts are organized like an outline for a research paper. Codes use substitutes for values called variables.

x=1

Every time a computer program has an "x" in the script, it will interpret the value as 1. Now, let's add another variable.

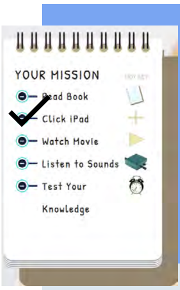
y=2

Computers can use variables in a function, such as an addition problem.

```
#Variable x equals 1
x = 1
#Variable y equals 2
y = 2
#What does variable x + y equal?
x + y
#Answer
[3]

#Change y value
y = 5
# What does x + y equal now?
x + y
[6]
```

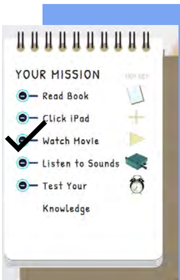
Task 2: Click iPad



The tablet has a coding exercise that enables students to create a sine wave of a tone.

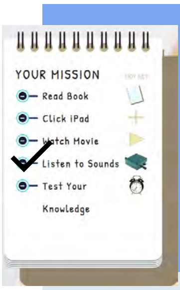
Extension: Reflection
Why do you think learning a programming language helps scientists? If you could create a new sound, what properties would you adjust?

Task 3: Watch Movie

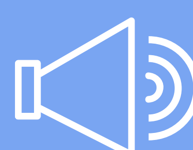


The movie is an instructional aid for understanding utility programs and codes that are useful in the data management for science that uses digital technology.

Task 4: Listen to Sounds



The contents of the song meter are a collection of sounds that were captured in remote places. Sounds are clickable, downlable, and shareable.

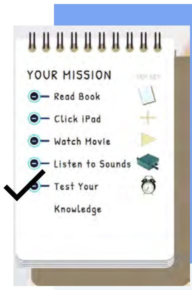


Extension: Listening
1. Listen to each recording
2. Download and share a favorite sound.

Extension: Reflection
This collection of sounds represents many biomes. How are the sounds from these biomes different? Which is your favorite?

Chapter 3: Activity 10

Task 5: Test Your Knowledge



IT'S TIME TO TEST YOUR KNOWLEDGE!
An interactive quiz is opened when you click on the "alarm" clock.

1. What is a role that engineers play in soundscape ecology?
A. help solve problems
B. they draw plans
C. they build bridges
D. they connect people

2. Where do scientists and engineers visit for the deployment of tools used in a research study?
A. field site
B. lunch room
C. battlefield
D. in the lab

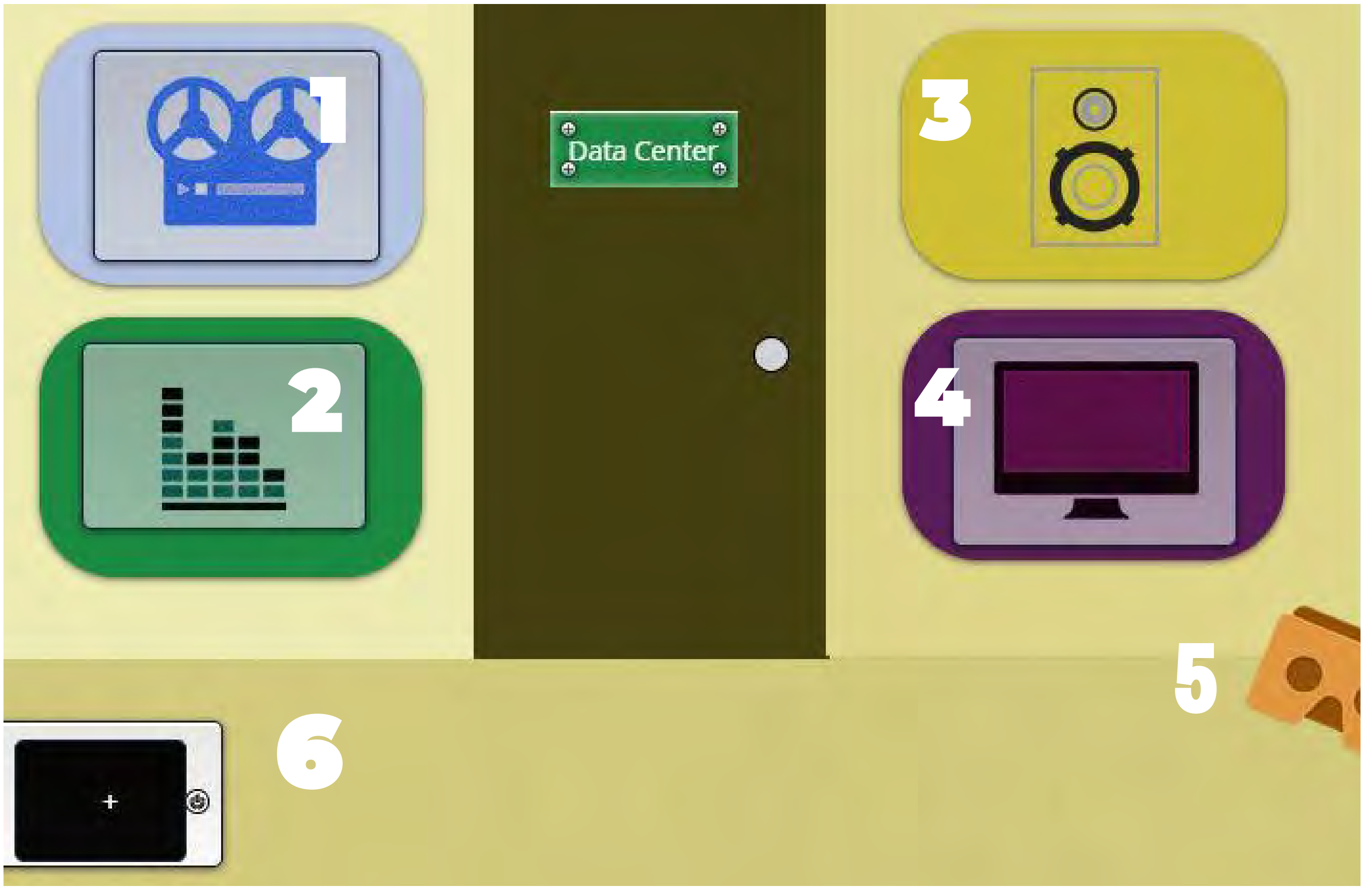
3. Why is a utility program helpful for soundscape ecologists?
A. cleans a hard drive
B. performs file uploads
C. schedules recording times
D. helps create spectrograms

4. What type of function is used to make a pure tone?
A. quadratic
B. linear
C. complex
D. sine

5. What do computer scripts use to simplify a coding problem?
A. letters
B. variables
C. pictures
D. text

Activity 11: Visit the Listening Lab (Door 4)

The Listening Lab gives students access to a number of video and visualization tools, including: 1) videos recorded at CGS field sites, 2) exploration of a spectrum and oscillogram of natural sounds, 3) exploration of the spatial arrangement of different sounds, 4) variations in types of waveforms, 5) 360 degree movie of a field site--Google Cardboard compatible, and 6) production tools to create a melody (Chrome only).



Activity 12: Visit Chorus (Globe)

The Chorus database is a tool that emulates the full database that the Center for Global Soundscapes uses to track and organize sounds that it has recorded from all over the world. Soundscapers can interact with this map to listen to sounds from the various biomes that CGS has studied.

Chapter 4: Missions

Mission Launch

The mission select screen is where a student can choose a mission to apply their skills (earned badges) and complete a science fair poster. A student can 1) pick 1 of 3 missions, 2) watch a video about that mission, 3) learn more about a mission or get help, and 4) start the mission.

Tip: Click an icon to learn about the mission. Then, click the icon in the "Launch to Field" console to start the mission.

Chapter 4: Missions

Activity 13: Explore a Jungle

The goal of this activity is to conduct a simulated research study. The research question is: Do sounds of animals change composition with the vertical structure of the rainforest? In the field station, 1) watch the movie (hover over bottom right corner to turn on sound), 2) learn about the species in this area, 3) read a book, 4) bonus (unique to each room), and 5) conduct a simulated research study.

Chapter 4: Activity 13: Mission

Task 1: Watch Movie

The movie brings you to a neotropical jungle in Costa Rica where you learn about changes in biodiversity.

Task 2: Use Computer

The information on this computer is designed as a web browser to discover species that live in the neotropical jungle.

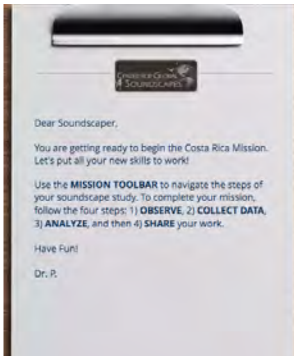
Task 3: Read a Book

The contents of the book introduce readers to the weather and general physical properties of the location. Readers can explore different types of research questions.

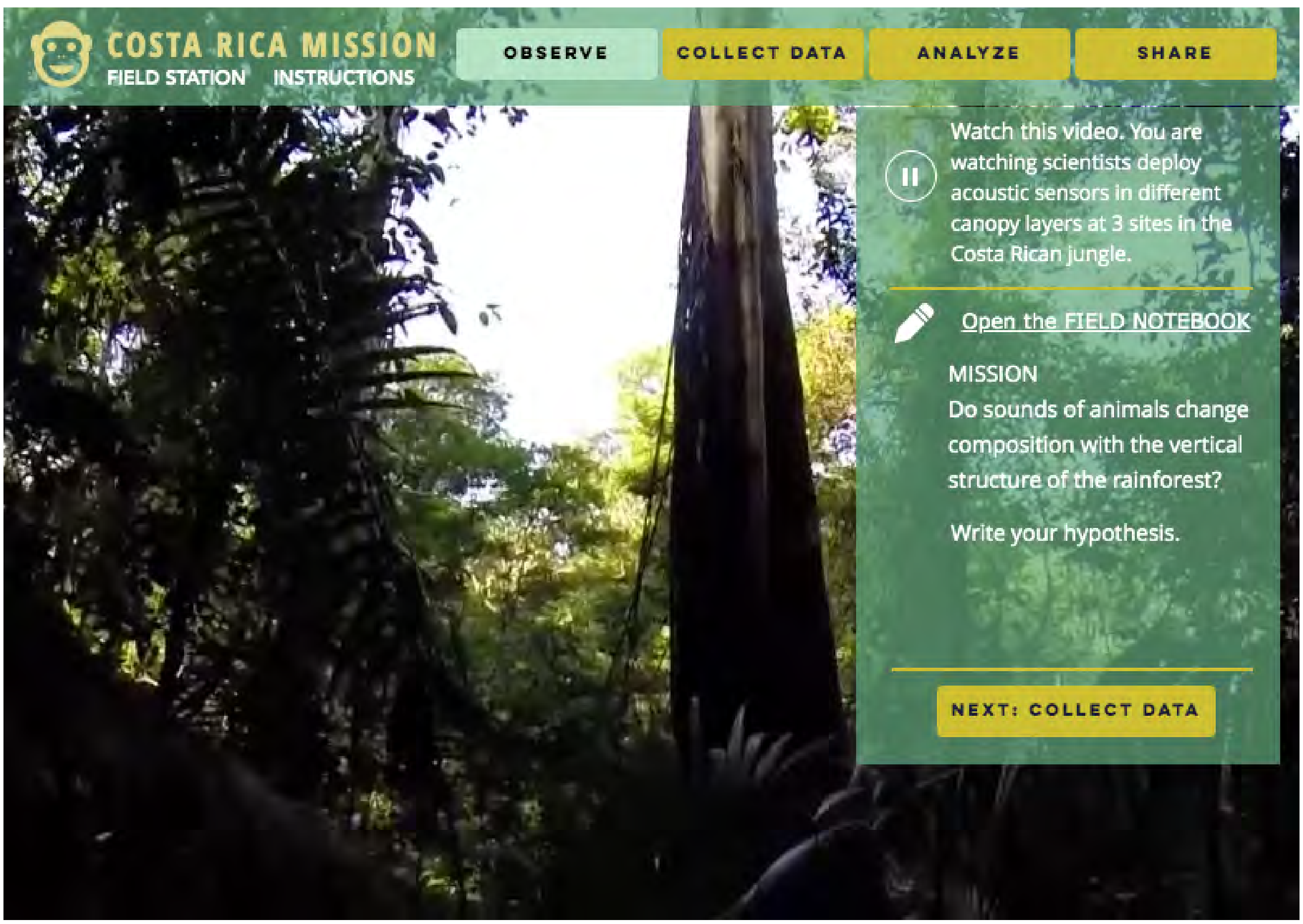
Task 4: Bonus

The bonus content in this room is a zoomable map of Costa Rica.

Task 5: Click Clipboard



The aim of the simulated research study is to follow the steps of the scientific method. Users complete an online notebook through four steps, 1) observe, 2) collect data, 3) analyze, and 4) share.
Tools allow for changing plots and printing them; fillable notebook that can be printed from the browser; and an online poster board drawing tool.

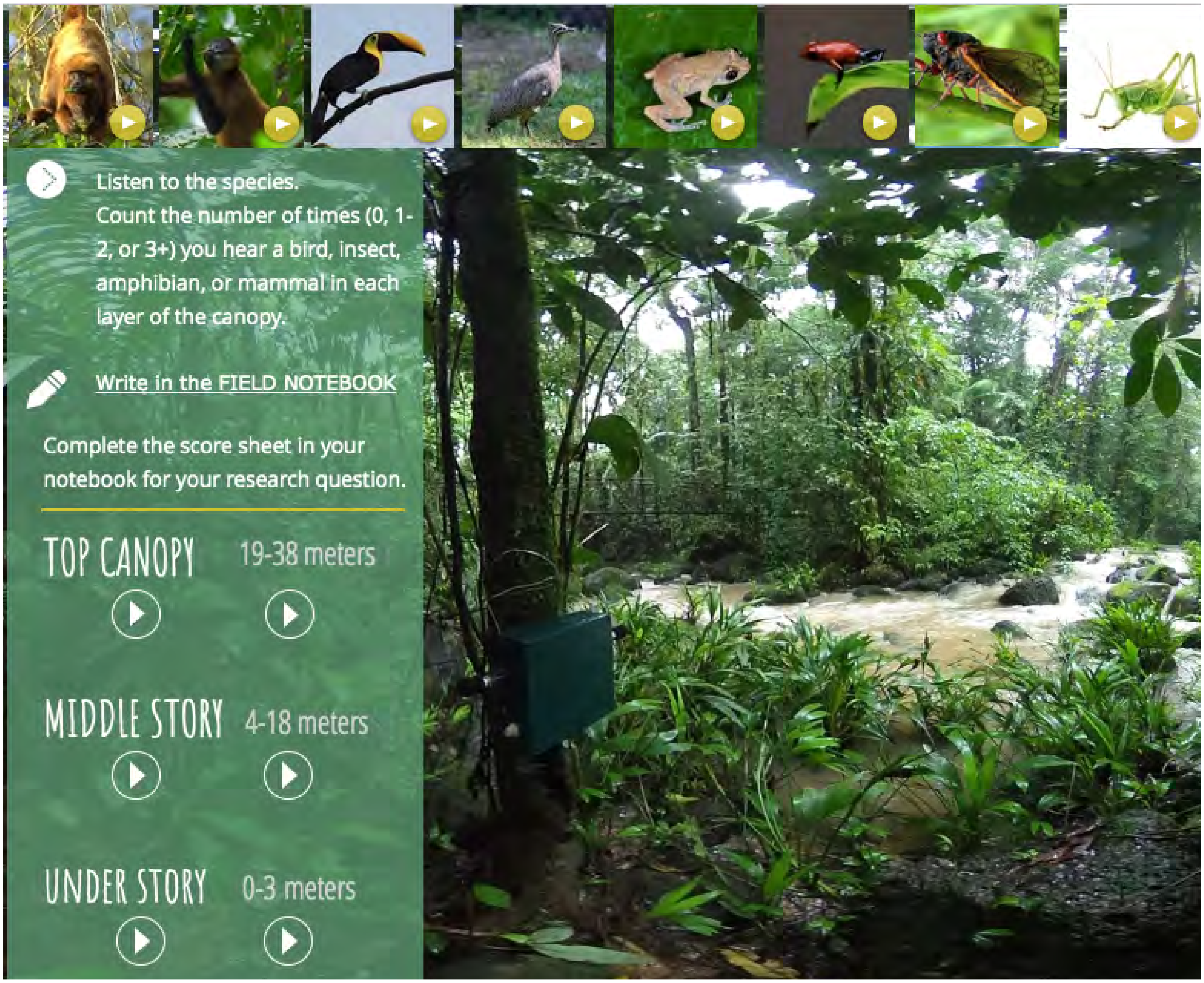


Step 1: Observe

Listen to a scientist talk about the field site with full screen video. Students should open their notebook and write a hypothesis.

EXTENSION: Students can write their own research question.

Step 2: Collect Data



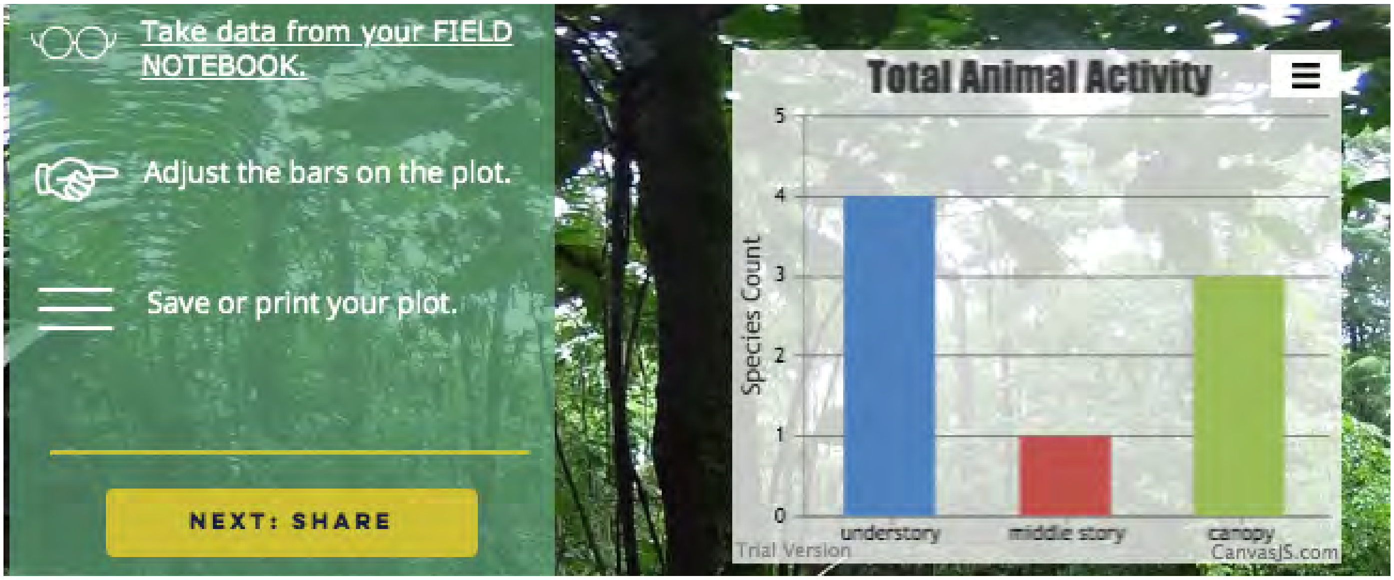
Students listen to the two samples (two different sound files) in each layer of the jungle. The lowest layer is called the understory (0-3 meters). The middle story is 4-18 meters high, while the top canopy (the highest layer) is 19-38 meters.

Samples of common sounds found in this jungle are on the top bar. Open the field guide by clicking on an animal to see the scientific class.

Students count the number of sounds they hear in each class and complete the table in the field notebook.

EXTENSION: Compare the two sounds in each site.

Step 3: Analyze Data



Review the collect data table from the field notebook.
Count the total number of sounds (if the sound is 1-2, then use the highest number) of all classes (mammals + insects + amphibians + birds) for each section of the canopy. **Adjust the bars** on the bar plot, drag the top of the bar to the desired count. **Save or Print** by clicking on the top right icon to export your finished plot to print or to save as a jpg image.

Step 4: Share (see Field Notebook for instructions)

Field Notebook

Use the answers in the field notebook to complete your poster. **Click the Share** button and select the template. **Customize template** (or build a new one). Include your hypothesis, a paragraph about your study site, your results, and your conclusion. Finally, **share or print** from the saved PDF of your poster.

Costa Rica Mission Field Notebook

Do sounds of animals change composition with the vertical structure of the rainforest?

Write your hypothesis.

My hypothesis is that there will be more birds in the top canopy than the understory because they need to fly.

Listen to the collected samples. Select what sounds you heard in each canopy layer.

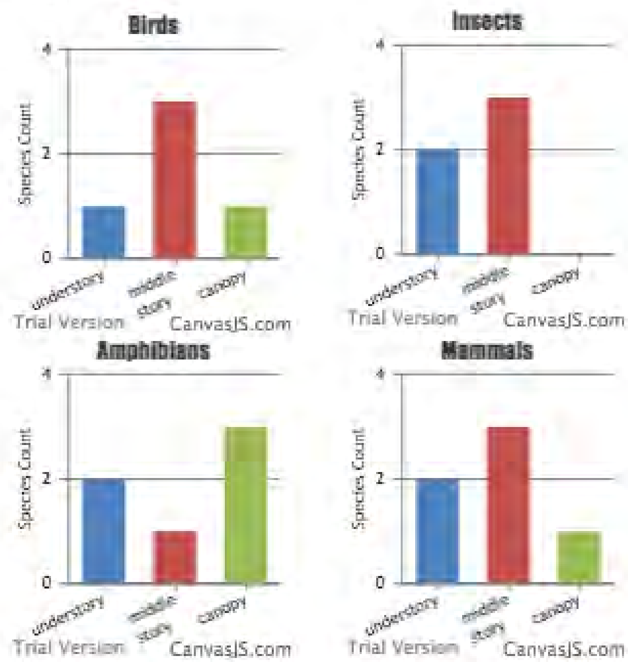
0 - you do not hear any species in the animal class (birds, insects, mammals, amphibians) in a single recording.

1-2 - you heard one or two calls or songs from an animal class in a single recording.

3+ - you heard more than two calls or songs from an animal class in a single recording.

	Birds	Insects	Amphibians	Mammals
CANOPY	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+
MIDDLE STORY	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+
UNDERSTORY	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+

Plot your results.



Describe your results.

Each plot represents to total count between my two samples for each section of the vertical structure. Overall, there were more birds in caopy while there were less amphibians in the canopy.

Write your conclusion.

My conclusion is that birds were not more prevalent in the canopy because tinamous, a flightless bird, made sounds in the understory.

Chapter 4: Missions

Activity 14: Explore a Coral Reef

The goal of this activity is to conduct a simulated research study. The research question is: Do underwater soundscapes change near a shipping corridor? In the field station, 1) watch the movie (hover bottom right corner to turn on sound), 2) learn about how underwater environments are structured, 3) read a book, 4) conduct a simulated research study.

Chapter 4: Activity 14: Mission

Task 1: Watch Movie

✓ The movie brings you to coral reefs where you learn about noise in the environment.

Task 2: Use Touch Pad

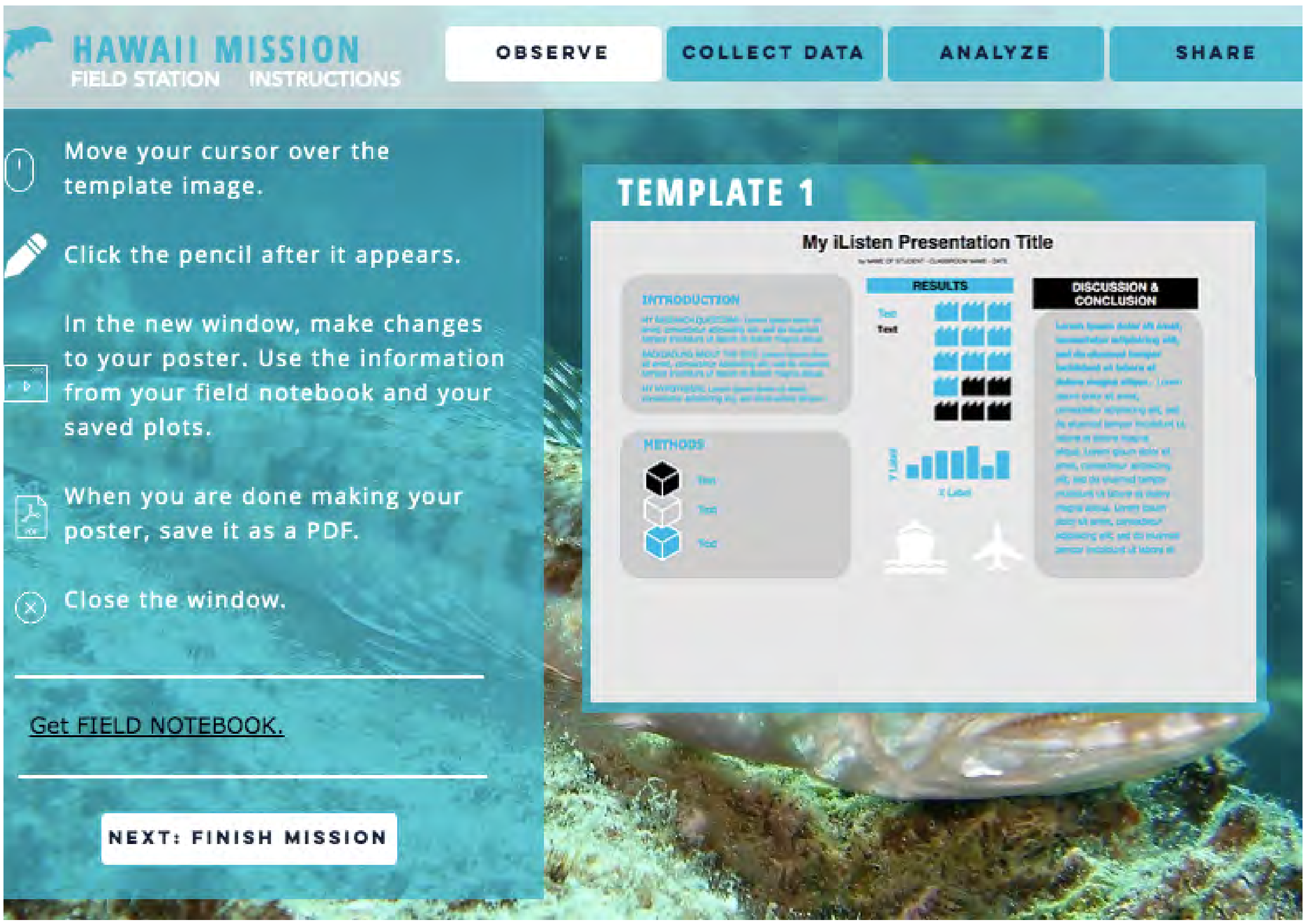
✓ The information on this computer is designed as a web browser to discover sounds found near a coral reef.

Task 3: Read a Book

✓ The contents of the book introduce readers to the weather and general physical properties of the location. Readers can explore different types of research questions.

Task 5: Click Clipboard

The aim of the simulated research study is to follow the steps of the scientific method. Users complete an online notebook through four steps, 1) observe, 2) collect data, 3) analyze, and 4) share.
Tools allow for changing plots and printing them; fillable notebook that can be printed from the browser; and an online poster board drawing tool.

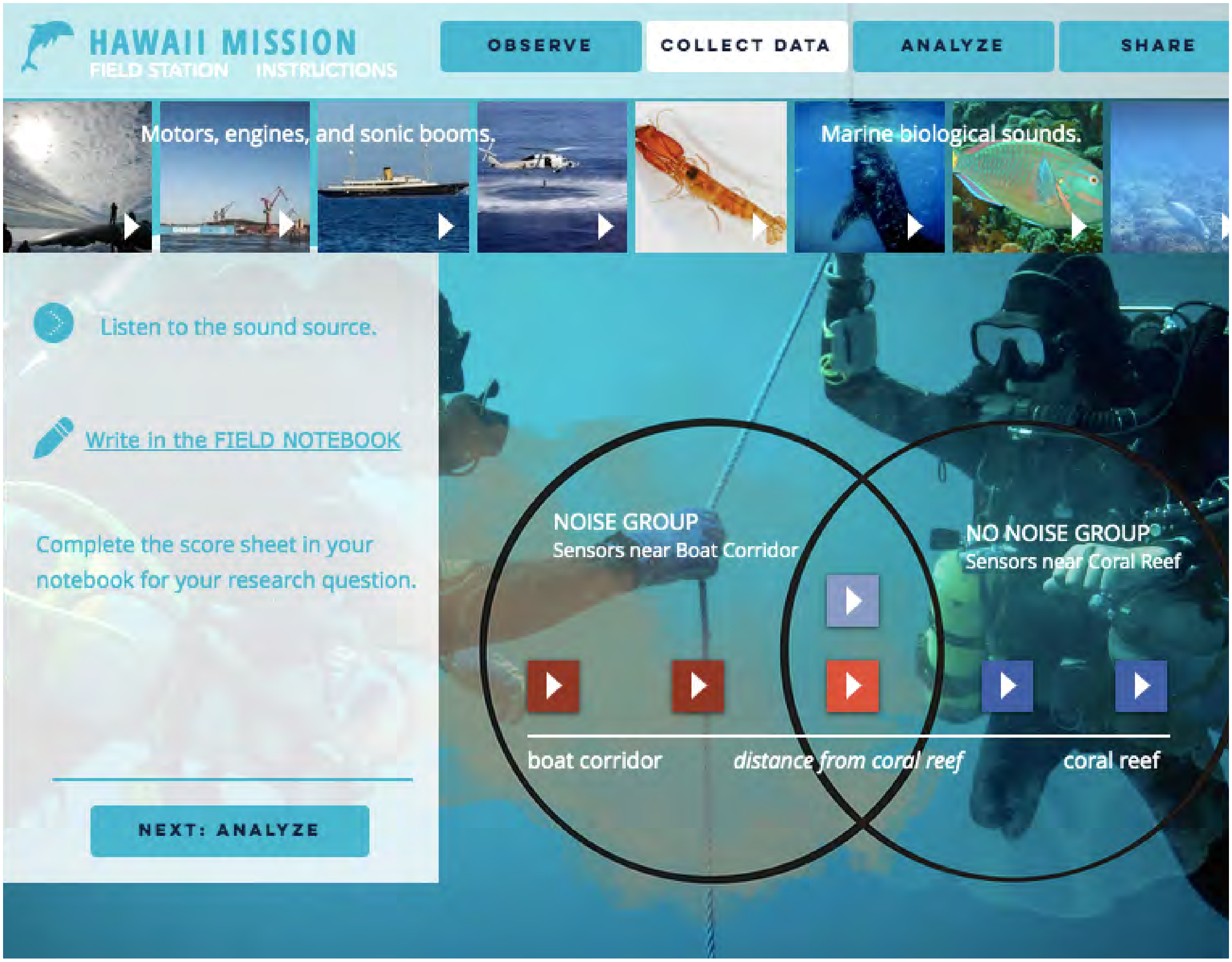


Step 1: Observe

Listen to a scientist talk about the field site with full screen video. Students should open their notebook and write a hypothesis.

EXTENSION: Students can write their own research question.

Step 2: Collect Data



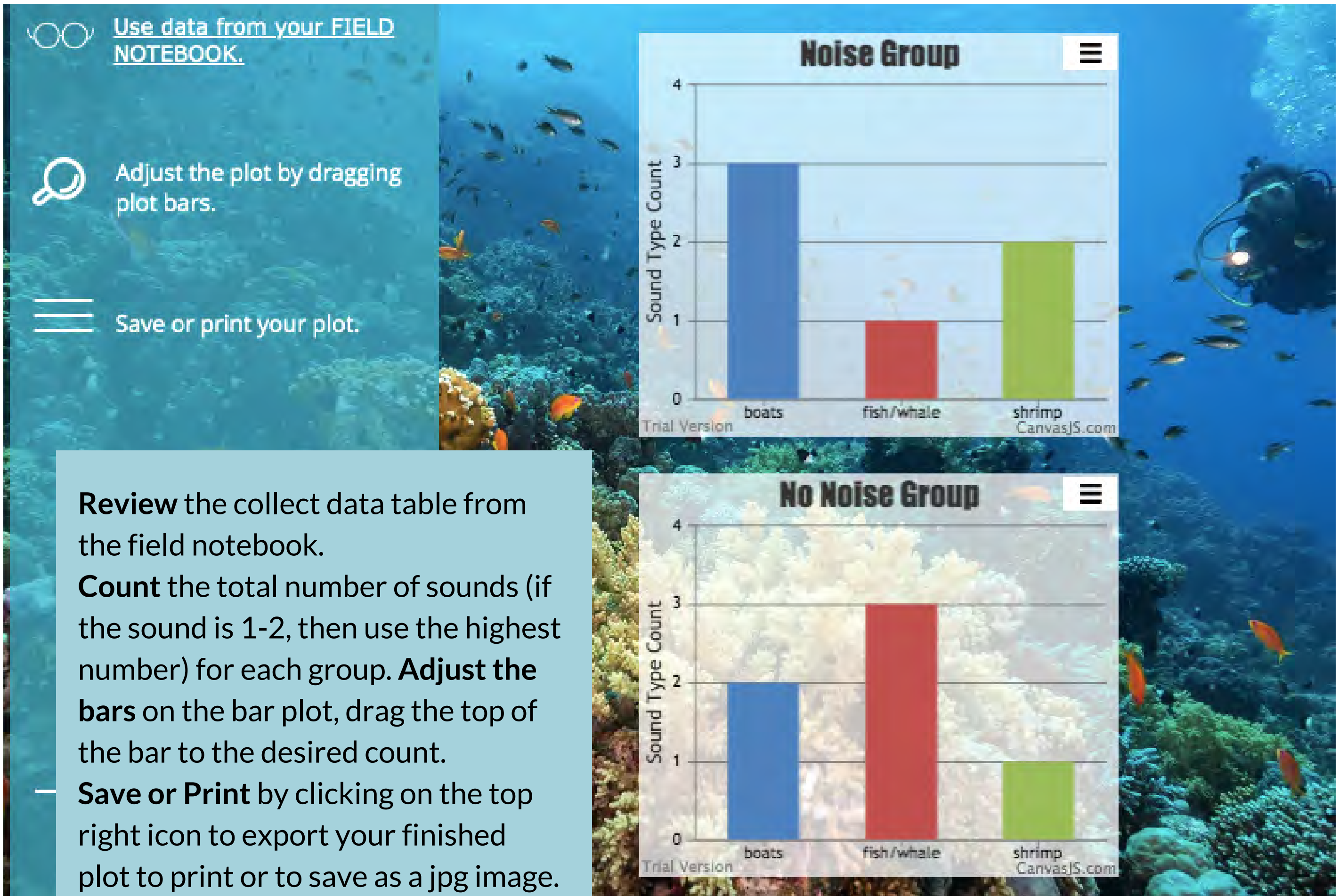
Students listen to the sounds in each group - the noise group, and the no noise group. Notice that as the sound gets farther from the coral reef and closer to the boat corridor, some sounds fall in between the two groups (Noise is Red, No Noise is Blue).

Samples of common sounds found in aquatic environments are on the top bar. Open the field guide by clicking on an image.

Students identify the sounds heard in each group.

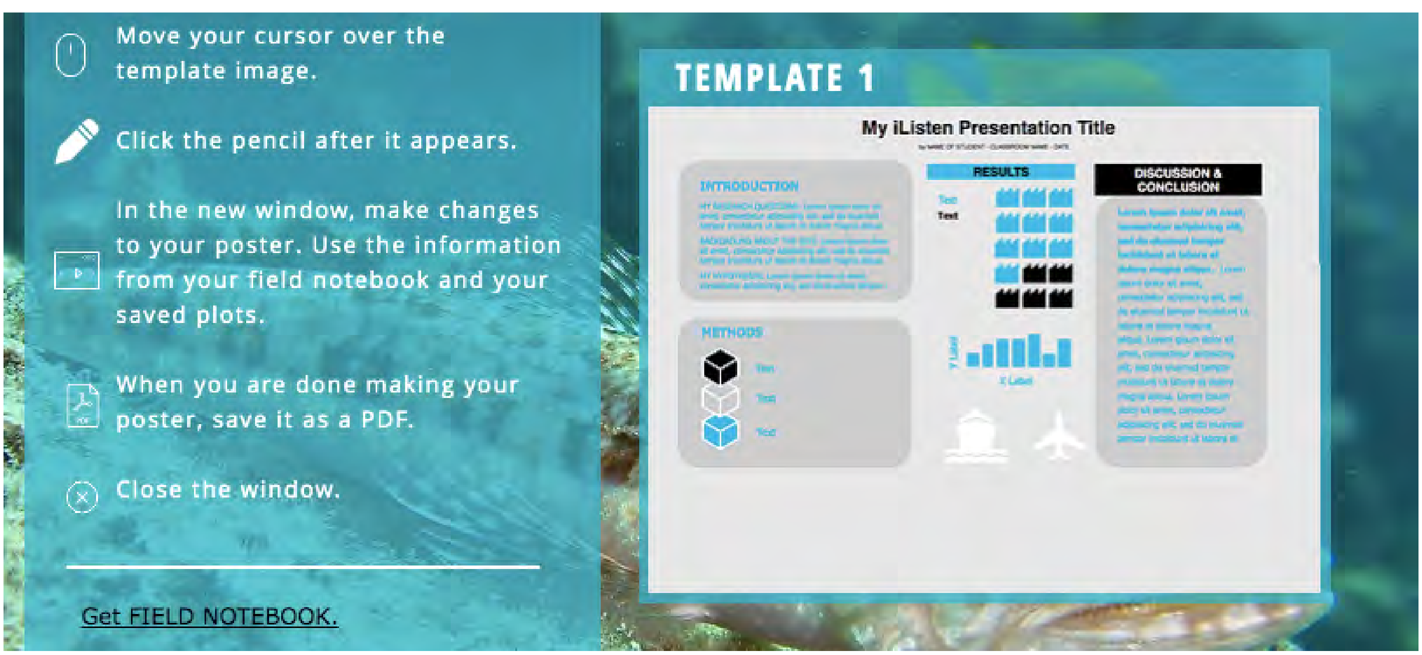
EXTENSION: Compare types of biological sounds in each group.

Step 3: Analyze Data



Review the collect data table from the field notebook.
Count the total number of sounds (if the sound is 1-2, then use the highest number) for each group. **Adjust the bars** on the bar plot, drag the top of the bar to the desired count.
Save or Print by clicking on the top right icon to export your finished plot to print or to save as a jpg image.

Step 4: Share (see Field Notebook for instructions)



Chapter 4: Activity 14: Mission Worksheet

Field Notebook

Use the answers in the field notebook to complete your poster. **Click the Share** button and select the template. **Customize template** (or build a new one). Include your hypothesis, a paragraph about your study site, your results, and your conclusion. Finally, **share or print** from the saved PDF of your poster.

Hawaii Mission Field Notebook

How do sounds of animals change in an aquatic environment when noise is present or not present?

Write your hypothesis.

B I U Tr

My hypothesis is that there will be less animal sounds when noise is present because they move to a new location.

Listen to the collected samples. Count the sound types you hear in the two sample groups (noise, no noise).

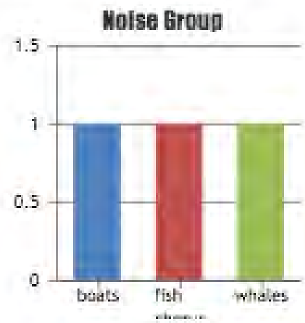
0 - you do not hear any sounds in a single recording.

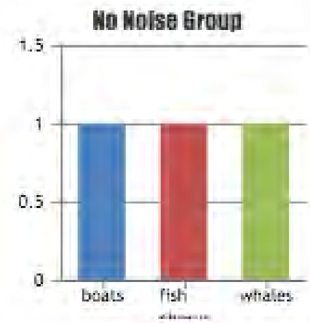
1-2 - you hear one or two instances of a similar sound in a single recording.

3+ - you hear more than two instances of a similar sound in a single recording.

	Boats	Fish	Whales
NOISE	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+
NO NOISE	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+

Plot your results.





Describe your results.

B I U Tr

The plots for both the noise and no noise group shows that there are similar sound counts for for boats, fish, and whales.

Write your conclusion.

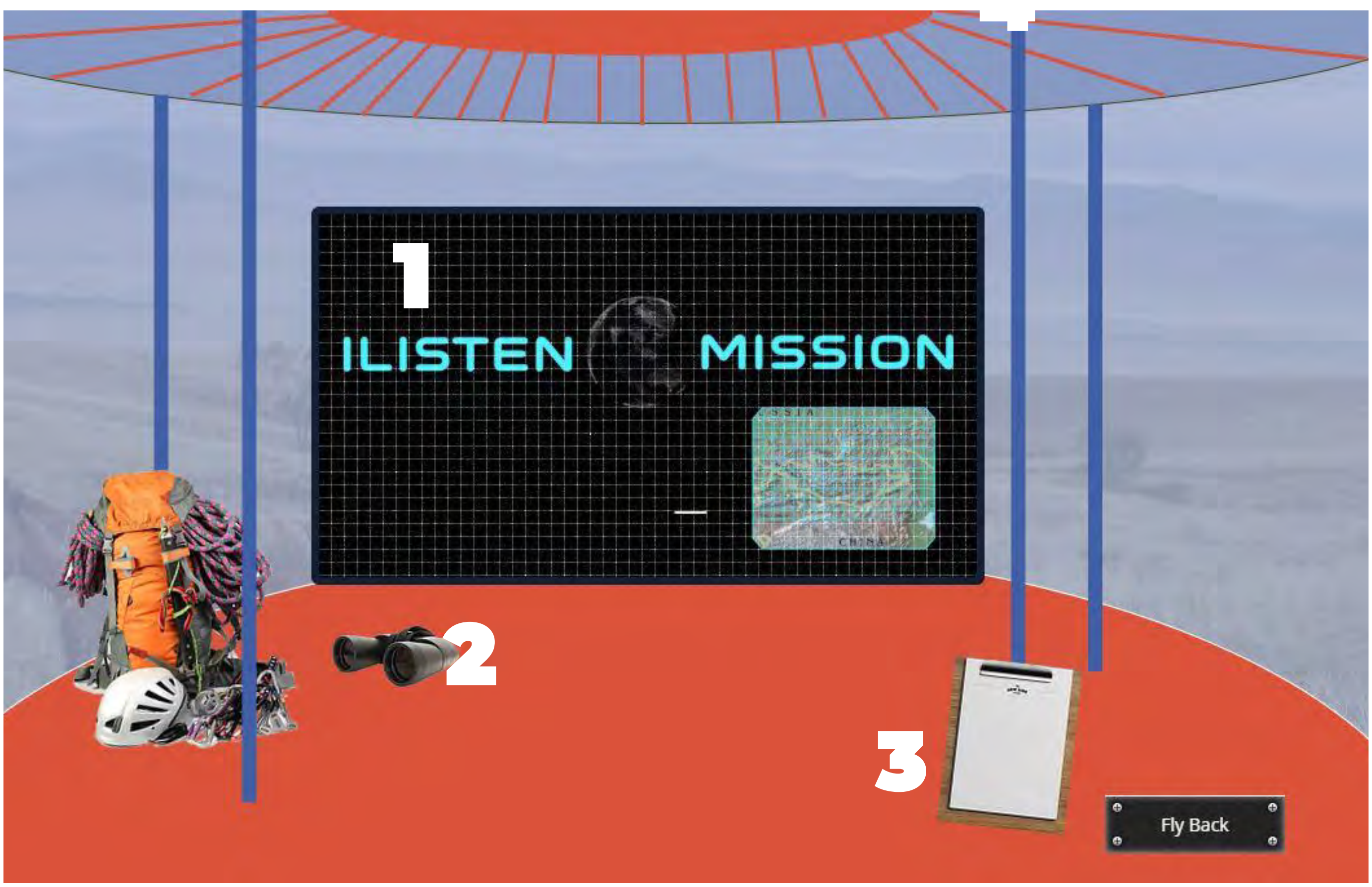
B I U Tr

My conclusion is that although I thought that there would be a difference in the groups, there wasn't. This could be because I only listened to a small group of sounds, or because both groups were close to a coral reef.

Chapter 4: Missions

Activity 15: Explore a Grassland

The goal of this activity is to conduct a simulated research study. The research question is: How does grazing impact the soundscape of a grassland environment? In the field station, 1) watch the movie (hove bottom right corner to turn on sound), 2) read a book, and 3) conduct a simulated research study.



Chapter 4: Activity 15: Mission

Task 1: Watch Movie

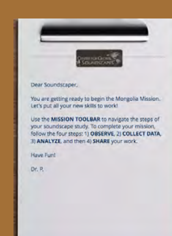
✓ The movie brings you to the steppes (grassland) in Mongolia where you learn about grazing patterns.

Task 2: Read Book

✓ The contents of the book introduce readers to the weather and general physical properties of the location. Readers can explore different types of research questions.

Task 3: Click the Clipboard

✓ Conduct a simulated research study by clicking on the clipboard.



Dear Soundscaper,

You are getting ready to begin the Mongolia Mission. Let's put all your new skills to work!

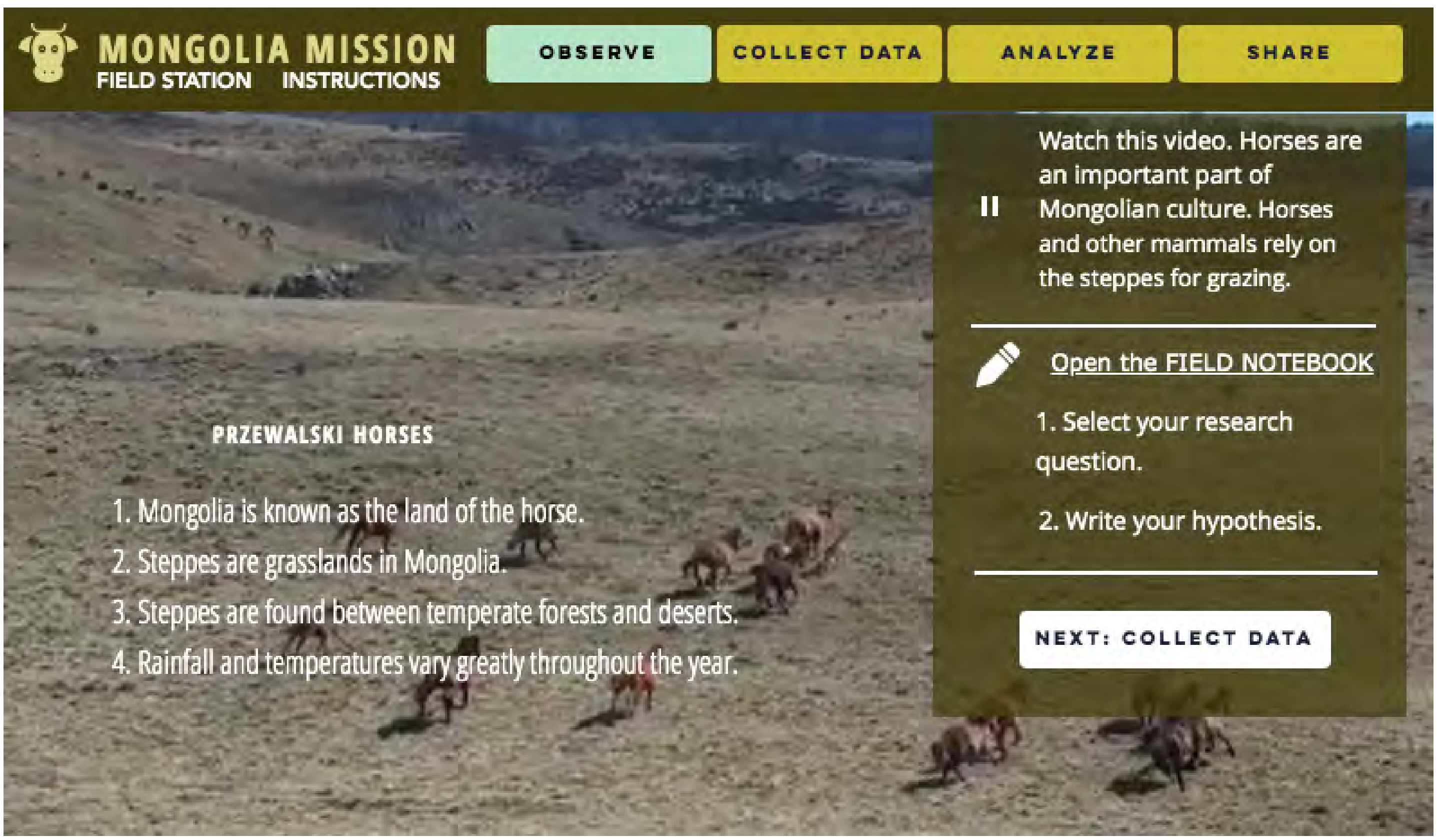
Use the **MISSION TOOLBAR** to navigate the steps of your soundscape study. To complete your mission, follow the four steps: 1) **OBSERVE**, 2) **COLLECT DATA**, 3) **ANALYZE**, and then 4) **SHARE** your work.

Have Fun!

Dr. P.

Task 3: Click Clipboard (cont.)

The aim of the simulated research study is to follow the steps of the scientific method. Users complete an online notebook through four steps, 1) observe, 2) collect data, 3) analyze, and 4) share.
Tools allow for changing plots and printing them; fillable notebook that can be printed from the browser; and an online poster board drawing tool.

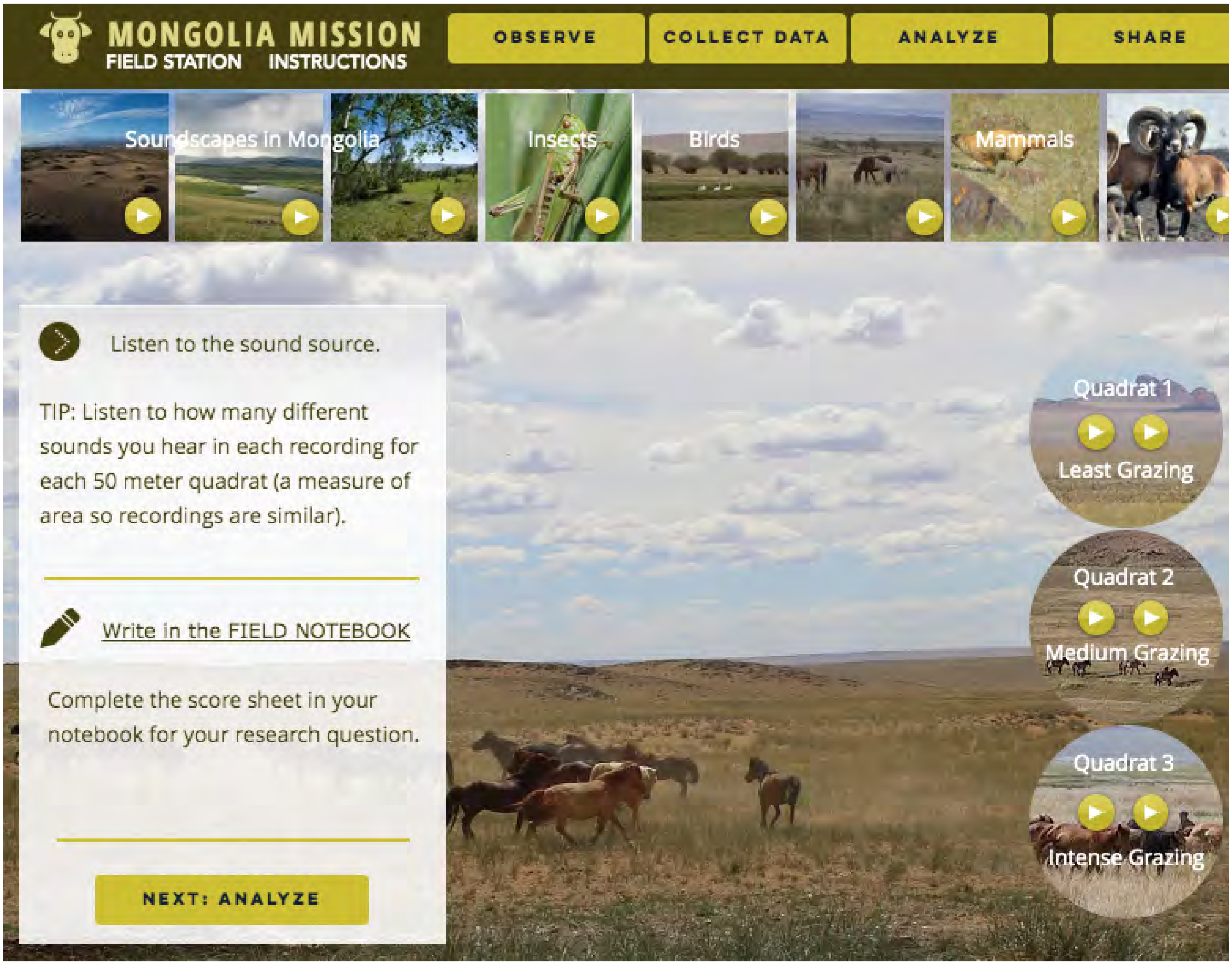


Step 1: Observe

Listen to a scientist talk about the field site with full screen video. Students should open their notebook and write a hypothesis.

EXTENSION: Students can write their own research question.

Step 2: Collect Data



Students listen to the two samples (two different sound files) in each quadrat (a term used to describe area, so samples have less bias). Quadrat 1 is least grazing. Quadrat 2 is medium grazing. Quadrat 3 is intense grazing. These groups represent a "gradient transect" experimental design.

Samples of common sounds found in Mongolia are on the top bar.

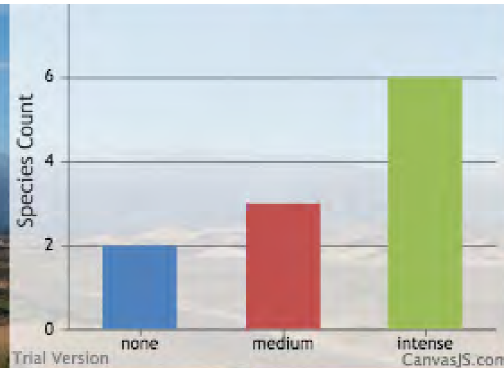
Students count the number of insects, birds, and mammals they hear in each quadrat and complete the table in the field notebook.

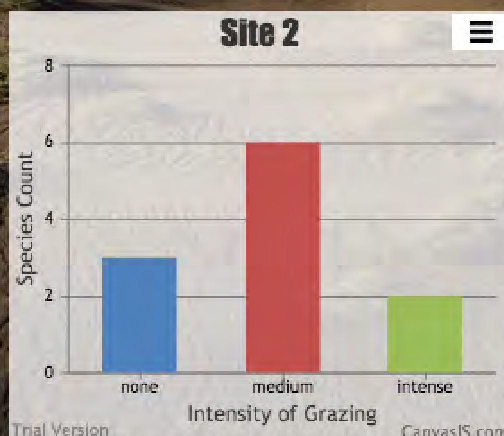
EXTENSION: Use the field guidebook sounds to answer other research questions found in the Mongolia flipbook.

Step 3: Analyze Data

Count the number of different species (bird, cricket, bee, marmot, sheep, or horse) in each quadrat.

Adjust the bars on the plot for each site.





Review the collect data table from the field notebook.
Count the total number of sounds (if the sound is 1-2, then use the highest number) of all classes (mammals + insects + birds) for each section of the canopy.
Adjust the bars on the bar plot, drag the top of the bar to the desired count.
Save: Click on the top right icon to export your finished plot to print or to save as a jpg image.

Step 4: Share (see Field Notebook for instructions)

Move your cursor over the template image.

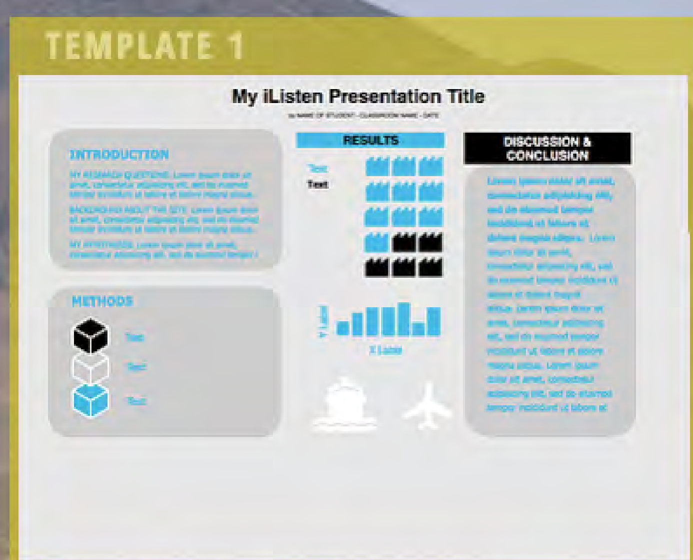
Click the pencil after it appears.

In the new window, make changes to your poster. Use the information from your field notebook and your saved plots.

When you are done making your poster, save it as a PDF.

Close the window.

Get FIELD NOTEBOOK.



Field Notebook

Use the answers in the field notebook to complete your poster. Click the Share button and select the template. Replace template (or build a new one). Include your hypothesis, a paragraph about your study site, your results, and your conclusion. Finally, share or print from the saved PDF of your poster.

Mongolia Mission Field Notebook

How does animal grazing change the soundscape?

Write your hypothesis.

B I U Tт

My hypothesis is that there will be more diverse sounds in places with less grazing because the grazing animals are not present.

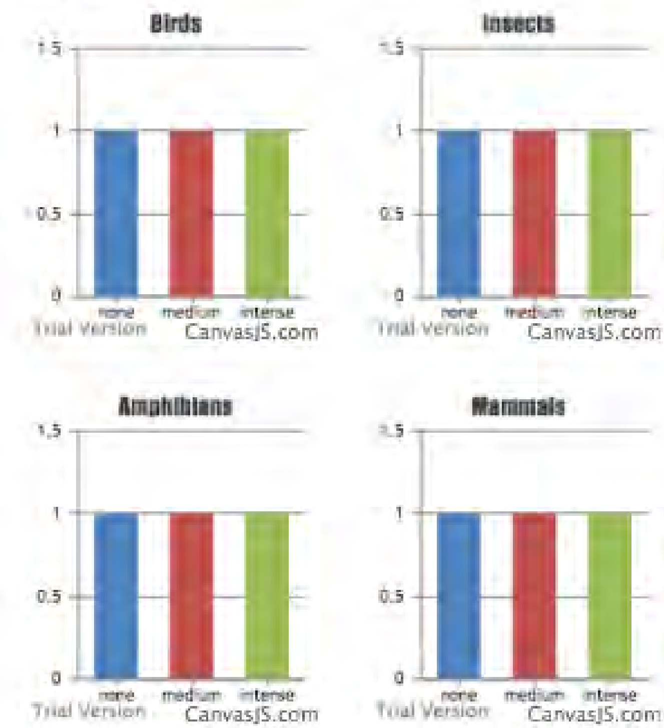
Listen to the collected samples. Select what sounds you heard in each section of the transect.

0 - you do not hear any species in the animal class (birds, insects, mammals, amphibians) in a single recording.

1-2 - you heard one or two calls or songs from an animal class in a single recording.

3+ - you heard more than two calls or songs from an animal class in a single recording.

	Birds	Insects	Amphibians	Mammals
INTENSE	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+
MODERATE	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+
NONE	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+	○ 0 ○ 1-2 ○ 3+



Describe your results.

B I U Tт

Each plot shows some variation in the grazing transect. Overall, there were more mammals in the intense grazing. There were no amphibians. The birds were present in all groups.

Write your conclusion.

B I U Tт

My conclusion is that grazing is very important part of more species being present.

APPENDIX

The appendix contains resources for educators to understand more about the scientific principles involved in the activies and case studies. Developed from guidelines provided to actual researchers, these principles can be useful if learners want to conduct their own research.

Appendix A: Standards

About Badges

NGSS Standards

Appendix B: Understanding the Missions

Visiting the Field

Checklist for Site Documentation

About the Case Studies

iAppendix C: The Real Chorus 4 Nature Database

Chorus 4 Nature Information Sheet

Appendix A: About Badges

Team Member	Theme	Badge	Description
MaryAm	Major sound sources, why animals make sound		Learn about the sound sources that contribute to a soundscape and how these sources help to describe the environment
Kristen	Physics of Sound		Learn the basics about the physics of sound and how this helps animals in the environment to communicate
Ben	Microphones and Recording		Learn about ways to capture sounds heard in nature and convert them to digitized signals
Dante	Visualizing Sound Data		Learn how sound can be visualized using a mathematical function
Matt	Databases and coding, structure of data		Learn how engineers help ecologists study and solve problems that affect the environment
Amandine	Scientific Method		Learn about the scientific method that researchers use to study different systems and problems in the world
Dr. P.	Soundscape History		Learn about a new field of science that is preserving natural sounds from around the world and using these sounds to help reverse the decline of biodiversity

Appendix A: Standards

	Standard		Description	Dimension 1: Practices	Dimension 2: Disciplinary Core Idea	Dimension 3: Crosscutting Concepts	
PHYSICAL SCIENCE	MS-PS4-1	PS4.A: Wave Properties	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	Scientific Knowledge is Based on Empirical Evidence: Scientific knowledge is based upon logical and conceptual connections between evidence and explanations.	A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.	Patterns: Graphs and charts can be used to identify patterns in data.	MaryAm, Kristen, Ben, Dante, Jack, Library, Listening Lab
				Using Mathematics and Computational Thinking: Use mathematical representations to describe and/or support scientific conclusions and design solutions.	A sound wave needs a medium through which it is transmitted		Kristen, Ben, Jack, Library, Listening Lab
	MS-PS4-3	PS4.C: Information Technologies and Instrumentation	Integrate qualitative scientific & technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.	Obtaining, Evaluating, and Communicating Information: Integrate qualitative scientific & technical information in written text with that contained in media and visual displays to clarify claims and findings.	Digitized signals are a more reliable way to encode and transmit information.	Influence of Science, Engineering, and Technology on Society and the Natural World: technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations.	Dr. P, Ben, Dante, Record the Earth, Engineering, Library, Listening Lab, Mission
						Science is a Human Endeavor: Advances in technology influence the progress of science and science has influenced advances in technology.	Dr. P, Dante, Engineering

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Appendix A: Standards

	Standard		Description	Dimension 1: Practices	Dimension 2: Disciplinary Core Idea	Dimension 3: Crosscutting Concepts	
LIFE SCIENCE	MS-LS2-1	LS2.A: Inter-dependent Relationships in Ecosystems	Analyze & interpret data to provide evidence for the effects of resource availability on organisms & populations of organisms in an ecosystem	Analyzing and Interpreting Data: Analyze and interpret data to provide evidence for phenomena.	Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.	Cause and Effect: Cause and effect relationships may be used to produce phenomena in natural or designed systems.	Kristen, Ben, Dante, Jack, Amandine, Mission
					Growth of organisms and population increases are limited by access to resources.		MaryAm, Library, Mission
	MS-LS2-4	LS2.C: Ecosystem Dynamics, Functioning, and Resilience	Construct an argument supported by empirical evidence that changes to physician or biological components of an ecosystem affect populations.	Engaging in Argument from Evidence: Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.	Stability and Change: small changes in one part of a system might cause large changes in another part.	Main, Dr. P, Amandine, Library, Mission
				Scientific Knowledge is Based on Empirical Evidence: Science disciplines share common rules of obtaining and evaluating empirical evidence.			Main, Dr. P, Amandine, Library, Mission

Appendix A: Standards

	Standard		Description	Dimension 1: Practices	Dimension 2: Disciplinary Core Idea	Dimension 3: Crosscutting Concepts	
LIFE SCIENCE	MS-LS2-5	LS2.C: Ecosystem Dynamics, Functioning, and Resilience,	Evaluate competing design solutions for maintaining biodiversity and ecosystem services.	Engaging in Argument from Evidence: Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness of integrity of an ecosystems biodiversity is often used as a measure of its health.	Influence of Science, Engineering, and Technology on Society and the Natural World: The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.	Dr. P, Amandine, Library, Listening Lab, Mission
		LS4.D: Biodiversity and Humans;			Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services tha humans rely on - for example, water purification and recycling.	Science Addresses Questions About the Nature and Material World: Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.	Dr. P, MaryAm, Amandine, Library, Mission
		ETS1.B: Developing Possible Solutions			There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.		Engineering, Library, Mission

Appendix A: Standards

	Standard		Description	Dimension 1: Practices	Dimension 2: Disciplinary Core Idea	Dimension 3: Crosscutting Concepts	
EARTH AND SPACE SCIENCES	MS-ESS3-3	ESS3.C: Human Impacts on Earth Systems	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.	Constructing Explanations and Designing Solutions: Apply scientific to design an object, tool, process or system.	Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.	Cause and Effect: Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.	Dr. P, Jack, Amandine, Library, Mission
						Influence of Science, Engineering, and Technology on Society and the Natural World: The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.	Dante, Amandine, Record the earth, Engineering, Library, Mission

VISITING THE FIELD

Researchers visit a site where data is collected with an acoustic sensor. The sites they visit are called field locations. During a site visit, a researcher will write about physical observations, such as describing surrounding plants and trees, animals, unusual physical features like an abandoned building, and other interesting sounds in the soundscape such as a stream or airport (Cook, Olson, Kanciruk, & Hook, 2001; Jones, Schildhauer, Reichman, & Bowers, 2006; Michener, 2006). They often will take photographs, videos, and handheld audio recordings to take back to the lab too. They will record notes about basic information, the equipment they use, and the location of a recorder. Overall, documenting a site visit is a very important part of acoustic research.

NOTES AT FIELD SITE VISIT

1. Site Name (a nickname) and a Prefix name (usually the name of the sensor)
2. Date Sensor was Deployed and Date Sensor was Retrieved
3. Names of Researchers Deploying Sensor and Retrieving Sensor
4. Latitude, Longitude, and Elevation of Site
5. Site Notes and Observations
6. Variables relevant to the survey design (such as disturbance level)

ABOUT THE CASE STUDIES

In our case studies of Costa Rica, Hawaii, and Mongolia, users are presented with a single research question, data that was collected, and a type of plot that is useful for analysis. Analysis methods are useful in turning recordings into a useful dataset, whether that dataset consists of indices and measurements or observations of specific sounds or species. However, those datasets still need to be applied to a relevant ecological question. Some ecological questions may be answered relatively simply, for example whether the prevalence of a given species is greater inside or outside a protected area.

In any acoustic analysis program, it is important to consider the variability of the acoustic signal, both spatially and temporally. Soundscapes can vary dramatically both over the course of a day (think of the dawn and dusk choruses), and over the course of weeks, months, or years(Krause, Gage, & Joo, 2011). There are many potential drivers of this long-term temporal variation, including species starting or ending their mating season, arriving or leaving as part of a migration cycle, or even becoming completely extirpated from a site.

Many studies have successfully used acoustic indices to evaluate broader biodiversity or disturbance level, (Gasc, Sueur, Pavoine, Pellens, & Grandcolas, 2013b; Gómez, Isaza, & Daza, 2018; Sueur et al., 2008).

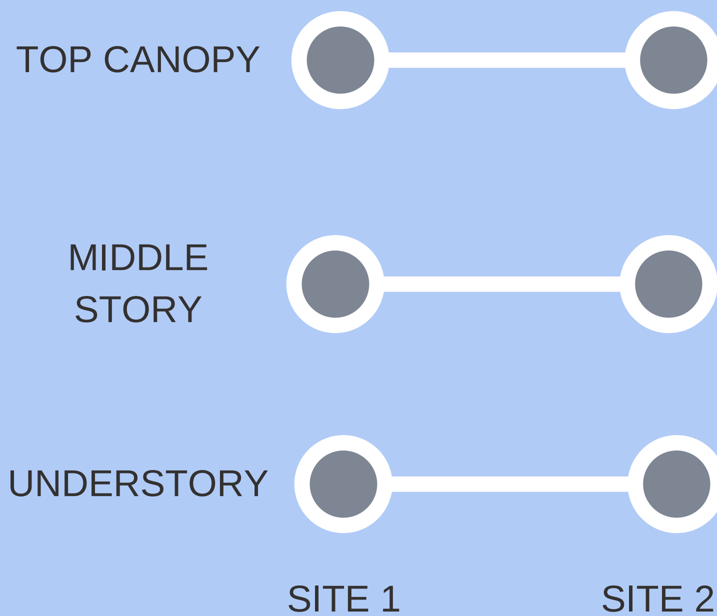
For example, suppose that the goal of the program is to determine whether a given conservation action is effective in terms of increasing population in a given area. To accomplish this using acoustics, researchers need to establish a correlation between the acoustic measurement of species activity that they are using and the actual population of the species in question. This can be done through a variety of methods, such as using camera traps or human observers at the same sites at the same time as the acoustic monitoring is taking place. To help manage the various data, researchers use an experimental design. In the iListen.org simulated studies, participants will use gradient and control/treatment experimental designs.

Appendix B: Worksheet: Jungle

This case study used an experimental design that looked like this - a gradient from the lowest part of the canopy to the highest.

SENSORS

SOUND SOURCES VARY
ECOLOGICAL FACTOR



Appendix B: Worksheet: Coral Reef

This case study used an experimental design that looked like this - a comparison of an undisturbed habitat to a disturbed habitat.

SENSORS

DISTANCE FROM SHIPPING CORRIDOR

STUDY SITES

Treatment (noise)

Control (No noise)

Appendix B: Worksheet: Grassland

This case study used an experimental design that looked like this - a transect that had three different levels of grazing.

SENSORS

INTENSE

MODERATE

LEAST

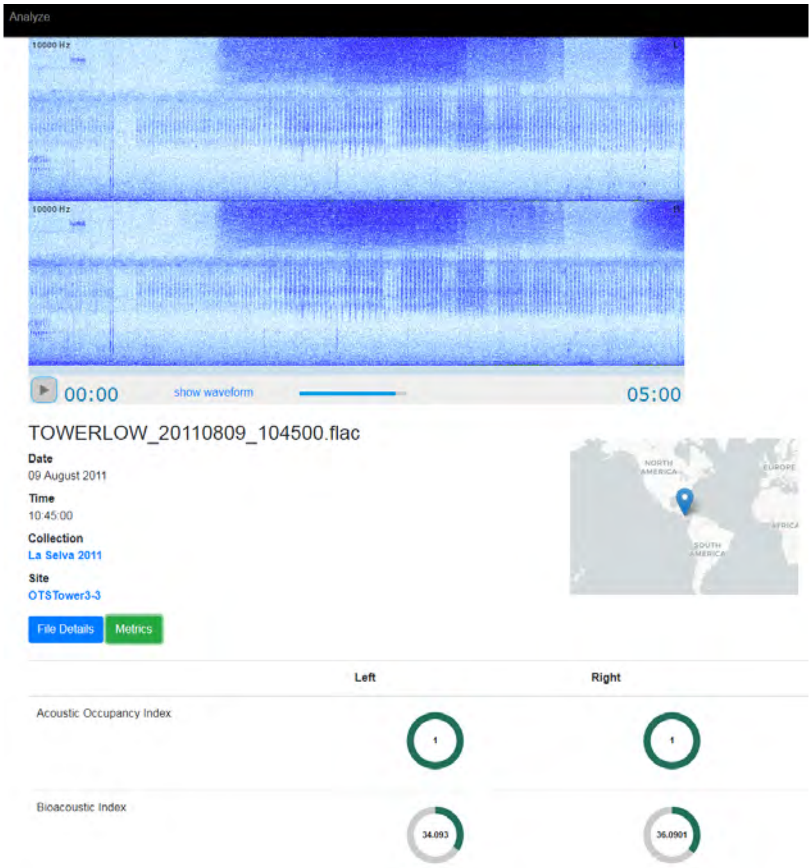
GRAZING GRADIENT

Appendix C: Chorus 4 Nature Database

Purdue's Acoustic Information System: Chorus4Nature

As part of an effort to improve data storage, tracking, and analysis, the Center for Global Soundscapes at Purdue University has developed Chorus4Nature.io, often referred to as "Chorus", the second generation of the Pumilio database system (Villanueva-Rivera & Pijanowski, 2012). This system will enable a researcher, or even a member of the public, to visualize and listen to the entirety of the Center's audio library, as well as providing:

- The location of a collection of studies, including a description of the site, relevant ecological variables such as Koppen-Geiger climate classification, key threats and ecological challenges, research partners, and summaries of the studies contained in the collection
- Photographs and videos that were taken at the site or are relevant to the studies included in the collection
- A list of sounds in the collection, with spectrograms and temporal information on each
- File information, including size, format, channels, duration, sampling rate, spectrogram settings, sensor used, and information about the specific site
- Visualizations showing the acoustic indices that have been calculated for that file.



Certified Soundscapers gain access to this tool and participate in real science.