WAVES

GRADE LEVEL: 6-8

TEACHING TIME: 1 HOUR

Explore the science of ocean and sound waves. Visualize how an ocean wave moves as you create an ocean wave model and identify parts of a wave. Investigate the movement of sound waves by engineering your own communication device. Discover how animals use sound under the sea to navigate and communicate.

This lesson is part of the NESS Tacklebox. This document was created by the education staff at New England Science and Sailing Foundation (NESS) using supplemental resources from the National Oceanic and Atmospheric Administration (NOAA) and financial support from a NOAA B-WET grant. Designed for students within an alternative setting, these activities were tested by NESS B-WET Teacher Cohort, tasked with investigating best practices of teaching experiential learning in alternative schools. We encourage you to learn from and adapt these activities to best fit the needs of your students.

STANDARDS ADDRESSED

NEXT GENERATION SCIENCE STANDARDS

- **MS-PS4-1** Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.
- **MS-PS4-2:** Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
- **MS-ETS1-1** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

OCEAN LITERACY PRINCIPLES

Principle #2: The ocean and life in the ocean shape the features of Earth

- **A.8.** Erosion and deposition of rocks, sediments, and other particles by wind, rain, waves, ice, gravity, or living organisms can alter coastlines.
- **A.10.** Beach profiles change seasonally due to different wave action and water flow.

Principle #2: The ocean and life in the ocean shape the features of Earth

- **B.10.** Humans obtain energy from the ocean via wind, waves, oil, and natural gas.
- **D.** Human activity contributes to changes in the ocean and atmosphere.

- **D.13.** Human activity can lead to the excess input of greenhouse gasses into the atmosphere, which can alter the temperature of Earth's atmosphere and affect the ocean.
- **E.** Individual and collective actions are necessary for maintaining, conserving, and sustaining a healthy ocean

CASEL SOCIAL-EMOTIONAL LEARNING STANDARDS

Relationship Skills: The abilities to establish and maintain healthy and supportive relationships and to effectively navigate settings with diverse individuals and groups.

- Communicating effectively
- Practicing teamwork and collaborative problem-solving

Responsible Decision-Making: The abilities to make caring and constructive choices about personal behavior and social interactions across diverse situations

- Demonstrating curiosity and open-mindedness
- Learning how to make a reasoned judgment after analyzing information, data, and facts
- Recognizing how critical thinking skills are useful both inside and outside of school

Self-management: The abilities to manage one's emotions, thoughts, and behaviors effectively in different situations and to achieve goals and aspirations.

- Exhibiting self-discipline and self-motivation
- Using planning and organizational skills

PROGRAM SUMMARY

ESSENTIAL QUESTION

A question is essential when it: *Questions that probe for deeper meaning and set the stage for further questioning, ones that foster the development of critical thinking skills and higher order capabilities such as problem-solving and understanding complex systems.*

How do waves form & what impact do they have on the environment?

ESSENTIAL LEARNING TARGETS

Educator Objectives
Students will be able to….

- **Diagram** parts of the wave
- **Explain** how a wave moves using keywords
- **Model** how ocean waves are created
- **Engineer** a model wave machine to demonstrate how a wave moves

Student Objectives
I can…

- **Identify** different parts of a wave
- **Model** how waves move objects and transfer energy
- **Create** model ocean waves
- **Build** a model wave machine with teammates

BACKGROUND INFORMATION

KEY CONCEPTS

Waves are created by energy passing through water, causing it to move in a circular motion. Waves transmit energy, not water.

Waves are most commonly caused by wind. Wind-driven waves, or surface waves, are created by the friction between wind and surface water.

Hazardous waves are a result of extreme weather, such as a storm surge.

Waves can be caused by underwater disturbances that displace water, such as earthquakes, landslides, or volcanic eruptions.

The gravitational pull of the sun and moon on Earth causes tidal waves.

Waves with more energy have a higher frequency and amplitude. Slower waves have a longer wavelength.

KEY WORDS

Crest - the highest surface part of a wave

Trough - the lowest part of the wave between crests

Amplitude - the distance from a midpoint to a crest or trough

Wavelength - the distance between successive crests of a wave

Friction - the resistance that one surface or object encounters when moving over another

Longitudinal wave - a wave vibrating in the direction of propagation

Transverse wave - a wave vibrating at right angles to the direction of its propagation

Disturbance - the disturbed state of a medium through which any waveform of energy is being propagated, such as an earthquake or underwater volcanic eruption

Energy - capacity of a physical system to perform work

MATERIALS

INTRODUCTION	ACTIVITY 1	ACTIVITY 2	ENVIRONMENTAL ACTION PROJECT
• Pipe cleaners • Whiteboard & markers Wave Term Cards	• Crayons • Skewers • Gummy Bears / Gum Drops • Duct tape • *Plastic Beads • *Hot Glue *Optional	• Gutter • Fans • Extension cord • Rocks • Sand • Shells • Ping pong balls / rubber ducks • Buckets • Large, shallow bins • Clipboards • Wooden Blocks • Plastic cups	• Projector for websites • Ecological Footprint Calculator

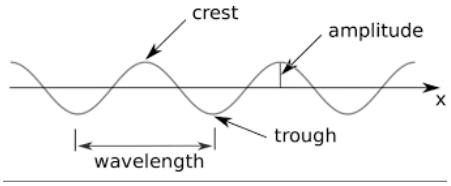
INTRODUCTION

EDUCATOR PREPARATION

Prepare pipe cleaners and an open space for students to discuss and see each other. **Prepare** print-out Wave Term Cards to use in groups or on the board.

TASK

EDUCATOR ACTIONS	STUDENT ACTIONS
Activate prior knowledge by **asking**, "What are some types of waves?" • Radio, X-ray, light, sound, micro, ocean, etc. **Identify** that the group will be investigating ocean waves with these activities. **Pass out** pipe cleaners to the group. **Instruct** students to make the shape of a wave with their pipe cleaner. **Instruct** students to hold up their designs. **Ask** students to identify similarities and differences between the designs. **Connect** student responses as you identify the following parts of a wave. **Diagram** a wave with the figure below, then **identify** and **define** the parts of a wave. Students will **locate** the	**Activate prior knowledge** and **share** the different waves they have seen, heard, or felt before. Creatively **design** a model wave. **Observe** differences in wave formation, identifying characteristics such as: • Change in amplitude • Change in wavelength **Actively listen** and **apply** new key terms to their model.

corresponding anatomy on their waves as you introduce the terminology: • **Crest** (top) • **Trough** (bottom) • **Amplitude** (distance from midline to crest) • **Wavelength** (distance from crest to crest or trough to trough)  **Explain** that all waves are a disturbance that transfers energy through matter and space (without moving mass). All waves have specific parts. **Ask** students what parts of the wave might change to indicate more or less energy. **Inform** students that there are longitudinal waves (such as sound waves and x-rays) and there are transverse waves (such as ocean waves). Throughout these activities, we will be investigating transverse waves.	**Locate** and **identify** corresponding parts of their wave. **Connect** diagram labels to their model waves. **Connect** that waves transfer energy and **hypothesize** how wave anatomy might vary depending on higher or lower energy in the system.

ACTIVITY 1
Gummy Bear Wave Machine

EDUCATOR PREPARATION

If prepared beforehand, this activity can take anywhere from 10 - 20 minutes.

Students can participate in the building process to create the "Gummy Bear Wave Machine". By having opportunities to work together, they will exercise skills in team building, communication, and self-control. It also provides them with opportunities to experiment with changes along the way. If you choose to have students help prepare the Gummy Bear Wave Machine, be prepared to have that take 20 - 30 minutes.

PREPARATION TASK

EDUCATOR ACTIONS	STUDENT ACTIONS
Prepare skewers, gummy bears, duct tape, and an open space.	**Engineer** a Gummy Bear Wave Machine!

Support the building process with roles and demonstrations. In order to create a successful wave machine, the skewers must have an even amount of weight (gummy bears, gum drops, or hot glued beads) on each side that is also evenly distributed (Figure 1). *While you can use gummy bears or gum drops, if you prefer a longer-lasting wave machine you can also hot glue plastic beads (2-3) on each side of the skewer.* **Encourage** students to change the weight distribution on a few skewers and **experiment** with the impacts on the wave machine. If time allows, you can make additional wave machines with weight placed in different spots for a side-by-side visual comparison.	**Collaborate** and split into groups to start building 1. Skewer builders 2. Wave machine blueprinters: The skewer builders will evenly place gummy bears on each side. The wave machine blueprinters will lay out the duct tape to the desired length of the machine, measure the midline, place skewers, and secure skewers with an additional strip of duct tape on top. **Experiment** with unequal distributions to **observe** changes in wave frequency and amplitude. **Celebrate** their successful design and build!

EDUCATOR ACTIONS	STUDENT ACTIONS
Facilitate an open space for students to investigate the wave machine. The wave machine can be tensioned between two chairs or held tightly between two students. **Provide time** for students to investigate on their own, and then use the challenge prompts for students to demonstrate on the wave machine. • Increased amplitude • Decreased amplitude • Increased wavelength • Decreased wavelength **Introduce** frequency as a new term. **Ask** students to demonstrate increased frequency and brainstorm a definition. **Connect** responses that frequency is the number of waves that pass a single point each second.	**Investigate** the wave machine and **observe** how changes are created when pulling, twisting, or stopping skewers. **Connect** key terms from the introduction and **demonstrate** changes on this wave machine. **Analyze** the impacts of changing amplitude and wavelength on frequency.

Review the definition of waves with students. **Ask** for a student to recall from the introduction activity.
 	
Ask students to identify the parts of the wave machine that show the energy moving.
 	
• "Do the gummy bears/gum drops/beads move side to side?"
 	
Facilitate time for creative investigation and let the students run the show! If students need an additional challenge, use some of the following prompts. Before executing each challenge, **encourage** students to say a hypothesis of what they think will happen. **Listen** for proper use of key terms introduced.
 	
• Can you make two waves from either end?
  • One up and one down?
  • Both up?
  • Both down?
• If you hold a skewer still in the middle, what happens?
• What happens if you provide slack to the duct tape vs more tension?
 	
Review with students that waves transfer energy. **Project** this video showing ducks floating. **Ask** students the following prompts:
 	
• Why are the ducks in the same location?
• What does this mean for the water underneath the ducks? Is it moving from side to side?
 	
Expand on student responses that the water molecules move similarly to the gummy bears, the water moves up and down in small circles.
	Recall that waves are a disturbance that transfers energy from one place to another.
	
	Think critically about the skewers moving up and down, not side to side. **Share** observations and **identify** that the energy seen here is the twisting of the skewers that gets passed along.
	
	Investigate freely to see converging waves, barriers, etc.
	
	Hypothesize, observe, and **analyze** the impacts of each challenge.
	
	Connect observations using wave anatomy terminology.
	
	Observe and **draw connections** to wave definition. **Think critically** about how the water moves up and down, not from one side to another.
	
	Tie together the connections between the wave machine and ocean waves.

ACTIVTY 2
Wave Investigation

EDUCATOR PREPARATION
Prepare a way to project or share the NOAA breaking waves animation.

Set up the following stations:
Station 1: Gutter with about 2 inches of water with a fan on at low speed. You may add rocks, shells, or sand to one end of the gutter to examine how a sloping shoreline can impact how a wave crashes.
Station 2: Black bin with 2 inches of water, plastic beaker, wooden black, and a clipboard.
Station 3: Gutter with 2 inches of water with a fan on at high speed.
Station 4: Gutter with 2 inches of water and wooden blocks

TASK

EDUCATOR ACTIONS	STUDENT ACTIONS
Ask students how ocean waves formed. **Connect** student responses and **explain** that water waves are formed by three methods: • **Wind** • **Disturbances** (earthquakes, volcanic eruptions, boat wakes, etc.) • **Tides** (caused by gravity)	**Activate prior knowledge** and **brainstorm** the driving forces of waves. **Build confidence** and **create connections** between prior knowledge and new concepts.
Explain that we will be modeling wind and disturbance-driven waves in this activity. **Explain** that we have four stations to investigate. **Stations 1-4** are outlined above in the preparation section. **Facilitate** engaged investigation by asking what students are observing at each station, providing time for creative play, and adding a ping-pong ball (or rubber duck!) to each after the initial investigation.	**Experiment** with different wave types and observe the differences and similarities between them at the stations. **Station 1:** Observe and draw the shape of the waves that you see along the gutter. Be sure not to touch the water or the fan. **Station 2:** Use the cup upside down in one corner of the bin. Observe and draw the shape of the waves from where the cup is making the disturbance. **Station 3:** Observe and draw the shape of the waves that you see along the gutter. Be sure not to touch the water or the fan. **Station 4:** Use the wooden blocks to make a wave. This is

	your chance to experiment and make waves (but keep the water in the gutter!) Write down your process. Test, observe, and draw your results.
Review student observations as a group. **Recap** how the ping-pong ball moved with each one. **Ask** students, "Do you think these are good models of water waves? Why or why not?"	**Think critically** about the limitations and strengths of each model.
Now that students know how waves form, **ask** them to pretend they are gearing up for a surf at their local shoreline. **Check out** the Surfline surf report. What do these wave conditions mean for the surf?	**Make observations** on wind-driven and disturbance-driven waves during the **investigation.**
Typically surfers look for an offshore wind with a longer wave period, meaning that the waves are more "groomed" and the water is less choppy. After that, students can view the NOAA breaking waves animation to observe how the shape of the shoreline indicates what spots will be ideal to surf. Cowabunga dude!	**Role-play** as surfers and **practice using a forecast** to make informed decisions. **Connect knowledge** of waves to a practical application.

WRAP UP
Environmental Action Projects

TASK

EDUCATOR ACTIONS	STUDENT ACTIONS
Reflecting on student investigations and discussions, facilitate discussion with the following prompts: · Why do we care about the science of waves? · How does this impact our daily life?	**Reflect** on the activities completed throughout the lesson and **discuss** the prompts provided as a group.
Connect student responses and **expand** that waves are ENERGY! There are opportunities to harness wave energy as a form of **renewable energy! Ask** students to identify other forms of renewable energy. · Solar, wind, hydropower, geothermal, etc.	**Understand** that the ocean is a source of renewable energy! **Identify** other known sources of renewable energy.
Present or share the links to review methods that convert wave energy into electricity. · Tidal Power 101 · Underwater Buoys · Wave Buoys	**Investigate** methods to capture energy from the ocean. **Share observations** after each video and **ask questions**.

After investigation, **review** with students the impact of climate change and why renewable energy is important. *Connect to the Climate Change NESS B-WET Lesson for additional information.* **Facilitate** a time for students to calculate their Ecological Footprint. **Record** the "ecological footprint" (measured in Earths) or "carbon footprint" (measured in CO_2 emissions) on the board. **Facilitate** a student discussion using the following prompts: · What is our average ecological footprint or carbon footprint as a class? · How did this survey make you feel? · What can you do as an individual to reduce your carbon emissions? · What can we do as a group to reduce our carbon emissions? **Provide** a space for students to think creatively about how they can make a difference as a team, and **encourage** them to take the lead! **Provide** boundaries and support where needed based on your classroom and school environment, and let your students' creativity shine!	**Calculate** their ecological footprint/carbon footprint. **Analyze** the group's average ecological footprint/carbon footprint. **Collaborate** to identify ways to minimize carbon emissions as an individual: • Turning off lights • Walking/biking to work • Unplugging unused electronics • Wearing clothes more than once, etc. **Brainstorm** possible projects they would like to develop as a team: • Green School challenges • Classroom Advocacy posters • School mini-announcements for "green tips" • Etc. **Celebrate** successes along the way! • Creative thinking • Working together collaboratively • Encouraging teammates • Project milestones

EXTENSION ACTIVITIES

For further support in facilitating Meaningful Watershed Education Experiences (MWEEs) with your students, use the MWEE Educator Guide. This will provide a detailed framework for you to create an engaging, multi-step Environmental Action Project (EAP) with your students throughout the year. Use NESS B-WET lessons to support EAP development in the investigation phase!

RESOURCES

Duck Surfs the Waves Video
https://www.youtube.com/watch?v=268v2pLe29k
(Accessed on 4/11/24)

NOAA Ocean Explorer
https://oceanexplorer.noaa.gov/edu/learning/9_ocean_waves/activities/breaking_waves.html
(Accessed on 4/11/24)

Surfline Charts
https://www.surfline.com/surf-charts/@0,-71.9069,0.5?type=wave-height
(Accessed on 4/11/24)

NOAA Ocean Explorer: Breaking Waves
https://oceanexplorer.noaa.gov/edu/learning/9_ocean_waves/activities/breaking_waves.html
(Accessed on 4/11/24)

NOAA Ocean Service
https://oceanservice.noaa.gov/facts/wavesinocean.html
(Accessed on 4/11/24)

NOAA Education: Waves & Currents
https://oceanservice.noaa.gov/education/tutorial_currents/media/supp_cur03a.html
(Accessed on 4/11/24)

BBC: Bite Size - Properties of Waves
https://www.bbc.co.uk/bitesize/guides/zgf97p3/revision/1
(Accessed on 4/11/24)

Tidal Power 101 Video
https://www.youtube.com/watch?v=VkTRcTyDSyk
(Accessed on 4/11/24)

Underwater Buoys Video
https://www.youtube.com/watch?v=6MhBHQzEoRo
(Accessed on 4/11/24)

Wave Buys Video
https://www.youtube.com/watch?v=8miWW2QyN_4
(Accessed on 4/11/24)

Ecological Footprint Calculator
https://www.footprintcalculator.org/home/en
(Accessed on 4/11/24)