Animal Welfare Institute

LESSON TITLE: OCEAN NOISE

LESSON TOPIC: Ocean Noise and Its Effects on Marine Species

GRADE LEVEL(S): 6

TECHNOLOGY & MATERIALS NEEDED

- Internet access
- Laptop and projector/screen to view opening video
- Copies of the "Sound in the Ocean" info packet
- Copies of Ben White's journal and blank "notebook page" for each student
- Pens or pencils to complete the journal activity, colored pencils or markers, rulers and extra paper to complete the closure activities
- Dictionaries or online access to dictionary to help complete vocabulary list

OBJECTIVES

AT THE END OF THIS LESSON:

The students will be able to identify major anthropogenic sources of ocean noise, identify species impacted by ocean noise, explain how sound waves travel through water and why this noise can be harmful to marine creatures, and explore possible ways to mitigate the impacts of ocean noise.

CHARACTER CONCEPTS TAUGHT:

- Empathy and perspective-taking
- Critical thinking
- Multicultural competence

STANDARDS ADDRESSED:

COMMON CORE ELA-

CCSS.ELA-LITERACY.RI.6.1
Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

CCSS.ELA-LITERACY.RI.6.2
Determine a central idea of a text and how it is conveyed through particular details; provide a summary of the text distinct from personal opinions or judgments.

CCSS.ELA-LITERACY.RI.6.3
Analyze in detail how a key individual, event, or idea is introduced, illustrated, and elaborated in a text (e.g., through examples or anecdotes).

	CCSS.ELA-LITERACY.RI.6.4 Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings. CCSS.ELA-LITERACY.RI.6.6 Determine an author's point of view or purpose in a text and explain how it is conveyed in the text. CCSS.ELA-LITERACY.RI.6.7 Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue. **NEXT GENERATION SCIENCE STANDARDS & DISCIPLINARY CORE IDEAS** MS-LS-2-4 ECOSYSTEMS, INTERACTIONS, ENERGY & DYNAMICS Construct an argument supported by empirical evidence that demonstrates that changes to physical or biological components of an ecosystem affect marine creature populations. MS-ESS3-3 EARTH AND HUMAN ACTIVITY Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. MS-PS-4-2 WAVES & ELECTROMAGNETIC RADIATION Develop and use a model to describe how waves are reflected, absorbed, or transmitted through various materials. A sound wave needs a medium through which it is transmitted.
OPENING ACTIVITY OR ACTIVATING STRATEGY	• Activate prior knowledge by asking the class, or providing turn-and-talk opportunities to answer the following: • What is communication? How do humans communicate? Do other animals communicate? What do you know about how ocean animals, such as whales or dolphins, communicate? • Say something along the lines of the following: "As you watch this video, pay attention to the way whales communicate and the kinds of things that can cause problems in their communication." • Show Ted-Ed video "Why do Whales Sing?" on YouTube https://www.youtube.com/watch?v=7Xr9BYhIceA for an overview of how marine mammals generate sound and communicate using sound underwater.
PREPARATIONS	Teachers will need a laptop with internet access and a projector or large screen television to view the opening video. They will need to make copies of the "Sound in the Ocean" packets and Ben White's journal for each student.

LESSON BODY	The lesson plan includes an informational packet explaining the properties of underwater noise, a journal excerpt from an activist who worked to protect marine life from ocean noise, discussion questions, and a list of vocabulary words that students will come across in the readings, which they may complete during the readings. 1. After watching the opening video, students should review the informational packet to gain a better understanding of how sound travels underwater and how it impacts marine species. Students can complete the vocabulary list at this time. 2. Break students into five groups. Each group is responsible for using the info packet to answer an assigned question from the list below. After the question has been answered, they will share it with the class. • What kinds of anthropogenic activities create ocean noise? • How do scientists know that marine animals are affected by the noise? • What are some things that can happen in the long-term if ocean noise continues to affect a species? • Who else would be impacted by reducing noise in the ocean? • Why might it be important to consider how humans are affected by ocean noise? 3. Students will read Ben White's journal and complete the writing exercise to create their own journal entry: *Imagine you are a citizen of the fishing village that Ben wrote about in his journal. Write your own journal entry describing how the noise generated by the experiment might affect your family and the ocean wildlife near your home.*
CLOSURE & WRAP UP	Students will share their journal entries with the class. This activity can be used as a formative assessment.
EXTENSION	Students will choose one source of anthropogenic noise and explain how it can affect one marine species by creating an infographic, recording a short newscast, or writing a short newspaper article or letter to government officials to persuade others to stop—or find alternatives to—the noise-generating activity. This can be used as a summative assessment.

VOCABULARY WORDS

anthropogenic:

concentric:

decibels:

echolocation:

fisheries:

hydrophone:

laryngeal sacs:

logarithmic:

mangroves:

propagate:

seismic:

thermocline layer:

BEN WHITE'S JOURNAL

Ben White was passionate about defending the oceans and their inhabitants against ocean noise. Ben's last direct action was to oppose a seismic experiment off the Yucatan peninsula of Mexico. The experiment was conducted by the Research Vessel Maurice Ewing, funded by the National Science Foundation, and took place in January 2005.

Yucatan Diary Day 1 Progreso, Yucatan
January 3, 2005

Things are beginning to heat up on the Mexican seismic front. Today journalists heard from the government that the seismic experiment slated to begin this Saturday near Progreso represents a huge leap forward for humankind's knowledge of the Chicxulub Crater. They were also told that even though the tests do indeed involve pumping almost unbelievably loud sounds (up to 255 decibels) every 20 seconds during daytime across over 3,000 kilometers for almost two months directly into the living oceans, the experiment will do absolutely no harm.

As for the whales, dolphins, turtles, fish and countless other creatures, the scientists say they will just move on. Never mind the fear people have here that this kind of repetitive shock waves could trigger another horrific earthquake across this delicate peninsula of porous rock honeycombed with caves. And never mind that almost everyone along this coast fishes for a living, except for the few who eke out a living from a struggling tourist trade. Twenty to 25 thousand fishing folk along this coast. All of the little villages along the coast are fishing villages, or trying to be. Catches have been down by more than half over the last two years. Catches of the preferred fish are down more than that.

One thing is for sure about these seismic airguns—they do not benefit struggling fisheries. One of the main sources of fish is Scorpion Reef just

offshore from Progreso. The other source of almost everything small and essential are the endless mangroves that separate the true mainland of Mexico from the barrier beach strip where Progreso is located on the northern coast of Yucatan. This vast experiment will affect both. When I have talked with people involved with seismic work about the consequences of their work with local fisheries, they give a wink and say, well it's actually good for fish and bad for fisheries—we just move them along. I wonder if they would be so cavalier if they actually met the people who live here.

I come into the little town putting my flyers up on telephone poles and talking to whoever will listen. I greet them and hand the oldest one my flyer with the big "ALERTA" across the top, telling of this killer ship coming to the Yucatan. I tell them about it. More people gather around us. Soon there are over a dozen. All the men are fishermen. They have heard of this, a little. They have no doubt that the seismic test is really for oil, not just scientific knowledge. They ask me how the scientists know it won't cause a tectonic shift like in Asia. I show them the number on the bottom of the sheet where they can call if they see anything strange—lots of dead fish or a stranded turtle, whale or dolphin. I say we really need them to be our eyes along the coast. At this they smile and promise to help.

After this journal entry is sent, I will go east along the coast road for a hundred miles or so to paper the poles of as many little villages as I can find. The sun is blasting, the iguanas and tarantulas are out, and the noreaster still flaps the flags and shudders the palapas on the beach. And this old activist is jazzed to be gearing up to battle again and happy to be getting such a warm reception. Win or lose in this fight, the argument will not be the same.

Imagine you are a citizen of the fishing village that Ben wrote about in his journal. Write your own journal entry describing how the noise generated by the experiment might affect your family and the ocean wildlife near your home.

SOUND IN THE OCEANS INFORMATION PACKET

THE SPEED OF SOUND

Sound travels at different speeds in solids, liquids, and gases. It's generally faster in solids than in liquids and faster in liquids than in gases: for example, it goes about 15 times faster in steel than in air, and about four times faster in water than in air.

That's why whales use sound to communicate over such long distances and why submarines use SONAR (sound navigation and ranging; a sound-based navigation system similar to radar only using sound waves instead of radio waves). It's also one of the reasons why it's very hard to figure out where the noise of a boat engine is coming from if you're swimming in the sea.

explainthatstuff.com/sound.html

HOW FAR DOES SOUND TRAVEL IN THE OCEAN?

While sound moves at a much faster speed in the water than in air, the distance that sound waves travel is mostly dependent upon ocean temperature and pressure. While pressure continues to increase the deeper you go, the temperature of the ocean only decreases up to a certain point. Past this point, it remains relatively stable. These factors have an interesting effect on how (and how far) sound waves travel.

Imagine a whale is swimming through the ocean and calls out to its pod. The whale produces sound waves that move like ripples in the water. As these sound waves travel through the water, their speed decreases with increasing depth (as the temperature drops), causing the sound waves to refract downward. Once the sound waves reach the bottom of what is known as the thermocline layer, the speed of sound reaches its minimum.

The thermocline is a region characterized by rapid change in temperature and pressure which occurs at different depths around the world. Below the thermocline "layer," the temperature remains constant, but pressure continues to increase. This causes the speed of sound to increase and makes the sound waves refract upward.

The area in the ocean where sound waves refract up and down is known as the "sound channel." The channeling of sound waves allows sound to travel thousands of miles without the signal losing considerable energy. In fact, hydrophones, or underwater microphones, if placed at the proper depth, can pick up whale songs and manmade noises from many kilometers away.

Adapted from oceanservice.noaa.gov/facts/sound.html

HOW LOUD IS ANTHROPOGENIC OCEAN NOISE?

Sound energy is measured in decibels (dB) relative to the threshold of human hearing. The decibel scale is logarithmic, which means 20dB is not merely twice as loud as 10dB, but rather represents 10 times more sound energy; 30dB is 100 times more. In the infographic below, the supertanker produces over 100 times more sound energy than the tanker.

IMPACTS OF OCEAN NOISE ON MARINE LIFE

Negative responses to anthropogenic noise have been seen in at least 27 species of marine mammals in scientific studies. Effects can include the following:

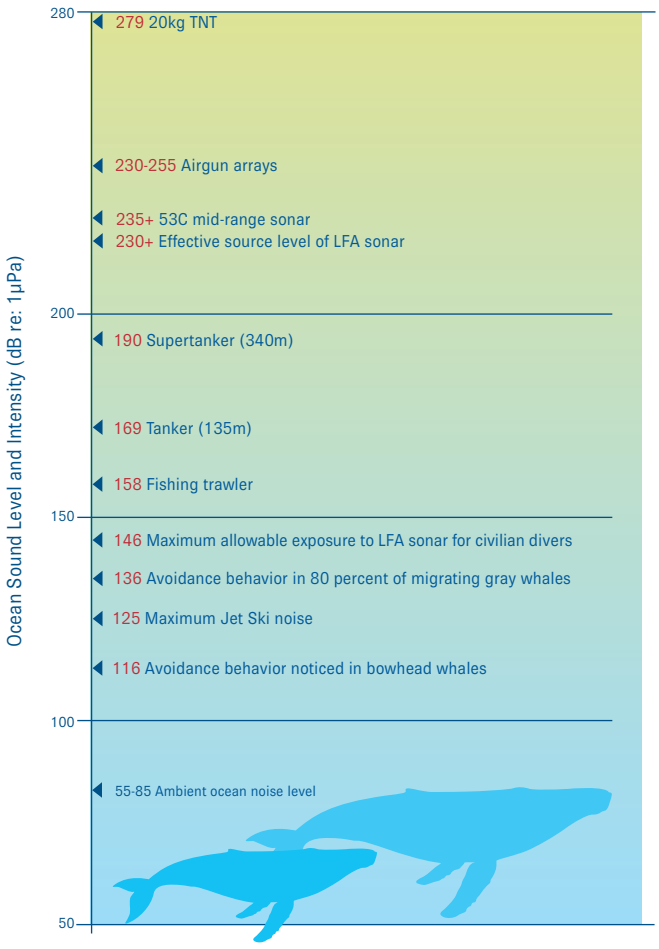
- Temporary or permanent loss of hearing, impairing an animal's ability to perform essential life functions, such as communication, avoiding predators, avoiding vessel traffic, finding mates, and catching prey
- Stranding caused by the above factors
- Avoidance behavior, which can lead to abandonment of habitat or migratory pathways and disruption of mating, feeding, or nursing
- Aggressive behavior, which can result in injury
- Masking of biologically meaningful sounds, such as the call of predators or potential mates
- Depletion of prey species

IMPACTS ON FISH AND OTHER MARINE SPECIES

Intense ocean noise damages fish and fisheries. Research so far has indicated reactions to noise in 21 species of fish. Since anthropogenic ocean noise can travel hundreds of miles from its source, the potential impact to fisheries from domestically unregulated foreign noise activities is immense. This could have significant effects on national economies, commercial fisheries, and local fishing communities. Harmful effects include the following:

- Extensive damage to fish ears and hearing
- Catch rates reduced 40–80% and fewer fish near seismic surveys reported for cod, haddock, rockfish, herring, sand eel, and blue whiting
- Disruption in schooling structure, swimming behavior, and, possibly, migration in bluefin tuna
- A significant increase in heart rate in embryonic clownfish with exposure to noise
- Negative impacts on sand eels from airguns
- Avoidance behavior in capelin and eels when exposed to noise
- A reduction in growth and reproduction in brown shrimp exposed to noise

COMPARATIVE SCALE OF KNOWN OCEAN NOISES AND THEIR NOISE LEVELS



SOURCES OF HUMAN-GENERATED NOISE

Commercial, scientific, military, and recreational marine activities can all generate noise sufficient to impact marine life.

EXPLOSIVES

Explosives are detonated in the ocean by the military, scientific researchers, and the oil and gas industry for demolition purposes and seismic exploration. They are also used in ship shock trials, whereby ships are deliberately struck with explosives to test their durability. Explosions cause extremely high noise levels and are characterized by rapid rise times—a sudden burst which can permanently damage hearing structures.

SEISMIC AIRGUNS

Seismic airgun arrays are used primarily for oil and gas exploration and research purposes. The airguns produce sound by forcing air into the water at high pressure, usually directed toward the sea floor. Up to 20 guns may be fired at the same time, while hydrophones listen for echoes. Seismic surveys with airguns can last for many weeks at a time. During the surveys, every airgun in the array produces a pulse of noise lasting 20 to 30 milliseconds, which is repeated every 10 seconds, often for 24 hours a day.

MILITARY SONAR

Active sonar is used by military vessels during exercises and routine activities to hunt for objects in the path of the vessel. These mid-frequency active (MFA) and low-frequency active (LFA) sonar systems usually emit 100-second-long "pulses" of sound that can be deployed for hours and are designed to focus as much energy as possible in a horizontal direction. LFA sonar is a type of long-range surveillance sonar that saturates thousands of cubic miles of ocean with sound. Frequencies commonly used by sonar systems range from around 0.1 to 10 kHz, with source levels in excess of 230 decibels.

SHIP TRAFFIC

Ships produce noise that generally falls in the low frequency band, between 10 Hz and 1 kHz—capable of spreading over vast distances in all directions. These low frequencies coincide with the frequencies used, in particular, by baleen whales, fish, seals, sea lions, and dolphins for communication and other biologically important activities. Ships generate sound primarily by propeller action, hull-mounted machinery, and hydrodynamic flow over the hull and the flexing of the hull. Over 90 percent of world trade is transported by ship, effectively producing an ever-present and rising aural "fog" that masks crucial natural sounds and is the most pervasive source of ocean noise today. In general, noise increases with vessel speed.

Although noise is a recognized form of pollution, sources of noise in the marine environment are not regulated at an international level. In the past half-decade, international institutions have begun to recognize the threat it poses to marine life and have been calling for precautions in the creation of anthropogenic ocean noise. Some of these precautions are as follows:

- Developing guidelines on technologies to make ships quieter and implementing navigational and operational practices that reduce noise at sensitive times and in sensitive areas
- Restricting the use of high-intensity active sonar
- Introducing guidelines on measures and procedures for seismic surveys and developing effective ways to reduce disturbance of, and potential physical damage to marine creatures.

DISCUSSION QUESTIONS

1. What kinds of anthropogenic activities create ocean noise?
2. How do scientists know that marine animals are affected by the noise?
3. What are some things that can happen in the long-term if ocean noise continues to affect a species?
4. Who else would be impacted by reducing noise in the ocean?
5. Why might it be important to consider the humans affected by ocean noise?