

LESSON 3 Harmonizing with Humpbacks

Lesson at a Glance

Students analyze popular and classical songs to understand how people use music to communicate, then, view a PowerPoint about humpback whale songs. Students construct a graph to diagram real whale song sounds and create lyrics for whale song phrases. In addition, students will examine ways scientists capture whale songs and human sources of noise pollution in whale habitats.

Lesson Duration

Two 45-minute periods

Essential Question(s)

Why might humpback whales sing?

How do scientists study whale songs?

How do human activities create noise pollution that may affect the behavior of humpback whales?

Key Concepts

- Male humpback whales sing during mating season in their Hawaiian breeding grounds.
- Scientists hypothesize that a humpback whale song is a communication behavior used to attract a mate, compete with other males for females and space, and to locate other whales in the breeding grounds. Researchers use technology to record and analyze whale song sounds.
- Some activities of people in the marine environment cause noise pollution that may affect the behavior of humpback whales.

Instructional Objectives

- I can describe the singing behavior of humpback whales during mating season in Hawai'i.
- I can describe tools scientists use to record and analyze humpback whale song.
- I can describe technology used in the marine environment that may affect the behavior of humpback whales.
- I can label the x-axis, y-axis, and title of a graph.
- I can write song lyrics that reveal insight about the singing behavior of humpback whales.
- I can infer why humpback whales sing during mating season in Hawai'i.

Related HCPSIII Benchmark(s):

Science SC.4.3.2
Describe how an organism's behavior is determined by its environment.

Science SC.4.1.2
Differentiate between an observation and an inference

Science SC.4.2.1:
Describe how the use of technology has influenced the economy demography, and environment of Hawai'i.

Math MA.4.11.2
Label the parts of a graph. (e.g., axes, scale, legend, title)

Fine Arts FA.4.2.6
Compare and contrast musical styles from two or more cultures



Assessment Tools

Benchmark Rubric:

Topic		Scientific Knowledge	
Benchmark SC.4.1.2		Differentiate between an observation and an inference	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Explain the difference between an observation and an inference and give examples	Differentiate between an observation and an inference	Provide examples of observations and inferences	Define an observation and an inference
Topic		Science, Technology, and Society	
Benchmark SC.4.2.1		Describe how the use of technology has influenced the economy, demography, and environment of Hawai‘i	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Explain how the use of technology has influenced the economy, demography, and environment of Hawai‘i and suggest ways to conserve the environment	Describe how the use of technology has influenced the economy, demography, and environment of Hawai‘i	Give examples of how the use of technology has influenced the economy, demography, and environment of Hawai‘i	Recognize that the use of technology has influenced the economy, demography, and environment of Hawai‘i
Topic		Interdependence	
Benchmark SC.4.3.2		Describe how an organism’s behavior is determined by its environment	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Explain and give examples of how different organisms’ behaviors are determined by their environments	Describe how an organism’s behavior is determined by its environment	Identify a way that an organism’s behavior is influenced by its environment	Recognize that an organism’s behavior is influenced by its environment
Topic		Data Collection and Representation	
Benchmark MA.4.11.2		Label the parts of a graph (e.g., axes, scale, legend, title)	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Effectively label the parts of a graph	Sufficiently label the parts of a graph	Label the parts of a graph, with a few omissions or errors	Label the parts of a graph, with significant omissions or errors
Topic		How the Arts Shape and Reflect Culture	
Benchmark FA.4.2.6		Compare and contrast musical styles from two or more cultures	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Compare and contrast musical styles from two or more cultures, in great detail	Compare and contrast musical styles from two or more cultures, in detail	Compare and contrast musical styles from two or more cultures, in some detail	Compare and contrast musical styles from two or more cultures, in minimal detail

Assessment/Evidence Pieces

Lesson

- Student Worksheet: *Harmonizing with Humpbacks*
- Student Worksheet: *What Are They Singing About?*
- Student Worksheet: *Spectacular Spectrographs*

Materials Needed

Teacher	Class	Group	Student
<ul style="list-style-type: none"> • PowerPoint: <i>Whale Song</i> 	<ul style="list-style-type: none"> • CD player • Computer projector or DVD Player 	<ul style="list-style-type: none"> • Three sheets of notebook paper • Dictionary • Materials for Illustration, i.e. colored pencils • GPS (Extended Activity) 	<ul style="list-style-type: none"> • Pencil • Student Worksheet: <i>Harmonizing with Humpbacks</i>

Instructional Resources

PowerPoint Presentation: *Whale Song*

Student Worksheet: *Harmonizing with Humpbacks*

Teacher Answer Key: *Harmonizing with Humpbacks*

Teacher Reading: *Spectacular Spectrographs*

Student Worksheet: *Spectacular Spectrographs*

Student Worksheet: *What Are They Singing About?*

Teacher Answer Key: *Teacher Guide for What Are They Singing About?*

Various types of songs (holiday, opera, symphony, reggae, rap, country, etc.), or ask students to bring in samples of the music they listen to (pre-screen for appropriateness in classroom)



Student Vocabulary Words

amplitude: the measure (in decibels) of the amount of energy in a sound wave; determines loudness of the sound.

bioacoustics: the study of how animals use sound for communication and echolocation.

breeding grounds: the location or environment where seasonal mating takes place.

communication: the exchange of messages or information through speech, signals, writing, or behavior.

competition: an interaction between two individuals that are requiring the same resource.

Ex: food, habitat, mates.

frequency: the number of sound waves that pass a point each second.

hydrophone: an underwater microphone used to listen to, and record, whale song sounds.

hypothesis: an educated guess that can be tested experimentally.

joiner: a lone male humpback whale engaged in a singing behavior in response to another singer.

Low Frequency Active sonar: (LFA sonar): a long-range, low frequency underwater sonar system used by the U.S. Navy to locate submarines.

pitch: the highness or lowness of sound determined by frequency vibrations.

singer: a lone male humpback whale engaged in a singing behavior.

spectrograph: a computer-generated visual image, or picture, of sound wave frequencies.

theory: scientifically accepted explanation for a pattern or phenomena.

underwater noise pollution: human-caused noise created by ship and recreational boat engines, props and sonar, oil drilling, near-shore construction, and military defense sonar.

whale song phrase: a series of sounds (units) repeated over time in patterns.

whale song theme: a repeated set of whale song phrases.

whale song unit: single, uninterrupted emissions of sound that last up to a few seconds.

x-axis: the horizontal number line on a coordinate plane.

y-axis: the vertical number line on a coordinate plane.

Lesson Plan

Lesson Preparation

- Review the Science Background provided in the Unit Overview.
- Select 3–4 popular songs and 2–3 classical songs that communicate different messages. (Pre-screen songs students bring to share.)
- Plan where to set up CD player so that all students can hear.
- Preview PowerPoint Presentation *Whale Song* and make arrangements to project it.
- Make copies of Student Worksheets *Harmonizing with Humpbacks* and *Spectacular Spectrographs*, one per student.
- Review the Teacher Reading *Spectacular Spectrographs*.

I. Communicating with Song: Presentation and Discussion

- Play segments of various songs, and engage students in a discussion about how people communicate through music using different sounds.
- Play short segments of 3–4 different popular songs, and ask the students to identify the type of music and to determine the message being communicated for each song. Examples of types of songs to play: rap, reggae, pop, religious, holiday, country, or songs the students brought to share (pre-screened for classroom appropriateness). Messages within the songs will vary depending upon song selections, but may include love, friendship, family, war, nature, and others.
- Play short segments of 2–3 different *classical* songs, and ask the students to identify the type of music and to determine the message being communicated for each song. For example, play part of a happy song (e.g., early Mozart), and part of a sad song (e.g., Tchaikovsky). (Suggested website to download free classical music: www.classiccat.net/.)
Ask the students to explain how they determined the message for each song. For example, the students might state that a song is about happiness or excitement because of the fast, upbeat tempo. If a slow, mournful song is played, the students might state that it is a song about sadness.
- Play the *Communicating with Song* humpback whale song sample found at http://Hawaiihumpbackwhale.noaa.gov/explore/sounds/whale_song.mp3. Ask the students to identify the type of music (singer), and what they think the song sample is communicating. Call on a few students for responses (guesses) on what they think the whale song might be communicating. Tell the students that they will learn more about what the whales might be communicating as they watch a power point on how scientists research whale song.
- Explain that what they are doing when they guess what the whale song might be communicating they are inferring. Reinforce the difference between an observation and inference as done in Lesson 1.
- Listen to live whale song in Hawai‘i (January – April), offered by The Whale song Project at <http://www.whalesong.net/>

II. Whale Song: Presentation, Reading Passage, and Discussion

- Present the *Whale Song* PowerPoint presentation.
- Distribute a copy of *Harmonizing with Humpbacks* student worksheet to each student. Review the directions with the students, and ask them to write in the missing words accurately and neatly.
- Allow time for all students to complete the worksheet then call on several students to read the passage aloud to the class. Ask the students to correct any mistakes.
- Ask the students to describe the two main tools scientists use to study whale song. Have the whole class repeat *hydrophone* and *spectrograph* together as each term is discussed, to practice pronouncing these vocabulary words. Make sure the students understand that a *hydrophone* is an underwater microphone that scientists use to listen to, and record, whale song, and a *spectrograph* is a computer-generated graph that shows a visual image (picture) of each whale song sound. Tell the students that in the next activity they will analyze and diagram spectrographs of real whale song recorded using a hydrophone.
- Discuss the importance of studying whale song with the students. Call on a few students to give examples of the information scientists can learn about whales from studying their song. The students

should recall from the PowerPoint presentation that studying whale song helps scientists learn more about **communication in the breeding grounds, identifying individual whales, population distribution, interactions between whales, migration, and the effects of underwater noise pollution caused by people.**

III. *Visualizing Whale Song and Constructing a Graph*

- A. Play the *Communication with Song* whale song sample again found at http://Hawaiihumpbackwhale.noaa.gov/explore/sounds/whale_song.mp3, and ask the students to describe the sounds they hear. List student responses on the board. Possible responses may include loud, quiet, high, low, squeaks, chirps, growls, moans, and others.
- B. Define the terms *pitch* and *amplitude*. Ask the students to explain their descriptions of the whale song phrase sounds (the words listed above) using the terms *pitch* and *amplitude*. Then have the students sound out the descriptive words, using the appropriate pitch and amplitude. For example, squeak = high pitch sound, where the student will say *squeak* in a high pitch voice; loud = high amplitude, where the student will say *loud* in a high amplitude (loud) voice. The students can also say the descriptive words using a combination of pitch and amplitude (e.g., say *squeak* with high pitch *and* high amplitude). Practice this until students understand *pitch* and *amplitude*.
- C. Explain that now the class will have a chance to be like scientists who study whale songs. They will listen to whale songs and track the sounds that they hear on a graph. Use the Teacher Reading *Spectacular Spectrographs* as an example for the students so that they understand how the next part of the activity will work. Then handout Student Worksheet *Spectacular Spectrographs*. Go over directions. After completing the worksheet have students share their graphs and discuss their findings.

IV. *Interpreting Whale Song*

- A. Handout Student Worksheet *What Are They Singing About?* Go over the instructions.
- B. Ask the students to write lyrics for the whale song data they analyzed and recorded on the *spectrographs* worksheet.
 - Remind the students that each line, or point, drawn on the spectrograph represents one unit. Several units make up a phrase. Their song will consist of six phrases, *including* the Demo Phrase and Phrases 1–5.
 - Lyrics must include the information listed in the worksheet directions.
 - Students may go through each graph and observe similarities, such as repeated units. The unit that is repeated could represent similar words or phrases in their lyrics.
 - Challenge the students to match their lyrics to the pitch and amplitude of the song units (e.g., students might interpret high pitch units to mean excitement).
- C. Have the students share their whale song lyrics with the class. You might want to put the students into pairs or small groups to begin the sharing process to *break the ice*, then ask for volunteers to share (sing their song) with the whole class. Challenge the students to sing their whale songs with similar pitch and amplitude as the whale song phrases.

V. *Human Impact*

Throughout the lesson, randomly cause noise disturbances (blow a whistle, clap hands loudly near students, and others), and ask the students to describe how each noise disruption affected them. Did the sudden noise change their behavior, thinking or work ability, or frighten them? Explain to the students that scientists are currently studying how technology in the marine environment (military defense sonar, oil drilling, and ship engines) affects the behavior and survival of whales. Ask the students to research more about the effects of human-caused underwater noise disturbances on humpback whales on the Internet, brainstorm ways people can help reduce underwater noise pollution, and share what they learn with the class.

LESSON 3 Harmonizing with Humpbacks

Name _____ Date _____

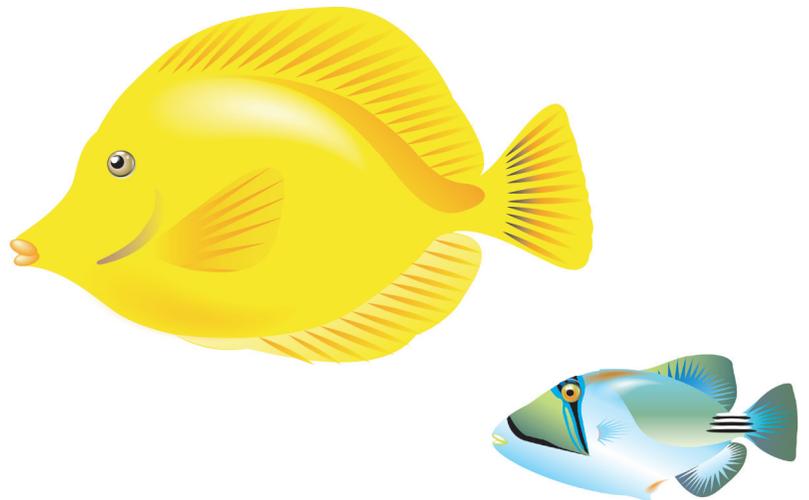
Reading Passage - Directions:

1. Read the paragraph about humpback whale song.
2. Fill in the missing words using the vocabulary listed below.

Vocabulary:

behavior	escort	mating	singer
competition	hydrophones	noise pollution	spectrograph
environment	joiner	respiratory	hypotheses

Humpback whales are famous for their complex song. Only the male humpbacks sing, and they only sing during the _____ season in their Hawaiian _____. The _____ is usually alone in a head-down, tail-up position. If the singer is following a cow and calf pair, he is called a(n) _____. When another whale joins in on the song, he is called a(n) _____. Humpback whales do not have vocal cords. They produce sounds by pushing air through tubes and chambers in their _____ system. Scientists use _____ to listen to, and record, whale song. The song is played into a computer that creates a(n) _____, a picture of each sound. Whale researchers study patterns on spectrographs to learn about why whales sing, and how they react to other whales around them. Scientists have developed some _____ to try to explain why whales sing: Scientists also study whale song to learn about how _____, caused by people, affects the behavior of whales. Ship engines, military sonar, and explosions used by oil and construction companies cause loud sounds under water that may cause changes in the whales' _____.



LESSON 3 Harmonizing with Humpbacks

Teacher Answer Key

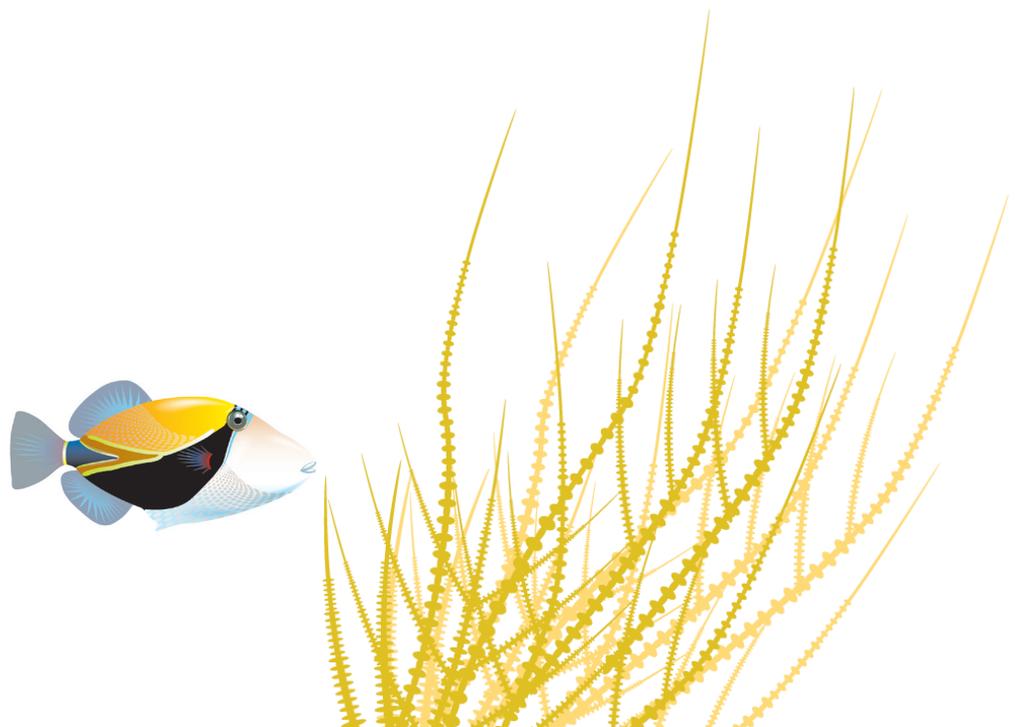
Reading passage:

1. Read the paragraph about humpback whale song, and how scientists study it.
2. Fill in the missing words using the vocabulary listed below.

Vocabulary:

behavior	escort	mating	singer
competition	hydrophones	noise pollution	spectrograph
environment	joiner	respiratory	hypotheses

Humpback whales are famous for their complex song. Only the male humpbacks sing, and they only sing during the [mating](#) season in their Hawaiian [environment](#). The [singer](#) is usually alone in a head-down, tail-up position. If the singer is following a cow and calf pair, he is called a(n) [escort](#). When another whale joins in on the song, he is called a(n) [joiner](#). Humpback whales do not have vocal cords. They produce sounds by pushing air through tubes and chambers in their [respiratory](#) system. Scientists use [hydrophones](#) to listen to, and record, whale song. The song is played into a computer that creates a(n) [spectrograph](#), a picture of each sound. Whale researchers study patterns on spectrographs to learn about why whales sing, and how they react to other whales around them. Scientists have developed some [hypotheses](#) to try to explain why whales sing: Scientists also study whale song to learn about how [noise pollution](#), caused by people, affects the behavior of whales. Ship engines, military sonar, and explosions used by oil and construction companies cause loud sounds under water that may cause changes in the whales' [behavior](#).

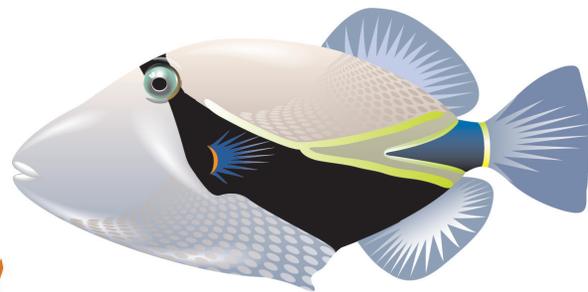
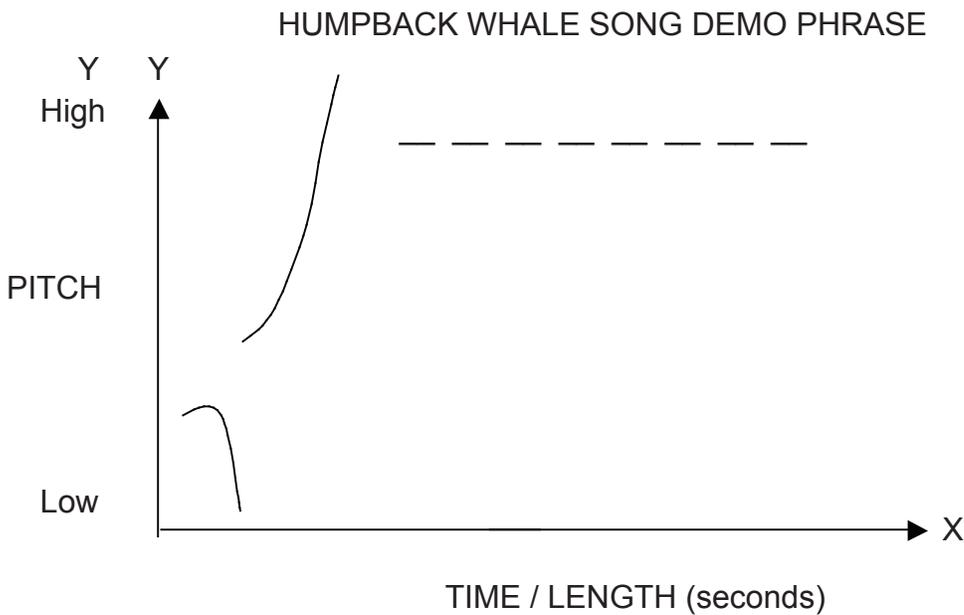


LESSON 3 Teacher Reading

Spectacular Spectrographs

DEMO WHALE SONG GRAPH:

This is an example of how to graph the whale songs as you listen to them. This whale song had a low dropping pitch first and then a swooping sound going up and then 8 short quick sounds that were all similar in pitch. Try singing this phrase.



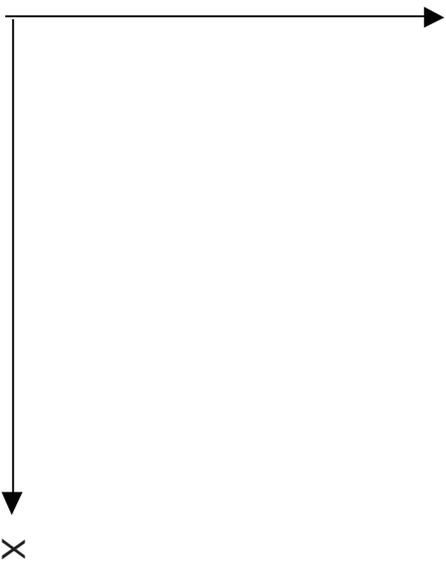
LESSON 3 Spectacular Spectrographs

Name _____ Date _____

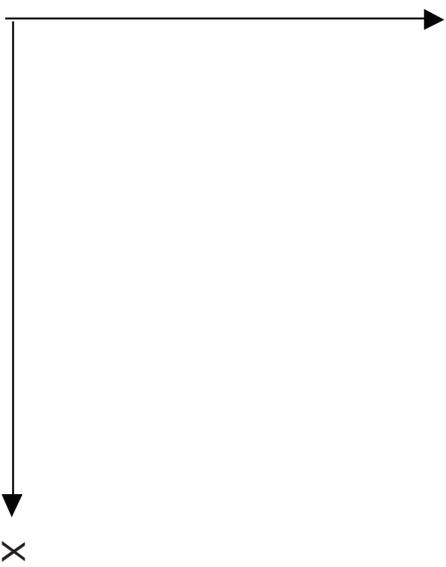
Directions:

Listen carefully to the Whale Songs. Draw the song pattern in the box. Give it a title. What does it sound like?

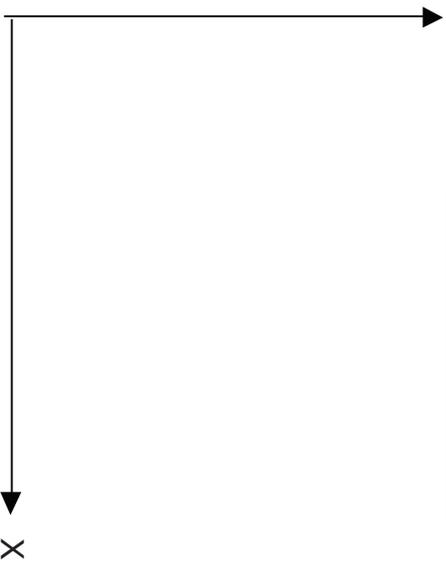
Y
Phrase _____



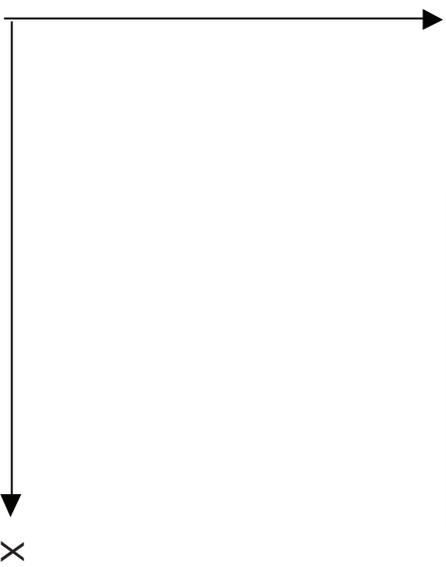
Y
Phrase _____



Y
Phrase _____



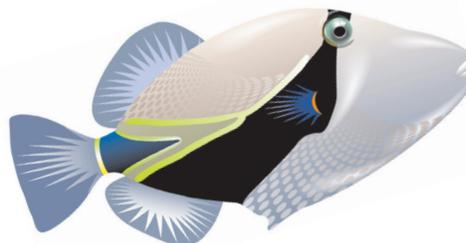
Y
Phrase _____



LESSON 3 Teacher Answer Key

Teacher Guide for What Are They Singing About?

TOPIC	ACCEPTABLE RESPONSES
WHO is singing?	<ul style="list-style-type: none"> • Male humpback whales, typically alone (Singer). • Joiner = male sings to join another male's song. • Escort = male sings while escorting cow and calf.
WHERE do whales sing?	<ul style="list-style-type: none"> • In their warm Hawai'i environment (winter breeding grounds). • Usually 15–30 meters below the surface of the water.
HOW do whales sing?	<ul style="list-style-type: none"> • In a head-down, tail-up posture. • Whales produce sounds by pushing air through tubes and chambers (sinuses) in their respiratory system.
WHY do whales sing?	<p>Scientists do not know why whales sing. Common Hypotheses:</p> <ol style="list-style-type: none"> 1. to attract a female (potential mate). 2. to compete with other males (display dominance). 3. to find the location of other whales.
RESEACH EQUIPMENT: What tools do scientists use to study whale song?	<ul style="list-style-type: none"> - Hydrophone (underwater microphone to listen and record sounds). - Spectrograph (visual representation of sounds; used to interpret and analyze song). - Bioacoustic computer programs.
HUMAN IMPACT: What human activities cause underwater noise pollution that may affect whales?	<p>Human activities that cause noise pollution: Ship and boat engines and sonar, military defense and research-LFA sonar, seismic explosions, and drilling (oil industry, construction).</p>
WHY STUDY WHALE SONG?	<p>To learn more about communication in the breeding grounds, identifying individual whales, population distribution, interactions between whales, migration, and the effects of underwater noise pollution.</p>



LESSON 3 What are they singing about?

Name _____ Date _____

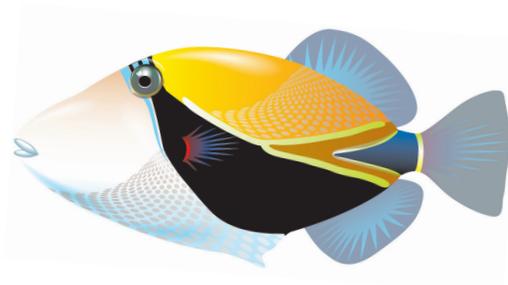
Directions:

1. Write lyrics for all of the whale song phrase spectrographs.
2. Include the following information in your song lyrics. You may spread the answers to these questions through all 4 songs:
 - a. WHO is singing?
 - b. WHERE is the singing taking place? (Describe the environment.)
 - c. What TOOLS do researchers use to study whale song?
 - d. How do people cause underwater NOISE POLLUTION that may affect whales?
 - e. One HYPOTHESIS of scientists explaining WHY humpback whales sing.
 - f. One hypothesis YOU create to explain WHY humpback whales sing. **Be creative!**

WHALE SONG LYRICS:

a) PHRASE 1:

b) PHRASE 2:



c) PHRASE 3:

d) PHRASE 4:

