Science & Literacy Activity

ACTIVITY OVERVIEW

This activity, which is aligned to the Common Core State Standards (CCSS) for English Language Arts, introduces students to scientific knowledge and language related to how scientists study the ocean.

This activity has three components:

1. **BEFORE YOUR VISIT**, students will read a content-rich article that will provide context for the visit, and also help them complete the post-visit writing task.
2. **AT THE MUSEUM**, students will read and engage with additional texts (including printed text, digital and physical/hands-on interactives, video, diagrams, models). This information will help them complete the post-visit writing task.
3. **BACK IN THE CLASSROOM**, students will draw on the first two components of the activity to complete a CCSS-aligned explanatory writing task.

Materials in this packet include:

For Teachers

- Activity overview (pp. 1-2)
- Article with teacher notes: "Listening to Life in the Deep" (pp. 3-9)
- Assessment rubric for student writing task (pp. 10-11)

For Students

- Article: "Listening to Life in the Deep" (pp.12-17)
- Student worksheet for the *Unseen Oceans* exhibition visit (pp. 18-19)
- Student writing task (pp. 20)

Common Core State Standards

RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

RST.9-10.2 Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.

WHST.9-10.2 Write informative/explanatory texts, including the narration of scientific procedures/experiments.

Next Generation Science Standards

Connections to the Nature of Science

Scientific Investigations Use a Variety of Methods
- New technologies advance scientific knowledge.
- Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge.

Science is a Human Endeavor
- Scientific knowledge is a result of human endeavor, imagination, and creativity.
- Individuals and teams from many nations and cultures have contributed to science and to advances in engineering.
- Scientists' backgrounds, theoretical commitments, and fields of endeavor influence the nature of their findings.

SEP 8: Obtaining, Evaluating, and Communicating Information
- Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
- Communicate scientific information or ideas in multiple formats (including orally, graphically, and textually).

1. BEFORE YOUR VISIT

Students will read a content-rich article about how scientists study the ocean. This article will provide context for the visit, and will help them complete the post-visit writing task.

Preparation

- Familiarize yourself with the student writing task (p. 20).
- Familiarize yourself with the teacher version of the article (p. 3-9), and plan how to facilitate the students' reading of the article.

Instructions

- Explain the goal: to complete a writing task about how scientists use tools to meet the challenges of studying the ocean.
- Tell students that they will need to read an article before visiting the Museum, and will read additional texts during the visit.
- Distribute the article, student writing task, and rubric to students.
- Review the rubric with students and tell them that it will be used to grade their writing.
- Read and discuss the article, using the teacher notes to facilitate.

2. DURING YOUR VISIT

At the Museum, students will read and engage with additional texts (including printed text, digital and physical/hands-on interactives, video, diagrams, models). The information they gather from these multiple sources will help them complete the post-visit writing task.

Preparation

- Review the educator's guide to see how themes in the exhibition connect to your curriculum and to get an advance look at what your students will encounter. (Guide is downloadable at **amnh.org/unseen-oceans-educators**)
- Familiarize yourself with the student worksheet (pp. 18-19) and the map of the exhibition.

Supports for Diverse Learners

This resource has been designed to engage all learners with the principles of Universal Design for Learning in mind. It represents information in multiple ways and offers multiple ways for your students to engage with content as they read about, discuss, view, and write about scientific concepts. Different parts of the experience (e.g. reading texts, or locating information in the Museum) may challenge individual students. However, the arc of learning is designed to offer varied opportunities to learn. We suggest that all learners experience each activity, even if challenging. If any students have an Individualized Education Program (IEP), consult it for additional accommodations or modifications.

Instructions

- Explain the goal of the Museum visit: to read and engage with texts (including printed text, digital and physical/hands-on interactives, video, diagrams, models), and to gather information to help students complete the post-visit writing task.
- Distribute and review the worksheet and map. Clarify what information students should collect, and where.

Additional Suggestions for Facilitating the Museum Visit

- Have students explore the exhibition in pairs, with each student completing his or her own student worksheet.
- Encourage student pairs to ask you or their peers for help locating information. Tell students they may not share answers with other pairs, but may point each other to places where answers can be found.

3. BACK IN THE CLASSROOM

Students will use what they have learned from the pre-visit article and at the Museum to complete a CCSS-aligned explanatory writing task about how scientists use tools to meet the challenges of studying the ocean.

Preparation

- Plan how you will explain the student writing task (p. 20) to students.

Instructions

- Distribute the student writing task and rubric. Explain that they will use it while composing, and will also use it to evaluate and revise what they have written.

Suggestions for Facilitating Writing Task

- Before they begin to write, have students use the writing task to frame a discussion around the information that they gathered at the Museum. They can work in pairs, small groups, or as a class, and can compare their findings.
- Referring to the writing task, have students underline or highlight all relevant passages and information from the article and from the notes taken at the Museum.
- Students should write their essays individually.

ARTICLE WITH TEACHER NOTES

Key for Teacher Notes

- Green text
  specific strategies
- Regular text
  instructions for teachers
- *Italicized text*
  teacher's instructions to students
- Underlined text
  important domain-specific words

Lexile: 1200

Word Count: 1471

Text Complexity: The Lexile level for this text falls toward the beginning of the 11-CCR CCSS grade complexity band. This text is suitable as a read aloud for students in grades 9 through 12. Teachers should use their professional judgment and knowledge of students' independent reading levels regarding assigning this text for independent reading.

Note:

- Assign each student a "talk partner" and have each pair designate "partner A" and "partner B."
- Set aside space on whiteboard or chart paper for a word wall.
- This interactive read-aloud is built around students making notes on the attached worksheet. The teacher notes provide recommended stopping points for students to Think-Pair-Share and Stop and Jot on their worksheets, but use your judgment about how you would like to use the worksheet with your students: it can be completed as a guided activity, but it can also be used as a tool for students to record notes as they read independently.

Listening to Life in the Deep

Preview the Text: *Let's read the title and subtitles to get an idea of what we can expect to learn from this article . . .*

Think-Pair-Share: *Turn and tell your partner what you think this article will teach us.*

When Dr. Kelly Benoit-Bird was in third grade, her family took a vacation at SeaWorld. There the future ocean ecologist learned about echolocation: how animals like dolphins use sound instead of light to sense their world, emitting "clicks" that bounce off objects and animals, then listening for the echoes. She says, "I found that idea completely fascinating: that dolphins can't see very well underwater, even during the day, and that they instead use sound. I got really excited about how different the ocean world was from ours. It's like another planet—really alien."

Setting a Purpose for Reading: *I overheard many of you say that we will learn about the work of a scientist who studies ocean life, specifically predator-prey interactions. Dr. Benoit-Bird is an ocean ecologist* (place on word wall; you will define when the word appears in the article). *Let's read this article through the lens of science and engineering practices that are used by scientists across all disciplines. The practices that are highlighted in this article include asking questions, defining problems, and designing solutions.* Put these terms on the word wall and have students construct definitions in pairs; use student suggestions to construct class definitions on the word wall. Explain that students will stop periodically to record notes on the worksheet about the work of ocean ecologist Dr. Benoit-Bird.

Kelly Benoit-Bird is an ocean ecologist at Oregon State University and the Monterey Bay Aquarium Research Institute.

Most of what was known about echolocation in marine mammals like dolphins came from studying captive animals, but Benoit-Bird wanted to know how they used this sense in their natural environment. For example, how do dolphins find food when there aren't any humans around feeding them from a bucket? How do they tell the difference between two species of fish?

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Such questions about animal behavior can be difficult to investigate in the complex underwater environment, especially in the open ocean, the vast expanse of water beyond the continental shelf. There are no landmarks or fixed boundaries there; everything moves with the currents. Little light penetrates further down than 200 meters (650 feet). It's hard for people to reach the depths of the ocean, and instruments that work well on land, such as cameras, are often little help in this dark environment. Because of these challenges, much less is known about life in the open ocean than in coastal regions.

Word Wall: Put echolocation and ocean ecologist on the word wall. Invite students to locate the definition of each in the text, and then to work with a partner to paraphrase that definition and add it to the bottom section of their worksheet. (Prompt students to study the diagram on page 10 representing echolocation).

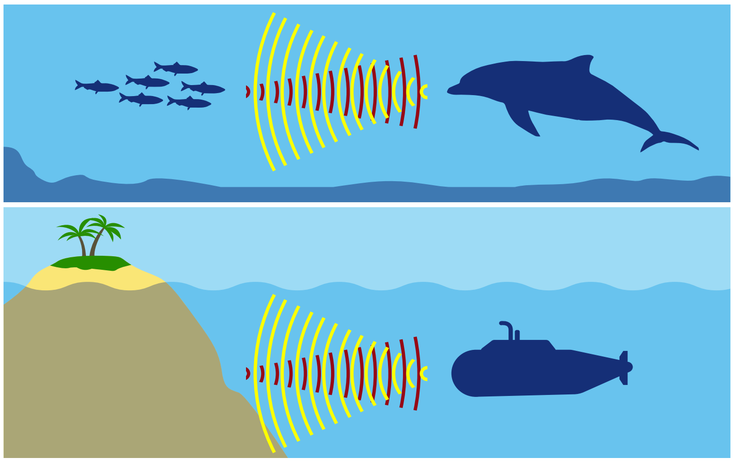
Think-Pair-Share: *What practices do you think Dr. Benoit-Bird is engaging in so far?* (Listen in and select students to share out. Students should notice that Dr. Benoit-Bird is asking questions and identifying problems).

Stop and Jot: *Look at your worksheet and identify questions that you think you can answer based on what you have read so far. Answer the questions.* Students should be able to answer "What are they studying" and "What are the challenges of studying this?" You might:

- Invite students to share their responses with their partners
- Select students to share out their responses

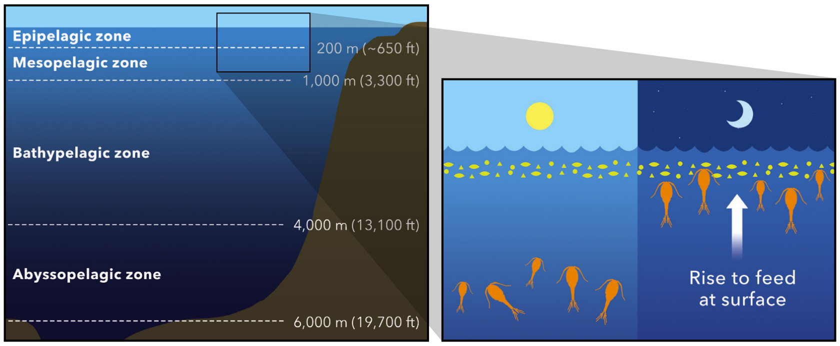
Using Sound to Study Life Underwater

Benoit-Bird wanted to know: How do animals interact in the complex and mysterious world beneath the waves? The difficulties of studying the ocean's depths don't scare her; instead they excite her, offering a greater chance of discovering something new. That's where her love of tinkering comes in. The only child of a mechanic, she grew up helping her father in his garage. "My dad can fix and build pretty much anything," she says. "Some of the best memories I have of my childhood are of being his 'second pair of hands.'"



Sonar uses echolocation in the same way that dolphins use clicks.

When Benoit-Bird can't find the tools she needs, she modifies old ones or invents new ones. Most of her tools involve sound. Unlike light, which travels only a few meters through water, sound can travel long distances. Sonar, a tool developed to detect submarines, works much the same way as dolphins use clicks: Sonar operators send out sound waves and then record and analyze the echoes to create images. During World War II in the 1940s, sonar operators were mystified to find that the ocean floor seemed to be rising at night and falling during the day. This "deep scattering layer" turned out not to be the ocean floor at all. Instead, their sonar was bouncing off a vast population of small marine organisms that live between 200 and 1,000 meters (660 and 3,300 feet) beneath the ocean's surface. They rise at night to feed on phytoplankton—small photosynthetic organisms that live in the sunlit upper reaches of the ocean—and return to the depths during the day to hide in the dark from predators.



Light, temperature, pressure, and salinity change with depth, creating a vertically stratified environment. Many species migrate between the mesopelagic zone, where they hide from predators during the day, and the epipelagic zone, where they feed at night.

Since then, advances in acoustic technology, including techniques that Benoit-Bird developed, have allowed scientists to better distinguish among marine organisms. Different animals reflect sound in different ways. Mammals such as dolphins, for example, with their air-filled lungs, create a very strong echo. Many bony fish have swim bladders, gas-filled organs that help them maintain their buoyancy and also create distinctive echoes. Large squid, with their soft, airless bodies, and tiny shrimp-like krill also bounce back distinctive echoes.

How Dolphins Herd Their Prey

Benoit-Bird had long been curious about how predators such as marine mammals and large fish find enough to eat in the ocean, where food is spread out over a large area. Benoit-Bird compares the dolphins' prey to a single bag of popcorn in a big movie theater. Instead of being collected neatly in a bag, however, the popcorn is scattered all through the theater, from floor to ceiling—and instead of sitting still and waiting to be eaten, the popcorn is fleeing for its life. So how do predators eat enough to survive, without spending more energy hunting the food than they get from eating it?

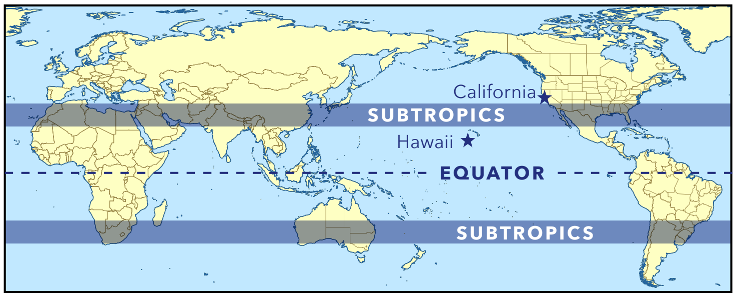
Spinner dolphins, for example, live in the subtropics and hunt at night, feeding on small prey such as lanternfish, shrimp, and squid, which live in the deep scattering layer. The prey are so small that each dolphin must eat, on average, about 1.25 of them every minute to meet its energy needs. From prior research, Benoit-Bird knew that groups of dolphins forage together in the same areas at the same time. Was that just because the individual dolphins knew that was the best time and place to find dinner, or was something else going on?

Stop and Jot / Think-Pair-Share: *What more have you learned about Dr. Benoit-Bird's use of science practices?* Students should notice that Dr. Benoit-Bird is continuing to ask questions ("Benoit-Bird wanted to know: How do animals interact in the complex and mysterious world beneath the waves?") and is designing solutions (sonar operators).

Stop and Jot: *Look at your worksheet and identify questions that you think you can answer based on what you have read so far. Answer the questions.* Students should be able to begin to answer the questions under the heading "How do they study the ocean?"

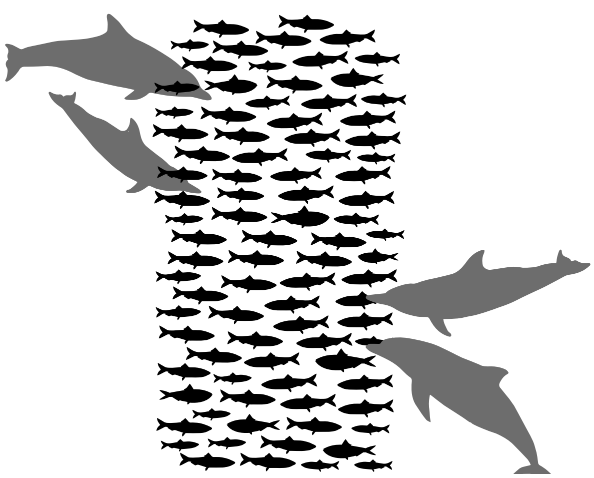
You might:

- Invite students to share their responses with their partners
- Select students to share out their responses



Food is especially scarce in the oceans of the subtropics, which lie roughly between the tropics at latitude 23.5° and the temperate zones at latitudes 35–66.5° north and south of the Equator.

When Benoit-Bird and her team used their acoustic techniques to study groups of spinner dolphins off the coast of Oahu, Hawaii, they discovered something very exciting: The dolphins were actively cooperating to herd prey. Groups of 16 to 28 dolphins would line up in pairs and swim perpendicular to the shore until they found a spot where prey happened to be more densely clustered than usual. Then the dolphins would tighten the line, with each pair swimming closer to the next pair, and push forward fast, plowing the fleeing prey ahead of them into an even denser clump. Next they would surround the prey, swimming in circles to create a column of prey. The confused prey, trying to flee and swimming chaotically, would head into the center of the column. This dance would create a high concentration of prey, on average 60 times the ordinary density. The dolphins would take turns diving in and feeding, with one pair from each side of the circle feeding together for a few seconds. It was as if they'd herded their popcorn into a virtual bag and were taking turns diving in to chow down. The whole thing would last four to five minutes at a time; then the dolphins would swim back to the surface for a lungful of air.



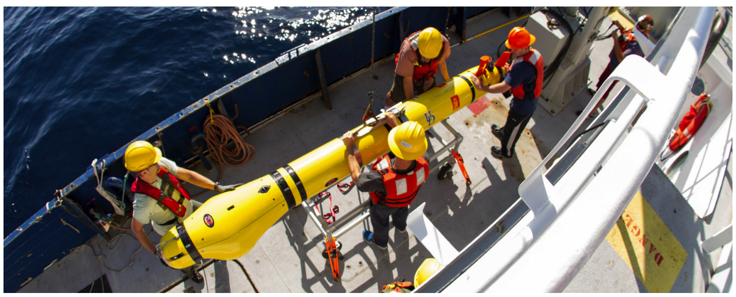
Dolphins swim in pairs to create a column of fish that is 20 to 40 meters (65 to 130 feet) in diameter.

Think-Pair-Share: *What new information have you learned? What questions can you begin to answer? After talking with your partner, answer the questions on the worksheet, and/or add to responses you already started.* Students should be responding to the questions "What are the scientists learning using this tool? Why do the scientists need to use this tool? What challenges are they trying to solve?"

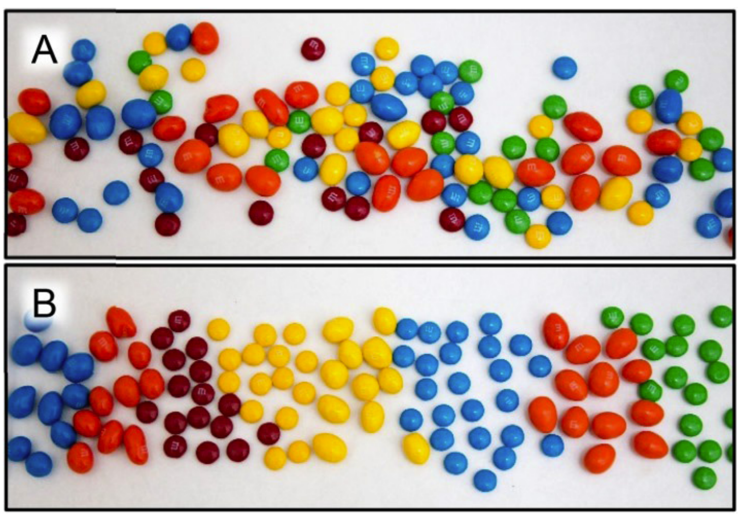
After listening to peer conversation and looking at students' responses, select students to share their thinking about these questions with the class. Encourage students to talk through the hunting behavior that Dr. Benoit-Bird and her team discovered.

How Prey Work Together to Foil Hunters

These days, Benoit-Bird is studying the other half of the predator-prey equation in the deep scattering layer: how prey avoid being eaten. She and her team equipped an underwater robot with acoustic instruments and sent it down into the scattering layers off the eastern coast of Catalina Island, California. Cramming the equipment into the slender vehicle took some doing, but fortunately, Benoit-Bird is an expert tinkerer. Previously, scientists looking down at the layers from ships at the surface had believed that the animals were all jumbled together like different colored M&Ms in a bag. From the point of view of the underwater robot, however, Benoit-Bird found that the layers are made up of distinct schools side by side, each comprising the same type of animal of the same size—as if the M&Ms were sorted into small clusters, each of a single color and size. Unlike the spinner dolphins' prey, these schools of marine animals coordinate their movements in a highly organized way.



Scientists equip an underwater robot with acoustic instruments.



Each color of M&Ms represents a different species of animal. From the ocean surface, it looks like the species are all jumbled together (A). But from the point of view of the underwater robot, it's clear that individuals within each species are actually grouped together (B).

Just as exciting was the animals' behavior when a predator appeared. The researchers often detected a different species of dolphins—called Risso's dolphins—apparently hunting their favorite food, squid. When the Risso's dolphins approached a school of squid, the squid moved nearer to their fellows. Schools of marine organisms often use this behavior, called "flash compression," to make it more difficult for their predators to target individuals. Unlike the chaotic movements of the spinner dolphins' prey, schooling is highly organized. The squid arranged themselves into dizzying patterns whose coordinated movements confuse the dolphins' senses, making it hard for the dolphins to single out any one squid so they could kill it.

Benoit-Bird and her colleagues were fascinated to find that when the squid moved closer together, these neighboring groups of other species responded by moving further apart. They expanded the space their own schools took up to absorb the space left by the flash-compressing squid, maintaining the horizontal layer. Benoit-Bird says, "We don't know exactly why they do this, but we think it must be beneficial, or they wouldn't do it."

Benoit-Bird's research into how animals behave in the mesopelagic zone is timely and crucial. Ten billion metric tons of animals live there, making up more than half the total weight of all the fish on Earth. These animals are a vital food source for many predators, from tuna and salmon to dolphins, whales, and penguins. But in 2018, for the first time, countries began issuing fishing permits for access to the mesopelagic. We are in a race, says Benoit-Bird, to figure out what impact that harvest might have on the environment, and how to make it sustainable. She says, "Now is the perfect time to address these questions before we've made potentially irreversible changes."

Think-Pair-Share: *What new question did Br. Benoit Bird and her team seek to answer in this last section? What conclusion was drawn?* After listening in and selecting students to share their thinking, you might invite students to add details to their worksheet.

Think-Pair-Share:

- What did you learn from this article that surprised you?
- What questions do you have after reading this article?

Listen in to peer conversations and facilitate a whole-group discussion based on ideas you select from students' stop and jots and/or peer conversations. You can also invite students to check their understanding by discussing Dr. Benoit-Bird's use of science practices (referring to the notes on their worksheets). You might do this by using discussion prompts such as:

- What discoveries did Dr. Benoit-Bird and her team make? How did their use of science practices lead to these discoveries?
- What obstacles motivated Dr. Benoit-Bird and her team to use innovation and design solutions?
- Why is Dr. Benoit-Bird's research important at this moment in time?

WORD WALL

Vocabulary Term	**Definition from article (verbatim)**	**Explanation of this term in my own words**
Echolocation		
Ocean Ecologist		
SEP: Asking Questions		
SEP: Defining Problems		
SEP: Designing Solutions		

SEP = Science and Engineering Practice
(select additional terms from the article that you think are most essential for your students to know)

ESSAY SCORING RUBRIC - page 1

	Exceeds	Meets	Approaches	Needs Additional Support
	4	3	2	1
Research: "Listening to Life in the Deep" Article	Accurately presents information relevant to all parts of the prompt with effective paraphrased details from the article	Presents paraphrased information from the article relevant to the prompt with sufficient accuracy and detail	Presents information from the article mostly relevant to the purpose of the prompt with some lapses in accuracy or completeness AND/OR information is copied from the text	Attempts to present information in response to the prompt, but lacks connections to the article or relevance to the purpose of the prompt
Research: *Unseen Oceans* Museum Exhibition	Accurately presents information relevant to all parts of the prompt with effective paraphrased details from the exhibition	Presents paraphrased information from the exhibition relevant to the prompt with sufficient accuracy and detail	Presents information from the exhibition mostly relevant to the purpose of the prompt with some lapses in accuracy or completeness AND/OR information is copied from the text	Attempts to present information in response to the prompt, but lacks connections to the exhibition content or relevance to the purpose of the prompt
Science Explanations	Develops the topic thoroughly by selecting the most significant and relevant facts and details to extensively describe scientists and the tools they use to study the ocean	Develops the topic by selecting the relevant facts and details to sufficiently describe scientists and the tools they use to study the ocean	Choice of facts and details is ineffective or lacking. Descriptions of scientists and the tools they use to study the ocean are incomplete	Does not describe scientists and the tools they use to study the ocean OR the descriptions are minimal
	Provides thorough explanations that demonstrate in-depth understanding of scientists and the tools they use to study the oceans	Provides sufficient explanations that demonstrate understanding of scientists and the tools they use to study the ocean	Provides some explanations of scientists and the tools they use to study the ocean, but explanations are incomplete or contain minor errors	Does not provide any explanations of scientists and the tools they use to study the ocean OR explanations are mostly inaccurate
	Consistent and effective use of precise and domain-specific language	Some or ineffective use of precise and domain-specific language	Little use of precise and domain-specific language	No use of precise and domain-specific language

ESSAY SCORING RUBRIC - page 2

	Exceeds	Meets	Approaches	Needs Additional Support
	4	**3**	**2**	**1**
Development	Includes an opening paragraph that clearly introduces the topic and previews what is to follow	Includes an opening paragraph that clearly introduces the topic	Includes an opening section that sufficiently introduces the topic	Includes an opening section that is insufficient or irrelevant OR does not include an introduction
	Includes more than sufficient highly detailed descriptions of scientists who study the oceans and the tools they use	Includes sufficient descriptions of scientists who study the oceans and the tools they use	Includes some descriptions of scientists who study the oceans and the tools they use but not sufficient to fully address the prompt	Does not include any examples
	Provides a concluding section that follows from and effectively supports the information or explanation presented	Provides a concluding section that follows from and sufficiently supports the information or explanation presented	Provides a concluding section that mostly supports the information or explanation presented	Provides a concluding section that does not support the information or explanation presented OR provides no concluding section
Conventions	Demonstrates and maintains a well-developed command of standard English conventions and cohesion, with few errors; response includes language and tone consistently appropriate to the purpose and specific requirements of the prompt	Demonstrates a command of standard English conventions and cohesion, with few errors; response includes language and tone appropriate to the purpose and specific requirements of the prompt	Demonstrates an uneven command of standard English conventions and cohesion; uses language and tone with some inaccurate, inappropriate, or uneven features	Attempts to demonstrate standard English conventions, but lacks cohesion and control of grammar, usage, and mechanics

ARTICLE

Listening to Life in the Deep

When Dr. Kelly Benoit-Bird was in third grade, her family took a vacation at SeaWorld. There the future ocean ecologist learned about echolocation: how animals like dolphins use sound instead of light to sense their world, emitting “clicks” that bounce off objects and animals, then listening for the echoes. She says, “I found that idea completely fascinating: that dolphins can’t see very well underwater, even during the day, and that they instead use sound. I got really excited about how different the ocean world was from ours. It’s like another planet—really alien.”

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Such questions about animal behavior can be difficult to investigate in the complex underwater environment, especially in the open ocean, the vast expanse of water beyond the continental shelf. There are no landmarks or fixed boundaries there; everything moves with the currents. Little light penetrates further down than 200 meters (650 feet). It’s hard for people to reach the depths of the ocean, and instruments that work well on land, such as cameras, are often little help in this dark environment. Because of these challenges, much less is known about life in the open ocean than in coastal regions.

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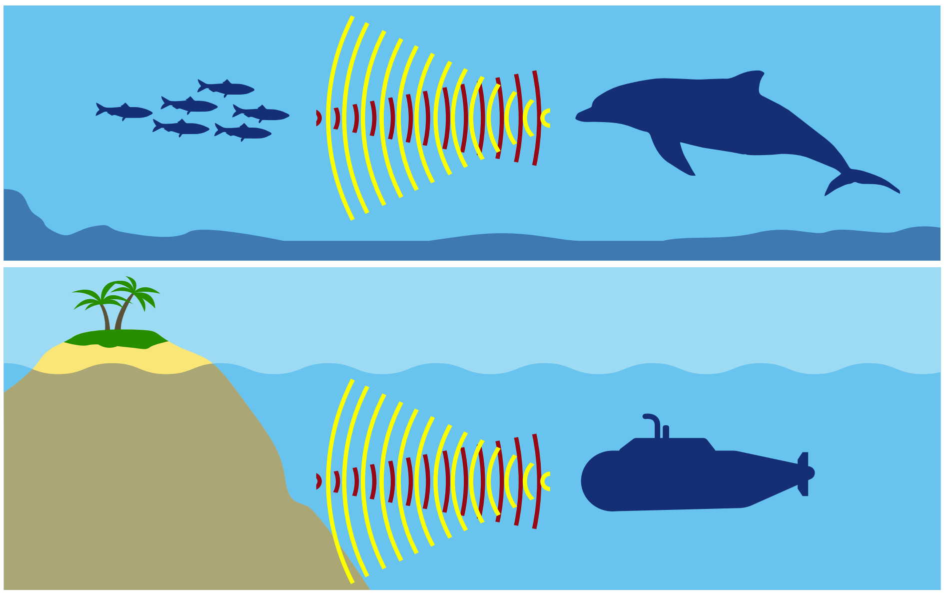

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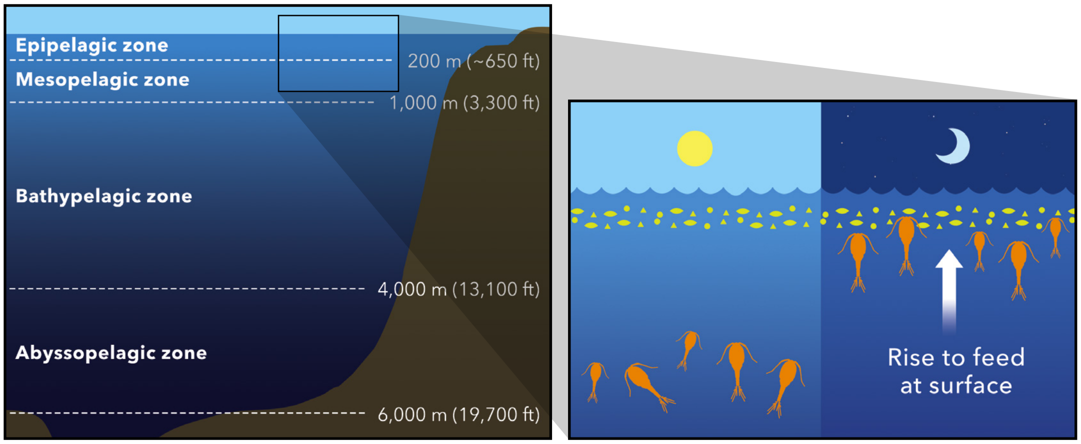

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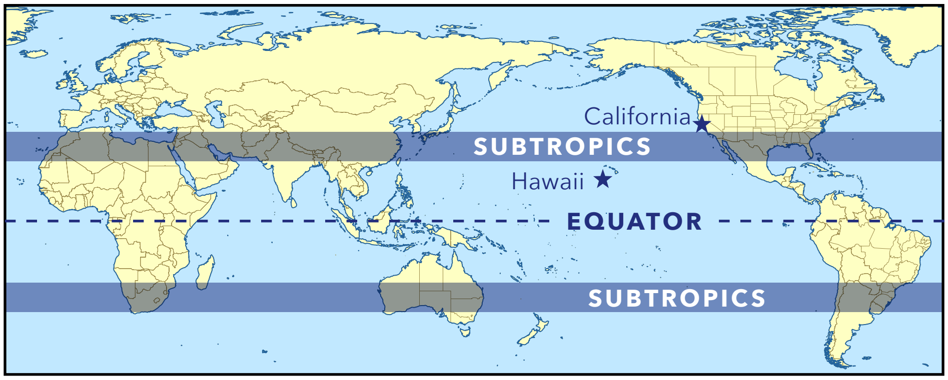
How Dolphins Herd Their Prey

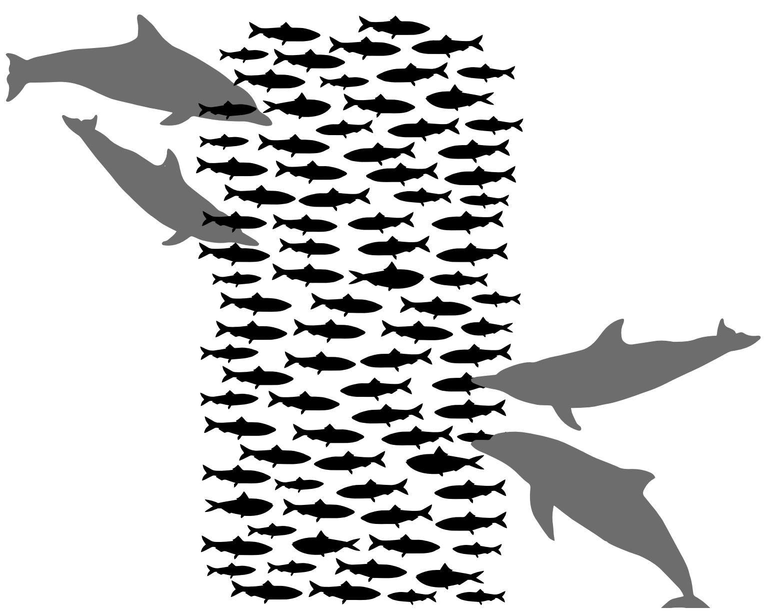
Benoit-Bird had long been curious about how predators such as marine mammals and large fish find enough to eat in the ocean, where food is spread out over a large area. Benoit-Bird compares the dolphins' prey to a single bag of popcorn in a big movie theater. Instead of being collected neatly in a bag, however, the popcorn is scattered all through the theater, from floor to ceiling—and instead of sitting still and waiting to be eaten, the popcorn is fleeing for its life. So how do predators eat enough to survive, without spending more energy hunting the food than they get from eating it?

Spinner dolphins, for example, live in the subtropics and hunt at night, feeding on small prey such as lanternfish, shrimp, and squid, which live in the deep scattering layer. The prey are so small that each dolphin must eat, on average, about 1.25 of them every minute to meet its energy needs. From prior research, Benoit-Bird knew that groups of dolphins forage together in the same areas at the same time. Was that just because the individual dolphins knew that was the best time and place to find dinner, or was something else going on?



Food is especially scarce in the oceans of the subtropics, which lie roughly between the tropics at latitude 23.5° and the temperate zones at latitudes 35–66.5° north and south of the Equator.

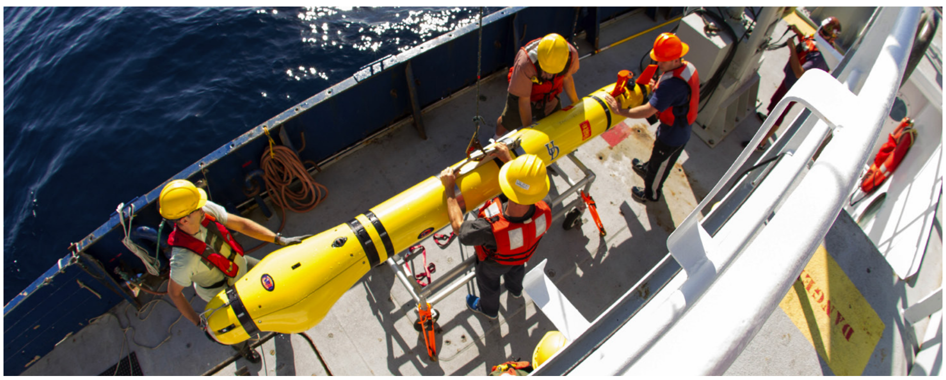
When Benoit-Bird and her team used their acoustic techniques to study groups of spinner dolphins off the coast of Oahu, Hawaii, they discovered something very exciting: The dolphins were actively cooperating to herd prey. Groups of 16 to 28 dolphins would line up in pairs and swim perpendicular to the shore until they found a spot where prey happened to be more densely clustered than usual. Then the dolphins would tighten the line, with each pair swimming closer to the next pair, and push forward fast, plowing the fleeing prey ahead of them into an even denser clump. Next they would surround the prey, swimming in circles to create a column of prey. The confused prey, trying to flee and swimming chaotically, would head into the center of the column. This dance would create a high concentration of prey, on average 60 times the ordinary density. The dolphins would take turns diving in and feeding, with one pair from each side of the circle feeding together for a few seconds. It was as if they'd herded their popcorn into a virtual bag and were taking turns diving in to chow down. The whole thing would last four to five minutes at a time; then the dolphins would swim back to the surface for a lungful of air.



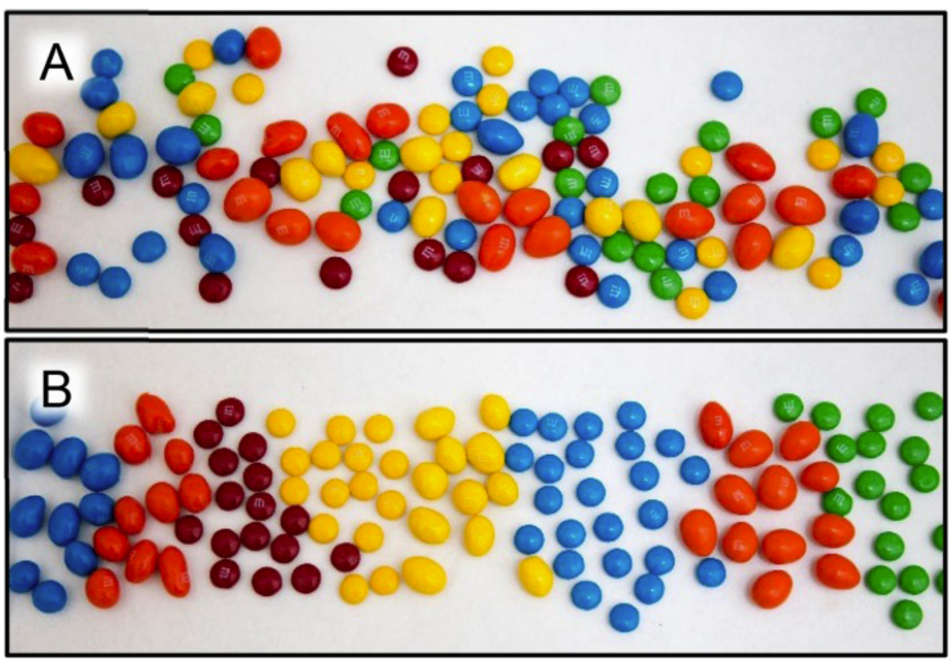
Dolphins swim in pairs to create a column of fish that is 20 to 40 meters (65 to 130 feet) in diameter.

How Prey Work Together to Foil Hunters

These days, Benoit-Bird is studying the other half of the predator-prey equation in the deep scattering layer: how prey avoid being eaten. She and her team equipped an underwater robot with acoustic instruments and sent it down into the scattering layers off the eastern coast of Catalina Island, California. Cramming the equipment into the slender vehicle took some doing, but fortunately, Benoit-Bird is an expert tinkerer. Previously, scientists looking down at the layers from ships at the surface had believed that the animals were all jumbled together like different colored M&Ms in a bag. From the point of view of the underwater robot, however, Benoit-Bird found that the layers are made up of distinct schools side by side, each comprising the same type of animal of the same size—as if the M&Ms were sorted into small clusters, each of a single color and size. Unlike the spinner dolphins' prey, these schools of marine animals coordinate their movements in a highly organized way.



Scientists equip an underwater robot with acoustic instruments.



Each color of M&Ms represents a different species of animal. From the ocean surface, it looks like the species are all jumbled together (A). But from the point of view of the underwater robot, it's clear that individuals within each species are actually grouped together (B).

Just as exciting was the animals' behavior when a predator appeared. The researchers often detected a different species of dolphins—called Risso's dolphins—apparently hunting their favorite food, squid. When the Risso's dolphins approached a school of squid, the squid moved nearer to their fellows. Schools of marine organisms often use this behavior, called "flash compression," to make it more difficult for their predators to target individuals. Unlike the chaotic movements of the spinner dolphins' prey, schooling is highly organized. The squid arranged themselves into dizzying patterns whose coordinated movements confuse the dolphins' senses, making it hard for the dolphins to single out any one squid so they could kill it.

Benoit-Bird and her colleagues were fascinated to find that when the squid moved closer together, these neighboring groups of other species responded by moving further apart. They expanded the space their own schools took up to absorb the space left by the flash-compressing squid, maintaining the horizontal layer. Benoit-Bird says, "We don't know exactly why they do this, but we think it must be beneficial, or they wouldn't do it."

Benoit-Bird's research into how animals behave in the mesopelagic zone is timely and crucial. Ten billion metric tons of animals live there, making up more than half the total weight of all the fish on Earth. These animals are a vital food source for many predators, from tuna and salmon to dolphins, whales, and penguins. But in 2018, for the first time, countries began issuing fishing permits for access to the mesopelagic. We are in a race, says Benoit-Bird, to figure out what impact that harvest might have on the environment, and how to make it sustainable. She says, "Now is the perfect time to address these questions before we've made potentially irreversible changes."

STUDENT WORKSHEET **Name:** ______________________

Welcome to the *Unseen Oceans* exhibition! Today you will dive beneath the waves and learn about the scientists who study this fascinating underwater world. Your task is to pick two different scientists (or teams of scientists) who use tools to meet the challenges of studying the ocean. Use the **map** below to help you select and locate the scientists; there are six options. Use the **worksheets** to gather information about each scientist (or team).

Location	Scientist (or Team of Scientists)	Tool / Technology
1	David Gruber and John Sparks	high resolution underwater camera
2	Ari Friedlaender and Jeremy Goldbogen	whale tag
3	Kakari Katija and Aran Mooney	jellyfish tag
4	Kaitlyn Becker	soft gripper
5	Dawn Wright	submersible
6	Jules Jaffe	m-AUEs (mini autonomous underwater explorers)
★	Kelly Benoit-Bird	sonar

STUDENT WORKSHEET Name: ____________________

Who?

Scientist(s): ____________________

What are they studying? Where?

Why is what they're studying important?

What are the challenges of studying this?

Record additional information about the scientists, such us who they are, where they work, and what motivates them. Record any details and quotes you find important or interesting.

How do they study the ocean?

Tool / technology used: ____________________

Draw and label the tool:

Caption:

Describe the tool: What is it made of? How does it work? What does it do?

What are the scientists learning by using this tool?

Why do the scientists need to use this tool? What challenge are they trying to address?

Additional info/wonderings:

STUDENT WRITING TASK

Exploring the deep ocean and the animals that live there is difficult, but scientists use technology to meet the challenges and to advance scientific knowledge. Write an essay in which you describe three different scientists (or teams of scientists) and explain how they use different tools to meet the challenges of studying the ocean.

Be sure to:

- Describe three different scientists who study the ocean using different tools: Kelly Benoit-Bird from the article and two scientists (or teams of scientists) of your choice from the *Unseen Oceans* exhibition.
- Provide any relevant information about the scientists. Who are they? Where do they work? What motivates them? Include additional details that you think are important or interesting.
- Discuss what each scientist (or team) studies. Explain the importance and the challenges of studying it.
- Describe and draw the tools that each scientist (or team) uses and explain how these tools address specific challenges.
- Discuss what each scientist (or team) is learning using the tools.
- Include an introduction and a conclusion in your essay.