

# EDUCATOR'S GUIDE



unseen

# OCEANS

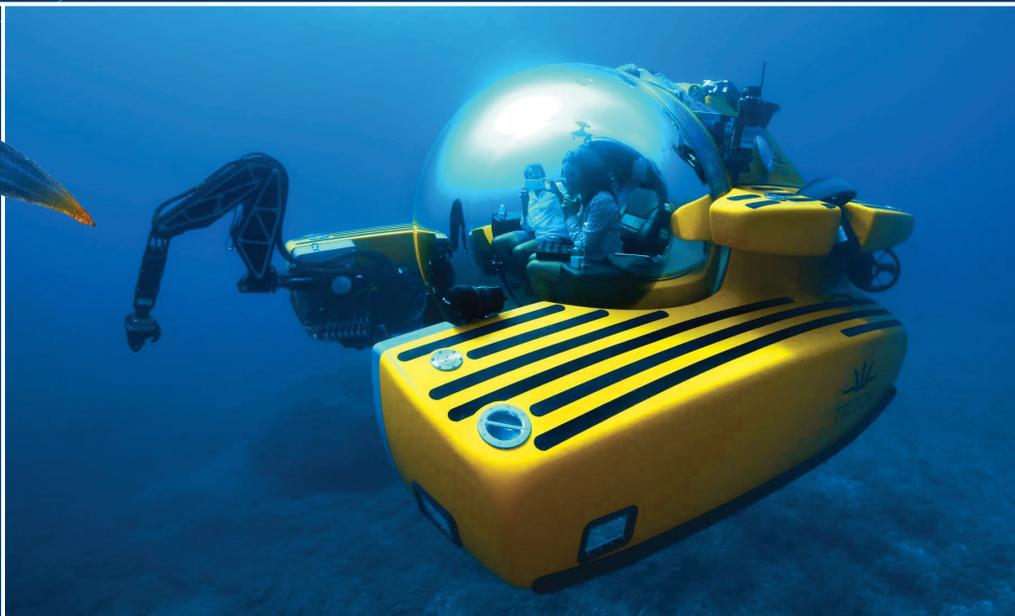
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# Essential Questions

## What are the physical characteristics of the ocean?

Beneath the waves is a world of wonders. There are vast plateaux. There are undersea mountains that would dwarf Mount Everest. And there are plummeting trenches deeper than the mountains are tall. The **topography** of these seascapes is formed over millions of years by geologic processes such as **plate tectonics**, **erosion**, and **deposition**. On much shorter timescales, mighty currents churn the oceans, helping to moderate the climate by redistributing heat from the Sun, which is concentrated along the equator. Currents at the surface of the ocean, such as the Gulf Stream in the Atlantic, are driven by wind. Below the surface, other factors drive a global movement of water called the Great Ocean Conveyor Belt. Frigid, salty water near the poles, more dense due to salinity and cold temperatures, sinks and travels along the seafloor toward the equator, where it warms, becoming less dense and eventually rising. Throughout the ocean, dramatic variations in light, temperature, pressure, and **salinity** create a vertically stratified environment that's home to a great diversity of ecosystems.

## How do scientists study the ocean and the organisms that live there?

Since the early 19th century, scientists have been making oceanic voyages to study the world's oceans and its inhabitants. With the advent of submarine and SCUBA technologies in the 20th century, scientists have been using research vessels, buoys, and depth-sounding equipment to collect data about ocean currents, temperatures, and depths in near-shore environments. Exploring the deep ocean and tracking animal **migration** across the vast ocean is still enormously challenging, but new technology is making inroads. For example, scientists chart the seafloor using **radar**, **lasers**, and **sonar** emitted from instruments on satellites, planes, drones, and ships.

As new questions arise about ocean life, scientists are engineering new tools to address them. For example:

- To understand more about large marine animals, scientists are designing devices that adhere to animals better and can collect more data, such as audio, visual images, and location coordinates.

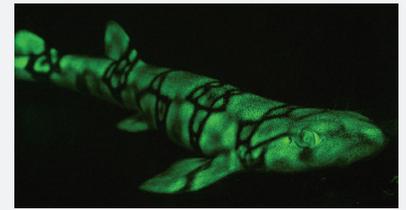


Scientist tagging a whale

Now scientists can listen to Antarctic humpback whales singing in intense bursts as they feed on krill. They can watch the sealife swimming around the tagged animals. And when a tagged great white shark dives—sometimes as deep as 1,200 meters (4,000 feet)—they can even receive coordinates sent via satellite.

- To investigate **biofluorescence**, the re-emission of light absorbed by an organism, marine biologists are designing camera lenses that allow them to see glowing fish the way the fish see each other. They're discovering that biofluorescent patterns make it easier for these animals to recognize members of their own species.

In deep waters, it's more difficult to distinguish between colors. Fluorescent pigments on the bodies of chain catsharks create high-contrast patterns, allowing them to recognize one another.



- To collect and study fragile deep-sea creatures with a minimum of harm, marine biologists are designing remotely-operated grippers with squishy, padded fingers. Now when their submersibles encounter animals such as sea cucumbers, soft corals, or sea pens, they can pick them up gently to take a closer look.



Fingers padded with memory foam can wrap gently around delicate marine organisms.

## How is human activity impacting the ocean?

From overfishing to altering Earth's climate, human activity is changing the ocean, threatening all living things in ways that are not yet fully understood. Worldwide, 20% of the protein people consume comes from the ocean, but fisheries are shrinking at alarming rates, both in numbers of fish and in the sizes of individuals. And as we burn **fossil fuels**, we release carbon dioxide (CO<sub>2</sub>), which causes the atmosphere and oceans to warm. The gas also dissolves in water, making it more acidic; ocean CO<sub>2</sub> levels are higher than they've been in 20 million years. Increased ocean temperature and acidity stresses many organisms, such as types of **plankton** that build tiny shells. In addition, unprecedented melting of ice at the poles is lowering the salt concentration of the surrounding water, making the water too light to sink and potentially disrupting the ocean conveyor belt. Since the conveyor belt is part of the system that brings up necessary nutrients from the deep to the surface, this disruption could threaten the **phytoplankton** that supply most of the oxygen we breathe. Efforts that have set strict limits on fishing and established protected marine habitats demonstrate that it is possible to make progress toward protecting marine life. However, the development of new policies at the local, regional, national, and international levels is still much needed.

# Map of the Exhibition

Explore how new technology is helping scientists study the ocean and the organisms that live in it.

## 1. INTRODUCTION

1a. Projected video

## 2. MYSTERIOUS DRIFTERS

2a. Plankton models and photos

2b. "Find My Baby Picture" matching game

2c. Microscopes

2d. Live ctenophores

2e. Scientist at Work media installation

## 3. SECRET LIVES

3a. Biofluorescent models and interactives

3b. Live seahorses, pipefish, scorpionfish, eels, chain catsharks

3c. Scientist at Work video and camera interactive

## 4. ENCOUNTERING GIANTS

4a. Wall projection

4b. Fossils and whale teeth

4c. Scientist at Work videos

## 5. GOING DEEP

5a. Galápagos installation

5b. Topography interactives

5c. Ocean conveyor belt model

5d. Scientist at Work video and soft robotics

5e. Kinetic sand table

## 6. TAKING A DIVE

6a. Theater

6b. Submersible photo op, styrofoam cups, and plexiglass

## 7. VITAL ABUNDANCE

7a. Media experience

7b. Conservation scientist stories

7c. Submersible interactives

7d. Scientist at Work display

## 8. NEXT GENERATION

8a. Scientist at Work stories



# Teaching in the Exhibition

## 1. INTRODUCTION

**1a. Projected video:** As students enter the exhibition, the lapping waves of a virtual beach will invite them to journey below the ocean surface and discover what's beneath.

## 2. MYSTERIOUS DRIFTERS

This section investigates plankton: organisms that drift with the winds and currents.

**2a. Plankton models and photos:** Plankton are abundant, diverse, and vital to life on Earth. Students can survey the diversity of phytoplankton (photosynthesizing organisms) and zooplankton (animals) and learn about their importance to other marine life.



Phytoplankton like this diatom (left), a marine alga, are just as vital to life on Earth as grass and trees. Zooplankton include permanent drifters, like *Phronima* (center), pictured here eating its barrel-shaped prey from within, and larvae of larger marine animals, like this baby form of the ocean sunfish (right).

**2b. "Find My Baby Picture" matching game:** Some zooplankton are actually the larvae of much larger marine animals; these newborn drifters can look very different from their adult forms. In this matching game, students can examine the differences between the juvenile and adult forms.

**2c. Microscopes:** Most individual plankton are too small to see with the naked eye. Students can examine live rotifers and copepods under the microscope to experience the tiny scale of these creatures, as well as the immense scale differences between types of plankton.

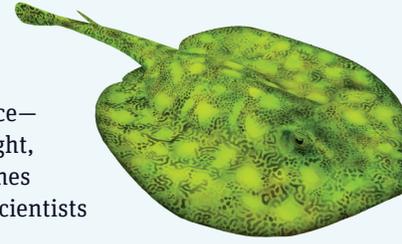
**2d. Live ctenophores:** Despite their name, comb jellies are ctenophores, not jellyfish. They use their hairlike cilia to move around, as the ocean currents carry them over long distances. Students can watch their waving, shimmering movements in the tank.



**2e. Scientist at Work media installation:** Many large marine mammals eat plankton as a main food source. Students can explore the work of marine biologist Kelly Benoit-Bird, who uses sonar to investigate plankton and marine food webs.

## 3. SECRET LIVES

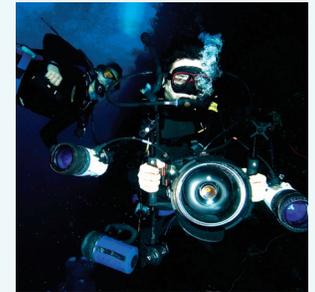
Some marine organisms biofluoresce—molecules in their bodies absorb light, then re-emit it. This section examines these glowing creatures, and how scientists study them in dark waters.



**3a. Biofluorescent models and interactives:** Different wavelengths of visible light penetrate ocean water to different depths, with blue light penetrating the deepest. As each wavelength peters out, the world undersea gets bluer. In this environment, many animals recognize members of their own species by their biofluorescent patterns. Students can experience how some marine animals, such as lizardfish, flatfish, and the chain catshark, appear to each other.

**3b. Live seahorses, pipefish, scorpionfish, eels, chain catsharks:** Students can observe animals and read about how biofluorescence keeps them camouflaged and helps them recognize mates.

**3c. Scientist at Work video and camera interactive:** To capture the glow of biofluorescent animals, marine biologists John Sparks and Dave Gruber use specially designed cameras and lighting that mimics the oceans' light. Students can watch this video and look through the "lens" of a mock underwater camera to see how biofluorescent animals look in different light.



To photograph biofluorescent organisms, scientists dive with specially designed, high-resolution underwater camera.

## 4. ENCOUNTERING GIANTS

This section presents some of the ocean's largest inhabitants, both past and present, and how scientists track and study them.



Recently, tags recorded long, intense bursts of song by humpback whales feeding on krill and diving to nearly 300 meters (1,000 feet).

**4a. Wall projection:** Through life-size animations, students will experience the real scale of ocean giants.

**4b. Fossils and whale teeth:** Giant animals have lived in Earth's oceans for hundreds of millions of years. Students can examine fossil evidence of extinct marine animals, such as ichthyosaurs and ammonites.

**4c. Scientist at Work videos:** Scientists use specially designed tags to collect data about marine animals, such as whales and jellies. Students can find out how scientists develop tags best suited to investigate their questions.

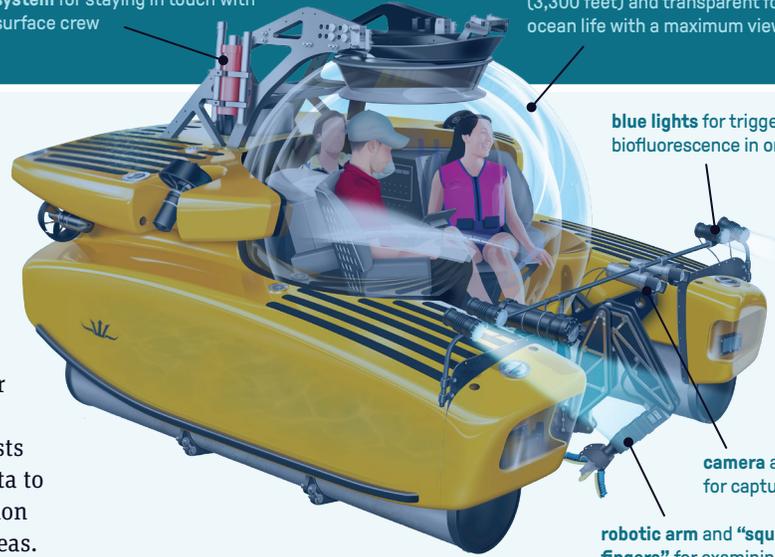
navigation and communication system for staying in touch with surface crew

acrylic sphere, strong enough to withstand pressure at 1,000 meters (3,300 feet) and transparent for observing ocean life with a maximum view

blue lights for triggering biofluorescence in organisms

camera and lights for capturing images

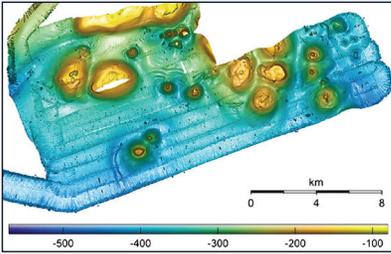
robotic arm and "squishy fingers" for examining and collecting specimens



## 5. GOING DEEP

This section follows scientists as they investigate abiotic (non-living) and biotic (living) factors of the ocean, such as undersea topography and ocean currents, and how these factors affect marine ecosystems.

**5a. Galápagos installation:** While existing maps of the seafloor cover the whole ocean, much of the coverage is at a very low resolution, so scientists are collecting new data to create higher-resolution maps of particular areas. Here, students can see how they're mapping the Galápagos Islands, a seamount chain formed by a hotspot.



Map of the Galápagos seamount chain

**5b. Topography interactives:** Around the central installation, students can examine the topography of three locations, learning about how they formed and the array of life they support:

- **Mariana trench**, formed by subduction of one oceanic tectonic plate beneath another
- **Hudson Canyon**, shaped by an ancient river that carved a deep channel through what was then dry land
- **Hawaiian islands**, an archipelago (island chain) formed by a hot spot

**5c. Ocean conveyor belt model:** Temperature and salinity determine the density of water, which drives global currents. Students can trace the circulation of warm, less salty water from the tropics and cold, saltier water from the poles through the world ocean.

**5d. Scientist at Work video and soft robotics:** It's not easy to observe marine animals without scaring them away, or to collect fragile specimens without harming them. Students can learn about engineer Kaitlyn Becker's collaborative work in designing, building, and testing tools that help marine biologists study deep sea organisms.

**5e. Kinetic sand table:** The ocean floor contains dramatic landforms, such as mountains and canyons. Students can sculpt their own structures to visualize how islands are actually mountaintops that have peeked above the ocean surface.

## 6. TAKING A DIVE

This section focuses on the challenges of deep-sea exploration, the technology that makes it possible, and some of what scientists are discovering about the creatures that live at different depths.

**6a. Theater:** In this seven-minute video, students will learn about creatures that live at different depths, from near the ocean surface to the abyssal zone.

### 6b. Submersible photo op, styrofoam cups, and plexiglass:

Traveling to the deep ocean involves major logistical challenges. The objects on display will give students insight into the deep ocean's extreme pressure and the technology necessary to explore it.

## 7. VITAL ABUNDANCE

This section surveys human behaviors that threaten the ocean and its inhabitants, and looks at ways we can conserve the ocean.

**7a. Media experience:** Humans can play a critical role in sustaining fish populations. In this open space, students can gesture to interact with projected fish on the floor: to corral, increase the population of, or release fish.

**7b. Conservation scientist stories:** In these three videos, students can find out how conservationists are protecting marine life in habitats threatened by overfishing, environmental damage, and climate change.

**7c. Submersible interactives:** Students can pilot a submersible into an animated underwater realm to explore the seascape, survey marine life, collect samples, and even respond to an emergency.

**7d. Scientist at Work display:** In this area, students can examine what marine scientist Jules Jaffe has been learning by following ocean currents using small and inexpensive devices called mini-autonomous underwater explorers (m-AUEs).



Artist's conception of m-AUEs drifting with the current

## 8. NEXT GENERATION

**8a. Scientist at Work stories:** As new questions arise about the ocean and the organisms that live there, scientists are engineering new tools to investigate them. Students can read about scientists from different parts of the world who are just launching their careers.

## COME PREPARED CHECKLIST

- Plan your visit.** For information about reservations, transportation, and lunchrooms, visit [amnh.org/fieldtrips](http://amnh.org/fieldtrips).
- Read the Essential Questions** to see how themes in the exhibition connect to your curriculum.
- Review the Teaching in the Exhibiton section** for an advance look at what your class will encounter.
- Download activities and student worksheets** at [amnh.org/unseen-oceans-educators](http://amnh.org/unseen-oceans-educators). They are designed for use before, during, and after your visit.
- Decide how your class will explore the exhibition:**
  - You and your chaperones can facilitate the visit using the Teaching in the Exhibiton section.
  - Students can use the worksheets and/or maps to explore on their own or in small groups.

## CORRELATION TO STANDARDS

### A Framework for K-12 Science Education

**Scientific and Engineering Practices** • 1. Asking questions and defining problems • 2. Developing and using models • 3. Planning and carrying out investigations • 4. Analyzing and interpreting data • 6. Designing solutions

**Crosscutting Concepts** • 1. Patterns • 2. Cause and effect: Mechanism and explanation • 3. Scale, proportion, and quantity • 6. Structure and function • 7. Stability and change

**Disciplinary Core Ideas** • LS1.A: Structure and Function • LS2.A: Interdependent Relationships in Ecosystems • LS2.C: Ecosystem Dynamics, Functioning, and Resilience • ESS2.A: Earth Materials and Systems • ESS2.B: Plate Tectonics and Large-Scale System Interactions • ESS2.D: Weather and Climate • ESS3.A: Natural Resources • ESS3.C: Human Impacts on Earth Systems • ESS3.D: Global Climate Change • ETS1.A: Defining and Delimiting an Engineering Problem • ETS1.B: Developing Possible Solutions • ETS1.C: Optimizing the Design Solution • ETS2.A: Interdependence of Science, Engineering, and Technology

## CREDITS

Lead funding for *Unseen Oceans* and its educational resources is provided by



The American Museum of Natural History gratefully acknowledges the **Richard and Karen LeFrak Exhibition and Education Fund.**

*Unseen Oceans* is generously supported by **Chase Private Client.**

## GLOSSARY

**biofluorescence:** the process by which molecules in an organism absorb higher-energy, shorter-wavelength light (e.g. blue) and re-emit it as lower-energy, longer-wavelength light (e.g. green or red)

**deposition:** the laying down of sediment by wind, water, ice, or gravity

**erosion:** the process by which sediments are moved elsewhere by wind, water, ice, or gravity

**fossil fuels:** combustible substances such as oil, coal, and natural gas that formed tens of millions to hundreds of millions of years ago from the remains of ancient plants and animals buried deep in Earth's crust

**laser:** a device that emits a focused beam of single-color light

**migration:** the large-scale movement of animals from one location to another

**overfishing:** catching so many fish that too few remain to replenish the population

**plankton:** free-floating marine organisms. There are two major types: **phytoplankton**, photosynthetic organisms that inhabit the sunlit layer of water; and **zooplankton**, marine animals, including permanent drifters as well as larvae—immature stages of larger animals that will eventually swim or settle on the ocean floor when they mature to adulthood

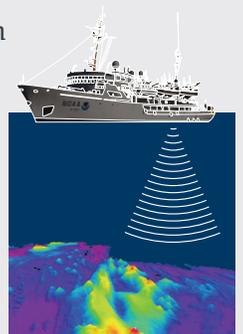
**plate tectonics:** the theory that Earth's rigid outer layer is divided into plates that are carried by motions in the mantle below

**radar:** a method of finding an object's position and velocity by bouncing a radio wave off it and analyzing the reflected wave

**salinity:** the amount of salt dissolved in a body of water

**sonar:** a method of finding an object's position by analyzing its interaction with sound waves

**topography:** the arrangement of the physical features of an area



Mapping the seafloor with sonar

## PHOTO CREDITS

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