American Museum of Natural History

Educator's Guide

Irma and Paul Milstein Family

HALL OF OCEAN LIFE

INSIDE

- Map of the Hall
- Essential Questions
- Teaching in the Hall
- Come Prepared Checklist
- Correlation to Standards
- Glossary

ONLINE

- Science & Literacy Activities
- Additional Resources

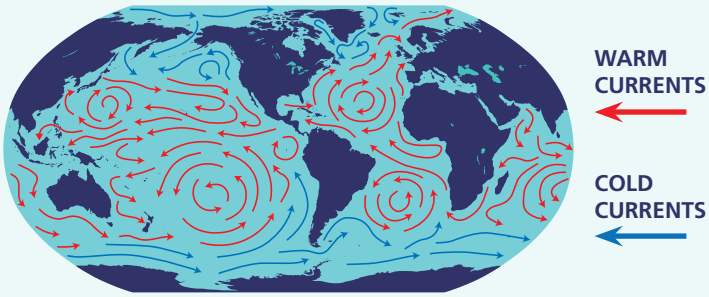
amnh.org/ocean-life-educators

ESSENTIAL QUESTIONS

Orange terms are defined in the Glossary

What is the ocean?

The ocean is an immense body of salty water that covers more than two-thirds (70%) of the planet. Five great oceans—the Pacific, Atlantic, Indian, Southern, and Arctic—connect to form the World Ocean. The ocean is where life began some four billion years ago, and it contains more than 95% of the planet's space habitable for complex life. Below the waves, geologic processes such as erosion, deposition, and tectonic forces shape mountains, trenches, and vast plateaux. Variations in depth, light, temperature, pressure, and **salinity** give rise to a great diversity of **ecosystems**, from coastal waters to the deep sea. All life on the planet continues to depend on the ocean. **Phytoplankton** supply most of the oxygen we breathe, currents regulate the climate by circulating warm water from the tropics and cold water from the poles, and the ocean is an immensely important source of food, livelihoods, and medicines.



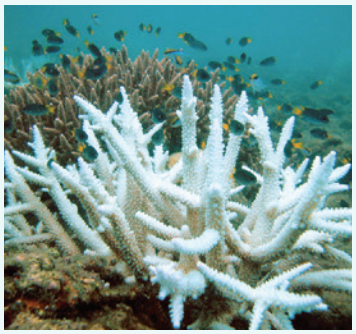
What lives in the ocean—and where?

From microscopic **plankton** to the massive blue whale, a multitude of organisms are **adapted** to life in the ocean. Biotic (living) and abiotic (nonliving) factors, such as sunlight and water temperature, determine which organisms live where. Sunlit and nutrient-rich, shallow waters near the shore are some of the most productive areas on Earth. For example, coral reefs, which are built by millions of small invertebrates, shelter an abundance of species that vie for food and living space. Further out, as the shallows give way to the open ocean, vast blooms of plankton thrive at the surface. Further down, where little or no sunlight penetrates, bioluminescence (the ability to generate light) helps organisms find food and mates. Even in the deep sea, sources of energy—like particles of organic matter that fall from above and superheated chemicals that surge from vents in the sea floor—sustain life.

Unique communities of organisms colonize cracks in the sea floor called hydrothermal vents. The food web here is based on chemosynthesis (energy from chemicals) instead of photosynthesis (energy from sunlight).

What threatens marine life and ecosystems?

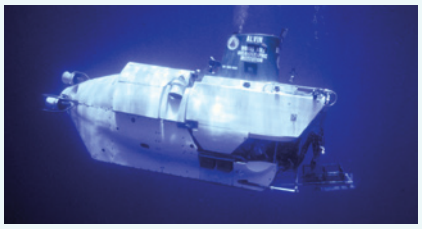
The ocean faces many threats. Human-induced global warming is increasing ocean temperatures and causing polar ice caps to melt, which is altering ocean currents and raising sea levels. Higher levels of carbon dioxide in the atmosphere are **acidifying** the ocean, which particularly affects marine organisms that make shells. Some marine species have been driven to the edge of extinction by **overfishing**. Development encroaches on coastlines, decimating ecosystems and leaving coastal communities more vulnerable to storm surges and flooding. From solid waste to oil spills to agricultural runoff, pollution affects almost all marine organisms and ecosystems. Ocean traffic is yet another threat, transporting invasive species, striking marine mammals, and generating noise pollution that disrupts communication for many marine species, especially whales.



When corals are stressed by environmental change, they expel the algae that live in their tissues, turn white, and die.

How do scientists study the ocean?

Since the 19th century, scientists have been making oceanographic voyages to study the world's oceans and the organisms that live there. In the 20th century, with the advent of submarine and SCUBA technologies, scientists have used research vessels, data-collecting 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 ocean is still enormously challenging, but new technology is making inroads. For example, manned and unmanned submersibles chart the deep sea, satellites map patterns of biological productivity, and Global Positioning System (GPS) devices track turtles, sharks, and whales in the open ocean. This research has enormous potential, from harnessing microbes for medical use to uncovering the keys to the origin of life and understanding the role of the ocean in extreme weather events such as hurricanes.



This submersible takes scientists down 900 meters (3,000 feet). On-board cameras record underwater scenes while a robotic arm and samplers collect specimens.

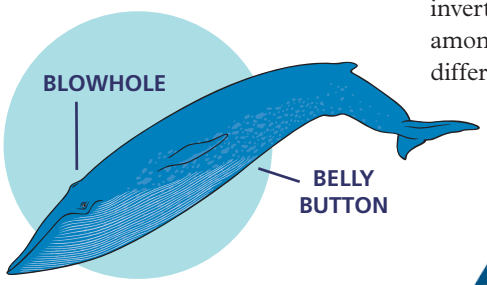
TEACHING IN THE HALL

Numbers correspond to map locations

1. OPEN OCEAN

Represented by the central space in the hall in which the blue whale model swims, the open ocean is the vast expanse of water beyond the continental shelf. Without visible landmarks, it's water, water, everywhere. Students can walk along the mezzanine railing to explore the following:

1A. Blue whale model and panel: This is a life-size model of the largest animal that has ever lived on the planet. Have students look for evidence that the blue whale is a mammal (its blowhole and belly button, or umbilicus). Like other mammals, the blue whale breathes air and gives birth to live young.



1B. "Ocean Exploration" panel: Scientists use many tools, such as satellites and robotic vehicles, to investigate the ocean.

1C. "Migrants" panel: Some ocean dwellers travel vast distances in search of food and mates; new technologies help scientists track these journeys.

1D. "Whales of the World" videos: Short clips about whale conservation, behavior, migrations, and songs.

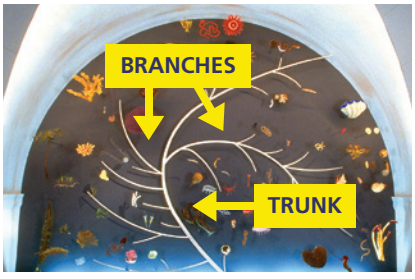
1E. "Drifters" panel: Instead of swimming or attaching to something, planktonic organisms drift with the currents.

1F. "Food Web" panel: The primary producers of the open ocean include dinoflagellates, diatoms, and many other photosynthetic microbes that convert the Sun's energy into nourishment for nearly all life in the sea.

2. TREE OF LIFE & LIFE IN WATER

To either side of the entrance, diagrams called cladograms show how groups of marine organisms are related. Panels and touch-screen interactives provide detailed information about groups of related species. A display next to each cladogram highlights how organisms breathe, feed, move, and reproduce in water.

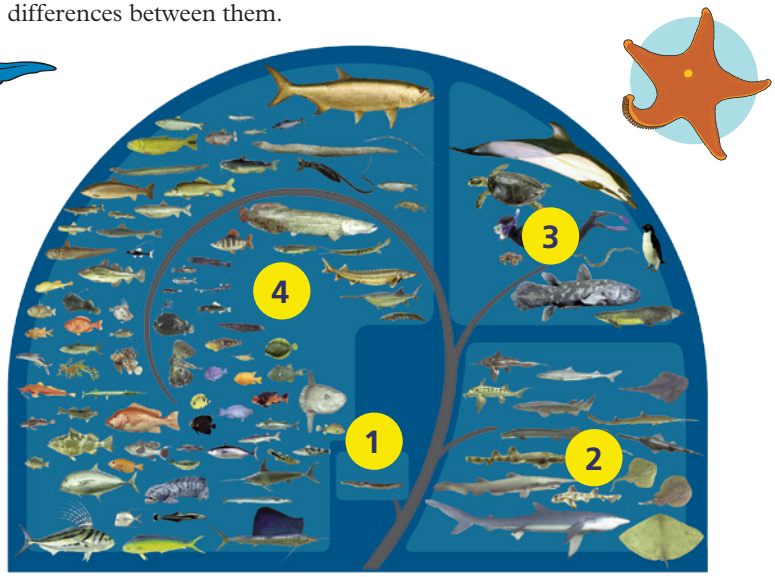
2A. Invertebrate groups section: This cladogram shows a small sampling of the millions of marine invertebrate species. The branches represent all major lineages living on Earth today.



To help students read a cladogram, call their attention to its "trunk" and "branches." Point out that animals that branch off the same point are more closely related than ones that branch from a point further up or down the tree.

Organisms at the end of each branch represent the large number of species within each lineage. Students can use the "Tree of Life" panel to locate similar adaptations within branches of the tree. For example, all animals in the bilateria group have two-sided symmetry.

2B. Vertebrate groups section: This cladogram, as noted on the center panel, is a continuation of one branch on the marine invertebrate tree. Have students use the panels to find similarities among organisms within each of the four main groups as well as differences between them.



(1) Jawless fishes, (2) sharks and rays, (3) lobefin fishes and tetrapods, (4) rayfin fishes

3. ANCIENT OCEANS

Paleontologists examine fossil evidence, such as those displayed here, to infer what the oceans were like millions of years ago.

3A. Fossil slab: Have students examine a 150-million-year-old fossil of *Mesolimulus walchi*, an animal closely related to the modern horseshoe crab, and trace its trail across the sea bottom.

3B. "Life in Ancient Oceans" dioramas and fossils: For a glimpse across geologic time, students can observe depictions of life in the Ordovician Seas (about 450 million years ago), the Permian Seas (about 270 mya), and the Cretaceous Seas (about 70 mya), and examine organisms from each era, including stromatolites, trilobites, brachiopods, and ammonites.

About 70 million years ago, much of North America was covered by water. This diorama depicts life in a Cretaceous sea that covered present-day Tennessee. At left, the animal with a spiral shell and tentacles is an ammonite, an extinct relative of the modern squid. Ammonites may have used jet propulsion, expelling water through a funnel-like opening to propel themselves away from the seafloor.

4. MARINE ECOSYSTEMS

The ocean contains more types of ecosystems than occur on land. On the mezzanine level, eight exhibits feature more than a dozen marine ecosystems (bolded below). Each uses models, text, and graphics to illustrate the ecosystem's abiotic (nonliving) and biotic (living) components. Videos above each show organisms interacting.

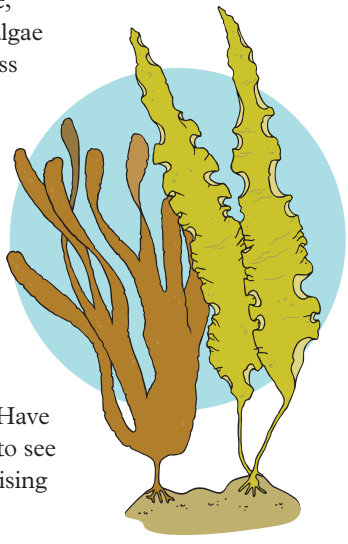
4A. Mangrove Forests: These unusual trees thrive in seawater along tropical coastlines. The main section of this exhibit features red mangroves in the Caribbean. Here students can observe the many species that depend on these trees and read about how mangroves protect coastal communities from erosion and storm surges by trapping mud around their roots. A smaller section of the exhibit features **seagrass**, which often grows just offshore from mangrove forests; students can find out why.

Mangroves and seagrass are the only two true plants in the oceans.

4B. Coral Reefs: Layer by layer, living corals and other reef-building animals create massive limestone structures known as coral reefs. This exhibit features an Indo-Pacific coral reef at night (left) and during the day (right). Have students note the activities of different organisms throughout the day-night cycle. Then have them observe interesting behaviors of some reef dwellers, such as cleaning stations and algae farming. They can also read about threats to the animals that build coral reefs and how their loss affects the entire ecosystem.

4C. Sea Floor: This vast landscape is pitch dark and mostly flat. Have students observe the center section, which represents the vast **abyssal plain** where organisms survive on marine snow, particles of organic matter that fall from above. Then compare it with the sections to each side, which depict two other ecosystems on the sea floor: a **whale carcass** and a **hydrothermal vent**, where life thrives on more concentrated influxes of nutrients.

4D. Kelp Forests: Near the shoreline, undersea forests of a type of brown algae called giant kelp are home to countless species. The main section of this exhibit features a single giant California kelp shown at three different depths: rocky bottom, midpoint, and the surface. Have students compare the different conditions, and observe the organisms that live at each level. The smaller section features the **rocky shore**, where habitats are repeatedly submerged and exposed. Have students observe the different zones to see how the organisms have adapted to rising and falling tides.

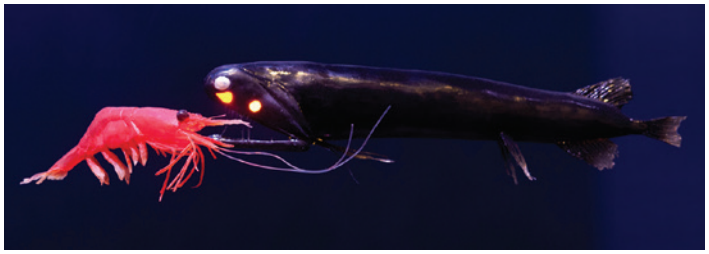


4E. Continental Shelf: Most sea life is concentrated near the shore over a narrow ribbon of sea floor called the continental shelf, which provides most of the fish we eat. This exhibit features a section off the Gulf of Maine. Have students explore the abiotic factors that make the continental shelf so rich in marine life. They can also read about overfishing and discuss how to reduce this threat. The smaller section features the bottom of an **undersea canyon** that winds to the deep sea. Have students explore the organisms that live in the canyon's muddy and rocky areas and how they're adapted to these conditions.

4F. Polar Seas: Here, a wide range of species depends on nutrients distributed when chilled surface water mixes with warmer bottom water. The main section of this exhibit features McMurdo Sound in Antarctica. Have students investigate how animals of the polar seas have adapted to such frigid conditions, and how some are able to grow to giant sizes. The smaller area features **sea ice**. Have students observe the organisms—including algae, krill, and penguins—that live on or under the ice, and describe the food web that connects them.

4G. Estuaries: Estuaries, where tides carry salt water upstream into freshwater rivers, are highly dynamic systems. Salinity varies with the tides and seasons. The main section of this exhibit features the nearby Hudson River estuary. Have students explore how organisms adapt to changing salinity and tides. They can also read about how estuaries are important to the life cycle of many species, and how they can be protected. The smaller section features **tidal marsh**—a wetland within an estuary where sediments and nutrients collect. Have students explore how the location and structure of the marsh make it an ideal source of food and shelter for a wide variety of species.

4H. Deep Sea: An unexpectedly large number of organisms live in this vast region, in near or total darkness. The main section features two parts of the deep sea water column: the mesopelagic zone (200 to 1000 meters) and the bathypelagic zone (below 1000 meters but above the sea floor). Have students explore animals that move up and down the water column in order to find food and to protect themselves from predators. The smaller exhibit features bioluminescence. Have students observe organisms that can generate light and talk about the various purposes this adaptation serves.



Most deep-sea animals can see only blue light, and many have red bodies, which makes them invisible to most predators. Not to the stoplight loosejaw: this fish not only sees red light but gets its name from two "head lamps" that light up red animals like deepwater shrimp.

5. DIORAMAS

The lower level contains fourteen dioramas that depict animals in and near the ocean at a particular place and moment in time. Most were originally selected many decades ago to illustrate how humans used marine animals as resources. Encourage students to observe how the organisms interact with each other and their environments, and tell a story based on their observations.

5A. Northern Sea Lion: A large male, two females, and a pup are resting on a rocky shore. Females nurse their pups for up to two years while teaching them to dive and hunt.

5B. Diving Birds: The auks and loons shown here are hunting in Newfoundland's Grand Banks. The auks use their flipper-like wings to propel themselves towards the fish, while loons rely on their large webbed feet.

5C. Harbor Seal: These seals are resting on the rocky shore. A harbor seal can be solitary, but sometimes joins groups along the shoreline.

5D. Dolphin & Tuna: Even though they're not closely related (common dolphins are mammals and yellowfin tunas are fish), streamlined shapes allow both animals to slip through water and similar coloring camouflages them from above and below. Both are chasing frigate tuna and flying fish, which are also being pursued from the air by red-footed boobies.

Knowing that tuna tend to hunt near dolphins, fishing boats would set their nets around dolphin pods to bag the tuna. Sadly, many dolphins drowned in the process—over a million by 1970. The Marine Mammal Protection Act of 1972 now protects dolphins, but regulators continue to monitor the effect of the fishing industry on both tuna and dolphin populations.

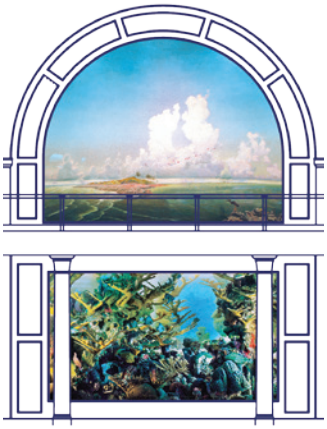
5E. Sea Otter: After wrapping itself with a strip of kelp to stay put, this sea otter is ready to eat the urchin on its chest.

5F. Tiger Shark: Two young tiger sharks are pursuing a loggerhead turtle. The sea turtle's shell provides some protection against the sharks' powerful jaws and teeth, although the turtle cannot retract its head and legs.

5G. Sperm Whale & Giant Squid: A giant squid uses its tentacles to defend itself against a sperm whale's attack. No one has ever witnessed such a deep-sea battle, but circular scars on whales' bodies left by the squids' suction cups are evidence that these battles take place.

Use a flashlight to find the scars on this whale model.

5H. Coral Reef: This reef in the Bahamas was created by massive colonies of small, soft-bodied coral polyps, whose hard skeletons form much of the reef's structure. Microscopic algae within the coral gives it its bright colors, and the maze of caves and crevices shelters an abundance of fish and other marine organisms.



Visit the mezzanine to explore the top half of the coral reef diorama, which depicts the landscape above the reef.

5I. Diving for Pearls: Two Polynesian divers collect oysters for their valuable pearls and shells. Bivalves (mollusks with two shells) like the black-lipped pearl oysters pump water through their bodies to filter out food. When small particles or organisms get stuck inside, they can become encased with layers of calcium carbonate over time, forming pearls.

5J. Polar Bear: This top predator hunts seals, its main food, by travelling across pack ice. Global warming has shortened winters, causing sea ice to form later and melt earlier in the season, which is endangering the bears.

5K. Sargasso Sea: Loggerhead turtles and dolphinfish are attracted by smaller animals that cling to the sargassum, a type of brown algae. Currents in the Atlantic collect this floating seaweed in this nearly windless region, where it feeds and shelters hundreds of animal species.

5L. Walrus: A herd of these massive mammals piles onto an ice platform. Easily recognized by their ivory tusks, walruses use these huge teeth to maintain breathing holes in the ice, haul their bodies out of the water, and joust for territory.

5M. West Indian Manatee: This solitary herbivore is foraging for seagrass and algae in warm, shallow waters. It comes up for air every few minutes.

Manatees may look like seals, but they are more closely related to elephants.

5N. Northern Elephant Seal: A large male throws back its head for a battle cry—amplified by its trunk-like nose—intended to ward off other males.

COME PREPARED CHECKLIST

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

CORRELATION TO STANDARDS

A Framework for K-12 Science Education

Scientific and Engineering Practices • 1. Asking questions • 2. Developing and using models • 4. Analyzing and interpreting data • 6. Constructing explanations • 7. Engaging in argument from evidence • 8. Obtaining, evaluating, and communicating information

Crosscutting Concepts • 1. Patterns • 2. Cause and effect: Mechanism and explanation • 3. Scale, proportion, and quantity • 5. Energy and matter: Flows, cycles, and conservation • 6. Structure and function • 7. Stability and change

Disciplinary Core Ideas • LS1.A: Structure and Function • LS1.D: Information Processing • LS2.A: Interdependent Relationships in Ecosystems • LS2.B: Cycles of Matter and Energy Transfer in Ecosystems • LS2.C: Ecosystem Dynamics, Functioning, and Resilience • LS2.D: Social Interactions and Group Behavior • LS4.A: Evidence of Common Ancestry and Diversity • LS4.B: Natural Selection • LS4.C: Adaptation • LS4.D: Biodiversity and Humans • ESS2.A: Earth Materials and Systems • ESS2.C: The Roles of Water in Earth's Surface Processes • ESS3.A: Natural Resources • ESS3.C: Human Impacts on Earth Systems • ESS3.D: Global Climate Change

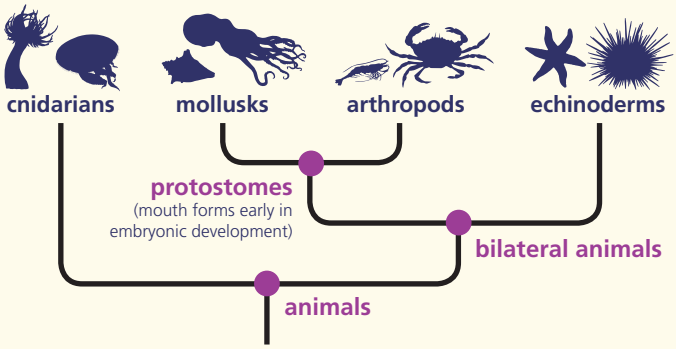
GLOSSARY

acidification: the decrease in the pH of the ocean caused by the dissolving of carbon dioxide from the atmosphere into seawater

adaptation: a characteristic that evolved over time in response to environmental and biological changes

algae: a diverse group of mostly aquatic, mostly photosynthetic organisms; can be unicellular or multicellular, and range in size from microscopic diatoms to giant kelp

cladogram: a branching diagram that shows which species and groups are more closely related based on the unique traits they share



Species that branch from a common point, or node, share similar traits because they descended from a common ancestor with those traits.

ecosystem: communities of interacting organisms and their physical environments

overfishing: to catch so many adult fish that too few remain to replenish the population

plankton: tiny, free-floating marine organisms. There are two major types: **phytoplankton**, photosynthetic microscopic organisms that inhabit the sunlit layer of water; and **zooplankton**, small marine animals and immature stages of larger animals.

plants: a diverse group of multicellular, photosynthetic organisms

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

CREDITS

Support for this Educator's Guide is provided by the **Dalio Ocean Initiative**.

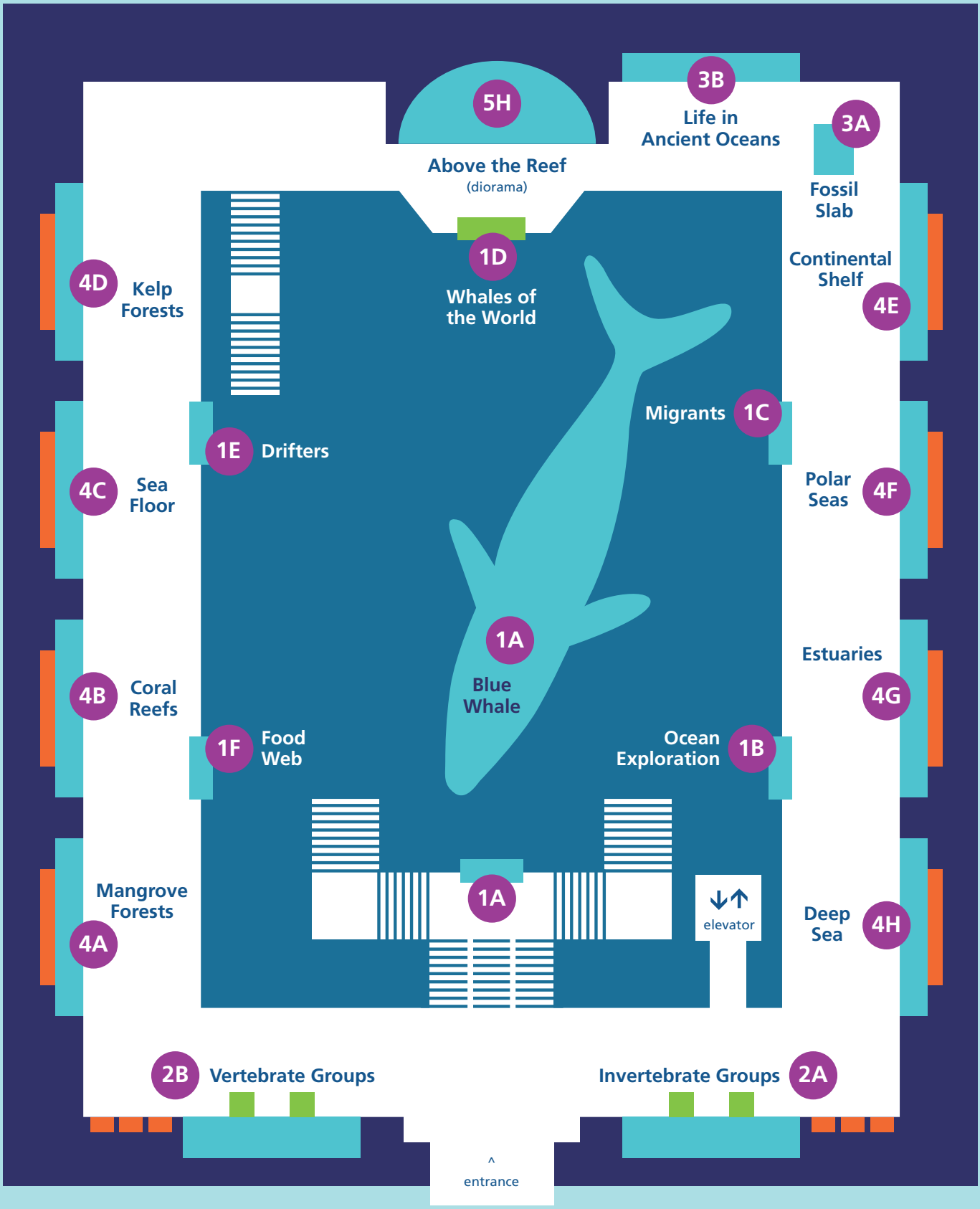
PHOTO CREDITS

All Pages: all hall photos, ©AMNH/Denis Finnin/Craig Chesek/Roderick Mickens/Matthew Shanley; all illustrations, ©AMNH. **Essential Questions:** bleached coral, Acropora/Wikimedia Commons; submersible, Rod Catanach/WHOI. **Teaching in the Hall:** mangrove and seagrass, Bernard Radvaner/AGE Fotostock.

MAP OF THE HALL Milstein Hall of Ocean Life

MEZZANINE LEVEL

KEY Video Interactive



MAP OF THE HALL Milstein Hall of Ocean Life

LOWER LEVEL

KEY Video Interactive