



THE SANT OCEAN HALL EDUCATORS' GUIDE
Smithsonian
National Museum of Natural History

THE SANT OCEAN HALL

EDUCATORS' GUIDE

WHAT'S INSIDE?

Classroom Lessons Before
and After Your Field Trip

Student Activities to Use
During Your Field Trip

Activities for Grades 4-6,
7-9 and 10-12

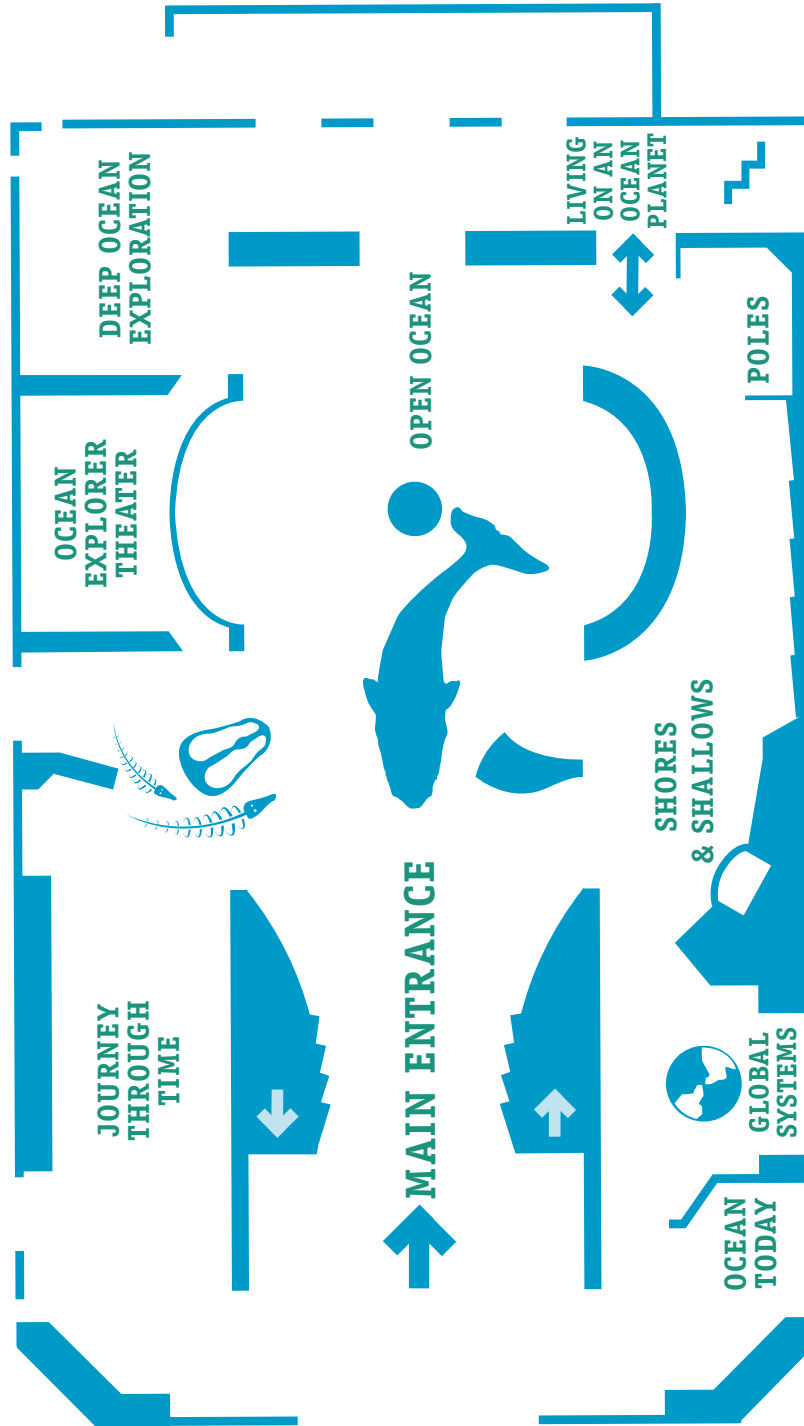
► www.ocean.si.edu

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Map of the Sant Ocean Hall



Educators' Guide to the Sant Ocean Hall

This guide includes activities and ideas for implementing an *Ocean Hall Expedition* to the *Sant Ocean Hall*. Students will explore the hall the way that scientists investigate the ocean. By using the *Sant Ocean Hall* to answer their own questions, students will increase their ocean literacy and their understanding of how ocean science is conducted.

Introduction to the Sant Ocean Hall

The *Sant Ocean Hall* at the *National Museum of Natural History* presents the ocean from a cross-disciplinary perspective. It's core message is that *the ocean is a global system essential to ALL life... including yours*. It was created by the museum in partnership with the National Oceanic and Atmospheric Administration (NOAA) as part of the Smithsonian's Ocean Initiative. The exhibits highlight the scientific expertise of museum and other scientists in **biology, geology, paleontology, ecology, oceanography, taxonomy and anthropology**, as well as marine physics and chemistry.

The major themes are that the ocean is vast, varied, and vital. Additional themes include how ocean science is conducted, human connections (including benefits from and threats to the ocean), and fun facts for kids.

Ocean Hall Galleries

Entrance: Showcases a *Tree of Life* and a diversity display including representatives from every ocean phylum to show marine biodiversity and how life is related. There is also a display highlighting the long-standing and diverse connections humans have with the ocean.

Open Ocean: Features the three open ocean zones from a vertical perspective—surface, midwater, deep—along with the organisms that live in each and their adaptations to the different environmental parameters found in each zone.

Living on an Ocean Planet: Highlights current cutting-edge research that will be updated annually. Also highlights critical ocean-related issues through interactive computer stations that focus on environmental decision-making and the challenges associated with managing marine fisheries and confronting climate change.

The Poles: Demonstrates the differences and similarities between the arctic and southern ocean regions, how life thrives at both locations through a variety of adaptations, and how climate change and other human impacts are affecting the polar oceans.

Shores and Shallows: Presents the important role of coastal ecosystems around the world and how humans affect them. It includes a 1,500-gallon Indo-Pacific coral reef aquarium.



Collections: Showcases examples of the world’s largest and most diverse collection of marine specimens. The specimens are housed at the museum and help scientists make sense of ocean life and unravel evolutionary relationships (located in the *Shores and Shallows* gallery).

Global Ocean Systems: Presents the tools and data used to study the ocean from different oceanographic disciplines. It includes *Science on a Sphere*, a high-tech, 6 ft. globe media experience that shows why the ocean’s constant motion and interaction with land and the atmosphere make it a complex global system.

Ocean Today: Broadcasts regular updates on ocean-related topics, current ocean news, and research from around the world.

Journey Through Time: Displays fossils from diverse groups and diverse time periods to show how fossil evidence is used to understand the past. Highlights include ocean top predators over time and the evolution of whales from terrestrial mammals.

Ocean Explorer Theater: Shows a 10-minute dive to the deep open ocean with scientists as they uncover some of the planet’s deepest mysteries aboard the manned-submersible Alvin.

Native North Pacific Cultures and Salmon Shows the importance of salmon: a dependable and renewable resource—to historic and modern native cultures rimming the North Pacific ocean and threats to this resource today.

Exhibit Icons

The following icons can be found throughout the Hall and can assist students in finding useful content.



Point out information about threats to the ocean’s health and how people interact with the ocean.



Provide information about how scientists make sense of evidence to learn about ocean phenomena.



Provide thought-provoking questions about topics related to the ocean.

The Sant Ocean Hall Online

The *Sant Ocean Hall* website (www.ocean.si.edu) has additional resources and information about the Hall and ocean science. There is an interactive map, stories about its construction, information on ocean life and conservation, a coral reef interactive, pod casts with museum scientists, and more.



The Sant Ocean Hall and Science Standards

The degree to which national and local science education standards are addressed will depend on the questions students explore and the particular features of the *Ocean Hall Expedition* you choose to implement.

The following table provides a broad indication of the relationships between an *Ocean Hall Expedition*, the National Science Education Standards, and the Ocean Literacy Principles developed by the Ocean Literacy Network.

For more information on Ocean Literacy Principles visit Ocean Literacy Network at <http://oceanliteracy.wp2.coexploration.org/>

Sant Ocean Hall Objectives	National Science Education Standards	Ocean Literacy Principles
To inspire awe for how vast, diverse and unexplored the ocean is, and for how fundamentally different it is from land.	Content Standard A: Science as Inquiry Content Standard D: Earth and Space Science	Earth has one big ocean with many features.
To provide a unique and engaging experience that demonstrates how the ocean works and how it is interconnected with other global systems.	Content Standard D: Earth and Space Science Content Standard C: Life Science	The ocean and life in the ocean shape the features of Earth. The ocean is a major influence on weather and climate.
To demonstrate how life evolved in the ocean over billions of years and changed dramatically over time.	Content Standard C: Life Science	The ocean makes Earth Habitable.
To instill in students an awareness of the great diversity of ocean habitats and ocean life, and of how much is still being discovered.	Content Standard A: Science as Inquiry Content Standard C: Life Science Content Standard G: History and Nature of Science	The ocean supports a great diversity of life and ecosystems. The ocean is largely unexplored.
To inform students about the exciting technologies and other approaches used by scientists and ocean explorers to uncover the ocean's mysteries.	Content Standard E: Science and Technology Content Standard G: History and Nature of Science	The ocean is largely unexplored.
To inspire and empower students to make the connection between the ocean and their daily lives, and to encourage them to continue exploring the ocean and to help conserve it.	Content Standard F: Science in Personal and Social Perspectives Content Standard G: History and Nature of Science	The ocean and humans are inextricably linked.

Why Learn about the Ocean?

A recent survey by the Ocean Project found that 45% of Americans believe that “*What I do in my life does not impact ocean health much at all.*” This statistic illustrates the need for education to help people of all ages raise their awareness that they are connected to the ocean and can alter this fragile life-support system—for better or worse. The *Sant Ocean Hall* responds to this growing need for ocean literacy.



Taking Your Students on an Ocean Hall Expedition

Going on scientific expeditions is one of the many ways scientists at this museum and around the world conduct their research. These explorers set out to collect data related to questions or observations they are interested in, but they never know for sure what they will discover. Their journeys may provide evidence to support or refute their original ideas, and they often lead to unexpected findings or brand new questions. What a scientist finds (or does not find) will determine the next steps. The knowledge gained from each expedition provides the foundation for new ones.

We invite your students to accept the role of an ocean scientist and embark on their own expedition of the Ocean Hall in search of information, examples, and evidence related to questions that interest them. In the process, they will increase their ocean literacy and their understanding of how science is done.

Expedition Objectives

The students will:

- Take the role of scientists by generating and investigating their own questions about the ocean and why it is important.
- Record observations and document scientific evidence.
- Begin to use the evidence they collected to answer their questions.

Recommended Grades

The activities in this guide are written for grades 4-10, but we invite you to modify the activities and instructions for younger and older students.



Expedition Activities

The resources can assist you in helping your students to experience the museum from a scientist's perspective. They are intended as a sequence of activities, but they can be used in different orders, together or independently, to meet the needs of your students.

Preparing for the Expedition

- **Find Out What Students Know** brainstorming activities.
- **Plot the Course** resources for students.
- **Follow the Footsteps of Scientists** with *An Introduction to Ocean Science* at the *Smithsonian's National Museum of Natural History* (pages 25-36) reading activity and *What Do Scientists Study?* (pages 37-45) question categorizing activity.
- **Develop Expedition Questions** recommendations with a list of *Sample Questions to Explore* (pages 10-12).

While on the Expedition

- **The Student Guide Field Notes** (pages 18,21, and 24) for students.
- *Navigating the Hall* tips.
- **Pointers for Helping Students Explore Their Questions.**

Completing the Expedition

- **Reflect on the Expedition** ideas.
- **Share the Expedition** assignment ideas.
- **Become an Ocean Friendly Class.**
- **Explore Further** website recommendations.



Preparing for the Expedition

These activities can be used in sequence or independently to **help students generate at least one question to investigate before arriving at the museum.**

1. Find Out What Students Know

- Use questions like these to elicit responses as either an individual journaling or a whole-class activity.

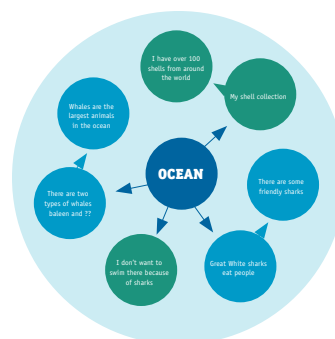
What is the ocean?

What do you know about the ocean?

Why should we care about the ocean?

What do you want to know about the ocean?

- Have students make a **personal meaning map** by having students write the word OCEAN in the center of a blank page. They should then write information that comes to mind about the ocean and link different ideas together. Follow-up by having them write questions they want to learn about.



Large example shown on page 9

2. Plot the Course

These resources provide students additional information about what they will see at the Ocean Hall.

- The *Sant Ocean Hall* website: www.ocean.si.edu
- The *Sant Ocean Hall* map

3. Follow the Footsteps of Scientists

Before asking students to develop their own scientific questions to investigate, help them understand why and how scientists explore the ocean.

- **Assign *An Introduction to Ocean Science at the Smithsonian's National Museum of Natural History*** (pages 25-36) to help students become familiar with how ocean science is conducted by Smithsonian scientists. The reading includes a brief article and questions about how marine biologist Michael Vecchione and his colleagues investigated contaminants in deep sea squid. Three versions exist: A is written for the most basic readers (typically for grades 4-5); B is written for more advanced readers (typically for grades 6-8); and C is written for the highest reading levels (typically grades 9-10).



- Use *What Do Ocean Scientists Study* (pages 37-45) as a question sorting activity to help students understand the types of questions scientists from different disciplines ask about the ocean. Three levels of questions are provided for differentiating student needs.

4. Develop Expedition Questions

Developing scientific questions can be difficult for students and some may need more guidance than others. Students should consider both their interests and the expectations for their follow-up activity (see recommendations below) as they develop questions to explore.

- Reflect on previous questions students discussed or brainstormed.
- Use the *Sample Questions to Explore* (pages 10-12) as a database of questions that are possible to investigate in the Ocean Hall.

Students do not have to select questions from provided resources. Rather, encourage students to explore any question that inspires them. Consider having students alter questions in provided resources as a way to guide them to develop their own. For example, *What lives in sand?* could be changed to *What lives in the coral reef?* The question *Why do coral reefs have high biodiversity?* could be changed to *What factors affect biodiversity?*

Note

The fields of marine biology, ecology, paleontology, and anthropology are most strongly represented in the *Sant Ocean Hall*.

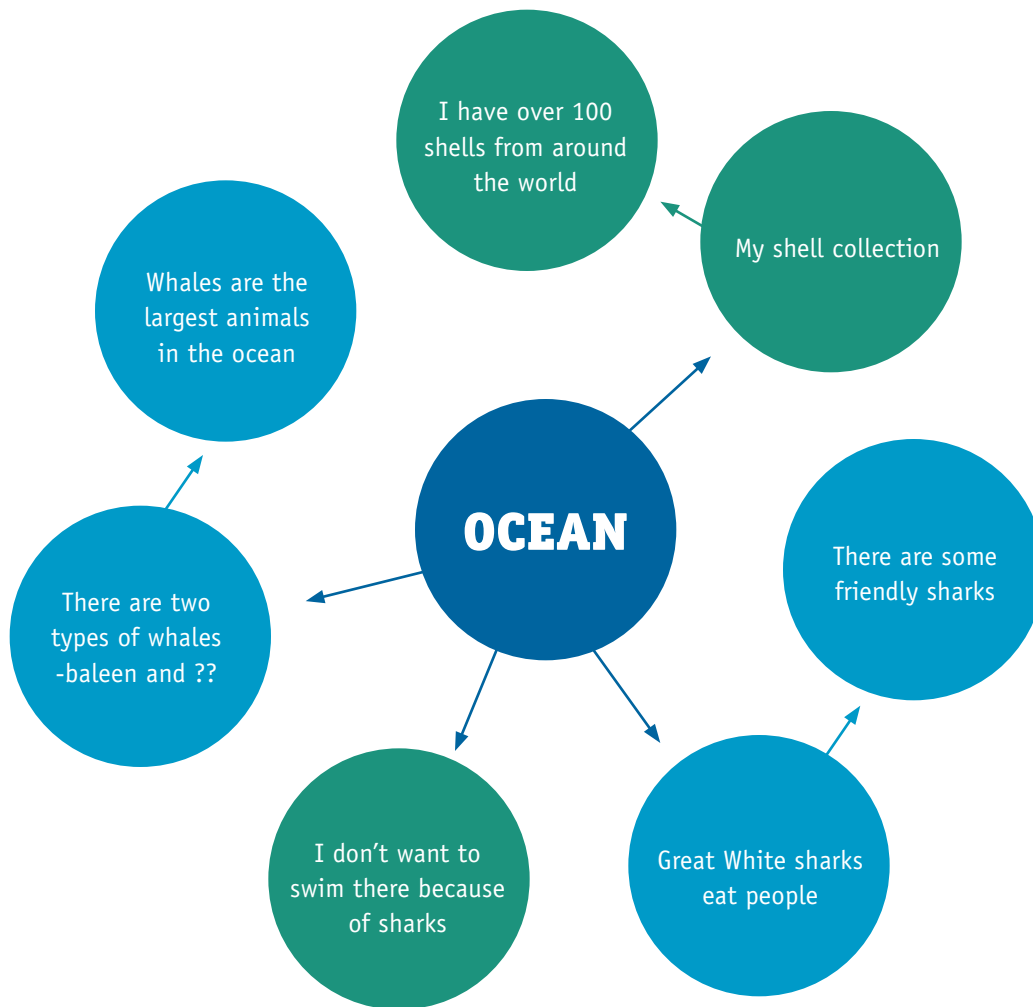


Taking a Team Approach

Since scientists very rarely work in isolation, consider having your students work as a team to generate questions from different science disciplines.



Personal Meaning Map



Differentiation for more advanced students

Consider having students develop alternative hypotheses about each of their questions before they begin their expedition. For example, if a student wants to explore *Why do ocean animals glow?* he or she could come up with several explanations and then test them at the museum. For example, ocean animals glow 1) to scare away predators, 2) to catch food, and 3) to find mates.



Sample Questions to Explore at the Sant Ocean Hall

The following is a list of some generalized questions that are searchable in the *Sant Ocean Hall* at the *National Museum of Natural History*. They are organized by discipline.

Marine Biologists (and Biological Oceanographers)

- How much living space does the ocean hold?
- What lives where?
- What are some patterns of what lives where?
- How are living things in different parts of the ocean adapted to find food, move, breath, reproduce, survive predators and survive the conditions?
- How are living things dependent upon each other in food webs?
- How do young stages of ocean organisms look different from the adults? Where do they live?
- How is ocean life related? How does it evolve?
- What is marine biodiversity?
- What phyla can be found in the ocean?
- How is variation important for speciation?
- How do scientists study different types of ocean life?
- How are museum collections used to study the ocean?
- What new ocean life has recently been discovered? What is left to discover?
- Who is Phoenix and why is she important?

Marine Geologists (and Geological Oceanographers)

- What does the ocean floor look like?
- What is the ocean floor made of?
- What is under the ocean floor?
- How do the valleys, peaks, and canyons in the ocean compare with those found on land?
- What kinds of geological activities shape the ocean?



- How have plate tectonics or volcanic activity shaped the ocean?
- Was the ancient ocean different than the present ocean?
- How do scientists study marine geology?

Marine Physics (and Physical Oceanographers)

- How big/deep is the ocean?
- How does the ocean affect weather, global climate?
- How does the ocean interact with the land, air, atmosphere?
- What are the physical conditions of the deepest parts of the ocean? The most shallow?
- How and why is the bottom of the ocean being reshaped?
- How do scientists study ocean physics?

Marine Chemists (and Chemical Oceanographers)

- What is sea water made of?
- Why is the ocean salty?
- Is the ocean chemistry different in different parts of the ocean?
- What causes the salinity (saltiness) in the ocean to change?
- What are some important chemicals in the ocean besides water and salt?
- How do scientists study ocean chemistry?

Paleontology (Paleobiology)

- How were past oceans different from the ocean today – in geology, chemistry, biology, climate?
- How did life in the ocean begin?
- How did early life affect the earth, ocean, atmosphere, climate?
- What can fossils tell us about past; life, extinctions, climate, evolution?
- How have living things like echinoderms, mollusks, whales, and reef communities adapted to changing conditions over time?
- How did trilobites evolve?



- When have mass extinctions occurred? What went extinct? How much survived?
- How do scientists study marine paleontology?

Anthropologists

- How do people celebrate, use, explore, protect the ocean?
- How do different cultures rely on the ocean?
- How did early civilizations celebrate, use, explore, protect the ocean?
- How have decades of using ocean resources impacted the ocean?
- How do people show their connection to the ocean through objects and tools?
- What tools and technology have been used to explore the ocean?
- How has the ocean influenced human history and culture?

Ocean Conservationist

- Why should we care about the ocean?
- How is the ocean important to humans?
- How does the ocean benefit us?
- What are the five biggest threats to the ocean?
- How have human activities affected the ocean?
- What do I do that impacts the ocean?
- Is the ocean really as threatened as some people say?
- How can we conserve and still benefit from the ocean?
- What is—habitat transformation, marine pollution, invasive species, climate change, overexploitation of resources.
- Why is some ocean life going extinct?

Other

- What are some recent discoveries in ocean science- marine biology, marine chemistry, marine physics, paleobiology, taxonomy, anthropology?
- What types of technology are useful for studying the ocean?
- How do scientists study the ocean?



While on the Expedition

These resources will help students to **successfully explore the Hall and document what they find.**

1. The Student Guide

- Three versions exist (pages 17-24): A is written for the most basic readers (typically for grades 4-5); B is written for more advanced readers (typically for grades 6-8); and C is written for the highest reading levels (typically grades 9-10).
- Students can write the question(s) they would like to investigate in **part one** of the *Field Notes* section in the *Student Guide*. Consider providing students one *Field Notes* page for each question they want to investigate, or make sure they provide ample space between notes for each question.
- In **part two**, students brainstorm in advance locations where they think they can find information related to their question(s). This question is not included in advanced version C. The *Sant Ocean Hall* map and Ocean Hall website can be used as references for students.
- In **part three**, students can record their observations, information, and examples that relate to each of their questions.
- In **part four**, students can record how ocean scientists explore their questions and evidence used to explain what we know about the ocean. These could include examples of data, names and descriptions of the technology and tools used to collect the data, observations, or any other feature of ocean science.
- Please note that the *Ocean Explorer Theater*, *Deep Ocean Exploration*, and *Global Systems* galleries and the *How Do We Know* icons in the *Sant Ocean Hall* are the best places to find information about how technology assists scientists in collecting evidence about the ocean. In these locations, students can discover, for example, sonar, satellites, and ROVs.
- The Student Guide also contains brief examples of qualitative and quantitative observations, and examples of what kinds of information are appropriate to include.



2. Navigating the Hall

- Students should be aware that they can find material for their assignment in a variety of formats including **text, specimens, photographs, videos, models, murals, science tools, and interactives.**
- Museum volunteers are available to answer questions.



Point out information about threats to the ocean's health and how people interact with the ocean.



Provide information about how scientists make sense of evidence to learn about ocean phenomena.

Helping Students Explore Their Questions

Students may not find the exact information, examples, or evidence to help them with their questions. If faced with this problem, encourage them to turn to strategies that scientists use.

- Find clues to help them develop their own explanations or answers.
- Revise their questions. For example, a student might not find information to answer how their favorite animal is adapted to find food, however they could revise their question to be more general such as *How are animals at the North Pole adapted to survive?*
- Generate new or additional questions to add to their list.
- Keep all questions. They could be important for later investigations.



Recommended Materials to Bring

Student Field Notes sheet

Notebook or clipboard with paper for additional recording space, pencil, sketch pad, camera, video camera, audio recorder (these are tools scientists use to document and share what they learn).



Completing the Expedition

These activities will help students:

- Reflect on their experience and connect it to their prior knowledge.
- Synthesize and present what they learned in a meaningful way.
- Inform others about the ocean and its importance.

1. Reflect on the Expedition

- Students can add to or alter information they brainstormed before the field trip. This is a good way for you and the students to document what they learned from their *Ocean Hall Expedition*.
- Students can develop additional questions they would like to explore. For example, a student may have learned that blue fin tuna are over fished. This could lead them to ask *What types of tuna are safe to eat? Are there other animals that are over fished? What is being done to protect over fished animals?*

2. Share Findings

Below are some ways students can share what they learned from their expedition.

Basic: Little Preparation and Time

- Write a letter to friends or family.
- Compile a book of student essays for the classroom or library.
- Create a collage or poster that gets hung up at school.
- Use the experience as a foundation for a research paper.

Advanced: Moderate Preparation and Time

- Hold an Ocean Science Night of talks and/or displays.
- Publish a Science Essay in the local newspaper.
- Design a class web page that gets hosted on the school server.
- Develop a PowerPoint or video presentation for the school news show or for another class.
- Create a class ocean science MySpace or Facebook page and invite friends and family to visit.



- Develop and pass out Ocean Flyers to the local community.
- Host an Ocean Science Blog.

3. Become an Ocean Friendly Class

You and your class can join others who are making a difference in ocean health. Visit <http://ocean.si.edu/ocean-news/how-you-can-help-ocean> for more information.

4. Explore Further

Check out the **Learn More about the Ocean: Resources** at www.ocean.si.edu to help students further investigate their questions and the ocean further.

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Writer

Jennifer Collins

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Exploring the Sant Ocean Hall: A Guide for Students

Version A

Ocean Hall Expedition

Some things at the *Sant Ocean Hall* come from scientific expeditions. Scientists go on expeditions to collect evidence to help answer questions they wonder about.

On your trip to the *Sant Ocean Hall*, you can collect information about ocean questions that interest *you!*

Goals:

- Make up your own questions about the ocean.
- Explore the *Sant Ocean Hall* like a scientist to help answer your questions.
- Record Field Notes about what you learn.
- Find out how scientists study the ocean.

Directions:

1. In part one write your question about the ocean.
2. In part two write where you think you can find answers to your questions.
3. In part three write what you learn about your question.
4. In part four write down what you find out about how scientists study the ocean.

Tips for Exploring

What to look at:

Signs, specimens, photographs, videos, models, murals, science tools, and computers.



Shows ways people use the ocean and threats to the ocean's health.



Tells about how scientists study the ocean.

If you have a hard time finding an answer to your question, you can change your question or make a new one!



Field Notes

Part 1: Question(s)

Part 2: Where I can look for answers to my questions in the *Sant Ocean Hall*

Part 3: Evidence I found (observations, information, and examples)

Part 4: How scientists study the ocean (technology, tools, techniques)

Example: *Scientists used sonar to follow the fish.*

Example: *Scientists count the rings on the clam to tell how old it is.*



Exploring the Sant Ocean Hall: A Guide for Students

Version B

Ocean Hall Expedition

Some of the things you will see and experience at the *Sant Ocean Hall* come from information learned on expeditions. Many of the scientists who work at the museum go on expeditions to collect data about questions they wonder about. They never know for sure what they will find. Many times they come back with new questions. On your trip to the National Museum of Natural History, you can collect information about ocean questions that interest *you*.

Goals of your Expedition:

- Explore the Ocean Hall as a scientist to investigate your own questions about the ocean and why it is important.
- Record Field Notes about what you learn.
- Find out how the scientists learn about the ocean.

Directions:

1. In part one of the *Field Notes*, write the questions you want to explore.
2. In part two write down your ideas about where you can find evidence to help answer your questions.
3. In part three write what you learn about your question. Make your own observations, record information and examples. You can also make sketches.
4. In part four write information that explains how scientists learn about the ocean. For example, you can include examples of data, names of technology and tools, observations, techniques, or anything you learn about what scientists do.

Taking pictures and recording video and sound are good ways to remember what you learn, but be sure to get your teacher's permission first.



Tips for Exploring

What to look at:

Signs, specimens, photographs, videos, models, murals, science tools, and computers.



Shows ways people use the ocean and threats to the ocean's health.



Tells about how scientists study the ocean.

If you have a hard time finding information, try these strategies:

- Change your question so it is more specific.
- Make a new question based on what you see in the *Sant Ocean Hall*.
- Remember to keep all of your questions. They could be important for later investigations!

Observations Can Be:

Qualitative

What you see, hear, or feel.

Example: *The fish scales were shiny, grey, and smooth.*

Quantitative

What you measure or count.

Example: *There were 12 different types of fish with the scales.*



Field Notes

Part 1: Question(s)

Part 2: Where I can look for answers to my questions in the *Sant Ocean Hall*

Part 3: Evidence I found (observations, information, and examples)

Part 4: How scientists study the ocean (technology, tools, techniques)

Example: Scientists used sonar to follow the fish.

Example: Scientists count the rings on the clam to tell how old it is.



Exploring the Sant Ocean Hall: A Guide for Students

Version C

Ocean Hall Expedition

You are about to visit the *Sant Ocean Hall* at the *Smithsonian National Museum of Natural History*, where more than 100 scientists work with others from around the world to better understand the ocean and its health. Going out on expeditions is one of the many ways these scientists do their research. These explorers set out to collect data related to questions or observations they are interested in, but they never know for sure what they will discover. They are sometimes surprised by what they find and very often end up with brand new questions. Some of the things you will see and experience at the *Sant Ocean Hall* comes from information learned on expeditions.

Goal of your Expedition:

- Explore the *Sant Ocean Hall* as a scientist to investigate your own questions about the ocean and why it is important.
- Record information that helps answer your questions.
- Find out how the scientists learn about the ocean.

Directions:

1. Decide what scientific questions you want to investigate at the *Sant Ocean Hall*. Write these in **part one** of the *Field Notes*.
2. In **part two**, record your observations, information, and examples, as you explore the *Sant Ocean Hall*. Take notes and make sketches to help you answer your questions.
3. In **part three**, record any information you discover about the science behind the information presented. For example, you can include examples of data, names and descriptions of the technology and tools used to collect the data, observations scientists have made, techniques that are used, or any other feature of ocean science.

Taking pictures and recording video and audio can be valuable ways to record your data, but be sure to get your teacher's permission first.



Tips for Exploring

What to look for:

Be sure to look at text, specimens, photographs, videos, models, murals, science tools, and interactive computer stations located throughout the Ocean Hall.



Shows ways people use the ocean and threats to the ocean's health.



Tells about how scientists study the ocean.

If you do not find the type of information, evidence, or examples that are helpful for a question try this:

- Find clues to help you come up with your own explanation or answer.
- Change your question so it is more specific.
- Make a new question based on what you see in the *Sant Ocean Hall*.
- Keep all of your questions. They could be important for later investigations.

Observations Can Be:

Qualitative

What you see, hear, or feel.

Example: *The fish scales were shiny, grey, and smooth.*

Quantitative

What you measure or count.

Example: *There were 12 different types of fish with these scales.*



Field Notes

Part 1: Expedition Question(s)

Part 2: Observations, information, and examples

Part 3: How the scientists learn about the ocean (examples of data, technology, tools, observations and techniques)

Example: Scientists used sonar to follow the fish.

Example: 100 core samples were taken from the ocean floor in the Atlantic to determine when the climate was the warmest.



An Introduction to Ocean Science

Version A

When you visit the *Sant Ocean Hall* you will learn about the ocean and how we explore it. Right now the scientists at the museum are trying to learn even more. *How do they do it?* It depends on what they want to learn and what they discover.

Why is studying the ocean important?

We have a lot to learn about the ocean. Understanding the ocean helps us make decisions like how can we use the ocean and how can we protect the ocean.

Who studies the ocean?

Many different types of scientists study the ocean. Some study ocean life and some study how the ocean works. Other scientists study the history of the ocean or how humans interact with it.

What questions do different scientists ask?

Different kinds of scientists at the museum ask and explore different questions about the ocean. Here are some examples.

- Brian Huber is a paleontologist. He studies tiny fossils to learn *How has the ocean changed over millions of years?*
- Cynthia Gilmour is a chemist. She studies questions about pollution in the water.
- Ellen Strong and Allen Collins are biologists. They study *How are different ocean animals related?*



How do scientists study their questions about the ocean?

People study the ocean in many different ways. Sometimes they start with a question. For example, biologist Carole Baldwin wants to know *Which fish larvae (babies) grow to be which adults?* Other times a scientist like Carole sees something that makes them wonder. She found new types of fish that all look the same. Now she is trying to figure out why they look the same.

Scientists come up with hypotheses or possible explanations to “answer” their questions. Then they make observations and collect data to test their ideas. They use lots of different tools to do this. Some tools are simple like a hammer. Some are complicated like an underwater submersible.

Scientists share what they learn with other scientists by writing papers. No matter what a scientist discovers (or does not discover) they help us better understand the ocean and how it is important. And there is still a lot more to learn!

We hope you come to the museum with questions to ask and leave with even more questions to explore!



Did You Know?

Anyone can become a marine scientist? Scientists are creative, logical, curious, and skeptical.

Scientists can be motivated and inspired by many different things. What questions do you wonder about?



A Story of Ocean Research: The Pollution of Squid

Michael Vecchione loves squid. He looks for squid all over the world. He wants to learn *What types of squid live in which parts of the ocean?* but he never knows what he will find.

Looking for squid is exciting, but it is also hard work. When Mike goes out on an expedition, he works day and night to collect squid from the dark, deep ocean. He uses a giant net called a mid-water trawl to catch the animals and bring them onto the ship to study.

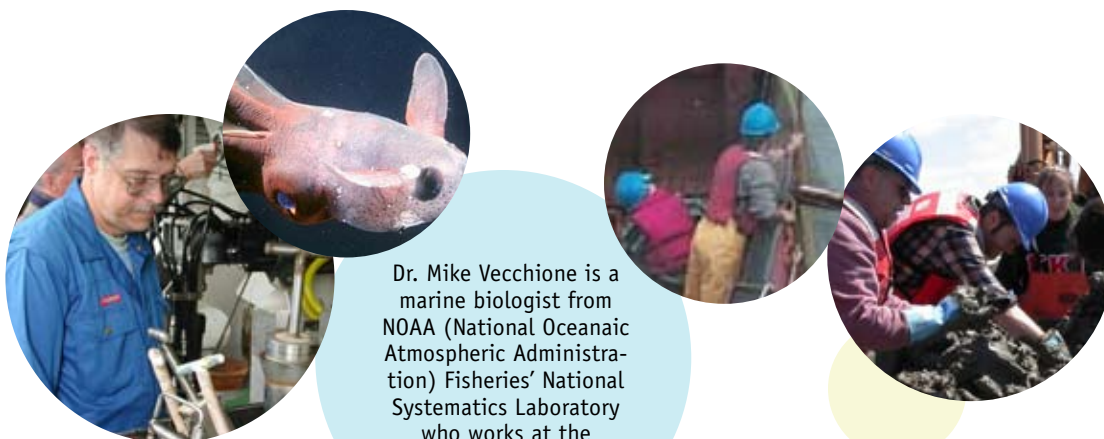
Mike knows lots of scientists who also study the ocean. Sometimes he helps them investigate different questions. For example, when some of his friends wanted him to test the squid for dangerous chemicals made by humans Mike thought *why not?* He did not expect to find anything because the squid live so deep and far away from people. But he tested them anyway.

Everyone was very surprised when the results came back. They found evidence that some of the squid had poisonous chemicals. They also found these toxins in octopus, and “vampire squid”.

Mike and the other scientists shared what they learned by writing a paper for a journal called *Marine Pollution Bulletin*. The squid specimens are now in the museum’s collections for other scientists to study.

But the research does not end there. Other scientists have found the chemicals in whales and dolphins. They want to know *Where are marine mammals getting poisons?* Squid are a favorite food of the whales and dolphins. *Could they be getting the poison from the squid they eat?* Mike is now helping them answer this question.

Mike does not know what he will discover next, or how his research will be used, but he does know that he will never run out of questions to investigate.



Dr. Mike Vecchione is a marine biologist from NOAA (National Oceanic Atmospheric Administration) Fisheries' National Systematics Laboratory who works at the *National Museum of Natural History*.



Questions

1. What did you learn about how scientists investigate the ocean?

2. What other scientific questions does Mike's work make you wonder about?

Additional Background and Information

Octopods, squid show signs of contamination

<https://scienceblog.com/16641/octopods-squid-show-signs-of-contamination/>

The Sant Ocean Hall

www.ocean.si.edu



An Introduction to Ocean Science

Version B

The *Sant Ocean Hall* presents just some of what we know about the ocean and how we explore it. But what you will see is just the beginning. Right now, scientists at the museum and around the world are trying to learn more. *How do they do it?* It depends on what they want to learn and what they discover.

Why is studying the ocean important?

The ocean makes up 71% of Earth's surface but we know more about the moon.

Understanding what lives in the ocean and how the ocean works is important for our curiosity. But it is also important for helping us use its resources (like food) responsibly and for making predictions about our planet's future.

Who studies the ocean?

Many different types of scientists study the ocean, including marine biologists, geologists, oceanographers, paleontologists, and anthropologists.

What questions do different types of scientists explore?

Different kinds of scientists at the museum ask and explore different types of questions about the ocean.

Brian Huber, a paleobiologist, studies tiny fossils to learn *How has Earth's environment changed during the past 120 million years?*

Cynthia Gilmour is a chemist who investigates questions like *How can we control Mercury pollution in our oceans?*

Ellen Strong and Allen Collins are biologists who study *How are different marine animals related?*



How do scientists investigate their questions about the ocean?

Scientists do not follow any single set of steps when investigating the ocean. Instead, science happens in many different ways.

Carole Baldwin is a biologist who studies the question *Which fish larvae (babies) grow to be which adults?* She collects all kinds of data to study this question, including DNA. Sometimes, while studying one question she finds data that create new questions. Recently, Carole found several different types of fish that all look the same. So now she wants to know *Why do they look the same? How did they evolve?*

Most investigations involve testing hypotheses. As Carole investigates her new questions, she will have several hypotheses (logical explanations) to explain possible “answers.” She will then make observations and collect data to test her ideas.

Scientists use many of different types of tools and technology to make observations and collect data. These can be as simple as a hammer or as complicated as an underwater submersible. Sometimes scientists invent their own technology. For example, Ian MacIntyre, a paleogeologist at the museum, developed a drill to study coral reefs. Since its invention, the tool has been used by many other scientists.

Scientists publish what they learn in scientific journals to inform others. No matter what a scientist discovers (or does not discover) they help us better understand the ocean and how it is important. And there is still a lot more to learn!

We hope you come to the museum with questions to ask and leave with even more questions to explore!



Did you know that anyone can become a marine scientist? Scientists are creative, logical, curious, and skeptical. Scientists can be motivated and inspired by many different things. What questions do you wonder about?



A Story of Ocean Research: The Pollution of Squid

Michael Vecchione loves squid. He travels the world looking for squid as part of a survey (called Census of Marine Life) aimed at finding and describing all ocean life.

Searching for squid is exciting, but it is also hard work. When Mike goes out on an expedition, he works day and night collecting squid from the dark, deep ocean. He uses a tool called a mid-water trawl. A trawl is like a giant net that gets dragged through the water by the ship. It collects all kinds of things that get pulled up on board the ship and studied.

Searching for squid can lead to new questions and unexpected results. Mike wants to learn *What types of squid live in which parts of the ocean?* However, when other scientists who study harmful chemicals in fish suggested that he look for these same pollutants in squid Mike thought *why not?*. He did not expect to find anything because the squid live so deep and far away from people. But he tested them anyway.

Everyone was very surprised when the results came back. Some of the squid had poisonous chemicals like DDT (once used to kill insects but now illegal to use in the US) and PCBs (also illegal). They found these same chemicals in octopus, and “vampire squid”.

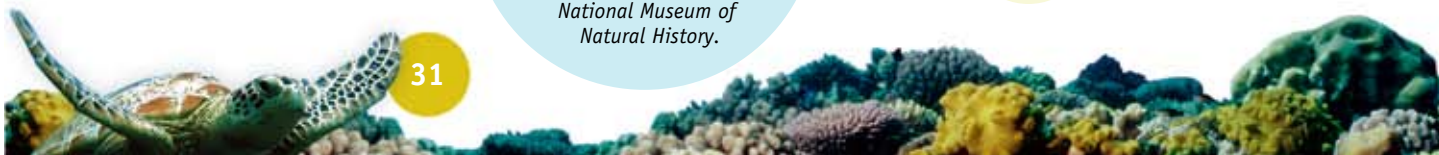
Mike and his colleagues published their findings in a scientific journal called *Marine Pollution Bulletin* to share what they discovered. The squid specimens are now in the museum’s collections for other scientists to study.

But the research does not end there. Other scientists have found PCBs and DDT in whales and dolphins. They want to know *Where are marine mammals getting poisons?* Squid happen to be a favorite food of these animals. *Could they be getting the poison from the squid they eat?* Mike is now working with the researchers to help them find possible answers to their questions.

Mike does not know exactly what he will discover next, or how his research will impact others, but he does know that the questions he could explore are endless!



Dr. Mike Vecchione is a marine biologist from NOAA (National Oceanic Atmospheric Administration) Fisheries' National Systematics Laboratory who works at the National Museum of Natural History.



Questions

1. What did you learn about how scientists investigate the ocean?

2. What other scientific questions does Mike's work make you wonder about?

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An Introduction to Ocean Science

Version C

The *Sant Ocean Hall* presents just some of what we know about the ocean and how we explore it. What you will see is just the tip of the iceberg. Right now, scientists at the museum and around the world are trying to learn more. *How do they do it?* It depends on what they want to learn and what they discover.

Why is studying the ocean important?

The ocean makes up 71% of Earth's surface yet we know more about the surface of the moon than about the ocean. Understanding what lives in the ocean and how the ocean works doesn't just satisfy our curiosity. It is also important for helping us use its resources (like food) responsibly and for making predictions about our planet's future.

Who studies the ocean?

Many different types of scientists at the *Smithsonian's National Museum of Natural History* and other places study the ocean, including marine biologists, chemists, geologists, physicists, paleontologists, taxonomists, oceanographers, and anthropologists.

What questions do different types of scientists explore?

Different kinds of scientists at the museum ask and explore different types of questions about the ocean.

Marine paleobiologist Brian Huber has traveled the world studying tiny fossils to investigate the question *How has Earth's environment changed during the past 120 million years?*

Cynthia Gilmour is a marine chemist at the Smithsonian Environmental Research Center in Maryland. She investigates questions like *How can we control Mercury pollution in our oceans?*

Ellen Strong and Allen Collins are invertebrate zoologists who use animals and their DNA stored at the museum to answer questions such as *How are different marine animals related?*



How do scientists investigate their questions about the ocean?

Scientists do not follow any single set of steps when investigating the ocean. Instead, science happens in many different ways.

Carole Baldwin is an ichthyologist who specializes in fish larvae (babies). She asks questions like *Which larvae grow to be which adults?* She collects all kinds of data to study this question, including morphology (body structures) and DNA.

Sometimes she finds data that create a new question. For example, scientists basically stopped looking for new fish in the Caribbean a long time ago because it was assumed every fish had been identified. But recently, while Carole was matching larvae with adults using DNA, she discovered many new species of coral-reef fishes. It turns out that some species that look very similar are actually different species. This discovery has set her research in a new direction. She now wants to know *How many fish species are there in the Caribbean? How did different fish evolve to look the same? And Which parts of the Caribbean have the same fish species and which parts have different ones?*

Most investigations involve testing hypotheses. As Carole pursues her new questions, she will have several hypotheses (logical explanations) about what could be possible answers to her questions. She will then make observations and collect data to test these ideas.

Scientists use a variety of tools and technology to test their hypotheses. These can be as simple as a hammer or as complicated as an underwater submersible. Sometimes scientists need to invent their own technology. For example, Ian MacIntyre, a paleogeologist in the museum, developed the first submersible drill to study the geology of coral reefs. Since its invention, the tool has been used by many other scientists.

When enough data have been collected, scientists publish what they learn in scientific journals so others can evaluate and use the information. No matter what a scientist discovers (or does not discover) they help us better understand the ocean and how it is important. And there is still a lot more to learn!

We hope you come to the museum with questions to ask and leave with even more questions to explore!



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Michael Vecchione loves squid. He travels the world—from the Antarctic to the top of northern Atlantic seamounts—collecting and identifying squid as part of a survey (Census of Marine Life) aimed at finding and describing ocean life.

Searching for squid is exciting, but it is also hard work. When Mike goes out on an expedition, he works day and night for two solid weeks collecting squid from the dark depths of the ocean. A mid-water trawl, basically a net with a collecting box at the end, gets dragged through the water by the ship, trapping anything too big to fit through the holes in the mesh. When the trawl gets hauled back up on deck, scientists sort through it to see what they caught.

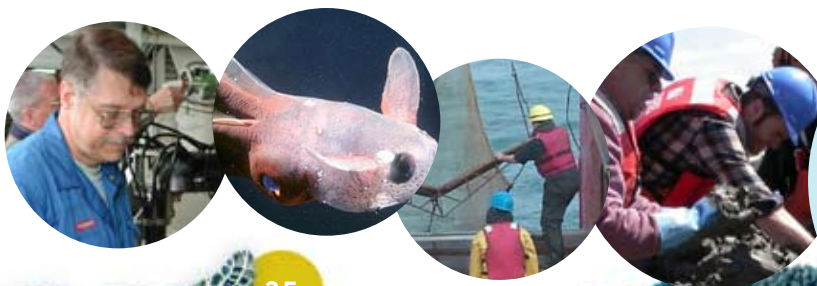
In his pursuit to learn *What types of squid live in which parts of the ocean?* Mike works with lots of different people. When colleagues who study human pollutants in fish suggested that he look for these same pollutants in squid, Mike thought *why not?* He did not expect to find anything because these animals live in a very deep and remote ecosystem, far from where humans live. But he wrapped and froze samples of squid in special chemically cleaned tin foil and brought them back to be analyzed.

Everyone was very surprised when the results revealed that some of the squid were loaded with toxic chemicals. The chemicals they found included DDT, a pesticide that is now illegal in the US but still used in other countries to control malaria. They also found PCBs, a poisonous chemical that used to be found in wires and electrical equipment. Squids were not the only animals they found with these pollutants. Other cephalopods (close relatives of squid) including octopus, and “vampire squid” were also contaminated.

Mike and his colleagues published their findings in a scientific journal called *Marine Pollution Bulletin* to share what they discovered. Similar squid specimens from the same samples are now in the museum’s collections for other scientists to study.

But the research does not end there. Different scientists have found PCBs and DDT in marine mammals like whales and dolphins. Knowing that squid, which are a favorite food of many marine mammals, are contaminated helps them with their question *Where are marine mammals getting poisons?*

Mike does not know exactly what he will discover next, or how his research will impact others, but he does know that the questions he could explore are endless!



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Questions

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What Do Scientists Study? Teacher Instructions

In this activity, students sort a set of provided questions by discipline before writing their own scientific questions.

Objectives

- To expose students to a wide variety of ocean-related questions.
- To help students identify questions that scientists from different disciplines explore.
- To give students practice writing scientific questions.
- To provide ideas for their own exploration of the *Sant Ocean Hall*.

Preparation:

- Make student copies of *What Do Scientists Study?* (1 copy per student).
- Select the list of *Ocean Science Questions* most appropriate for your students. Three versions exist: A is written for the most basic readers (typically for grades 4-5); B is written for more advanced readers (typically for grades 6-8); and C is written for the highest reading levels (typically grades 9-10).
- Cut out the questions and put into envelopes (1 set per team).

Using the Activity

1. Explain that many different types of scientists study the ocean. The *Sant Ocean Hall* presents information about what different types of scientists have learned (and not learned) about the ocean and its importance.
2. Ask students to name some of the types of scientists who investigate the ocean. Answers could include: biologists, paleontologists, chemists, geologists, physicists, ecologists, taxonomists, anthropologists, or oceanographers.
3. Pass out *What Do Scientists Study?* and *Ocean Science Questions*. Instruct students to group the questions by the disciplines included in their instructions. Some of the questions relate to the threats facing the ocean. Encourage students to group these as a separate category.



4. Ask students to write their own scientific questions. Students can use the questions in the activity as a model. For example, the question *What lives in sand?* could be changed to *What lives in the coral reef?* The question *Why do coral reefs have high biodiversity?* could be changed to *What factors affect biodiversity?*

Alternative Approach:

This activity can also be completed by giving each student one question that they categorize as part of a whole-class activity.



Some ocean questions are investigated from different perspectives by scientists trained in different disciplines.



What Do Scientists Study?

Answer Key

Note, Because of the interdisciplinary nature of ocean science, some of these questions can be placed in more than one category.

Ocean Science Questions: List A (Elementary School)

Marine Biologists

- What lives in the sand?
- Why do some animals glow?
- Why do so many things live in coral reefs?

Marine Geologists

- What does the bottom of the ocean look like?
- Where can you find underwater volcanoes?
- How are islands made?

Physical Oceanographers

- How cold is the ocean?
- What causes ocean currents
- How salty is ocean water?

Marine Chemists

- What comes out of underwater volcanoes?
- How much oxygen is in the water?
- What is ocean water made of?

Marine Paleontologists

- What lived in the ocean when dinosaurs were alive?
- How warm was the ocean millions of years ago?
- What did the ocean's first fish look like?

Anthropologists

- Why is the ocean important to people?
- What type of food do people get from the ocean?
- How do people celebrate the ocean?

Ocean Threats

- Why are polar bears disappearing?
- What is destroying the coral reefs?
- What kind of pollution gets into the ocean?



Ocean Science Questions: List B (Middle School)

Marine Biologists

- What lives in the sand?
- Why do some animals glow?
- What types of whales live in the ocean?
- What adaptations allow some animals to float?
- Why do so many things live in coral reefs?

Marine Geologists

- How is the bottom of the ocean similar to land?
- What kinds of rocks can you find in the ocean?
- How do plate tectonics shape the ocean floor?
- Where do you find underwater volcanoes?

Physical Oceanographers

- Where will the next tsunami hit?
- What are the physical conditions of the deep ocean?
- Why is the ocean more salty in some areas?
- How does erosion from land affect the ocean?

Marine Chemists

- What chemicals make up seawater?
- What comes out of hydrothermal vents?
- How much oxygen is in the water?

Marine Paleobiologists

- What lived in the ocean when the dinosaurs were alive?
- What was the climate like millions of years ago?
- Why did trilobites go extinct?
- How warm was the first ocean?

Marine Anthropologists

- How is the ocean important to humans?
- How do people celebrate the ocean?
- How have years of fishing affected the ocean?
- What cultures rely on the ocean?

Ocean Threats

- What types of ocean animals have been over fished?
- How are beaches important to protecting the ocean?
- How does human activity threaten the polar bear?
- What is destroying the coral reefs?
- What kind of pollution gets into the ocean?



Ocean Science Questions: List C (High School)

Marine Biologists

- What kinds of organisms live between sand grains?
- How does bioluminescence help organisms live in the deep ocean?
- How is variation important for evolution?
- How are animals living on the ocean surface adapted for survival?
- Why do coral reefs have high biodiversity?

Marine Geologists

- How does the topology of the ocean compare to land?
- What geological forces affect ocean topology?
- How do seamounts form?
- Does tectonic activity affect the ocean today?

Physical Oceanographers

- Where will the next tsunami hit?
- What are the abiotic conditions of different ocean zones?
- How does erosion from land affect the ocean?
- How does the ocean impact our climate?

Marine Chemists

- What comes out of hydrothermal vents?
- In what ways do organisms impact ocean chemistry?
- How can we remove harmful chemicals like mercury that get into the ocean?
- How does carbon dioxide move from the ocean into our atmosphere?

Marine Paleobiologists

- How do mass extinctions affect the evolution of new organisms?
- How have whales evolved?
- How do past extinctions help us understand the health of our planet today?
- How can microfossils (tiny fossils) be used to determine past climates?

Marine Anthropologists

- In what ways has the ocean been important to humans throughout history?
- How has our use of the ocean changed over time?
- Why do different cultures celebrate the ocean?
- How has decades of fishing impacted the ocean?

Ocean Threats

- Which marine ecosystems are being affected by human activity?
- How are changes in coastal habitats impacting the ocean?
- How are scientists monitoring threatened and endangered species?



What Do Scientists Study?

Student Instructions

Introduction

There are many different kinds of scientists who study the ocean, and they each ask different types of questions. On your expedition to the *Sant Ocean Hall* at the *National Museum of Natural History*, you will investigate your own questions like a scientist. This activity will help you get started.

Directions

Use the descriptions of scientists to help you organize the question cards that your teacher will give you. Try to match each scientist with the kinds of questions he or she would ask.

Descriptions of Scientists

Marine biologists study ocean life and ecosystems.

Marine geologists study what the ocean floor is made of and how it is formed.

Physical Oceanographers study currents, tides, and waves, and the temperature, acoustics (sound), and salinity (amount of salt) of the ocean.

Marine Chemists study ocean chemicals such as oxygen.

Marine Paleontologists study the ocean, climate, and life in the past.

Marine Anthropologists study how people interact with the ocean.



Ocean Science Questions: List A

How are islands made?	Why do so many things live in coral reefs?
Why are polar bears disappearing?	How much oxygen is in the water?
Why do some animals glow?	How warm was the ocean millions of years ago?
What is destroying the coral reefs?	What causes ocean currents?
What does the bottom of the ocean look like?	What comes out of underwater volcanoes?
What type of food do people get from the ocean?	Why is the ocean important to people?
How salty is ocean water?	What lives in sand?
What did the ocean's first fish look like?	What lived in the ocean when the dinosaurs were alive?
What is ocean water made of?	How do people celebrate the ocean?
How cold is the ocean?	Where can you find underwater volcanoes?
What kind of pollution gets into the ocean?	



Ocean Science Questions: List B

What lives in sand?	What are the physical conditions of the deep ocean?
Why is there mercury in ocean water?	How are beaches important to protecting the ocean?
What kind of pollution gets into the ocean?	What chemicals make up seawater?
Why do so many things live in coral reefs?	How is the bottom of the ocean similar to land?
How have years of fishing affected the ocean?	What cultures rely on the ocean?
How does erosion from land affect the ocean?	Where do you find underwater volcanoes?
How does human activity threaten the polar bear?	What adaptations allow some animals to float?
What was the climate like millions of years ago?	What lived in the ocean when the dinosaurs were alive?
What types of ocean animals have been over fished?	Why do some animals glow?
What types of whales live in the ocean?	How do people celebrate the ocean?
What is destroying the coral reefs?	What comes out of hydrothermal vents?
How warm was the first ocean?	Why did trilobites go extinct?
How is the ocean important to humans?	What kinds of rocks can you find in the ocean?
How do plate tectonics shape the ocean floor?	Why is the ocean more salty in some areas?
How much oxygen is in the water?	Where will the next tsunami hit?



Ocean Science Questions: List C

How does erosion from land affect the ocean?	What kinds of organisms live between sand grains?
How do past extinctions help us understand the health of our planet today?	Which marine ecosystems are being affected by human activity?
How do mass extinctions affect the evolution of new organisms?	How can we remove harmful chemicals like mercury that get into the ocean?
How does bioluminescence help organisms live in the deep ocean?	How can microfossils (tiny fossils) be used to determine past climates?
Why do different cultures celebrate the ocean?	How has decades of fishing impacted the ocean?
What causes "red tides"?	Why do coral reefs have high biodiversity?
How do seamounts form?	How does carbon dioxide move from the ocean into our atmosphere?
Why is ocean acidification (the ocean becoming more acidic) affecting coral reefs?	How does the ocean impact our climate?
How are animals living on the ocean surface adapted for survival?	What comes out of hydrothermal vents?
How are scientists monitoring threatened and endangered species?	Does tectonic activity affect the ocean today?
How have whales evolved?	In what ways has the ocean has been important to humans throughout history?
Where will the next tsunami hit?	How is variation important for evolution?
How has our use of the ocean changed over time?	How are changes in coastal habitats impacting the ocean?
How does the topology of the ocean compare to land?	What are the abiotic conditions of different ocean zones?
In what ways do organisms impact ocean chemistry?	What geological forces affect ocean topology?

