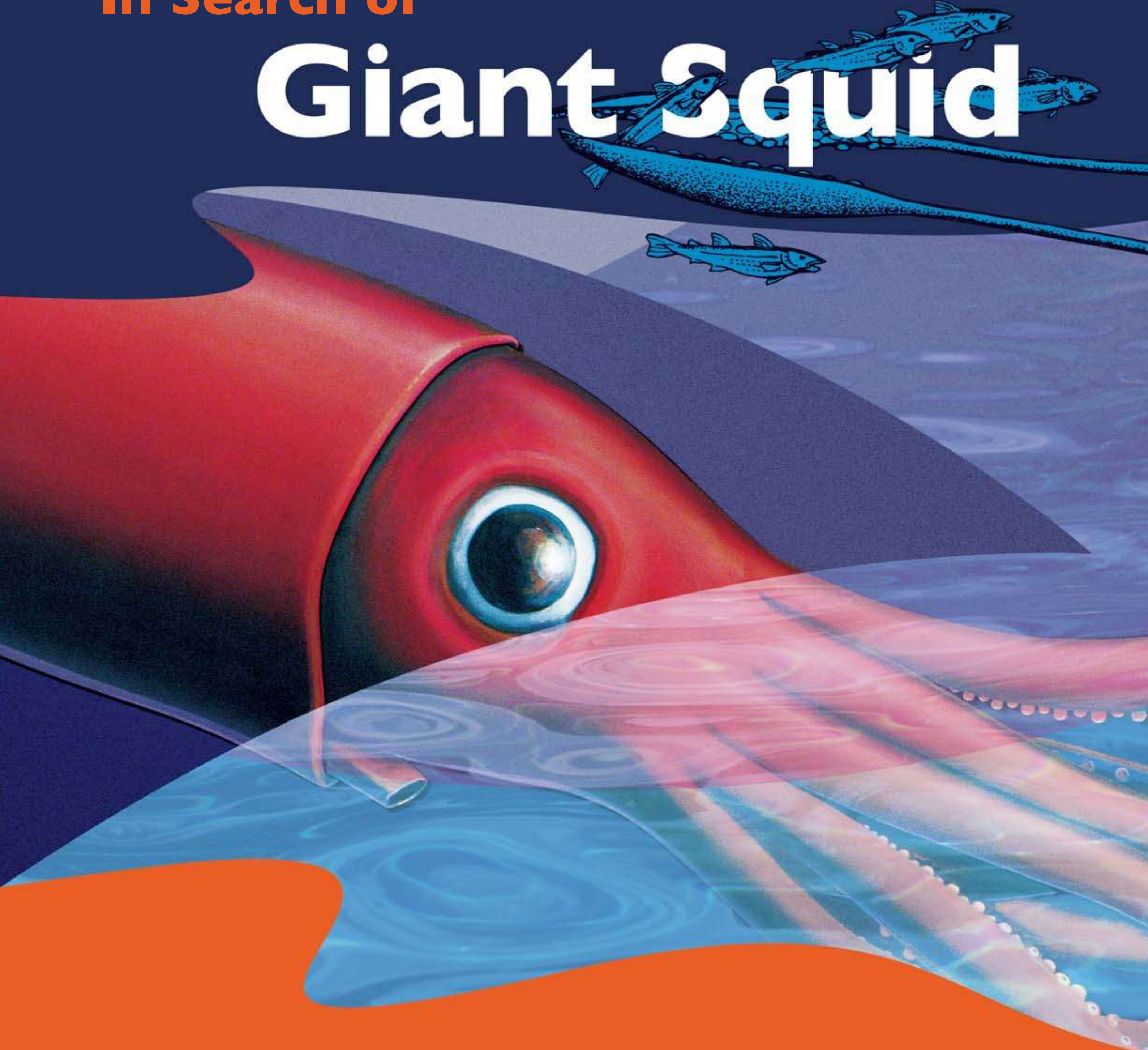
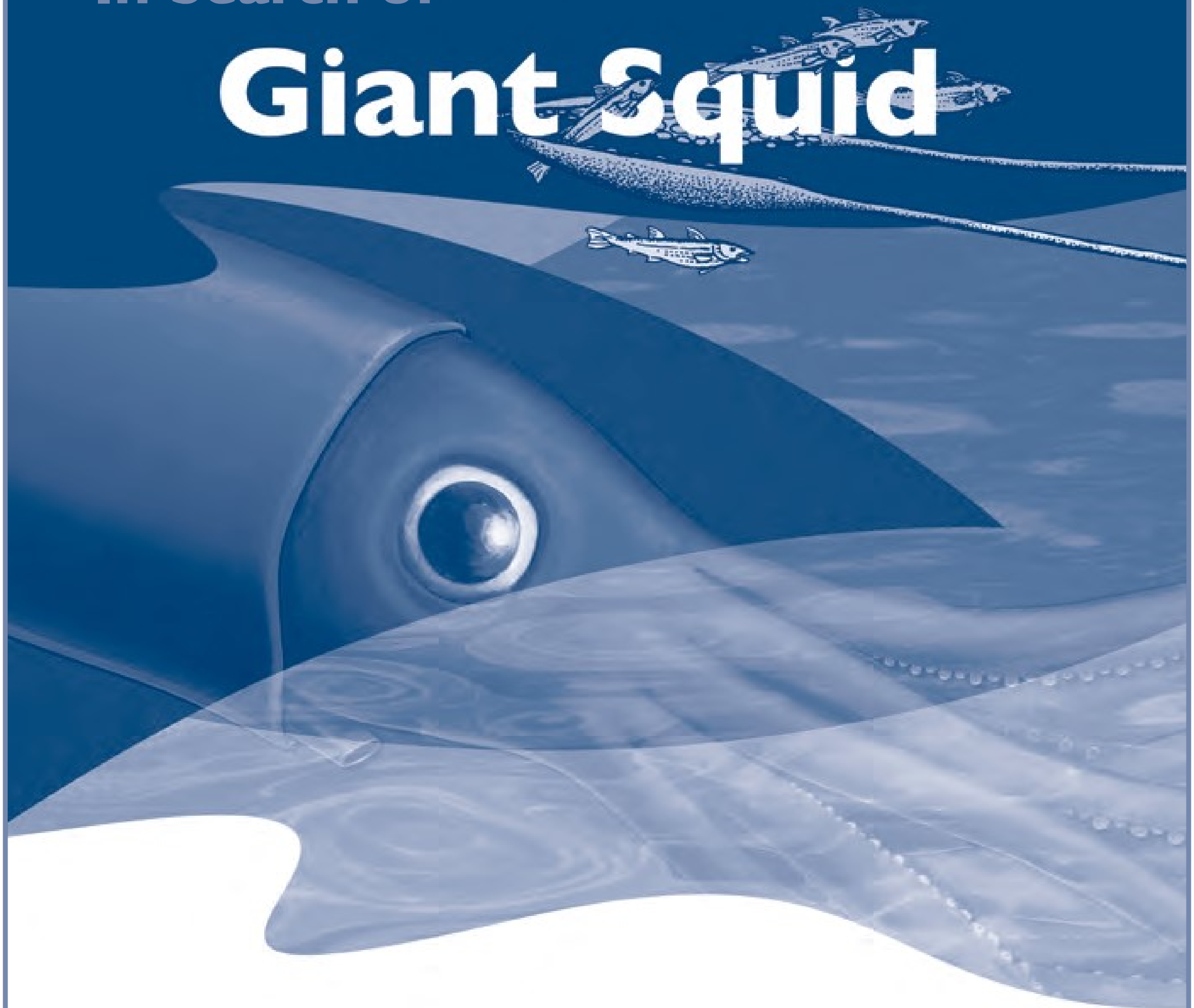
# In Search of Giant Squid



## Curriculum Guide

Smithsonian

# In Search of Giant Squid



## Curriculum Guide

Smithsonian

# Table of Contents



# Dear Educator,

We are pleased to provide you with a teacher's manual designed to accompany the Smithsonian traveling exhibition, ***In Search of Giant Squid***. The exhibition was organized by the Smithsonian Institution Traveling Exhibition Service (SITES), based on a permanent exhibition at the National Museum of Natural History, and presented with the support of the National Aeronautics and Atmospheric Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), and the Discovery Channel. Currently, the museum exhibit is closed, being updated as part of the spectacular "Oceans Hall." The new and improved giant squid exhibit will feature actual specimens!

***In Search of Giant Squid*** examines the legends spawned by this extraordinary creature, ***Architeuthis***, and compares it with other squids and mollusks while exploring what is known about how giant squid hunt, move, and defend themselves. The exhibition also traces the history of research into this amazing animal's anatomy, environment, and behavior. Specimens and interactive components allow visitors to compare their height to the length of a giant squid and to experience the adult giant squid's environment, 500 meters beneath the ocean's surface. Recently, Japanese researchers obtained the first-ever photographs of a giant squid in its natural habitat. This exciting development and the many mysteries that still surround ***Architeuthis*** provide students with an exciting portal into the worlds of biology and oceanography.

This manual is divided into three sections in which students will gather basic facts about the giant squid, study its environment, and then design a research expedition to study the elusive giant. Each lesson was designed with National Science Education Standards in mind, and the applicable standards are noted with each lesson. While the manual was designed for 5-8 grade students, alternative "roadmaps" for younger and older students also are provided. Lesson One is designed for use within the exhibition, or students can find the information online at **http://seawifs.gsfc.nasa.gov/squid.html**.

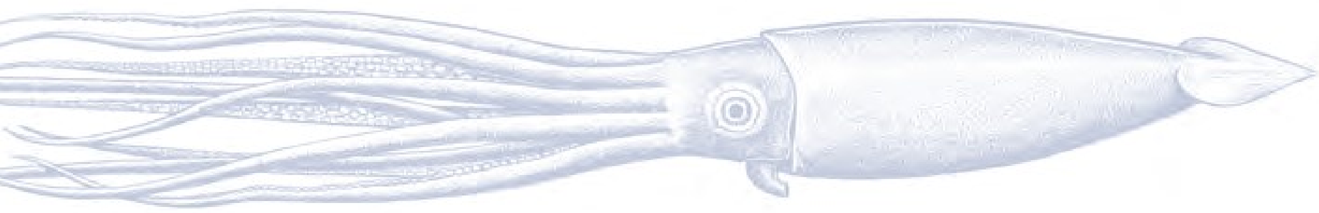
We are deeply interested in how you use this guide in your classroom. Please contact us via email at **SITESGiantSquids@si.edu** or write to:


**Attn: Giant Squid**

**P.O. Box 37012**

**MRC 941**

**Washington, DC 20013-7012**



In ***Search of Giant Squid*** will be traveling across North America, and we hope you will have the opportunity to see it at a museum near you. For a complete tour schedule, please visit SITES' website, **www.sites.si.edu**.

Best regards,

**Anna Cohn**
SITES Director

**Dr. Eric Lindstrom**
NASA Physical Oceanography Program Scientist

**Dr. Clyde Roper**
Curator Emeritus, Smithsonian National Museum of Natural History

A giant squid's sucker. © C.F.E Roper

# Objectives and Standards

## Overview of Objectives

- Students will understand the challenges in finding a "relatively small" giant squid within a vast and deep habitat.
- Students will gain a better understanding of the giant squid's behavior and natural habitat.
- Students will learn about the ever-improving technological resources needed to find a live giant squid.

## National Science Education Standards

supported by these activities

### Grades 5-8

(For younger or older audiences, see ROADMAP on next page)

### Lesson One: Meet the Giant Squid

- Principles & Standards for School Mathematics: "Measurement Standards for Grades 6-8."

### Lesson Two: The Giant Squid's World

- National Science and Education Standards for Life Science: "Populations & Ecosystems," (Content Standard C for Grades 5-8).

### Lesson Three: Plan a Giant Squid Expedition

- National Science Standards for Science & Technology: "Understandings about Science and Technology," (Content Standard E for Grades 5-8); "Science in Personal and Social Perspectives," (Content Standard F for Grades 5-8).

Pierre Denys de Montfort's 1802 illustration of a sea creature swallowing a ship. Courtesy National Museum of Natural History. **Inset:** Rows of suckers provide strong suction, ensuring that the giant squid's prey doesn't escape. © C.F.E. Roper

# ROADMAPS

**Suggested Roadmap for Younger Audiences:**

## Lesson One

- Indoor/Outdoor Activity: How Big is the Giant Squid?
- Reading and Discussion: Meet the Giant Squid (worksheet #1)
- Map Activity: Where is the Giant Squid? (worksheet #2)
- Living Factors that Impact the Adult Giant Squid (worksheet #6)
- Non-living Factors that Impact the Giant Squid (worksheet #7)
- Ocean Surface Temperature Map (worksheet #8)
- Ocean Temperature—650 feet (200 meters) Map (worksheet #9)
- Ocean Temperatures Overview (worksheet #10)
- Ocean Surface Topography and Currents Map (worksheet #11)
- Ocean Color Map (worksheet #12)

## Lesson Two

- Scales (worksheet #3)
- Behavior and Biology (worksheet #4)
- Detection (worksheet #5)

## Lesson Three

- Activity: Plan a Giant Squid Expedition
- Plan a Giant Squid Expedition (worksheet #13)

**Suggested Roadmap for Older Audiences:**

## Lesson One

- Indoor/Outdoor Activity: How Big is the Giant Squid?
- Reading and Discussion: Meet the Giant Squid (worksheet #1)
- Map Activity: Where is the Giant Squid? (worksheet #2)
- Optional Activity: Dissect a Squid (step-by-step instructions available at **http://giantsquid.msstate.edu/LessonList/dissection.html**)
- Living Factors that Impact the Adult Giant Squid (worksheet #6)
- Non-living Factors that Impact the Giant Squid (worksheet #7)

## Lesson Two

- Scales (worksheet #3)
- Behavior and Biology (worksheet #4)
- Detection (worksheet #5)

## Lesson Three

- Ocean Surface Temperature Map (worksheet #8)
- Ocean Temperature—650 feet (200 meters) Map (worksheet #9)
- Ocean Temperatures Overview (worksheet #10)
- Ocean Surface Topography and Currents Map (worksheet #11)
- Ocean Color Map (worksheet #12)
- Activity: Plan a Giant Squid Expedition
- Plan a Giant Squid Expedition (worksheet #13)

# Meet the Giant Squid

**Lesson Objectives:** In this lesson, students will get acquainted with the habits, biology, and range of the giant squid.

**Standards:**
Principles & Standards for School Mathematics: "Measurement Standards for Grades 6-8."

**Suggested Grade Levels: 6-8:**
(For younger or older audiences, see ROADMAP on page 7)

**Group Activities:**
**Indoor/Outdoor Activity:** How Big is the Giant Squid?
**Activity (optional):** Dissect a Squid

**Student Handouts:** Scale, Behavior and Biology, and Detection worksheets may completed in groups during museum field trip or after online research

**Worksheet #1:** Meet the Giant Squid
**Worksheet #2:** Where is the Giant Squid?
**Worksheet #3:** Scale
**Worksheet #4:** Behavior and Biology
**Worksheet #5:** Detection

**Supplies:** Soccer or basketball, rope or twine, map of North America, world map, dissection tools for optional activity

## Background

Map and worksheet activities in this lesson provide students with an understanding of the size, eating habits, and territorial range of the giant squid. It is suggested that teachers begin the lesson with the indoor/outdoor activity, which gives students a sense of the immense size of the giant squid compared to other objects and animals. Metric conversions are included in the student handouts.

Students can be divided into three groups to complete the ***Scale***, ***Behavior*** and ***Biology***, and ***Detection*** questions (worksheets #3, #4, #5), with each group tackling a different worksheet. Once the worksheets are completed, students may reconvene to share answers and discuss as a class. This is especially useful when actually visiting the exhibition at your local museum. For those not attending the exhibition, "Background Research" is provided for students on the ***Meet the Giant Squid*** activity (worksheet #1), and more comprehensive information is located at **http://seawifs.gsfc.nasa.gov/squid.html** and **http://giantsquid.msstate.edu**.

After the questions are answered, students should discuss as a group: "What are the challenges in finding a live giant squid? What kind of expedition would you launch to find a live giant squid? What technique was recently successful in Japanese waters?"

The teacher's answer keys and activity guides are located on the following pages. The accompanying student handouts follow.

## Indoor/Outdoor Activity: How Big is the Giant Squid?

**For all age groups**

Lay out an average-sized female giant squid on the playground or in a hall with a rope or piece of twine–indicating overall length (40 feet or 13 meters), eye placement and size (use a soccer ball), mantle, arm, and tentacle lengths. Compare the animal's size to other familiar objects and distances (e.g., school bus, pitchers mound to home plate, etc.) Female giant squid average around 30-43 feet (9-13 meters) in length while males average 10-26 feet (3-8 meters) long. While this may not be the only reason, scientists speculate that the females' larger size helps them carry the ten million or so eggs they will eventually bear.

## Optional Activity: Dissect a Squid

**For older students**

Dissecting one of the giant squid's small cephalopod cousins will give students a better understanding of why squids, in general, are such mysterious and amazing creatures. Teachers may download precise directions and diagrams from the exhibition website, available at **http://giantsquid.msstate.edu/LessonList/dissection.html**. The website also includes instructions for making calamari (fried squid) after the dissection. Dissections must be carried out in an appropriate environment and with safe tools. Teachers should note that squid may have a strong odor and space with proper ventilation should be a prerequisite.

Dr. Clyde Roper with a giant squid specimen. © C.F.E. Roper

Teacher Answer Key to Student Worksheet (page 16)

## Worksheet 1 ▸ Meet the Giant Squid

(Can be handed out or read aloud)

1. ***How long is an adult giant squid?*** Length from head to the tip of the tentacles has been reported up to 60 feet (18 meters). However, recent findings are usually 50 feet (15 meters) or shorter.

2. ***What objects in your everyday life are equal in length to a giant squid?*** Examples: a 6-story building, 1.5 times the length of standard school bus, or the distance from a pitcher's mound to home plate.

3. ***What tool(s) would you use to measure a giant squid?*** Various answers are acceptable. Tape measures, pace it off, photograph with reference point for scale.

4. **What length are giant squid when they are born?** Giant squid paralarvae (small planktonic offspring) are 0.125 inches (0.3175 centimeters) in length.

5. ***How long might giant squid live?*** Typically 2-3 years, as best as we can estimate. Thus a 50-foot-long giant squid grows to 4800 times its original length in less than 3 years. In comparison, an average human baby is 20 inches (50 centimeters) long at birth. If humans grew at the same rate as the giant squid, we would be over 8,000 feet (2,666 meters) tall in 3 years!

6. ***What do giant squid eat (prey)?*** Stomach content data tell us that giant squid eat fish (e.g., hoki, orange roughy) and smaller squid species. In reality, they probably eat anything they want!

7. ***How does a giant squid hunt?*** We don't know exactly how giant squid hunt, but scientists can learn more by looking at the squids' feeding tentacles. Specialized suckers and corresponding knobs are found along the length of its tentacles. Giant squid can align these structures and then "snap" their tentacles tightly together. Once connected, the tentacles can seize and maneuver prey with greater strength and stability.

**8.** ***What eats full-grown squid (predators)?*** Sperm whales. These huge toothed whales are the only predators capable of catching and ingesting a giant squid.

**9.** ***How large is the giant squid compared to the sperm whale? Express as a ratio.*** Sperm whales (males) are about the same size as adult giant squid. The giant squid to predator length ratio is about 1:1. However, the sperm whale weighs 80 times more than a giant squid! Sperm whales weigh 40 tons (120,000 pounds or 36 metric tons) and giant squid weigh 0.5 tons (1,000 pounds or 0.45 metric tons).

**10.** ***How large is the giant squid compared to its prey.*** Express as a ratio? Hoki are up to 49 inches (125 centimeters) in length. Orange roughy are up to 29 inches (74 centimeters) in length. Some species of squid (other than the giant squid) grow up to 13 feet (4 meters) in length. Assuming a giant squid length of 50 feet (15 meters), the giant squid to prey length ratio varies from about 15:1 to about 27:1.

**Measurement and Weight Conversions (conversions also included on student worksheet #1).**

- **1 inch = 2.54 centimeter**
- **1 foot = .3048 meters**
- **1 mile = 1.6 kilometers**
- **1 ton (U.S.) = 2,000 pounds**
- **1 ton (U.S.) = .907 metric tons (U.K.)**
- **1 foot = 12 inches**
- **0°Celcius = 32°Fahrenheit**

Teacher Answer Key to Student Worksheet (page 18)

## WORKSHEET 2 ▸ WHERE IS THE GIANT SQUID?

**Only recently has anyone caught a glimpse of the giant squid in its natural habitat. Teachers should have a world map available for reference. This activity may be done as a group or individually.**


**Answers:**

1. ***Label saltwater bodies near the continental U.S. Be sure to include oceans and gulfs. Locate Bermuda and Newfoundland.*** Correct labels are shown above. Students should be able to identify the Pacific Ocean, Atlantic Ocean, and the Gulf of Mexico but may need help with the Gulf of California and the Gulf of Maine.

2. ***Find your own region on the above map. Draw an arrow to your locale.*** Answers will vary according to location.

3. ***Where are giant squid found in North American waters?*** Giant squid have been found off of the eastern and western coasts of the U.S. They have washed ashore around Florida, near California and Washington, off the New England coast, and as far north as Nova Scotia in Canada.

4. ***Do giant squid live in fresh water or salt water?*** They are found only in salt water.

5. ***What kind of ocean conditions (e.g. temperature, currents, and light levels) do you think giant squid prefer?*** Juveniles seem to prefer shallow depths, while adults live 650-3,300 feet (200-1,000 meters) below the surface, in cold, food-rich waters. It is pitch black where the adults live.

6. ***If you were to launch an expedition to find the giant squid from a location in North America, where would it be?*** In North American waters, most giant squid have been found off the coast of Newfoundland. In U.S. waters, most squid have been located off both coasts of Florida.

Teacher Answer Key to Student Worksheet (page 19)

## Worksheet 3 ▸ Scale

**Students should be divided into three groups, with each group given a different worksheet (worksheets #3, #4, #5). The groups may then reconvene after going through the exhibition or examining the website to discuss their answers. Visit http://seawifs.gsfc.nasa.gov/squid.html. Students are expected to provide metric conversions.**

1. ***How deep do the giant squid live? How does this measurement compare to a familiar object or standard?*** (***e.g., height of a skyscraper***) Giant squid probably live between 600 -3,300 feet (200 -1,000 meters) below the surface.

2. ***How big is a giant squid? How big are its eyes?*** Male squid are much smaller than females. Females average about 30-43 feet (9-13 meters) in length, while males are 10-26 feet (3-8 meters). The giant squid has enormous eyes (about the size of a volley ball or human head) to capture the minimal amounts of light available at great depths.

3. ***What size are the giant squid's paralarvae?*** At birth giant squid paralarvae are about 0.125 inch (0.3175 centimeters) in length.

4. ***What size are giant squid prey?*** Giant squid eat smaller species of squid and fish such as hoki (about 49 inches or 125 centimeters). Orange roughy are smaller (about 29 inches or 74 centimeters).

5. ***How big are giant squid predators?*** Its chief predator is the sperm whale which is about the same length (up to 60 feet or 18 meters) as the giant squid, but the sperm whale weighs up to 40 tons (120,000 pounds or 36 metric tons) while the giant squid weighs only about 0.5 tons (1,000 pounds or 0.45 metric tons).

6. ***How fast do giant squid grow from eggs to adults? How might this growth rate help them avoid being eaten?*** Giant squid are only about 0.125 inches (0.3175 centimeters) long after hatching. They must grow very quickly to reach their adult size (up to 43 feet), as fast as 20 feet (6 meters) a year, presuming that they live 2-3 years. Giant squid outgrow their predators rapidly.

Teacher Answer Key to Student Worksheet (page 20)

## Worksheet 4 ▸ Behavior and Biology

**Students may ask questions about squid behavior: what do they do when attacked?; when and how often do they mate?; is there a social relationship between one adult and another? The answer is "we don't know." At this stage, scientists know very little about the characteristics of behavior that help define this species. Students are expected to provide metric conversions.**

1. ***Does a squid have bones? What supports a squid's body?*** As an invertebrate, a squid has no bones. A feather-shaped blade, or gladius, helps support the body and serves as a site for muscle attachment. It is made of chitin, like your fingernails. Cartilage (tough, gristle-like tissue) surrounds a squid's brain.

2. ***How does a squid reproduce?*** Females release thousands of transparent eggs, either individually or in jelly-like strands into the water. Males produce long tubes, or spermataphores, filled with millions of sperm. Most species have a modified arm for depositing these in or on the female.

3. ***What is the size of the male giant squid compared to the female? Why is one bigger than the other?*** Male squid are much smaller than females. Females average about 30-43 feet (9-13 meters) in length while males are 10-26 feet (3-8 meters). Their larger size may help them carry the 10 million or so eggs they eventually bear.

4. ***How does a squid eat?*** A sharp, horny (chitinous) beak cuts up food into bite-sized chunks. The giant squid's beak is much larger than those of smaller squids.

5. ***How do giant squid move through the water?*** A series of split-second reactions that suck water into the mantle cavity, then squirt it out, make jet propulsion possible, moving the squid rapidly through the water.

6. ***Have you ever dived down to the bottom of a deep pool? How does depth affect your body? Does it affect the giant squid?*** The deeper you go, the more force is exerted on your body. You may even feel a squeezing around your ears and head. This is caused by water pressure. Water pressure is determined by depth and density. At the water's surface, the weight of the air is 14.7 pounds per square inch, but as you descend the pressure is greater. At 200 feet (66 meters), the pressure is twice what it was at 100 feet down. For giant squid, water pressure can reach thousands of pounds per square inch, but since giant squid do not have air spaces in their bodies, they are not affected by water pressure.

Teacher Answer Key to Student Worksheet (page 21)

## Worksheet 5 ▸ Detection

1. ***Giant squid are often found in nets with certain fish species (e.g., hoki, orange roughy) and in the stomachs of sperm whales. How might such clues help us find the giant squid?*** If scientists know where the giant squids' favorite foods and predators are found, then they may be able to determine where the giant squid will be as well.

2. ***How has "squid detection" technology changed over time?*** They are detected by chance encounters with squid carcasses, underwater cameras, unmanned submersibles, specialized trawling nets and, an array of satellite technologies. In 2004, an underwater camera snapped the first-ever photographs of the giant squid off the coast of Japan.

3. ***Could water temperature determine whether or not a squid might be found in a specific location? Why?*** Yes. Colder waters support more plants and the animals upon which the giant squid may feed.

4. ***How long have people known about the giant squid? In which parts of the world did sailors and fishermen claim to see such creatures?*** Encounters with these awesome creatures have always been rare and widely scattered. Over the centuries, legends arose as witnesses tried to make sense of what their astonished eyes had seen. Only recent scientific evidence has been available to explain or refute these legends.

5. ***Sketch on the world map (below) where giant squid specimens have been found:***

# Worksheet 1 ▸ Meet the Giant Squid

## Your Background Research

As members of the "Young Explorers Club of North America," you and your classmates have been asked to help scientists find the giant squid, ***Architeuthis***. This is a tremendous challenge, as this elusive creature has only once been photographed alive. Yet specimens have been discovered all over the world. Amazing tales come from ancient mariners and other seafarers who claim to have seen the giant squid alive. These stories, however, are from so long ago that they are difficult to document as anything but myths.

One thing that makes the giant squid so special is–as the name implies–its incredible size! Some specimens were reported to measure up to 60 feet (18 meters) long, although most recent studies reveal specimens up to 50 feet (16 meters) in length. Difficult to verify without live organisms to study, it is believed giant squid have a relatively short life span of 2-3 years. Because giant squid are only 0.125 inches (0.3175 centimeters) long at birth; they would need an amazingly fast growth rate to reach 50 feet in length during their short lives.

Once full-sized, the giant squid are larger than most of the ocean's predators. They can live wherever they find enough food, roaming the oceans undisturbed. Giant squid specimens have been found in the bellies of sperm whales, their only true predator as adults. Sperm whales are about the same length of the giant squid, but sperm whales weigh 40 tons (120,000 pounds or 36 metric tons), while giant squid weigh "only" about 0.5 tons (1,000 pounds or 0.45 metric tons).

By studying the giant squid's tentacles, with their specialized suckers and corresponding knobs, it is believed that they have tremendous hunting skills to capture their prey. Their favorite foods don't provide much challenge in terms of size. Giant squid primarily feed on fish such as hoki that average 49 inches (125 centimeters) in length, orange roughy that average 29 inches (74 centimeters) in length, and smaller species of squid.

You and the other explorers will learn a great deal about the giant squid as you prepare to launch an expedition to find a living specimen. Good luck on this endeavor. Your success will solve one of the many great mysteries held by the oceans.

# Worksheet 1 ▸ Meet the Giant Squid

**1.** How long is an adult giant squid?

**2.** What objects in your everyday life are equal in length to a giant squid?

**3.** What tool(s) would you use to measure a giant squid?

**4.** What length are giant squid when they are hatched?

**5.** How long might giant squid live?

**6.** What do giant squid eat (prey)?

**7.** How does a giant squid hunt?

**8.** What eats full-grown giant squid (predators)?

**9.** How large is the giant squid compared to the sperm whale? Express as a ratio.

**10.** How large is the giant squid compared to its prey? Express as a ratio.

**Measurement and Weight Conversions**

- 1 inch = 2.54 centimeters
- 1 foot = .3048 meters
- 1 mile = 1.6 kilometers
- 1 ton (U.S.) = 2,000 pounds
- 1 ton (U.S.) = .907 metric tons (U.K.)
- 1 foot = 12 inches
- 0°Celcius = 32°Fahrenheit

## Worksheet 2 ▸ Where is the Giant squid?

**This map shows locations where giant squid specimens have been found near the continental U.S.**

1. Label saltwater bodies near the continental U.S. Be sure to include oceans and gulfs. Locate Bermuda and Newfoundland.

2. Find your own region on the map above. Draw an arrow to your locale.

3. Where are giant squid found in North American waters?

4. Do giant squid live in fresh water or salt water?

5. What other ocean conditions (e.g., temperature, currents, and light levels) do you think giant squid prefer?

6. If you were to launch an expedition to find the giant squid from a location in North America, where would it be?

## Worksheet 3 ▸ Scale

When scientists prepare for an expedition, they must learn what is already known about the topic they are researching. Typically, they also work with other scientists who have expertise in similar areas. In this activity you will become the expert in a topic that pertains to the giant squid. After collecting the data specified below, you and other experts will share your knowledge in preparation for planning your expedition.

You will break into three groups and collect data either at the museum exhibit or online at **http://seawifs.gsfc.nasa.gov/squid.html** or **http://giantsquid.msstate.edu**.

The groups will investigate three topics in order to specialize their knowledge about scale, behavior and biology, and detection. When you begin your expedition planning later, you will share your findings with others. Eventually, you will form "proposal teams" comprised of at least one topical "expert" per team.  Scientists always use the metric system for measurements, temperatures, and distances, so you will be expected to include metric measures.

1. How deep do the giant squid live? How does this measurement compare to a familiar object or standard? (e.g., height of a skyscraper)

2. How big is a giant squid? How big are its eyes?

3. What size are a giant squid's paralarvae?

4. What size are giant squid prey?

5. How big are giant squid predators?

6. How fast do giant squid grow from eggs to adults? How might this growth rate help them avoid being eaten?

## Worksheet 4 ▸ Behavior and Biology

When scientists prepare for an expedition, they must find out what other scientists have already discovered. Typically, they also work with other scientists who have expertise in other topic areas. In this activity you will become the expert in a topic that pertains to the giant squid. After collecting the data specified below, you and other experts will share your knowledge in preparation for planning your expedition.

You will break into three groups and collect data either at the museum exhibit or online at **http://seawifs.gsfc.nasa.gov/squid.html** or **http://giantsquid.msstate.edu**.

The groups will investigate three topics in order to specialize their knowledge about scale, behavior and biology, and detection. When you begin your expedition planning later, you will share your findings with others. Eventually, you will form "proposal teams" comprised of at least one topical "expert" per team. Scientists always use the metric system for measurements, temperatures, and distances, so you will be expected to include metric measures.

1. Does a squid have bones? What supports a squid's body?

2. How does a squid reproduce?

3. What is the size of the male giant squid compared to the female? Why is one bigger than the other?

4. How does a giant squid eat?

5. How do squid move through the water?

6. Have you ever dived down to the bottom of a deep pool? How does depth affect your body? Does it affect a squid?

## Worksheet 5 ▸ Detection

When scientists prepare for an expedition, they must learn what is already known about the topic they are researching. Typically, they also work with other scientists who have expertise in other areas. In this activity you will become the expert in a topic that pertains to the giant squid. After collecting the data specified below, you and other experts will share your knowledge in preparation for planning your expedition.

You will break into three groups and collect data either at the museum exhibit or online at **http://seawifs.gsfc.nasa.gov/squid.html** or **http://giantsquid.msstate.edu**.

The groups will investigate three topics in order to specialize their knowledge about scale, behavior and biology, and detection. When you begin your expedition planning later, you will share their findings with others. Eventually, you will form "proposal teams" comprised of at least one topical "expert" per team. Scientists always use the metric system for measurements, temperatures, and distances, so you will be expected to include metric measures.

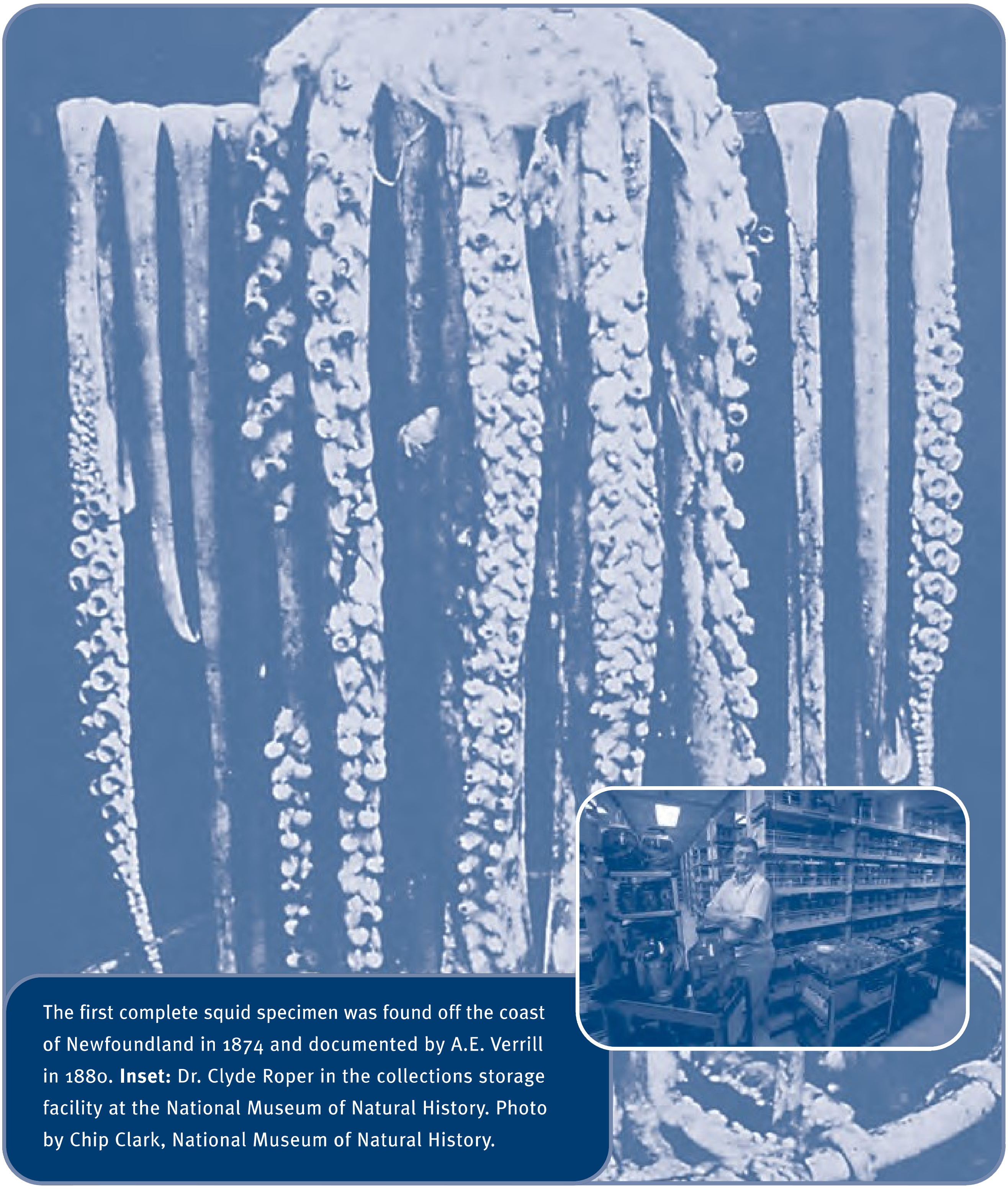
1. Giant squid are often found with in nets with certain fish species (e.g., hoki, orange roughy) and in the stomachs of sperm whales. How might such clues help us find the giant squid?

2. How has "squid detection" technology changed over time?

3. Could water temperature determine whether or not a squid might be found in a specific location? Why?

4. How long have people known about the giant squid? In which parts of the world did sailors and fishermen claim to see such creatures?

5. Sketch on the world map where giant squid specimens have been found:



The first complete squid specimen was found off the coast of Newfoundland in 1874 and documented by A.E. Verrill in 1880. **Inset:** Dr. Clyde Roper in the collections storage facility at the National Museum of Natural History. Photo by Chip Clark, National Museum of Natural History.

# The Giant Squid's World

**Lesson Objectives:** In this lesson, students will learn about the squid's natural habit and the living/non-living (biotic/abiotic) factors that affect both paralarval and adult squid.

**Standards:**
National Science Education Standards for Life Science: "Populations & Ecosystems," (Content Standard C for Grades 5-8)

**Suggested Grade Levels: 6-8**
(For younger or older audiences, see ROADMAP on page 7)

**Group Activities:**
The living/non-living factors charts may be completed in small groups or as a class.

**Student Handouts:**
**Worksheet #6:** Living Factors that Impact the Adult Giant Squid
**Worksheet #7:** Non-Living Factors that Impact the Giant Squid
**Worksheet #8:** Ocean Surface Temperature Map
**Worksheet #9:** Ocean Temperature—650 feet (200 meters) Map
**Worksheet #10:** Ocean Temperatures Overview
**Worksheet #11:** Ocean Surface Topography and Currents Map
**Worksheet #12:** Ocean Color Map

**Supplies:** Map of North America, world map

## Background

***Living Factors that Impact the Giant Squid*** (worksheet #6)
Because of the breadth of knowledge required, it may be preferable to complete the charts as part of group discussion. Information to help complete the chart can be obtained from the ***Meet the Giant Squid*** activity (worksheet #1) and at **http://seawifs.gsfc.nasa.gov/squid.html** or **http://giantsquid.msstate.edu**.

This exercise also provides an opportunity for students to conduct online research to learn about which biotic and abiotic factors are measured by orbiting satellites: this information is linked from the exhibit websites (above). Later, students should be encouraged to use these charts, including the worksheets that address water temperature and color for the ***Plan a Giant Squid Expedition*** (worksheet #13) in Lesson Three.

Students are asked to add information to a marine "food web." This chart should also be used to promote discussion of the relative abundance of organisms at various levels in the food web. For example, there are few sperm whales and giant squid, but phytoplankton are very abundant. The students also are asked whether these factors are regularly measured by vessel (e.g., ship, submarine, etc.) or satellite, marking these as “V” and “S,” respectively. Factors **not** measured regularly by vessel or satellite are marked as “N.”

Students are asked to consider whether these “living factors” are observed by vessel “V,” satellite “S,” or neither “N.” Because they don't live at the ocean surface, “V” or “N” is acceptable for organisms other than sperm whales and phytoplankton. The best answer for sperm whales is “V” as they occasionally come to the ocean surface to breathe. Phytoplankton (actually, the chlorophyll within phytoplankton) are the only organisms in the chart that should be marked as “S”: sheer abundance, coupled with their location near the ocean surface, makes them detectable by satellite.

To understand differences in the rate at which satellites observe the ocean compared to research ships, students are asked to calculate how long it would take a vessel cruising at top speed to travel the length of Florida (500 miles or 800 kilometers).

- **500** miles divided by **23** miles per hour **= 21.7** hours **OR**
- **800** kilometers divided by **37** kilometers per hour **= 21.6** hours

This calculation should lead students to conclude that data collection by satellite “S” is more efficient than by vessel “V.”

***Non-Living Factors that Impact the Giant Squid,*** (worksheet #7)
Students are asked to add information to a partially completed chart that lists non-living (i.e., abiotic) factors that affect ocean habitats and their importance to giant squid.

***Ocean Temperature Maps,*** (worksheets #8, #9, #10)
Surface water temperature data are from the National Oceanic and Atmospheric Administration (NOAA) satellite called AVHRR (Advanced Very High Resolution Radiometer). Satellites are unable to directly measure water temperature below the surface. Water temperature data at 650 feet (200 meters) depth were taken from ships, buoys, and other in-water sensors.

Using colored pencils, pens, or crayons, students will create two color-coded maps of water temperature patterns near the continental U.S. One map shows ocean surface temperatures averaged over a year, and the other map shows ocean temperatures at about 650 feet (200 meters) depth averaged over a year. The latter map is provided because scientists suspect that giant squid live in waters between 600-3,300 feet (200-1,000 meters) below the surface. Learn more about ocean temperature at

**http://seawifs.gsfc.nasa.gov/squid.html** or **http://giantsquid.msstate.edu**. These temperature maps complement worksheets #1, #10, #11, and #12.

***Ocean Surface Topography and Currents and Color Maps,*** (worksheets #11, #12)
Satellites are used to measure and map the topography or shape of the ocean's surface. The shape of the ocean surface is determined by many forces including gravity, ocean bathymetry (the configuration of depths, such as sea mounts, canyons, etc.), tides, and winds. Over the globe, ocean surface topography varies by about 6 feet (2 meters). Ocean surface topography maps are important because they are used to calculate current strength and direction. Like winds around highs and lows in atmospheric pressure, ocean currents flow around hills and valleys on the ocean bottom. In the Northern Hemisphere, surface currents move clockwise around highs and counterclockwise around lows (and move in the opposite direction in the Southern Hemisphere).

Ocean color is used principally to study populations of phytoplankton at the sea surface. Chlorophyll, a type of green pigment, is present in phytoplankton (and other plants). Chlorophyll absorbs the red and blue portions of sunlight to provide energy for photosynthesis and reflects the unused green wavelengths. The more phytoplankton present in any given area, the more chlorophyll is proportionally present. Satellite instruments can detect tiny differences in how green ocean surface waters appear to be and thus provide information about the relative concentrations of chlorophyll. They can also determine how much phytoplankton–the food that ultimately feeds all organisms in the oceans–is present in an area. Learn more about ocean color at **http://seawifs.gsfc.nasa.gov/squid.html** or **http://giantsquid.msstate.edu**.

Using colored pencils, pens, or crayons, students will create color-coded maps that show average ocean topography and phytoplankton concentrations near the continental U.S. Students also will use the ocean topography map to draw arrows that show the direction of major ocean currents. From the ocean color map, students will see that phytoplankton concentrations are high near the coasts. These maps complement worksheets #1, #8, and #9. Learn more about ocean topography at **http://seawifs.gsfc.nasa.gov/squid.html** or **http://giantsquid.msstate.edu**.

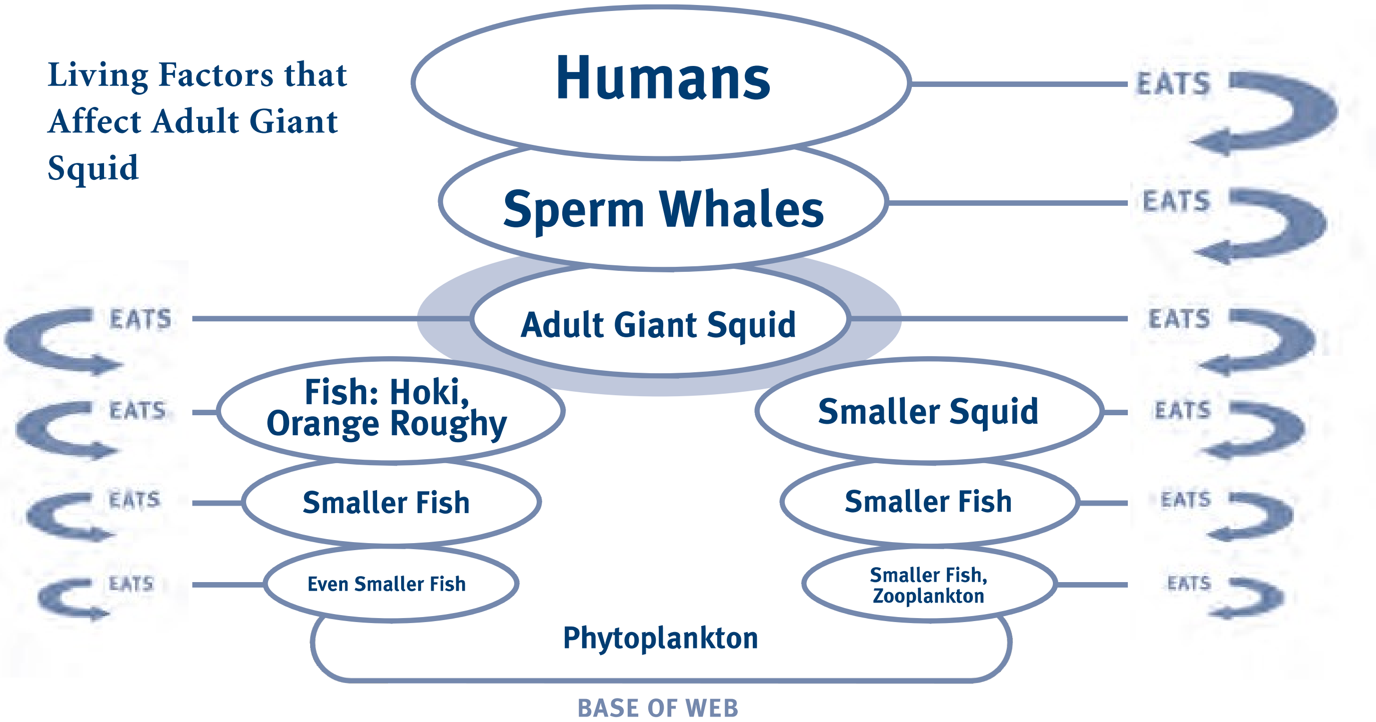
The teacher's answer keys are located on the following pages. The accompanying student handouts follow.

Teacher Answer Key to Student Worksheet (page 35)

# WORKSHEET 6 ► LIVING FACTORS THAT IMPACT THE ADULT GIANT SQUID

**Other than phytoplankton at the bottom of the food web, every box needn't be filled. The "food web" should have at least one entry per row including these types of organisms:**

- Humans (Environmental regulations exist to protect sperm whales, but the whales are still hunted in some countries that do not abide by the rules of the International Whaling Commission.)
- Sperm whales
- Adult giant squid (already in the chart)
- Fish (e.g., hoki, orange roughy), smaller squids
- Smaller fish, zooplankton
- Phytoplankton (base of the marine food web)



Teacher Answer Key to Student Worksheet (page 37)

# WORKSHEET 7 ▸ NON-LIVING FACTORS THAT IMPACT THE GIANT SQUID

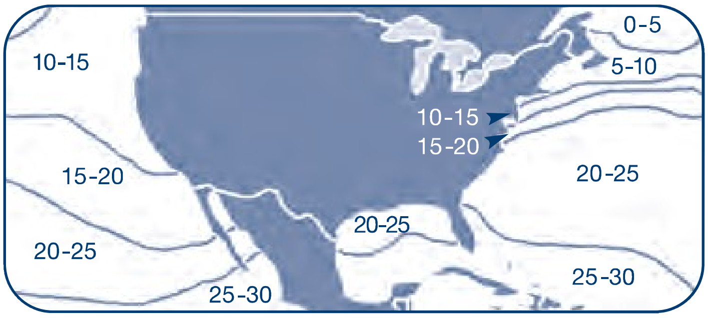
Students may add the following factors and measurement codes (and others are acceptable)

## NON-LIVING FACTORS THAT AFFECT OCEAN HABITAT

| Factors | Importance to giant squid | Regularly measured by vessel (V), satellite (S), or neither (N) |
|---|---|---|
| Weather | Weather can affect paralarvae in near-surface habitats. | V, S |
| Waves | Waves can affect transport of paralarvae in near-surface habitats. | V |
| Tides in the deep ocean | Not very important because deep ocean tides are only a few centimeters high. Near shore tides are amplified in relatively shallow coastal waters. | S |
| Water depth/bathymetry | Adult squid cannot survive for long periods in shallow water | V, S (Measured by vessels and estimated from satellite data) |
| Pressure | Adult squid cannot survive for long periods in shallow water | N (Calculated from depth data) |
| Pollution | May be important; Air-sea interactions bring airborne pollutants into ocean habitats. DDT has been found in marine animals worldwide even though it was banned in the U.S. in 1972. | V, S (Some types of air pollution—including carbon monoxide and aerosols but not DDT—are tracked by satellite) |
| Seismic activity/ tsunamis | Not known to affect giant squid. | N (This is tricky! seismic activity and tsunamis are regularly measured, but by land- and seafloor-based instruments) |

Teacher Answer Key to Student Worksheet (page 39)

## Worksheet 8 ▸ Ocean Surface Temperature Map




**Fill in the areas using colored pencils with this scheme:**

**0 – 5:** Purple
**5 – 10:** Dark blue
**10 – 15:** Light blue
**15 – 20:** Green
**20 – 25:** Yellow
**25 – 30:** Light orange

This map shows sea surface temperatures averaged over a year.

1. ***What do the colors represent?*** The colors represent average temperature at the sea surface. Students may write that the "warm colors" (i.e., orange and yellow) represent warm water and "cool colors" (i.e., blues and purple) represent cool water.

2. ***What temperature scale (Celsius or Fahrenheit) is shown on the map? Convert the Celsius temperatures to Fahrenheit.*** The temperature scale is in degrees Celsius, not Fahrenheit (which may be more familiar to students). Conversions from Celsius to Fahrenheit:

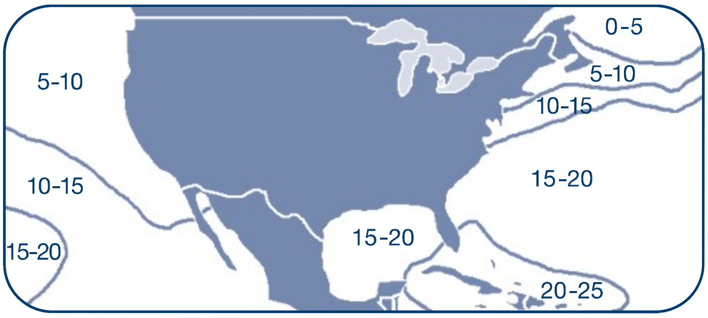
   **0°C** = **32°F**
   **0 to 5°C:** Purple = **32 to 41°F**
   **5 to 10°C:** Dark blue = **41 to 50°F**
   **10 to 15°C:** Light blue = **50 to 59°F**
   **15 to 20°C:** Green = **59 to 68°F**
   **20 to 25°C:** Yellow = **68 to 77°F**
   **25 to 30°C:** Orange = **77 to 86°F**

3. ***Where is surface water relatively warm?*** The surface temperature is warm in southern latitudes.

4. ***Where is surface water relatively cold?*** It is cold in the northern latitudes.

Teacher Answer Key to Student Worksheet (page 40)

## Worksheet 9 ▸ Ocean Temperature—650 feet (200 meters) Map




**Fill in the areas using colored pencils with this scheme:**

**0 – 5:** Purple
**5 – 10:** Dark blue
**10 – 15:** Light blue
**15 – 20:** Green
**20 – 25:** Yellow

Compare this map with the ***Ocean Surface Temperature Map***, worksheet #8. That map shows sea surface temperature averaged over a year. This map shows temperature at about 650 feet (200 meters) depth averaged over a year.

1. ***Compared to the surface, water temperatures at 650 feet (200 meters) depth are generally* colder. *Why is this the case?*** The sun's heat warms the upper ocean and does not penetrate effectively to 650 feet (200 meters) depth.

2. ***Compared to the surface, sunlight at 200 meters depth is generally dimmer. Why is this the case?*** Sunlight does not penetrate effectively to 650 feet (200 meters) depth. The red and orange wavelengths in the spectrum are absorbed by sea water at shallowest depths, the green component penetrates deeper, and the blue range of the spectrum penetrates the deepest of all. That's why the open ocean looks blue.

3. ***Which physical feature(s) on the giant squid might give a clue about the amount of sunlight where they live?*** The enormous eyes of the giant squid help them adapt to extremely dim light conditions.

Teacher Answer Key to Student Worksheet (page 41)

## WORKSHEET 10 ▸ OCEAN TEMPERATURES OVERVIEW

The following questions should be answered using the ***Ocean Surface Temperature Map*** and ***Ocean Temperature–650 feet (200 meters) Map***.

1. ***If giant squid liked warm water, in what part of the ocean would they live?*** Southern latitudes. This answer is the same whether looking at either map. However, the map representing ***surface*** water temperatures has generally warmer waters than the map with temperature at 650 feet (200 meters) depth so "at the surface" is also acceptable.

2. ***If giant squid like cold water, in which part of the ocean would they live?*** Northern latitudes. This answer is the same whether they refer to either map. However, the map representing water temperatures at 650 feet (200 meters) depth map has generally colder waters than the surface temperature map, so at 650 feet (200 meters) depth is also acceptable.

3. ***Compare the temperature maps with the earlier map showing locations where giant squid specimens have been found (Where is the Giant Squid?, worksheet #2). Keep in mind that the location map shows where non-living giant squid have been found, and that a live giant squid has only been seen once in its natural habitat, in Japanese waters.*** Multiple answers are acceptable.

4. ***Based on the information you've examined, it appears that giant squid might prefer to live in (choose one) and explain your choice:***

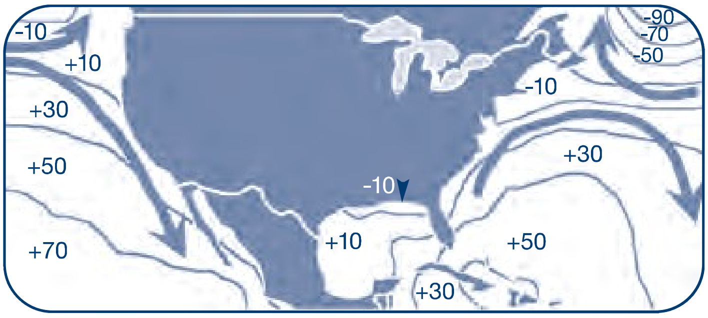
   - ***Deeper, colder, darker waters***
     Correct, if they state that most specimens were found in colder water at high latitudes and that relatively cool waters can be found at 650 feet (200 meters) depth, even at southern latitudes. The large eyes of the giant squid also indicate that they live in deeper waters.

   - ***Shallower, warmer, more sunlit waters***
     Correct, if they state that even though most squid specimens are found at high latitudes in colder waters, they may have been transported there by currents post-mortem.

   - ***Cannot determine from these data***
     Correct, with various acceptable explanations.

Teacher Answer Key to Student Worksheet (page 42)

## Worksheet 11 ▸ Ocean Surface Topography and Currents Map




**Fill in the areas using colored pencils with this scheme:**

**-90:** Dark gray
**-70:** Purple
**-50:** Dark blue
**-30:** Light blue
**-10:** Green
**+10:** Yellow
**+30:** Light orange
**+50:** Dark orange
**+70:** Red

Ocean topography maps are important because they are used to calculate currents, water that moves along paths through the ocean. Ocean currents are related to ocean topography like wind is related to atmospheric pressure: they flow around highs and lows, along lines of equal pressure. In the Northern Hemisphere, for example, currents move clockwise around highs and counterclockwise around lows.

This map shows sea surface height compared to a global average. Positive values show height above average in centimeters. Negative values show height below average in centimeters. By coloring the map as suggested above, you'll create an elevation map showing hills (in red and orange) and valleys (in gray and purple) on the ocean surface. What causes these hills and valleys? The shape is determined by many factors including gravity, ocean depth, tides, and winds. Over the globe "sea level" varies by about 6 feet (2 meters)!

1. ***Use this information to draw current directions (as arrows) around the highs and lows of ocean topography on the map above.*** Students will create a color-coded map. This activity will reveal "hills" colored as red-orange-yellow and "valleys" colored as blue-purple-gray. The next step is to add arrows that "flow" around these hills and valleys. Details may vary but the arrows should resemble the above.

Teacher Answer Key to Student Worksheet (page 42)

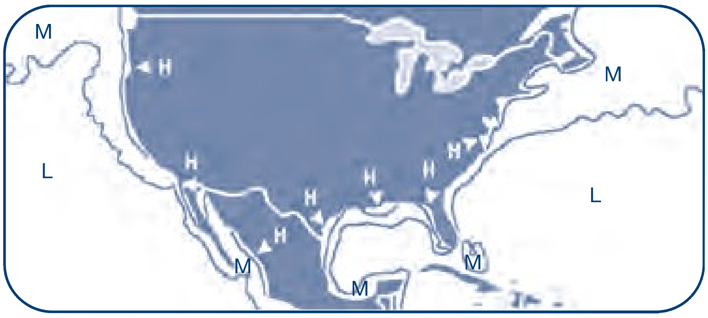
## WORKSHEET 11 ▸ OCEAN SURFACE TOPOGRAPHY AND CURRENTS MAP

2. ***If this map showed a location was in the Southern Hemisphere, currents would flow in (choose one): same direction / opposite direction.*** If this map showed a location was in the Southern Hemisphere, currents would flow in the opposite direction.

3. ***How would you use a map of ocean currents in your search for the giant squid?*** Comparing the ocean currents map with the locations where giant squid specimens have been found (***Where is the Giant Squid?***, worksheet #2), students may be able to guess that giant squid specimens are washed ashore by currents. For example, the Grand Banks off eastern Canada's Newfoundland coast are shallow, and specimens are swept there by the Gulf Stream. Some scientists, hoping to find the locations of living giant squid, use ocean currents data to "back track" the path of the giant squid specimens.

Teacher Answer Key to Student Worksheet (page 43)

## Worksheet 12 ▸ Ocean Color Map




**Fill in the areas using colored pencils with this scheme:**

**Low (L):** Dark blue
**Medium (M):** Green
**High (H):** Red

Chlorophyll, a natural pigment, is present in phytoplankton and most plants. Chlorophyll absorbs the red and blue portions of sunlight to provide energy for photosynthesis and reflects the unused green wavelengths. The more chlorophyll there is in any given area, the more phytoplankton are present. The map above is based on satellite data. Satellite instruments, however, do not ***directly*** measure chlorophyll concentration; they instead measure tiny variations in ocean color.

This map shows relative concentrations of chlorophyll averaged over a year. By coloring the map as suggested above, you'll easily see the overall pattern of chlorophyll concentration at the ocean surface.

1. ***How does ocean color relate to phytoplankton concentration?*** In general, the greener the ocean waters, the more phytoplankton are present. Satellite instruments can detect very subtle differences in how green the oceans appear to be and use this information to infer relative concentrations of chlorophyll. (Other factors, including ocean bottom layer type, can affect water color in shallow areas. This is why ocean color satellite data are not used to estimate chlorophyll concentration in shallow ocean waters.)

2. ***What ocean color would you expect to see in the deep Atlantic and Pacific Ocean basins? What ocean color is seen near continental margins?*** Relatively low concentrations of phytoplankton are found in the middle of ocean basins, and thus the ocean color is *blue.* Relatively high concentrations of phytoplankton are found near continental margins, and thus the ocean color is *green or blue-green.*

Teacher Answer Key to Student Worksheet (page 43)

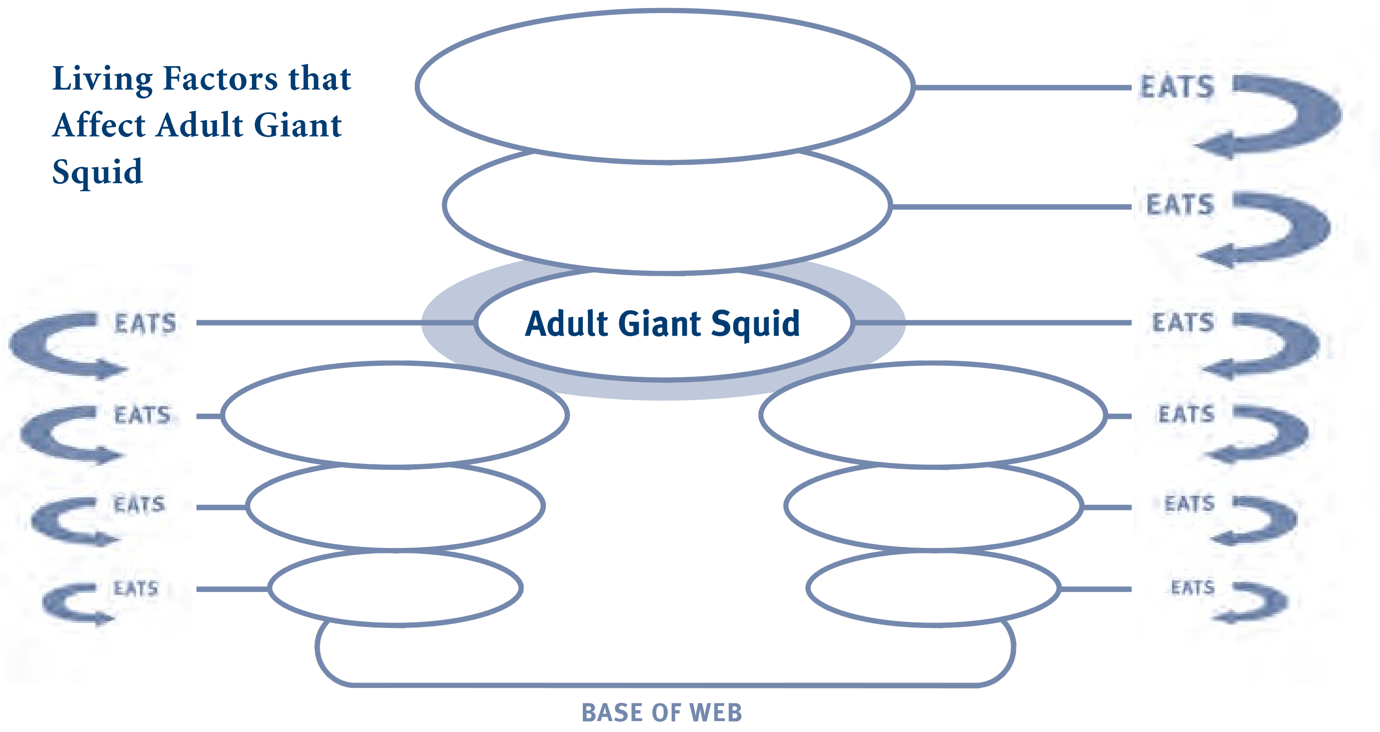
## Worksheet 12 ▸ Ocean Color Map

**3. How would you use a map of ocean color in your search for the giant squid?** Based on these maps, students should see a correlation between phytoplankton concentrations (signifying high marine productivity) and the locations where giant squid specimens have been found (***Where is the Giant Squid?***, worksheet #2). They may state that phytoplankton fuels the marine food web and that giant squid are located with their prey in highly productive marine areas. Another acceptable answer is that many giant squid specimens are caught in fishing nets and fishermen go "where the fish are" (i.e., areas of high marine productivity). Thus, the apparent correlation between these maps may simply reflect where fishermen are concentrated, ***not*** necessarily where giant squid are concentrated.

## WORKSHEET 6 ▸ LIVING FACTORS THAT IMPACT THE ADULT GIANT SQUID

To help with your search for the giant squid, it is important to understand their behavior, including their role in the marine food web. Given what you know about the giant squid from the ***Meet the Giant Squid***, worksheet #1. and other research, you will create a list of living, or biotic, factors that may affect the giant squid.

In the chart below, the **adult** giant squid is in the center of a marine food web. List known predators of the giant squid in the rows above. List known prey of the giant squid in the rows below. Add 1–2 examples per row, keeping in mind "who eats whom" as shown by the arrows. Fill in as many rows as possible (you can add more if you'd like), **making sure to fill in the bottom row**. What type(s) of organisms are at the base of this web?



## WORKSHEET 6 ▸ LIVING FACTORS THAT IMPACT THE ADULT GIANT SQUID

Now that you've listed living factors that may affect the giant squid, it's time to think more about whether or not these factors are measured on a regular basis. Why? Because knowing where its "favorite food" is found might help you to be the next person to find a giant squid in its natural habitat.

Consider how you might view marine organisms from different platforms. From a vessel such as a research ship, you can see tens of miles or kilometers, but only on a clear day. On a foggy day, or in a submersible, you can see to tens of feet or meters. Orbiting satellites can cover thousands of miles or kilometers each day, but their views can be obstructed by clouds or fog. Each of these platforms, however, can only view the uppermost part of the ocean. Do any of the organisms in the chart above live at the ocean surface?

**Look at your chart of living factors:**

1. Which are visible from a vessel (ship or submersible)? Mark these as "V."
2. Which are visible from a satellite? Mark these as "S."
3. Which are visible from neither a vessel nor a satellite? Mark these as "N."

   Data availability is an important part of any expedition, including your search for the giant squid. Vessels "V", like those used for scientific research, travel 20 knots (23 miles per hour or 37 kilometers per hour; 1 knot (nautical mile)= 1.125 statute miles) at maximum speed.

   To better understand this rate, calculate how long it would take a research vessel cruising at top speed to travel the length of Florida (500 miles or 800 kilometers). The outline of Florida can be seen on the ***Where is the Giant Squid?***, worksheet #2.

4. Length of Florida ________ (miles or kilometers) divided by rate ___________ (miles per hour or kilometer per hour) = ________ hours

   Compare this data gathering rate with satellites "S" that collect data **over the entire globe in a few days.**

5. Which type of platform "V" or "S" is more efficient for collecting some types of surface ocean data?

# Worksheet 7 ▸ Non-Living Factors that Impact the Giant Squid

Like all living organisms, giant squid are influenced by non-living, or abiotic, factors. Birds, for example, are affected by air conditions: wind speed, air temperature, precipitation (e.g., rain, snow, sleet), and visibility (e.g., fog, clouds).

Below is a list of non-living factors that affect ocean habitats. In the middle column, factors may affect giant squid are listed. In the right column, it's note whether each non-living factor is regularly measured by vessel "V" or satellite "S". Factors marked as "N" are not measured regularly by vessel or satellite.

Try to add other non-living factors to this chart (left column) and their possible importance to giant squid (middle column).

## NON-LIVING FACTORS THAT AFFECT OCEAN HABITAT

| Factors | Importance to giant squid | Regularly measured by vessel (V), satellite (S), or neither (N) |
|---|---|---|
| Temperature | Adults and paralarvae (i.e., tiny planktonic offspring) have specific temperature requirements. | V, S |
| Salinity | All marine squid live in salt water. | V |
| Currents | Especially important for paralarvae that cannot swim against strong currents. | V, S |
| Light penetration | Adult squid are finely adapted to hunting in low light conditions. | N |
| Nutrients | Adult squid are finely adapted to hunting in low light conditions. | N |
| | | |
| | | |

## Worksheet 7 ▸ Non-Living Factors that Impact the Giant Squid

Now that you've listed non-living factors that may affect the giant squid, it's time to think more about **how** these factors are measured.

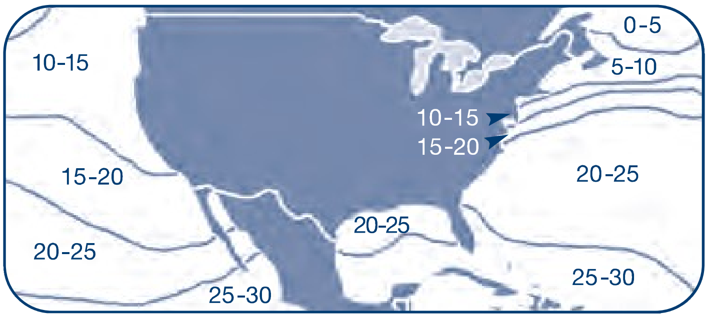
Although scientists aboard research vessels measure many types of ocean conditions, very few scientific research vessels operate continuously, because of high operating costs, multiple demands on very few ships in the research fleets, port-time for outfitting different types of research, and other factors. However, non-scientific vessels–including cargo ships and cruise liners–regularly measure ocean conditions that can affect the safety or performance of their ships.

In general, satellite-based instruments cannot penetrate beyond the first few inches of the ocean surface; thus deeper ocean conditions are not measured by satellite. You may learn more about ocean factors that are regularly measured by satellite at **http://seawifs.gsfc.nasa.gov/squid.html** or **http://giantsquid.msstate.edu**.

# WORKSHEET 8 ▸ OCEAN SURFACE TEMPERATURE MAP

**Fill in the areas using colored pencils with this scheme:**

**0 – 5:** Purple
**5 – 10:** Dark blue
**10 – 15:** Light blue
**15 – 20:** Green
**20 – 25:** Yellow
**25 – 30:** Light orange




This map shows sea surface temperature averaged over a year.

**1.** What do the colors represent?

**2.** What temperature scale (Fahrenheit or Celsius) is shown in the map? Convert the Celsius temperatures Fahrenheit. Use the conversion chart on worksheet #1 if you need help.

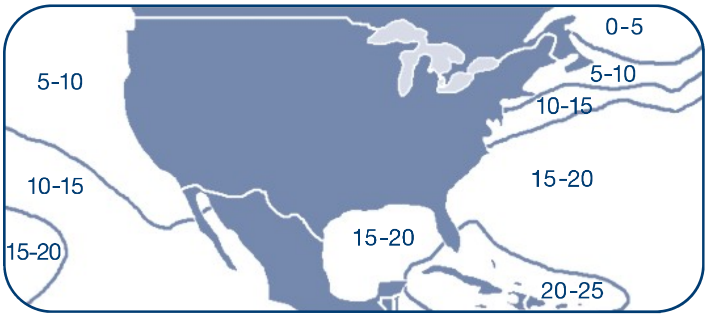
**3.** Where is surface water relatively warm?

**4.** Where is surface water relatively cold?

## WORKSHEET 9 ▸ OCEAN TEMPERATURE—650 FEET (200 METERS) MAP

**Fill in the areas using colored pencils with this scheme:**

**0 – 5:** Purple
**5 – 10:** Dark blue
**10 – 15:** Light blue
**15 – 20:** Green
**20 – 25:** Yellow




Compare this map with the ***Ocean Surface Temperature Map*** (worksheet #8). That map shows sea surface temperature averaged over a year. This map shows temperature at about 650 feet (200 meters) depth averaged over a year.

**1.** Compared to the surface, water temperatures at 650 feet (200 meters) depth are generally (choose one): colder / warmer / the same. Why is this the case?

**2.** Compared to the sea surface, sunlight at 650 feet (200 meters) depth is generally (choose one): dimmer / brighter / the same. Why is this the case?

**3.** Which physical feature(s) of the giant squid provide a clue about the sunlight conditions where they live?

Student Worksheet

## Worksheet 10 ▸ Ocean Temperatures Overview

Use both ***Ocean Temperature Maps*** (worksheets #8 and #9) to answer the questions below.

**1.** If giant squid like warm water, in which part of the ocean would they live?

**2.** If giant squid like cold water, in which part of the ocean would they live?

**3.** Compare the ***Ocean Surface Temperature Map*** and ***Ocean Temperature—650 feet (200 meters) Map*** with the one showing locations where giant squid specimens have been found (***Where is the Giant Squid?***, worksheet #2). Keep in mind that the location map shows where non-living giant squid have been found (and only one giant squid has been documented in its natural habitat).

**4.** Based on the information you've examined, it appears that giant squid might prefer to live in (choose one) and explain your choice:

- Deeper, colder, darker waters
- Shallower, warmer, more sunlit waters
- Cannot determine from these data

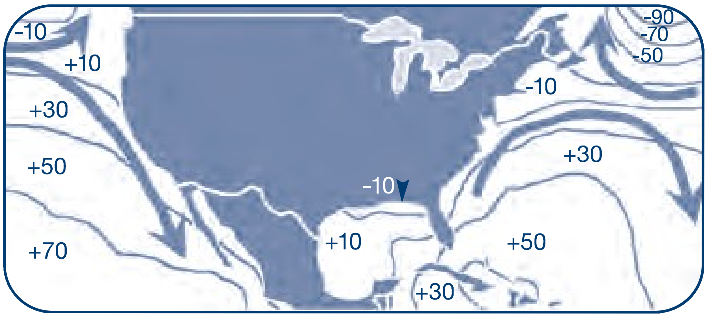
Student Worksheet

# WORKSHEET 11 ▸ OCEAN SURFACE TOPOGRAPHY AND CURRENTS MAP

**Fill in the areas using colored pencils with this scheme:**

**-90:** Dark gray
**-70:** Purple
**-50:** Dark blue
**-30:** Light blue
**-10:** Green

**+10:** Yellow
**+30:** Light orange
**+50:** Dark orange
**+70:** Red




Ocean topography maps are important because they are used to calculate currents, water that moves along paths through the ocean. Ocean currents are related to ocean topography like wind is related to atmospheric pressure: they flow **around** highs and lows, along lines of equal pressure. In the Northern Hemisphere, for example, currents move clockwise around highs and counterclockwise around lows.

This map shows sea surface height compared to a global average. Positive values show height above average in centimeters. Negative values show height below average in centimeters. By coloring the map as suggested above, you'll create an elevation map showing hills (in red, orange, and yellow) and valleys (in gray, purple, and blue) on the ocean surface. What causes these hills and valleys? The shape is determined by many factors including gravity, ocean depth, tides, and winds. Over the globe "sea level" varies by about 6 feet (2 meters)!

1. Use this information to draw current directions (as arrows) around the highs and low of ocean topography on the map above.

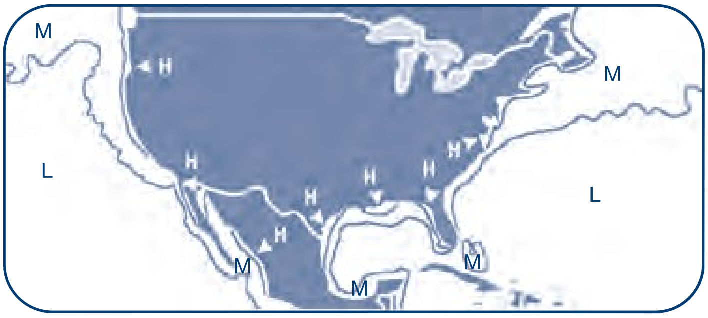
2. If this map showed a location was in the Southern Hemisphere, currents would flow in the (circle one): **same direction | opposite direction.**

3. How would you use a map of ocean currents in your search for the giant squid? Hint: Compare with the map showing locations where giant squid specimens have been found (***Where is the Giant Squid?***, worksheet #2).

## WORKSHEET 12 ▸ OCEAN COLOR MAP

**Fill in the areas using colored pencils with this scheme:**

**Low (L):** Dark blue
**Medium (M):** Green
**High (H):** Red




Chlorophyll, a natural pigment, is present in phytoplankton and most plants. Chlorophyll absorbs the red and blue portions of sunlight to provide energy for photosynthesis and reflects the unused green wavelengths. The more chlorophyll there is in any given area, the more phytoplankton are present. The map above is based on satellite data. Satellite instruments, however, do not directly measure chlorophyll concentrations; they instead measure tiny variations in ocean color.

This map shows relative concentrations of chlorophyll averaged over a year. By coloring the map as suggested above, you'll easily see the overall pattern of chlorophyll concentration at the ocean surface.

1. How does ocean color relate to phytoplankton concentration?

2. What ocean color would you expect to see in the deep Atlantic and Pacific Ocean basins? What ocean color is seen near continental margins?

3. How would you use a map of ocean color in your search for the giant squid? Hint: Compare with the map showing locations where giant squid specimens have been found (***Where is the Giant Squid?***, worksheet #2).

Dr. Clyde Roper dissects a giant squid found off the coast of New Zealand. **Inset:** Giant squid sucker marks found on a whale skin. © C.F.E. Roper

# Plan a Giant Squid Expedition

**Lesson Objectives:** In this lesson, students will develop their own giant squid expedition, creating a budget and using the information previously gathered to determine where and how to find the giant squid.

**Standards:**
National Science Education Standards for Science and Technology: "Understandings about Science in Personal and Social Perspectives," (Content Standard F for Grades 5-8)

**Suggested Grade Levels: 6-8:**
(For younger or older audiences, see ROADMAP on page 7)

**Group Activities:**
Plan a Giant Squid Expedition

**Student Handouts:**
**Worksheet #13:** Plan a Giant Squid Expedition

**Supplies:** Previous worksheets

**Setting the Stage:** Mounting an expedition to find the giant squid begins by creating a winning proposal. Students will write a 2-3 page proposal that includes **Goal(s), Rationale,** a **Project Plan, Project Budget** and **Justification**. The proposal format is outlined on the ***Plan a Giant Squid Expedition***, worksheet #13. Their expedition should last no longer than three weeks and cost no more than $1,000,000.

As individuals or groups, students should begin their proposal planning by sharing their findings, including data from their ***Scale, Behavior and Biology,*** and ***Detection*** worksheets (#3, 4, 5). Students may form proposal teams comprised of various "experts." Depending on class size, you may decide that more than one proposal will be funded. In that case, you may also consider allowing multiple "proposal teams" to collaborate and fund them collectively (i.e., give a collaborative team $2,000,000 rather than two teams $1,000,000 each). Good proposals will be well justified and will reference existing knowledge and data sets. The use of graphics such as "base maps" is also key to a winning proposal.

Students have been instructed to consult their teacher for a list of estimated costs. The list below can be used a starting point. Additional research can be done online.

The teacher's answer key to the worksheet is located below. The accompanying student handout follows.

- New orbiting satellites cost about $200,000,000 to develop and launch.
- Development of new technology for ocean research ranges from about $100,000 to $1,000,000.
  - Sonar and "fish finders" (including invertebrates) cost about $50,000.
  - Leasing a Remotely Operated Vehicle (ROV) costs about $100,000.
  - Purchasing equipment such as deep-sea cameras or sonar systems costs about $100,000.
  - Purchasing a fully-equipped Remotely Operated Vehicle (ROV) costs $1,000,000.
- Oceanographic research vessels cost $15,000 **per day** to operate (including shipboard personnel).
- Research vessels with a submersible aboard cost $20,000 **per day** to operate (including shipboard personnel).
- Existing data from operational satellites and vessels generally are cost-free.
- Be sure to remind them to include travel costs and salaries for the expedition team members:
  - Travel (e.g., airfare to/from the expedition departure site).
  - Salary for the scientific team during the expedition ($1,000 to $1,500 per week for each team member is a good estimate).

Dr. Clyde Roper sits in a submersible before a giant squid hunt. © I.H. Roper

# WORKSHEET 13 ▸ PLAN A GIANT SQUID EXPEDITION

Members of the Young Explorers Club of North America: You are now ready to help scientists find the giant squid, ***Architeuthis***. You've already learned a lot about the giant squid and the ocean environment. Now you will write a proposal to spend **up to three weeks** off the coast of the continental U.S. and Canada and **up to $1,000,000** to find the giant squid in its natural habitat.

In preparing research proposals, it is important to find partners with diverse expertise. In this case, you will want to consult experts on ***Scale, Behavior and Biology***, and ***Detection***. Your proposal will be a 2-3 page paper that addresses the items listed below. It should include your goals, rationale, the location(s) and depth(s) you will visit, data and technologies (new and existing) you will use, and the costs associated with your expedition. You should justify all of these decisions, using existing maps and data whenever possible. Go to the exhibition website **http://seawifs.gsfc.nasa.gov /squid.html** or **http://giantsquid.msstate.edu** for more information.

## GOAL(S)

1. State the goal(s) for your giant squid expedition.

## RATIONALE

2. Explain why it is important to achieve this goal. Include a brief overview of what is already known about this topic.

## PROJECT PLAN

3. Where will your expedition begin? Where do you plan to go? How long will you spend at these locations? Explain your choices and modes of transportation. (Note: Your expedition cannot last longer than three weeks.)

## WORKSHEET 13 ▸ PLAN A GIANT SQUID EXPEDITION

**4.** Which specific factors (living or non-living) will you measure to achieve your goals?

**5.** What types of data do you plan to use? Create a "data priorities" list and explain your priorities.

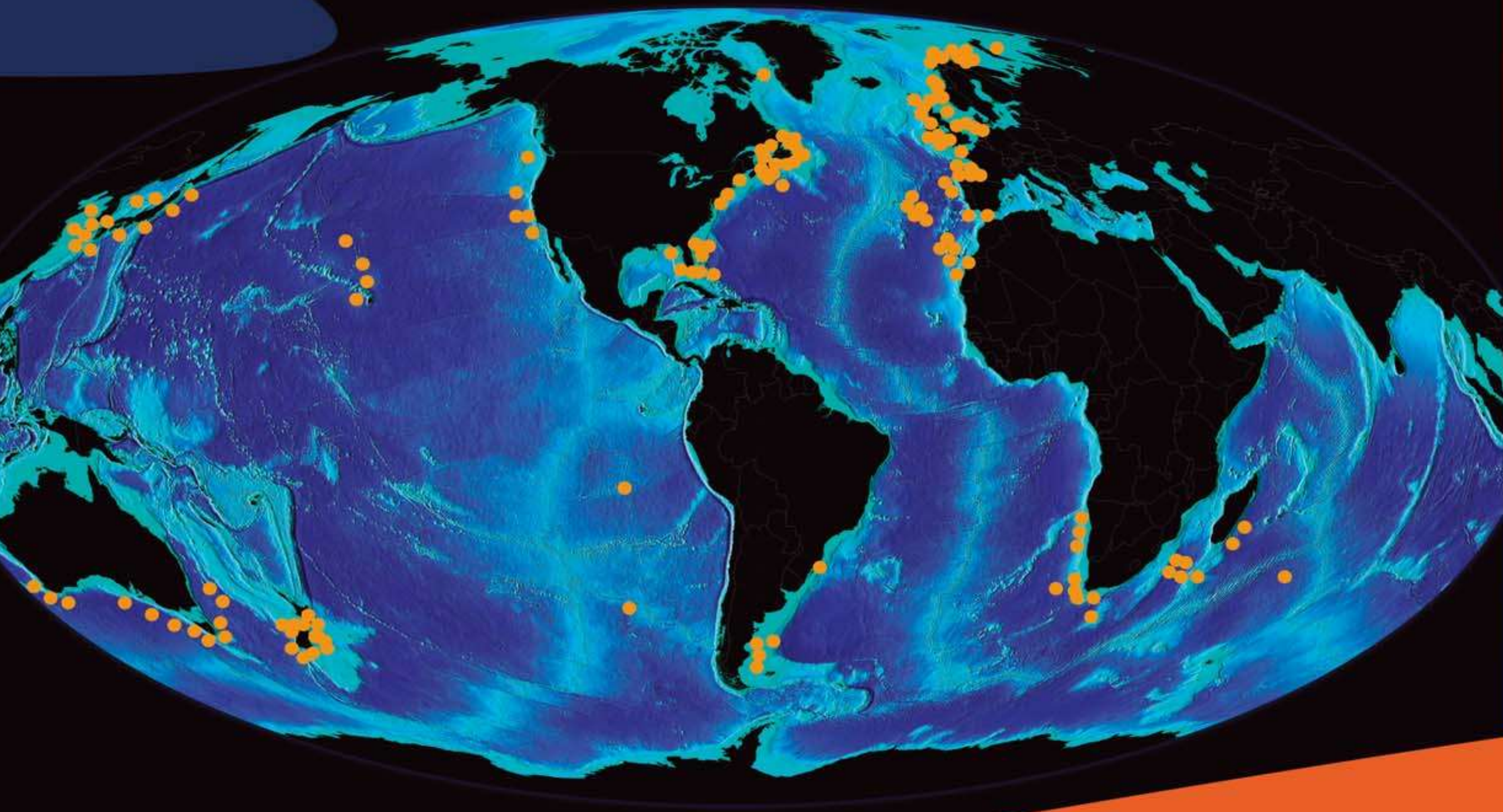
**6.** What types of technology do you plan to use? Create a "technological priorities" list and explain your priorities.

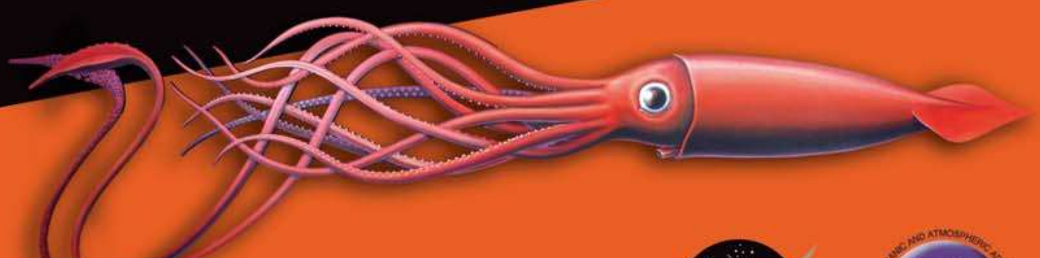
**PROJECT BUDGET & JUSTIFICATION** (Note: Your expedition cannot cost more than $1,000,000.)

**7.** State all costs associated with your expedition, including data, technology, personnel, and transportation. See your teacher for a list that will help you estimate these costs.

**8.** Briefly explain why these costs are necessary to achieve your goal(s).

**The dots on this map indicate where dead or dying giant squid have been found since the 1880s. Courtesy NASA**





Smithsonian

NASA

NOAA

Discovery Channel entertain your brain