Do You Know the Fish You're Eating?

"Third fisherman: …Master, I marvel how the fishes live in the sea.
First fisherman: Why, as men do a-land; the great ones eat up the little ones."
— Shakespeare

OVERVIEW

Students design and conduct research to discover firsthand what type of fish is being sold in their community, where this fish comes from, and whether that fish is an overfished species. This lesson gives students a chance to do their own market research and discover first-hand what type of fish is being sold to the public. It also provides an introduction to fish as an important food source and as an industry controlled partly by supply and demand. The results that emerge from this lesson will likely lead your students to question the role of public education in seafood choices for sustainable fisheries.

OBJECTIVES

Design a research project.
Conduct market research regarding the types and sources of fish sold in the local community.

GRADE LEVEL

8-12

SUBJECTS

Language Arts
Science
Social Studies

VOCABULARY

capacity, commodity, depletion, fishery, overfishing, populations, stocks, sustainability

MATERIALS

Handout #1: List of overfished and near-overfished fish species
Handout #2: Overview of world's ocean fisheries
Handout #3: Sample graphs and charts

NATIONAL SCIENCE STANDARDS:

This activity supports the following National Academy of Sciences science education standards.
Grades 5-8:
Unifying Concepts and Processes—Evidence, models, and explanation
Standard A: Science as Inquiry—Abilities necessary to do scientific inquiry
Standard A: Science as Inquiry—Understandings about scientific inquiry
Standard F: Science in Personal and Social Perspectives—Populations, resources and environments

Standard F: Science in Personal and Social Perspectives—Natural hazards
Standard F: Science in Personal and Social Perspectives—Risks and benefits

Grades 9-12:
Unifying Concepts and Processes—Evidence, models, and explanation
Standard A: Science as Inquiry—Abilities necessary to do scientific inquiry
Standard A: Science as Inquiry—Understandings about scientific inquiry
Standard F: Science in Personal and Social Perspectives—Natural resources
Standard F: Science in Personal and Social Perspectives—Environmental quality
Standard F: Science in Personal and Social Perspectives—Science and technology in local, national, and global challenges

NATIONAL SOCIAL STUDIES STANDARDS:
This activity supports the following National Council for the Social Studies standards.
Middle Grades:
Standard I: Culture—a
Standard IV: Individual Development and Identity—h
Standard VII: Production, Distribution, & Consumption—a, b, f
Standard IX: Global Connections—d

High School:
Standard I: Culture—a
Standard IV: Individual Development and Identity—h
Standard VII: Production, Distribution, & Consumption—b, f
Standard IX: Global Connections—d

BACKGROUND
Do your students know what type of fish they may be eating or whether that fish is an overfished species? How important is education in a supply and demand economy?

In recent years, humans have become more and more removed from the process of food production. This is especially true for the younger generation, as production methods have been altered dramatically in the last several decades. Small-scale food production has been replaced by larger-scale industry, and modern technology results in fewer people being employed or connected to the production process.

Consumers make choices regarding fish purchases in stores and restaurants that affect fish populations and environmental quality. This activity helps build understanding of the implications of those choices.

BEFORE YOU BEGIN
Make copies of **Handout #1**, **Handout #2**, and **Handout #3** for each student.

WHAT TO DO

1. Ask students what they know about the fish they buy at the store or order in a restaurant. Where does it come from? Is there an abundance of that species?

2. As an in-class introduction, students can brainstorm about the different human relationships with fish (recreational, food source, etc.). Introduce the current issues surrounding fisheries and the concepts of overfishing and sustainability. Also introduce fish farming and review the environmental and health issues associated with many farming practices.

3. Provide copies of handouts #1, #2, and #3 to students. Within groups of 3-5, ask students to develop a research project with detailed fieldwork to answer the following questions:

    - Where is fish sold in your community? (i.e. all supermarkets, seafood restaurants, fish markets, farmers' markets, fast food restaurants, etc.)
    - What type of fish is sold at each type of market?
    - Where does the fish come from? How are they caught? Are they farmed or from the wild?
    - What are the prices of fish—compare both species and locations.
    - What is the most popular fish species?
    - What is the frequency of different fish species in the markets?
    - Which of these species are facing overfishing pressures?

    Design and conduct a survey of fish being sold at markets and restaurants.

    Students can also design a survey and questionnaire to interview customers and sellers in different markets or to interview students in your school. This could yield information about consumer understanding of fish

4. Have groups analyze their collected data and prepare charts and graphs to present their findings to the rest of the class. What conclusions can be drawn from this study, using such factors as pricing, availability, demand, and overfishing threats?

5. Ask students to put themselves in the position of the fisher. Using their conclusions, what choices would they make in order to create the greatest profit?

6. As a group, reflect on these questions:
    - Will knowing more about overfished species change your eating and purchasing habits?
    - Can consumers really have an impact on what is sold?
    - What about the many species for which there is not enough data to judge whether they are overfished or not?

- Did the students have difficulty getting the information they needed, if so, what does this mean for consumer education?

7. Introduce your students to existing sustainable seafood choices programs. These programs maintain and make accessible information about fish species and the status of their populations. Why are different fish species placed in the different categories? Discuss how these programs can assist with making consumer choices regarding fish purchases in stores and restaurants.
    - Seafood Choices Alliance's Smart Choices program (www.seafoodchoices.com/smartchoices.php)
    - Monterey Bay Aquarium's Seafood Watch (www.mbayaq.org/cr/seafoodwatch.asp).
    - Environmental Defense (http://www.oceansalive.org/home.cfm)
    - Blue Ocean Institute (http://www.blueocean.org/#)

ASSESSMENT

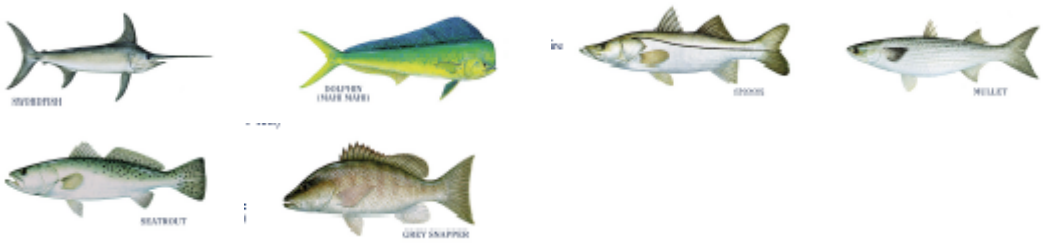
Use the group reports to assess students' research design, their use of statistical evidence, and the conclusions they draw to demonstrate mastery of key concepts, including overfishing, fish farming, supply and demand, and consumer choices.

EXTENSIONS

- Develop a consumer education campaign regarding sustainable fisheries.
- Investigate the impacts of different methods of fish farming and ocean fisheries and conduct a debate on managing these practices for sustainability.

USEFUL RESOURCES

National Marine Fisheries Service Regional Councils (www.nmfs.noaa.gov)
United Nations Food and Agricultural Organization (www.unfao.org)



HANDOUT #1 - Overfished Marine Species in the United States

Albacore—North Atlantic
American Plaice—North Atlantic
Atlantic Halibut—North Atlantic
Atlantic Salmon—North Atlantic
Barndoor Skate—North Atlantic
Bigeye Tuna--Atlantic
Black Grouper—South Atlantic
Black Sea Bass—South Atlantic
Bluefin Tuna—West Atlantic
Bluefish—Mid Atlantic except Gulf of Mexico
Blue King Crab—Pribilof Islands, Saint Matthew Island
Blue Marlin--Atlantic
Bocaccio--Pacific
Butterfish—Mid Atlantic
Canary Rockfish--Pacific
Cod—Gulf of Maine
Cod—Georges Bank
Cowcod--Pacific
Darkblotched Rockfish--Pacific
Golden Tilefish—Mid Atlantic
Goliath Grouper (Jewfish)—South Atlantic, Gulf of Mexico, Caribbean
Greater Amberjack—Gulf of Mexico
Haddock—Gulf of Maine
Haddock—Georges Bank
Nassau Grouper—South Atlantic, Gulf of Mexico, Caribbean
Ocean Pout—North Atlantic
Queen Conch--Caribbean
Red Drum—South Atlantic, Gulf of Mexico
Red Grouper—South Atlantic
Red Porgy—South Atlantic
Red Snapper—South Atlantic, Gulf of Mexico
Sailfish—West Atlantic
Shark Complex*
Snow Crab—Bering Sea
Snowy Grouper—South Atlantic
Speckled Hind—South Atlantic
Tanner Crab—Eastern Bering Sea
Thorny Skate—North Atlantic
Vermillion Snapper—Gulf of Mexico
Widow Rockfish—Pacific
Warsaw Grouper—South Atlantic
White Hake—North Atlantic
White Marling00Atlantic

Windowpane Flounder—Mid Atlantic
Winter Flounder—North, Mid Atlantic
Yelloweye Rockfish—Pacific
Yellowtail flounder—Mid Atlantic
Yellowtail flounder—Cape Cod/Gulf of Maine

*The Large Coastal Shark Complex is listed by its management complex rather than individual stocks. The complex includes Spinner Shark, Silky Shark, Bull Shark, Tiger Shark, Lemon Shark, Nurse Shark, Scalloped Hammerhead Shark, Great Hammerhead Shark, Smooth Hammerhead Shark, Dusky Shark, Bignose Shark, Galapagos Shark, Night Shark, Caribbean Reef Shark, Narrowtooth Shark, Sand Tiger Shark, Bigeye Sand Tiger Shark, Whale Shark, Basking Shark, and White Shark.

Overall Fishing Stock Status, 2004
Total stocks or stock complexes in the U.S.: 688
Number of stocks overfished: 56
Number of stocks not overfished: 144
Number of stocks approaching overfished status: 1
Number of stocks for which status is not known, not defined, or not applicable: 487

Source: NOAA's National Marine Fisheries Service, "Report to Congress: Status of the U.S. Fisheries for 2004,
http://www.nmfs.noaa.gov/sfa/domes_fish/StatusoFisheries/SOS8%20-05.htm

HANDOUT #2 - An Overview of the World's Fisheries

What is a commercial fishery?
A commercial fishery is the industry of catching a particular fish species or other marine species for profit. Commercial fisheries exist throughout the world.

What is the status of our fisheries?
Although humans have exploited marine species for millennia, advances in technology over the last few decades have greatly altered the way humans exploit fisheries. Overfishing—fishing faster than the fish can replenish—is now the greatest threat to marine biodiversity. Today, thirteen of the planet's fifteen major oceanic fishing areas are now fished at or beyond capacity. The problem has grown to such proportions that the populations of some fished species, such as haddock and bluefin tuna, have been decimated.

Is fish farming a better alternative?
With a growing world population and marine fisheries in decline, fisheries experts have long hoped that aquaculture might one day take up the slack. In some ways it already is, but a growing number of marine scientists believe that parts of the industry may instead contribute to the further decline of marine resources. The intense controversy pertains to which species are being farmed and how they are being farmed. Salmon, shrimp and tuna are examples of carnivorous animals that must be fed other fish. Most farms raising these species ultimately consume more fish than they produce. The profit motive also inclines many farms to implement large-scale, industrial practices that can result in pollution, the destruction of marine habitat, and a tendency to generate diseases that pose a risk to both wild fish and consumers.
In order to be truly sustainable, aquaculture operations need to operate in ways that do not harm marine ecosystems or coastal communities; that neither consume more resources than they produce. In China, millions of people depend on farms that raise carp, an herbivorous fish that requires no fishmeal. Carp are omnivorous species like catfish and tilapia that can be farmed with very little need of fishmeal or fish oil. Farms that raise shellfish like abalone, clams, oysters and mussels also produce a net gain in protein for a hungry world. These kinds of aquaculture are best suited for truly taking pressure off our over-exploited oceans.

What's the big deal?
For human populations, fishing has long been a way of life, a source of food and income. It is the livelihood for some 200 million people worldwide. Approximately 20 percent of the animal protein consumed by humans is derived from fish. Since living marine resources continue to be overexploited by an industry too large for the resources available, many fisheries are collapsing.

This means species are declining, a major world food source is being put at risk, jobs are being lost, and ecosystems are inalterably changing.

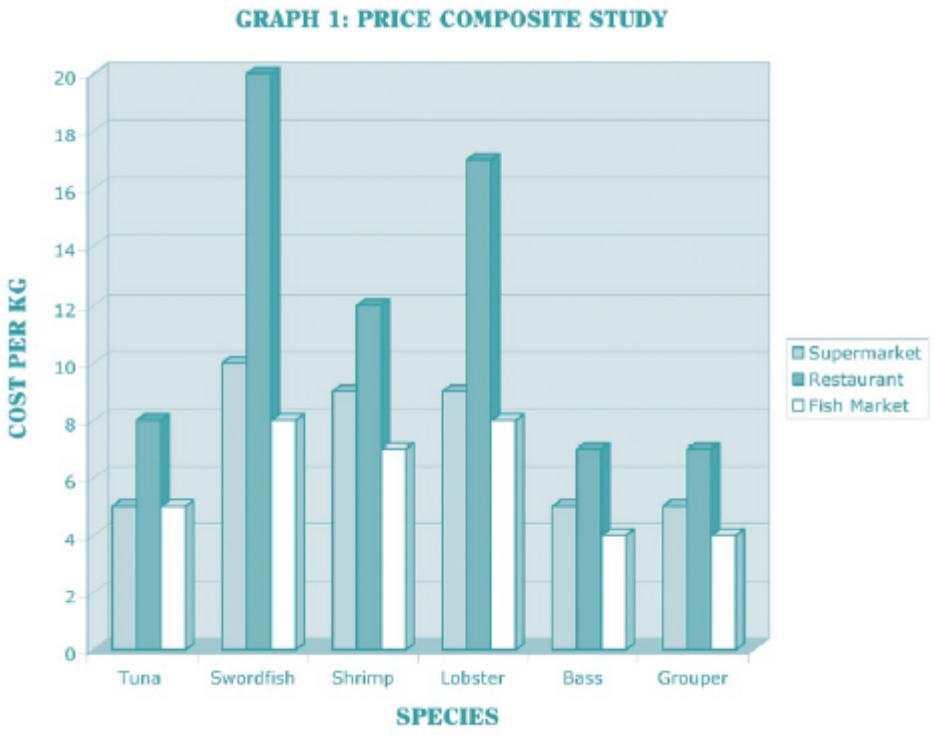
Handout #3: Sample Charts and Graphs

Example Fish Availability Study

This table selects six species as below, and compares the frequency of their availability within three categories (supermarkets, restaurants, and fish markets) This graph selects six separate fish species to use in a price study. The three categories used in-clude supermarkets, restaurants, and fish markets.

Fished Species	Supermarket	Restaurant	Fish Market
Tuna	Always	Always	Sometimes
Swordfish	Never	Sometimes	Never
Shrimp	Always	Always	Always
Lobster	Never	Sometimes	Sometimes
Bass	Sometimes	Sometimes	Sometimes
Grouper	Always	Sometimes	Never

This table selects six species as below, and compares the frequency of their availability within three categories (supermarkets, restaurants, and fish markets).



This graph selects six separate fish species to use in a price study. The three categories used include supermarkets, restaurants, and fish markets.

Fishing for the Future

OVERVIEW
Through a fishing simulation, students model several consecutive seasons of a commercial fishery and explore how technology, population growth, and sustainable practices impact fish catch and fisheries management.

OBJECTIVES
Students will:
Experience the "tragedy of the commons"[1] as it relates to fishing resources.
Consider social, environmental, and economic impacts of overfishing.
Identify sustainable fishing practices.

GRADE LEVELS
6-10

SUBJECTS
Social studies
Biology
Environmental studies
Geography
Economics
Mathematics

VOCABULARY
sustainability, tragedy of the commons

TIME
1 hour

MATERIALS
Plain M&Ms, one 14-ounce bag for up to 30 students
Peanut M&Ms, one 14-ounce bag for up to 30 students
Small cups, 1 per student
Serving bowls, medium size, 1 per group
Spoons, 1 per group
Straws, 1 per student
Watch, for timing activity
Handout ***Fishing Log***, 1 per student
Handout ***Fishery Facts***, 1 per student

NATIONAL SCIENCE EDUCATION STANDARDS

[1] The "tragedy of the commons" occurs when resources—such as the water we drink, and the fish we eat—shared by everyone (or held in common) are used at a rate that exceeds the resources' sustainable limit. Ultimately, as population grows and consumption increases, the "commons" collapse. The phrase was first coined by Garrett Hardin in 1968, www.garretthardinsociety.org/index.html.

This activity supports the following National Academy of Sciences science education standards.
Grades 5-8:
Unifying Concepts and Processes—Systems, order, and organization
Standard C: Life Science—Populations and ecosystems
Standard F: Science in Personal and Social Perspectives—Populations, resources, and environments
Standard F: Science in Personal and Social Perspectives—Science and technology in society

Grades 9-12:
Unifying Concepts and Processes—Systems, order, and organization
Standard C: Life Science—The Interdependence of Organisms
Standard E: Science and Technology—Understandings about science and technology
Standard F: Science in Personal and Social Perspectives—Natural resources
Standard F: Science in Personal and Social Perspectives—Environmental quality

NATIONAL SOCIAL STUDIES STANDARDS
This activity supports the following National Council for the Social Studies standards.
Middle Grades:
Standard III: People, Places, & Environments—k
Standard V: Individuals, Groups, & Institutions—g
Standard VII: Production, Distribution, & Consumption—c
Standard VIII: Science, Technology, & Society—b, d, e
Standard IX: Global Connections—d

High School:
Standard III: People, Places, & Environments—k
Standard V: Individuals, Groups, & Institutions—g
Standard VIII: Science, Technology, & Society—d, f
Standard IX: Global Connections—d

BACKGROUND
Garrett Hardin coined the phrase “tragedy of the commons” in 1968. Hardin describes cows grazing on a common land. Since there is no direct cost to using the land, individual ranchers are motivated to add to their herds in order to increase their personal wealth. But each added animal damages the pasture a small, perhaps imperceptible, amount. Ultimately, this gradual degradation destroys the commons. Each rancher acting alone is behaving in an appropriate, rational manner, yet the sum total of all the ranchers’ actions destroys the resource for them all.

From 1950 to 1990, there was a fivefold increase in the world annual fish catch. An increasing demand for fish coupled with environmentally damaging fishing practices are leading to another tragedy of the commons. Roughly 70 percent of the planet’s marine stocks are fully or over exploited, according to the Monterey Bay Aquarium’s Seafood Watch program.

In this activity, students will simulate fishery activity in different oceans. As students progress through the fishing seasons, they will likely overfish their oceans and will have to migrate to other oceans to meet their basic needs. Most groups will eventually create a total crash of fish stocks in all the oceans. This demonstration will clearly indicate the benefits of sustainable fishing practices.

BEFORE YOU BEGIN

1. Check for peanut allergies in your class. You can do the activity using only plain M&Ms, if necessary.
2. For a class of 20, you will have five or six groups of three to four students each. Each group will start with 20 plain and 10 peanut M&Ms. Count out the first round of M&Ms and place them in cups or bags.
3. Copy the *Fishery Facts* and *Fishing Log* handouts.
4. As a pre- or post-activity reference, have students read the handout *Fishery Facts*. For additional references, read Chapter 5 "Global Trends – Food, Water, and Income" and Chapter 6 "Environmental Sustainability" from Facing the Future's publication *Global Issues & Sustainable Solutions (*www.facingthefuture.org*).*

WHAT TO DO

Before the Activity

1. As a pre- or post-activity reference, have students read the handout *Fishery Facts*. For additional references, read Chapter 5 "Global Trends – Food, Water, and Income" and Chapter 6 "Environmental Sustainability" from Facing the Future's publication *Global Issues & Sustainable Solutions (*www.facingthefuture.org*).*

The Activity

1. Introduce and discuss the concept of sustainability using the following definition:

   > "Sustainability is meeting the needs of the present without limiting the ability of people, other species, and future generations to survive."

   Ask why sustainability might be an important goal for a society and what might be difficult about realizing this goal.

2. Tell students that today they're going to go fishing and explore some of these sustainability issues.

3. Explain the game rules:
   a. Each student will be a "fisher" whose livelihood depends on catching fish.
   b. Peanut M&Ms represent the largest and most valuable fish (tuna, swordfish, et cetera).

4. Plain M&Ms represent the next most-valuable fish (cod, salmon, et cetera).
   a. Each fisher must catch at least two fish (large or small) in each round to survive (i.e., get enough fish to either eat or sell).

   b. When the fishing begins, students must hold their hands behind their backs and use the "fishing rod" (straw) to suck "fish" (M&Ms) from the "ocean" (bowl) and deposit them into their "boat" (cup).
   c. The fish remaining in the ocean after each fishing season represent the breeding population, and thus one new fish will be added for every fish left in the ocean (bowl).

5. Divide the class into groups of three or four students and have each group choose an ocean name such as North Atlantic, North Pacific, Arctic, Mediterranean, et cetera.

6. Give each group one serving bowl and each student one cup, one straw, and one copy of the handout *Fishing Log*.

7. Put 20 plain and 10 peanut M&Ms in each group's bowl.

8. Say "start fishing" and give the students 20 seconds for the first "season" of fishing.

9. Have each fisher count his or her catch (M&Ms in their cup) and record the data in their *Fishing Log*.

10. Fishers who did not catch the two-fish minimum must sit out for the following round.

11. Add one new fish for every fish left in the ocean (bowl).

12. Allow fishers to use their hands on the straws during the second session to represent "new technology."

13. After the second fishing season, give one fisher from each group a spoon representing more new fishing technology such as trawl nets, sonar equipment, et cetera. Continue the game for round three.

14. Ask, "What happened when ocean group [name] ran out of fish? How are the fishers going to survive now?" (One option is to move to another ocean.) Allow students to "invade" other ocean groups when their ocean is depleted, but don't tell them that they can do this beforehand. Fishers may either go as a group to another ocean or they may disperse to other oceans.

15. Repeat fishing, recording, and replenishing fish stocks until either sustainable fishing is achieved or until all (or most) groups fish out their ocean.

Reflection

1. Have students do a free-write on the following quote by John C. Sawhill, relating it to the fishing activity: *"In the end, our society will be defined not only by what we create, but by what we refuse to destroy."* (John Sawhill is the former President and Chief Executive Officer of The Nature Conservancy.)

2. Use the following sample questions to lead a discussion about the activity:
    - How did you feel when you realized that you had depleted your fish stock?
    - How did you feel when other fishers joined your ocean group?
    - How does this activity relate to real ocean and fishery issues?
    - What's missing in this game? (Impacts to nonhuman animals that rely on fish for their survival, population growth, et cetera.)
    - What happens to a resource when you have infinite population growth, growing technology, and a finite resource?
    - Are there any commonly owned resources in our region or community? If so, what are some similar issues around them, and how can they best be managed? (Air is a commonly used resource—how do we deal with air pollution? Forestry or animal grazing rights also sometimes create similar discussions. You might also talk about city, national parks, and other public lands, and the competing uses and needs.)
3. Have students brainstorm ways to have a sustainable fishery. What rules could be developed? (For example, limits on type of equipment allowed, amount and type of fish, shorter seasons.)

ASSESSMENT

Ask students to write, draw, or chart an explanation of factors that affect management of fish populations and identifies the goal of sustainable fisheries. (Responses should reflect such factors as technology, environmental conditions, market prices, and consumer choices.)

EXTENSIONS

- Read Garrett Hardin's essay "The Tragedy of the Commons" and discuss how it is reflected in this game. For a downloadable version, go to www.garretthardinsociety.org/articles/art_tragedy_of_the_commons.html.
- Repeat the activity after the class has experienced the "tragedy of the commons" and discussed sustainable practices to see if they can harvest in a sustainable manner.
- Students can research which fish are harvested in a sustainable manner and which are being depleted. Have them do an advertising campaign in their school promoting the consumption of sustainable fish and avoiding the consumption of threatened fish. (This might include researching the kind of fish served in your school cafeteria, developing a system that protects threatened fish, and presenting it to your cafeteria staff, principal, and school board.) For recommendations about which seafood to buy or avoid, check out the Monterey Bay Aquarium's website "Seafood Watch" at www.montereybayaquarium.org or the Audubon website "What's a Fish Lover to Eat?" at http://magazine.audubon.org/seafood/guide/.
- Have students research a local fishery and include interviews with local fishers, biologists, and other people involved with the fishery.
- Have students choose one of the major world fisheries, such as salmon, cod, or tuna, and develop a sustainable fishing plan, paying attention to international laws and treaties.
- Have students investigate fish farming and its environmental and economic impacts.

- Have students research federal and state laws relating to economic use of public lands by private companies and individuals. Determine whether these laws balance environmental protection and economic development. If not, outline new laws to create such a balance.
- Do a watershed planning/protection project to help protect fisheries from environmental damage.
- Participate in a beach or river cleanup project.
- Join an Ocean/Fisheries Action Network such as:
  Center for Marine Conservation Ocean Action Network: www.cmc-ocean.org
  Marine Fish Conservation Network: www.conservefish.org
  National Audubon Society Living Oceans Program: www.Audubon.org/campaign/lo/
  SeaWeb: www.seaweb.org
  World Wildlife Fund Conservation Action Network: www.takeaction.worldwildlife.org

MORE INFORMATION
Visit the United Nations Food and Agriculture Organization Fisheries Resource website at www.fao.org/fi.

For information and pictures about the state of the world's fisheries, see the New International Magazine on-line issue on fishing at www.newint.org/issue325/facts.htm.

To explore sustainable seafood choices, visit the Seafood Watch web site at www.mbayaq.org/cr/seafoodwatch.asp or The Marine Stewardship Council (MSC), an independent non-profit organization that promotes responsible fishing practices. www.msc.org

Seafood Information Center, a clearinghouse for sharing seafood knowledge www.seafoodinfocenter.org

CREDIT
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FISHING FOR THE FUTURE—FISHERY FACTS

The world's fisheries are under more pressure than ever before. From 1950 to 1990, there was a fivefold increase in the world annual fish catch. The average yearly per-person fish consumption in the industrialized world (59 pounds) is three times that of people in the developing world (20 pounds). Fish demand remains high: An additional 15.5 million tons of fish will be required by 2010 just to maintain current rates of fish consumption. Today, 70 percent of the planet's marine stocks are fully exploited or overexploited.

The number of people fishing and practicing aquaculture worldwide has doubled since 1970. More than 21 million people are full-time fishers, and 200 million depend on fishing for their livelihood. Asia contains the vast majority of the world's fishers. In the early 1950s, developed countries took 80 percent of the world's fish catch. Today, they take only 36 percent of the catch, while developing countries take 64 percent.

The technology used to catch fish and the number of fish caught per fisher varies enormously. Modern fleets are the most environmentally destructive, as they use enhancements such as airplanes, radios, seafloor maps, and video sonar to track down fish schools. Once they have found the fish, these fleets use large nets to drag up not only the targeted fish but also coral, the seafloor, and around 27 million tons annually of "by-catch"—nonmarketable fish that are killed and thrown overboard.

To compensate for reduced wild fish stocks, more and more fish are being farmed. Nearly a third of all fish for food is harvested from aquaculture. For every 11 pounds of beef grown globally, there are now 4.5 pounds of farm-raised fish produced. Fish farming causes environmental destruction comparable to the replacement of rain forest with cattle ranches. About 11 pounds of wild ocean fish need to be caught to feed each pound of farmed species. Thailand, which has one of the biggest aquaculture industries, has lost half its mangrove forests due to shrimp farming. Densely stocked salmon farms in British Colombia, Canada, produce waste (including fertilizer, effluent, and fishmeal) equivalent to that generated by half a million people.

Despite these numbers, there is still hope for the world's fisheries. Fisheries can be restored through the adoption of sustainable fishing practices. With the proper incentives, fishers can be encouraged and rewarded in their effort to sustainably manage marine resources. For example, partnerships between local communities and scientists in the central islands of the Philippines resulted in the establishment of marine reserves to help manage overexploited fisheries. The establishment of no-fishing zones in the reserves has increased catches in adjacent fishing grounds. Another solution is to use the power of the market to encourage sustainable fishing practices. The Marine Stewardship Council together with the World Wildlife Federation and Unilever, one of the largest makers of fish products, has developed a certification process that includes a label telling consumers that fish products came from fisheries certified as sustainable.

References: *The New Internationalist* magazine issue 325, www.newint.org;
The United Nations Food and Agriculture Organization, www.fao.org; Environmental News Service, February 2002, www.enn.com

Fishing Log

Ocean Group:_____ Fishers:_____

Record your group's catch and fish left in ocean after each season:

Season	Catch			Fish Left in Ocean
	High Value Fish	Medium Value Fish	Total Catch	
1				
2				

Write a brief description of the status/health of your fishery: _____

_____

Season	Catch			Fish Left in Ocean
	High Value Fish	Medium Value Fish	Total Catch	
3				
4				

Discuss changes in fishing practices or regulations. Are any fisheries in trouble? What did they do and how did that impact your fishery?

_____

_____

Season	Catch			All Fish Left in Ocean
	High Value Fish	Medium Value Fish	Total Catch	
5				
6				

Write a brief description of the status or health of your fishery now:_____

_____

How could you have made your fishing sustainable? _____

_____

Net Results

OVERVIEW
Students will study and replicate a model of the factors affecting fisheries populations in the Chesapeake Bay (or any other bay). Through a game they will investigate how decisions by watermen, recreational fisherpeople, and lawmakers influence and are influenced by economics and the abundance or scarcity of fish and shellfish stocks.

OBJECTIVES
Students will:
Consider social, environmental, and economic impacts of overfishing from a variety of perspectives

GRADE LEVELS
8-12

SUBJECTS

VOCABULARY
Abundance, aquaculture, depletion, harvesting, harvesting gear, moratorium, natural mortality, regulation, replenishment, scarcity, waterman

TIME
2 hours

MATERIALS
For each student or pair of students:
Bottle Model diagram

For each group of six students:
Fishery Factor cards
Role cards and data charts
2 open top containers (250 ml or larger bowls, shoeboxes, Tupperware)
500 ml of dried pinto or small kidney beans
1 graduated cylinder (250 ml or larger)
4 measuring spoon sets (one per waterman and recreational fisherperson)
4 cups (50 ml or larger) (one per waterman and recreational fisherperson)
1 funnel with opening large enough to let beans through (or a piece of paper rolled into a cone)
Paper and pencils

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Standard E: Science and Technology—Understandings about science and technology
Standard F: Science in Personal and Social Perspectives—Population growth
Standard F: Science in Personal and Social Perspectives—Natural resources
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This activity supports the following National Council for the Social Studies standards.
Middle Grades:
Standard III: People, Places, & Environments—h, k
Standard V: Individuals, Groups, & Institutions—e, g
Standard VI: Power, Authority, & Governance—c
Standard VII: Production, Distribution, & Consumption—f,
Standard VIII: Science, Technology, & Society—d, e
Standard IX: Global Connections—d
Standard X: Civic Ideals & Practices—e

High School:
Standard III: People, Places, & Environments—h, k
Standard V: Individuals, Groups, & Institutions—e, g
Standard VI: Power, Authority, & Governance—c
Standard VII: Production, Distribution, & Consumption—f
Standard VIII: Science, Technology, & Society—d, f
Standard IX: Global Connections—d
Standard X: Civic Ideals & Practices—e

BACKGROUND
Whether the topic is catch restrictions on the blue crab or a moratorium on rockfish, fisheries management is almost always a contentious topic for citizens, scientists, watermen, lawmakers, and recreational harvesters alike. Yet, these groups want the same thing—populations of fish and shellfish that support and promise a viable future for our commercial and recreational harvesting industry.

Unfortunately, the scarcity of many of these resources makes polite cooperation difficult to achieve. When the devastating impacts of a hurricane, a more efficient harvesting gear, or a loss of habitat reduces populations, the resource may dwindle, but the demand for it continues to increase. The tough choices arising from this scarcity are the heart of current fisheries management.

In this activity, students grapple with these decisions through a game that illustrates how harvesting pressure, regulations, and other factors affect and are affected by the fisheries populations. By witnessing the rise and fall of populations in response to their actions and attempting to reach a compromise that is acceptable to everyone, students will gain an understanding of the challenge of fisheries management.

BEFORE YOU BEGIN

1. Photocopy the Bottle Model Handout for each pair of students.
2. Collect and organize a set of materials for each group. This activity is written for groups of six to eight students. This group size will allow each student to have an active role in the game. However, if you wish to approximate more closely the real-life proportions of lawmakers, watermen, and recreational fisherpeople, you may want to play the game as a full class. To do this, you will need to modify the recommended starting population and harvesting levels described in the first step of the teacher procedures. Other options when you have an extra student or two in a group are to add an extra fisheries scientist or an additional lawmaker to serve as a DNR police person.
3. Photocopy one set of "Fishery Factor" cards for each group and cut each set into individual cards. Copy the card originals back-to-back so that the fronts of the cards read "Fishery Factor" and the backs have specific instructions.
4. In the game, students will assume the roles of several people whose actions influence fisheries. Photocopy one role card for each student and divide each playing group according to the following roles:
   - Lawmaker (one per group)
   - Fisheries scientist (one per group)
   - Watermen/commercial fisherpeople (at least three per group)
   - Recreational fisherpeople (at least one per group)

WHAT TO DO

Part 1

1. Divide students into pairs. Distribute copies of the "Bottle Model" handout and instruct pairs to work together to complete the questions on the worksheet. The handout introduces the factors that influence fisheries populations. The rest of the activity is based on this student handout.

Part 2

2. Walk your full class through the following sequence once. (These instructions are also provided to the students on the "Student Instructions" handout.
   - The goal of the game is to maintain a fishery that is stable enough to keep everyone in business for at least ten rounds.
   - Divide students into group of six to eight students. Give each group a set of student instructions. Also give each student a role card that explains his/her role in the game. Give each group a few minutes to explain and clarify their roles within the group.
   - Each group places between 300 and 400 ml of beans in one of their containers, which they should label "Bay." The beans in this container represent the stock of beanfish in the Bay. The rest of the beans go in the second container, labeled "Extra." To make the

harvest more realistic, each group's Bay should be covered so that the harvesters cannot tell how much the stock has been depleted.

- The game is played in ten rounds, each representing a year. In each round, the watermen and recreational fisherpeople "harvest" from the container abiding by current harvesting laws. For the first round, watermen are allowed to scoop three tablespoons of beans into their cup; the recreational fisherpeople (who each represent 25 fisherpeople) are allowed to take two tablespoons. These harvesting levels will change in subsequent rounds.
- While the harvesters count their catch, the fisheries scientist calculates the reproduction of the species for the round and adds the appropriate quantity of beans to the Bay. For every one ml remaining in the container, the stock reproduces one ml.
- Students (except the lawmakers) must record their actions for this round on a data sheet on the back of their job card. Each bean harvested is worth $100 for the first round. Once recorded, all harvests for the round can be emptied into the "Extra" container and used by the fisheries scientist when he/she replenishes the stock in future rounds.
- After the first round, you can apply the effects of supply and demand to the game. If fewer than 150 beanfish are caught commercially then the price per fish rises to $110. If more than 210 beanfish are caught commercially, the price per fish falls to $90.
- All harvesters and the fisheries scientists make verbal recommendations to the lawmaker as to the type and extent of regulations they feel should be in place in the upcoming year (round). The lawmaker records everyone's recommendation in his/her data sheet. When making recommendations or laws, students should consider the suggestions on their role cards. They should also remember that watermen need to make $6,000 each round or they go out of business.
- Based on the recommendations, lawmakers make laws that must be followed by all harvesters in the next round.
- The round ends with the lawmaker drawing a "Fishery Factor" card that introduces additional and unexpected occurrences. If the instructions on a card conflict with the lawmaker's decision, the instructions on the card override the lawmaker's decision. Otherwise, both card instructions and laws apply.
- Repeat for ten rounds.

Part 3

1. After ten rounds of the game, have the students (individually or in groups) answer the follow-up questions on the student handout for Part 3.

Suggestions for a smooth game:

- Students may ask how to count broken or half beans. Any bean less than a full bean does not count toward the total; you may explain that these beans are under legal harvesting size.
- Any bean that falls off the spoon during harvesting goes back into the pool and does not count toward the student's harvest.
- To make sure that students are recording their harvests accurately, the fisheries scientist can count any person's harvest at any time. Anyone who has counted half beans or whose harvest is above the level recorded gets a $1,000 fine.
- If the students in the role of recreational fisherpeople have trouble calculating the percentage of fisherpeople who caught more than one beanfish, suggest the following formula:
  % = (# beanfish caught – 25) x 4

ASSESSMENT

The Bottle Model is only one representation of the way that replenishment and depletion influence a population. Ask students to draw and explain their own model of the way this process works.

EXTENSIONS

- Have students graph the data they collect (population and harvest) to investigate the following question: Does looking at harvest data really tell you how a species is doing? What are some of the problems associated with looking solely at harvest data when trying to determine the health of a species?
- Explore the role of technology in sustaining fish populations.
- Research and write about the influence of varying stakeholders on public policy.

Fishery Factor	***Fishery Factor***
Fishery Factor	***Fishery Factor***
Fishery Factor	***Fishery Factor***
Fishery Factor	***Fishery Factor***
Fishery Factor	***Fishery Factor***
Fishery Factor	***Fishery Factor***

If watermen caught **less than a combined total of 150 beanfish** this round, not enough of the fish are making it to market to meet the demand for tasty beanfish. Consumers are willing to pay more for a bit of this scarce fish and will now pay $110 per beanfish. If watermen caught **more than a total of 210 beanfish** this round, there is a surplus of beanfish at the markets. Seafood market owners are cutting their prices to get people to buy at their stores. Beanfish are selling for only $90 per fish. This card applies to every round.	The Maryland General Assembly has called for a public vote (referendum) on whether or not to reduce the amount of beanfish recreational fisherpersons are allowed to catch by reducing their scoop size. Use a show of hands to determine whether or not those fishing for recreation should use one size smaller scoop. Everyone may vote.
Each waterman has the option of buying bigger, more efficient equipment for $2000 that can be used until laws prohibit the use of such equipment. If you choose to make the purchase, subtract $2000 from your earnings this round or use any surplus you might have. In coming rounds, use one spoon size bigger than you used in the last round.	Everyone move one seat to the left and take over the job and the data chart of the person whose seat you have just taken.
Maryland students have begun a project raising beanfish in the classroom. This week they released their fish into the Bay in an effort to help restore the population. As a result of their project, the beanfish population in the Bay grows by 20 ml.	A disease from the Pacific Ocean is introduced into the Bay through ballast water released from a large ship docked in Baltimore. The disease is devastating to the beanfish population. Reduce your current beanfish population by one third.
A hurricane and its tremendous rainfall washes tons of sediment into the Bay, smothering delicate beanfish eggs and killing submerged aquatic vegetation, the preferred food of beanfish. Reduce the beanfish population in the Bay by 25%.	Recreational fisherpersons have just been shown how to perform careful catch, a technique where fish are caught for recreation and released back into the water unharmed. Fisherpeople: start a new column for the number of fish, if any, you decide to release. Fish released may be put back into the Bay before the fisheries scientist calculates reproduction.
The removal of a dam opens up prime beanfish spawning grounds and they have a reproductive year. Add 40 ml of beanfish to the Bay. The dam also opens up new areas for those fishing for recreation who are now allowed an additional scoop each round unless regulations change.	Students create a forest and wetland between a large mall and a local waterway. This vegetation helps to reduce the amount of sediment, oil, and nutrient runoff washing from the mall into the waterway. As a result, fewer beanfish die population-related deaths, leaving more to reproduce. Increase your population by 10 ml.
Suddenly, New Zealand starts shipping beanfish to your area which are just as good as yours. They are also cheaper than yours! This drives the market value of your beanfish down $20 per fish for one round.	No changes this round.

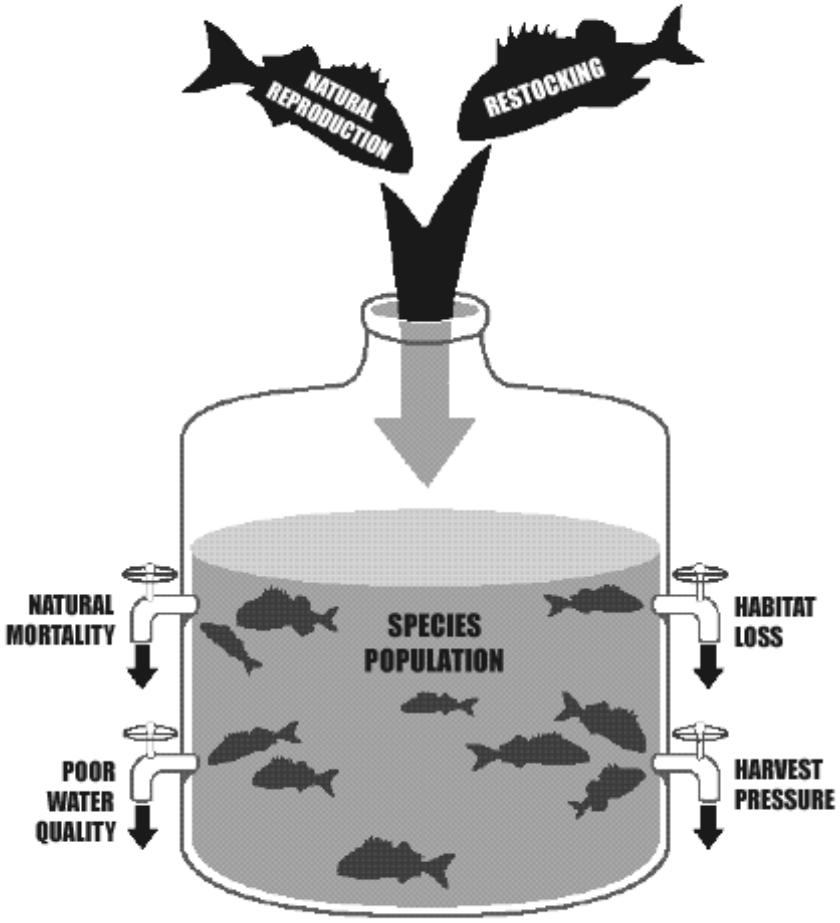
NET RESULTS – PART 1
The Bottle Model

1. Study the "Bottle Model" diagram below. This model represents the interaction between ways in which species are removed from the Chesapeake Bay and added back into the Bay (natural reproduction and stocking of waterways). Explain what you think the model illustrates about the factors that bring fish into the Bay and take them out of the Bay.

2. Under one faucet on the model, describe an event that could make the faucet flow faster. *For example, an event such as a heat wave could reduce the amount of oxygen in the Bay and increase natural mortality.*

3. If the event you described above did happen, what would happen to the population level in the bottle? Would the population be able to return to its original level after this event? How?

The Bottle Model



NET RESULTS—PART 2
Student Instructions

Your group is going to play a game that illustrates the way that people, fish and shellfish populations, and laws interact and influence each other. In the game, you will represent some of the people—lawmakers, scientists, watermen, and recreational fisherpeople—who influence and are affected by fisheries regulations.

1. **Preparing for the game:**
Your teacher will give each of you a Role card. Your Role card includes a chart for you to fill out during the game. Read your role description carefully and ask your teacher any questions you might have. Explain your role to the other members of your group and listen as they explain their roles to you.

2. Setting up the game:
Collect the rest of the game's materials from your teacher and distribute them among your group. Give the graduated cylinder to the fisheries scientist. Give each harvester (commercial and recreational) a set of measuring spoons. Label one of your containers "Bay" and put 400 ml of dried beans in this bowl. Cover your Bay with a cloth or a piece of paper so that the exact level of "beanfish" cannot be seen. Label the other container "Extra" and put the rest of your beans in this bowl.

3. Playing the game:
Round 1:
- Watermen may take up to three tablespoons of beanfish from the Bay. Recreational fisherpeople may take two tablespoons. Each person should put their individual harvest in a small cup so that they can count it later.
- After everyone has finished harvesting, fill in the data chart on the back of your role card. Check your role card to find out what this involves.
- Once the bean fish have been counted, watermen and fisherpeople pour their harvests into the "Extra" bowl.
- Using the graduated cylinder, the fisheries scientist measures the remaining population of beanfish in the Bay and calculates how much the fish reproduce. For every one ml of beanfish remaining, the scientist transfers one ml of beans from the "Extra" bowl to the Bay. The fisheries scientist fills out his/her data chart.
- Fisheries scientists, watermen, and recreational fisherpeople give recommendations to the lawmaker. Check your role card for ideas.
- The lawmaker decides which regulations (if any) harvesters must follow in the
- next round.
- The lawmaker draws a "Fishery Factor" card and reads it to the group.

Round 2 - Round 10
- Your group will repeat the procedure from **Round 1** following the new instructions from the Fishery Factor card and any new regulations (if there are any) from the lawmaker.
- The worth of beanfish may change as the game goes on. If your class is including the impact of supply and demand in your game, the cost of beanfish will vary depending on how many

are caught. If the total commercial catch is less than 150 fish, the cost per fish rises to $110 due to scarcity. However, if the commercial catch is more than 210 fish, the cost per fish falls to $90.

Every Round:

- The watermen must make $6000 each round to make a living. If a waterman makes under this amount for a total of three rounds, he/she is out of business and becomes a recreational fisherperson. Surplus from good rounds can carry a waterman through times of shortage. This means that if a waterman makes $6500 in one round, $500 can be used to make up for a bad catch in another round.
- Recreational fisherpeople represent 25 anglers each. For every angler to catch a fish, the recreational fisherpeople need to catch at least 25 beans each round.
- The most important thing to remember about this game is that you get to make most of the rules! You will need to come up with imaginative solutions as you encounter the challenges of fisheries management.

NET RESULTS—Part 3

After you have played ten rounds of the game "Net Results," answer the following questions:

1. Summarize the results of the game. What trends did you see in the beanfish population over time?

_____
_____
_____
_____
_____

2. Of the factors that increase and reduce the populations of species in the water, which can we control? Look back at the "Bottle Model" from Part I and circle the factors that people can control through various actions. Under each factor you circle, provide an example of an action that you, or other people, do or could do to decrease the flow from the faucet.

3. Describe three events, actions, or decisions in the game that most influenced the health of your fishery.

_____
_____
_____
_____
_____

4. List and explain three things that you would do diff e rently if you were to play “Net Results” again. How do you believe these changes would affect the outcome of the game?

_____
_____
_____
_____
_____

5. Because this was a game, or a model of a real-life process, there were many things that were not quite realistic. Even so, this game should have given you a good sense of the challenges, cooperation, and compromise involved in fisheries management. What other factors might influence populations and catches if this experiment were done in real life?

_____
_____
_____
_____
_____

6. This game deals with a very real issue: the role of laws in fisheries management. Think about how laws or regulations affected the watermen and recreational fisherpeople in your game. How did the regulations affect the fish population?

Write a persuasive paragraph to a classmate explaining whether or not you think we need laws, such as those you saw in the game, to manage fisheries. Use examples and evidence from the "Bottle Model," the game, and any prior knowledge you might have to support your perspective.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Lawmaker

Introduction to your role:
Your job is to make the laws that determine how many beanfish the commercial and recreational fisherpeople can take out of the Bay each year. Your goal is to listen to everyone's point of view about how the fishery is doing and then make regulations that are fair and sensible. It is a tough job, but someone has to do it! Ultimately, you are striving to keep the fishing industry healthy throughout the *entire* game.

At the end of each round, you will get a recommendation from each interest group (fisheries scientists, watermen, and recreational fisherpeople). Although the recommendations may say completely different things, you need to use them to help decide which regulations to make.

What does the lawmaker do?
As the lawmaker, you can regulate fishing in a number of ways. You can make everyone take fewer beanfish, or allow everyone to take more. You can change the size of the equipment that watermen and/or recreational fisherpeople are allowed to use (they all have a set of spoons sizes you can choose from). You can also set different limits for recreational fisherpeople and watermen. As a last resort, you can set a moratorium for a round or more. A moratorium is a ban on all harvesting of the species and will allow the species to reproduce without being harvested. The lawmaker is also responsible for enforcing the regulations he or she sets, when necessary.

Remember:
As a lawmaker, you take responsibility for many people's happiness, and sometimes for their financial survival. Watermen make a living by catching and selling beanfish. They are not making a decent living if they make less than $6000 per round. They will go out of business permanently if they make less than this for a total of three rounds. This means that severe restrictions, or a moratorium might put them out of business. On the other hand, watermen depend on the existence of beanfish to catch, so overfishing might put them out of business in future rounds. Your goal is to find laws that will balance present and future needs.

Here are a few examples of regulations you can set:
- If the beanfish stock seems to be in wonderful shape, you can increase the amount everyone can catch or allow for an unlimited catch, where everyone can take as much as they want.
- If you are afraid that the beanfish stock is becoming too low, you can forbid the use of tablespoons to scoop up beanfish. This means that watermen and recreational fisherpeople will have to use their smaller spoons, which do not catch as many beanfish.

Round #	Scientist's suggestions	Watermen's suggestions	Recreational fisherpeople's suggestions	Final decision for the round
Round 1				
Round 2				
Round 3				
Round 4				
Round 5				
Round 6				
Round 7				
Round 8				
Round 9				
Round 10				

Fisheries Scientist

Introduction to your role:
You are the person who studies the Bay's fish populations. You are an expert who provides hard facts to the lawmaker about how the beanfish population is doing. In this game, you are also the person who measures the fish left after each round and calculates how many get put back in to the pool through natural reproduction. This means that you are the only person who really knows how the beanfish are doing. Your goal in this game is to make sure that there are always enough beanfish left in the pool to replenish the stock after each round. In other words, you want to make sure that there will be a future for beanfishing in the Bay.

What does the Fisheries Scientist do?
To provide sound data to the lawmaker, you need to keep track of the amount of beanfish in the Bay before and after harvesting and beanfish reproduction. You will start the game by placing 200 ml of beanfish in the Bay. After each round of harvesting, you will measure the amount of fish left and calculate how much the beanfish population will reproduce that year. To do this, you will add one ml of beans to the Bay for every ml of beans left. For example: if there are 95ml of beanfish left in the Bay when harvest is finished, you will add 95ml more. This will bring the total amount of beanfish up to 190ml.

Based on what you know about the beanfish population after each round, you will need to make a verbal recommendation to the lawmaker, telling him/her what you think should be done to maintain a healthy beanfish stock.

Remember:
Since you are the only members of your playing group who actually measure the beanfish stock, you will need to explain to the others how the stock is doing. Most importantly, you need to convince the lawmaker to make regulations that will keep the stock healthy, and not bring it down to low levels.

- If you can see that the current regulations are allowing the beanfish stock to become seriously low, you can recommend that the lawmaker limit watermen to one scoop each per round or that the recreational fisherpeople use a smaller harvesting tool.
- If you think that the beanfish are doing particularly well, you can recommend that the lawmaker allow them to harvest more beanfish.

Round #	**Amount in Bay after harvest (in ml)**	**Amount added through reproduction (1ml for each remaining ml)**	**Final total after harvesting and reproduction (in ml)**	**Fraction gained or lost from previous round**
Round 1				
Round 2				
Round 3				
Round 4				
Round 5				
Round 6				
Round 7				
Round 8				
Round 9				
Round 10				

Watermen/Commercial Fisherperson

Introduction to your role:
You make your living by catching beanfish from the Bay and selling them commercially. Your goal is to stay in business for the entire game while obeying the laws and regulations set by the lawmaker.

What does a Waterman do?
To stay in business, you need to catch enough beanfish to make $6,000 (your expenses) each round. For the first round, each bean is worth $100, meaning that you have to catch 60 beans in the first round. The worth of each bean may change throughout the game.

If you make more than $6,000 in any round, you can save your surplus in your savings account for tighter times. If you make less than this amount in any round, you must make up the difference with surplus from another time or count the round as a strike against you. If you have a total of three strikes against you during the game, you go out of business and become a recreational fisherperson.

At the end of each round, you will need to give a verbal recommendation to the lawmaker, telling her/him how your business is doing and what you think should be done to keep you in business. Should you be allowed to use bigger and better gear or take more scoops? Should you or recreational fisherpeople be taking less? Are you making enough money to make a living? Do you want to save money in case times get tight? To help you make these recommendations, you need to keep track of your harvests using the chart on the back of this page.

Remember:
If there are no fish, you will have nothing to catch and no way to remain in business. On the other hand, if regulations are too strict, you may go out of business anyway. You may work with other watermen and/or the recreational fisherpeople, or you may wish to be secretive about your business. It's your choice.

Round #	**Amount harvested (# of beanfish)**	**Price per bean this round**	**Total amount earned**	**Amount earned abouve (+) or below (-) $6000**	**Savings account (total surplus)**
Round 1					
Round 2					
Round 3					
Round 4					
Round 5					
Round 6					
Round 7					
Round 8					
Round 9					
Round 10					

Recreational Fisherperson

Introduction to your role:
You do not make your living fishing, but it is still very important to you. You fish for fun, because you like to eat beanfish, or because you like to make a little extra money by selling beanfish on the side. Even though each of you only catches a small number of beanfish, there are so many of you that your harvest can be significant. For this reason, you must follow whatever laws are set by the lawmaker just as the commercial watermen do.

What do the Recreational Fisherpeople do?
Because there are actually many more recreational fisherpeople than watermen, you will represent 25 fisherpeople. This means that if you take a scoop of beans that has 25 beans in it, each recreational fisherperson has caught one bean. Not bad. However, if you only catch 10 beans, then only 10 out of 25, 2/5ths, or 40% of the recreational fisherpeople have caught a bean. Not so good! When your harvests get below one beanfish per person, recreational fisherpeople begin to get worried.

At the end of each round, you will try to influence the lawmaker through a verbal recommendation telling her/him how well fishing is going and what you think should be done. Should fisherpeople be allowed to catch more each round or use bigger and better fishing gear? Or are you worried that too much is being taken? Keep track of the number of fish that you are catching with the chart on the other side of this page.

Remember:
Just because fishing is a recreation to you doesn't mean that you don't care what regulations are set by the lawmaker. You want the freedom to continue your way of life.

Round #	# of beanfish caught total	What percentage of the 25 fisherpeople you represent caught one feanfish (up to 100%)	Percentage of fisherpeople who caught more than one beanfish (up to 100%)	How content are your 25 fisherpeople with their catch?
Round 1				
Round 2				
Round 3				
Round 4				
Round 5				
Round 6				
Round 7				
Round 8				
Round 9				
Round 10				

Salmon Scavenger Hunt

OVERVIEW
Go on a salmon scavenger hunt to find out about threats to salmon populations. Gather information about some of the reasons wild salmon have gone from such incredible abundance to relative scarcity, and about some of the things people are doing to help salmon recover.

OBJECTIVES
Describe several ways in which human activities impact salmon at various points in their life cycle.

GRADE LEVEL
6-8

SUBJECTS
Science
Social Studies
Language Arts (research skills)

VOCABULARY
alevin, aquaculture, dissolved oxygen, egg, fry, hatchery, silt, smolt

TIME
One session plus research time

MATERIALS
copies of the “Salmon Scavenger Hunt” handout
research materials
Internet access

NATIONAL SCIENCE STANDARDS
This activity supports the following National Academy of Sciences science education standards.
Grades 5-8:
Standard F: Science in Personal and Social Perspectives—Populations, resources, and environments

NATIONAL SOCIAL STUDIES STANDARDS
This activity supports the following National Council for the Social Studies standards.
Middle Grades:
Standard IX: Global Connections—d
Standard X: Civic Ideals and Practices—e, f, j

Before You Begin
Make one copy of "Salmon Scavenger Hunt" handout for each student, arrange for access to the Internet, and collect research materials about salmon. (See Salmon Resources at http://worldwildlife.org/windows/pdfs/salmon_resources.pdf.)

What to Do
1. Set up the scavenger hunt.
Begin by asking the students to tell you what they know about the status of salmon. Are the fish as abundant as they once were? Why or why not? What problems affect different stages of the salmon's life cycle? What kinds of things are people doing to help salmon? Once you've gotten an idea of the students' base of knowledge, explain that they are going to go on a scavenger hunt to find answers to these and other questions.

2. Hand out the scavenger hunt sheet.
Divide the group into teams of four or five students. Next, hand out a copy of the scavenger hunt sheet to each student. Explain that each team should work together to find as many of the items on the sheet as they can. They can divide up the work in any way they want. Suggest that they search on the Internet, in the library, or through any research materials you have collected. (Note: You may want to talk with your students about how they might evaluate the accuracy of information presented in resource materials, especially information found on the Internet. Remind them that, just because something has been printed or posted online, it isn't necessarily true. They should note where the information came from and try to determine whether the author or organization responsible for the information is a reliable source.) Also explain that they may not be able to find every item on the list in the time allotted, but that they should do the best that they can. Now give the students time to do their scavenger hunt.

3. Review student findings as a group.
Once the students have completed their scavenger hunts, gather as a large group. Review their findings and have them add up their points. Were there any surprises on the list? Did everyone understand the threats?

4. Review threats to salmon.
Ask your students to consider the ways in which people compete with salmon for the land and water essential for the well being of both. Name some human activities that threaten salmon *(overfishing, fish farms, dams, forestry operations, farming and ranching, mining, and development--see "Fish Fate" for more).* Do those activities have any benefits? To whom? *(Dams generate electricity, forestry supplies wood products, development provides people with homes, and so on.)* Why might that make salmon conservation a controversial issue? *(There are good reasons for and against activities that harm salmon populations, and it's difficult to balance the needs of people with the needs of salmon.)*

Fish Fate—Major Reasons Salmon Are in Trouble

Since 1991, at least 26 runs (specific populations) of salmon in the Pacific Northwest, excluding Alaska, have been listed as endangered or threatened under the Endangered Species Act. (And four more runs are candidates for listing.) In general, salmon species that spend a larger proportion of their lives in fresh water are in greater trouble than those that spend less time in fresh water. And the salmon that spawn in southern states are in more trouble than those that spawn further north. (For example, salmon in Alaska are doing better than salmon in California.)

The following list discusses some of the major reasons that salmon are in trouble.

1. Commercial and recreational overfishing have historically posed a major threat to salmon by removing too many wild salmon from natural populations. Fortunately, both types of fishing are now regulated, but overfishing is still a problem for some salmon populations.

2. Aquaculture (fish farm) operations, if not regulated properly, release wastes that can harm salmon by washing into waterways and decreasing oxygen supplies. Wastewater from these operations can also carry antibiotics and other pollutants. Escaped farm-raised fish (which are typically Atlantic salmon—even in salmon farms on the West Coast) can spread diseases to wild fish and may compete with wild populations for food and spawning areas. In addition, sea lice and other parasites are a problem for many farmed fish. When wild fish swim near a fish farm, those wild fish can pick up parasites that pose a significant threat to their survival.

3. Dams are one of the biggest causes of salmon decline. There are more than 1,000 dams obstructing the flow of water in Washington alone. By slowing and changing natural water flows, dams can lead to an inadequate water supply downstream, raising water temperatures and allowing too much silt to collect. Hydroelectric dams can block fish from moving upstream to spawn, and they can reduce the number of juvenile salmon that successfully migrate to the ocean. Even dams with fish ladders can create problems for salmon. Adults may have difficulty negotiating them, becoming disoriented or injured in the process. And juveniles can easily become caught in the turbines if they don't use the fish ladders while moving downstream.

Dikes prevent coastal flooding by reducing the size of flood plains or preventing tidal surges from the sea. Estuaries, where rivers meet the ocean, are primary habitats for young salmon to mature, feed, and adjust to salty, ocean water. Squeezing salmon populations in shrinking estuarian habitats can be extremely detrimental to salmon populations. When a dike is built between the ocean and the estuary, the lack of salt water quickly kills off salt-water dependent marsh fish (such as salmon, herring, and perch) and invertebrates (such as clams and mussels); this die-off, in turn, decreases the amount of food for marsh birds. The absence of salt water also causes the vegetation to shift dramatically from salt grasses to freshwater plants.

4. Forestry operations can create problems for salmon. Removing trees can lead to increased water flow across the surface of the ground, increasing erosion and subsequently allowing more silt to wash into the stream. Removing trees and other plants that grow along streamsides can also reduce stream shading and cause water temperatures to rise. And clearing of forests right up to the stream banks deprives the stream of large trees that would otherwise fall into the streams and provide crucial fish habitat. In the last 50 years, two-thirds of the old-growth forests in the state of Washington have been logged. Those forests were particularly important elements in keeping streams healthy for salmon as they provided essential shading and cover.

5. Farming and ranching may also remove vegetation that shades the stream or that would otherwise end up in the stream and provide fish habitat. Farming and ranching operations may channel streams and drain wetlands, drastically changing the flow of water that is needed by salmon. In addition, when livestock are allowed access to streams, they can destroy banks and stream bottoms, increase the amount of silt in streams, contaminate the water with their droppings, and destroy fish-nesting sites. By removing water for irrigation or livestock watering, farmers and ranchers can change stream flows. In addition, pesticides and fertilizers that wash off agricultural lands may poison fish or reduce oxygen supplies.

6. Mining for gravel is another threat to salmon because it destroys streambeds, disturbing spawning grounds and causing increased water flows.

7. Expansion of cities and housing developments across the land is another major source of problems for salmon. Humans are competing for the same water and land that are essential for the preservation and productivity of healthy wild salmon populations. People have altered natural water courses, eliminated or degraded wetlands, cut down trees, and introduced toxic chemicals—particularly petroleum products, lawn and garden chemicals, sewage, and air pollution byproducts—into waterways. Loss of the estuarine wetland habitat, which is essential for healthy salmon populations, has been especially extensive.

8. Hatcheries can also harm salmon, even though they were originally developed to boost salmon stocks. These facilities take salmon eggs and sperm from adult salmon, hatch the eggs, and raise the young. Then they release the young into streams. However, sometimes these successful “progeny” are returned to the hatchery and unknowingly bred together, which can create salmon that are unfit to survive in the wild. Today, hatcheries are usually careful to use eggs and sperm from parents that are well adapted to the stream in which they will be released. This was not the case in the past, which led to the release of fish that were less able to survive in the wild. Hatchery fish may carry diseases that affect wild fish, so that threat is monitored now too. And sometimes hatchery fish don’t return to their own streams. Instead, they end up in streams far from their origins. When this happens, they interbreed with wild fish and reduce the wild fish population’s ability to survive. Commercial and recreational fishers catch many hatchery-raised salmon. Because those fish don’t end up returning to salmon streams, they don't die in the streams and, subsequently, replenish the nutrient supplies in the streams.

9. Invasive species not native to the Pacific Northwest—including *Spartina* grass, zebra mussels, Chinese mitten crabs, European green crabs, and Eurasian millfoil (an aquatic plant)—are spreading through the region and altering salmon habitats. For example, *Spartina* grass has already spread across 6,000 acres in Washington, crowding out the eelgrass that provides important rearing habitat for young salmon.

10. Natural predators, such as seals, sea lions, and seabirds, now exist in numbers that are out of proportion to the numbers of salmon they prey upon. Salmon and their predators have coexisted for centuries, but salmon populations have come under stress from many sides, reducing salmon numbers and causing an unnatural predator-prey balance.

11. Global warming, many scientists believe, may cause exceptionally high sea temperatures at lower latitudes, which will force salmon and other fish to move north if they can.

ASSESSMENT

Using the information obtained through the scavenger hunt, have the students write an essay or a letter to a newspaper editor. The writing should describe the current status of salmon, what threats exist, and what is being done to alleviate those threats.

Unsatisfactory—Three or fewer concepts are incorporated; incomplete ideas are presented.
Satisfactory—Four concepts are included in the essay or letter, at least three of which are presented as complete ideas.
Excellent—Four or more well-developed concepts are included, and there is a logical flow to the essay or letter.

EXTENSIONS

- Depending on the level of your group, you may want to organize mini-debates or mock town meetings around one or more of the topics discussed in step 4. Have the students debate the merits of keeping or removing a local dam that generates inexpensive power for a substantial number of residents but threatens a salmon species. Or have them argue for and against a new housing development in salmon habitat. They can use the Internet to find reasons people cite for and against these activities.

- Many of the issues brought up in this activity tie directly to the concepts of watersheds. You may wish to expand this activity to take a more in-depth look at watersheds--including the watershed your students live in. You may even want to monitor the health of a nearby stream.

CREDIT

Activity adapted from *Oceans of Life—An Educator's Guide to Exploring Marine Diversity,* a resource of World Wildlife Fund's *Windows on the Wild* biodiversity education program. For more information on *WOW* please visit www.worldwildlife.org/windows.

Salmon Scavenger Hunt

1) List five things that can destroy salmon eggs. (2 points each)
1.
2.
3.
4.
5.

2) List four ways that urban development can harm wild salmon. (2 points each)
1.
2.
3.
4.

3) List two natural predators of wild salmon in each stage of development. (2 points each)
Egg
1.
2.
Alevin
1.
2.
Fry
1.
2.
Smolt
1.
2.
Adult
1.
2.
Spawner
1.
2.

4) List two ways each of the following can harm wild salmon. (3 points each)
Dams
1.
2.
Forestry
1.
2.
Farming/Ranching
1.
2.

Fish Farms and Hatcheries
1.
2.

5) List two other potential threats to wild salmon. (3 points each)
1.
2.

6) What are three steps people are taking to help wild salmon? (4 points each)
1.
2.
3.

7) What are three things you can do to protect salmon? (4 points each)
1.
2.
3.

ANSWER KEY

1) List five things that can destroy salmon eggs.

- Disturbance of gravel (such as by movements of adult salmon, animals crossing the stream, and so on)
- Predation
- High water temperatures
- Freezing
- Suffocation by being covered with silt
- Pollution
- Flooding that washes them downstream
- Disease

2) List four ways that urban development can harm wild salmon.

- Clearing trees and shrubs from stream corridors (which can increase water temperatures in rearing areas)
- Increasing water runoff by increasing the amount of pavement
- Reducing water flows in waterways by diverting water for human use
- Releasing pesticides, fertilizers, oil, coolants, road deicers, and other chemicals into waterways
- Filling in wetlands
- Putting dikes in estuaries

3) List two natural predators of wild salmon in each stage of development.

Egg
fish, raccoons, ducks
Alevin
large aquatic insects, fish
Fry
fish, minks, otters, fish-eating birds
Smolt
fish, minks, otters, fish-eating birds
Adult
humans, seals, sea lions, orcas, sharks
Spawner
bears, eagles

4) List two ways each of the following can harm wild salmon.

Dams

- Block salmon movement both upstream and downstream
- Alter water flow
- Slow movement of young fish to ocean and thus increase their risk of predation and disease
- Affect stream and river habitat by retaining sediments (such as gravel and cobbles) that would serve as spawning habitat

- Kill salmon in the turbines

Forestry

- Increase water temperatures by clearing vegetation and removing shade
- Reduce woody debris, which serves as fish habitat in streams
- Introduce pesticides to waterways
- Increase amount of sediment in waterways that may cover nests or cover stream bottoms and thus eliminate the habitat adults need to spawn

Farming/Ranching

- Increase soil erosion by washing silt into waterways
- Introduce fertilizers and pesticides into waterways
- Degrade streams when cattle have access to them
- Reduce amount of water in stream by diverting water for irrigation
- Channel streams
- Remove large trees and woody debris from waterways

Fish Farms and Hatcheries

- Fish from farms and hatcheries may interbreed with wild fish and reduce the genetic fitness of the offspring.
- Fish from farms and hatcheries may introduce diseases to wild fish and compete with wild fish for food.
- These operations use up limited spawning habitat.
- They expose wild fish to antibiotics and other chemicals and may decrease oxygen supplies by increasing the amount of wastes in waterways.

5) List two other potential threats to wild salmon.

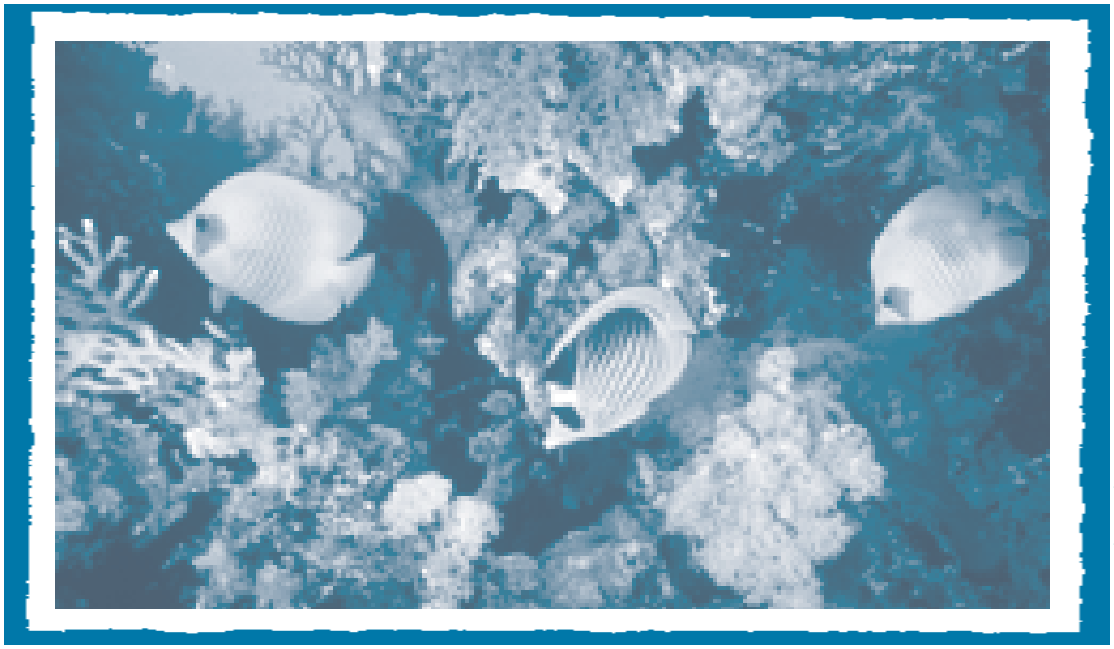
- invasive species
- climate changes
- changes in ocean conditions caused by global warming
- overfishing

6) What are three steps people are taking to help wild salmon?

- Leaving wide vegetation buffers along streams
- Keeping oil and other pollutants out of storm drains
- Removing dams that have outlived their usefulness and improving other dams so that fish can get past them
- Keeping livestock away from stream banks to prevent erosion and keep animal droppings out of the water
- Restricting the number of fish people are allowed to catch
- Reducing runoff and soil erosion
- Using cover crops between plant rows to absorb extra fertilizer and reduce runoff and erosion
- Reducing pesticide and fertilizer use
- Reducing the use of water and electricity
- Participating in stream restoration projects
- Educating others about the threats salmon face
- Writing letters to elected officials and fisheries managers to encourage them to take specific actions that will help salmon recover

7) What are three things you can do to protect wild salmon?

- Reduce use of water and electricity
- Participate in stream restoration projects
- Educate others about the threats salmon face
- Contact elected officials and fisheries managers to let them know how you feel about protecting wild salmon and their freshwater habitats

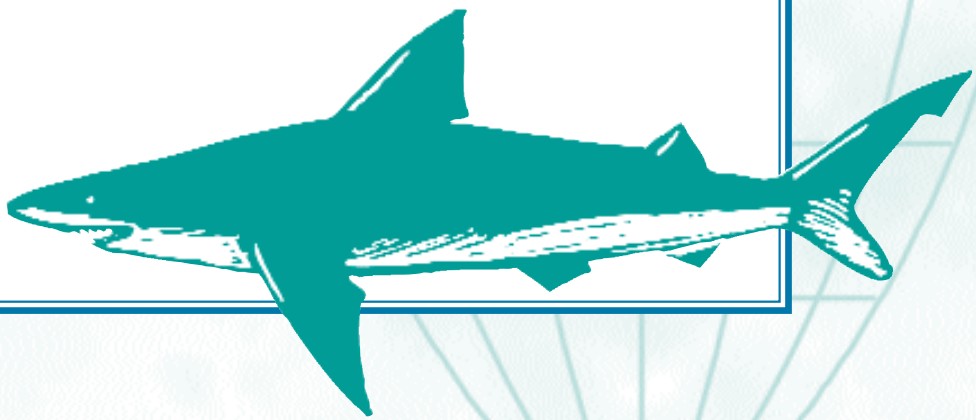


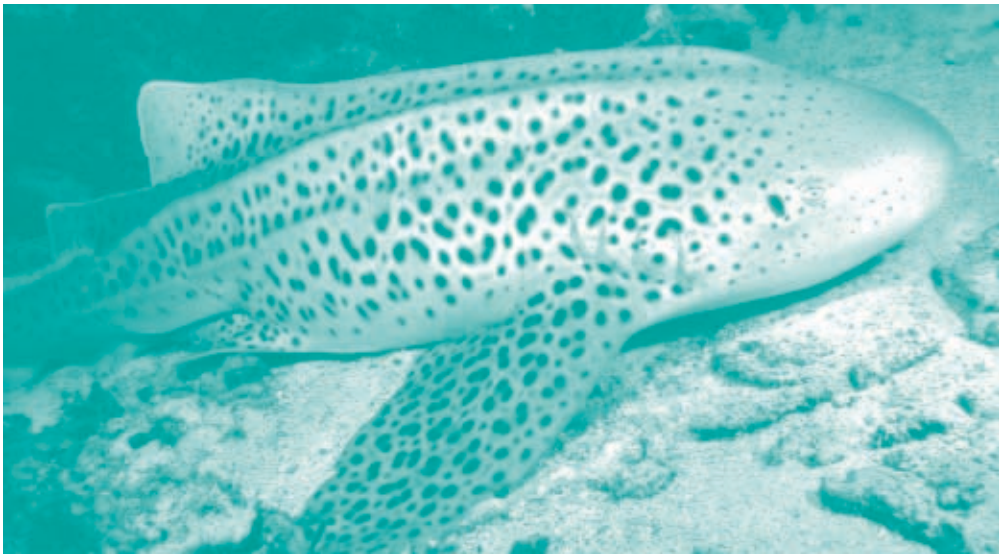
"We have overfished the seas systematically everywhere we have gone. We must act now, not 20 years from now . . . if we are to prevent further degradation of the marine environment."

–Elliot Norse, President, Marine Conservation Biology Institute

Case Study
Sharks

Read a recent article about sharks and you'll probably come away convinced that your next ocean swim will end with a deadly attack. But what those articles *don't* always say is that sharks rarely attack people. What's more, the frightening reports obscure a much bigger issue: Shark populations are actually declining rapidly worldwide. In this case study, your students will learn more about the diversity of shark species, the causes and costs of their decline, and the way attitudes and values of people around the world influence shark conservation.





WWF-Canon/Catherine Holloway

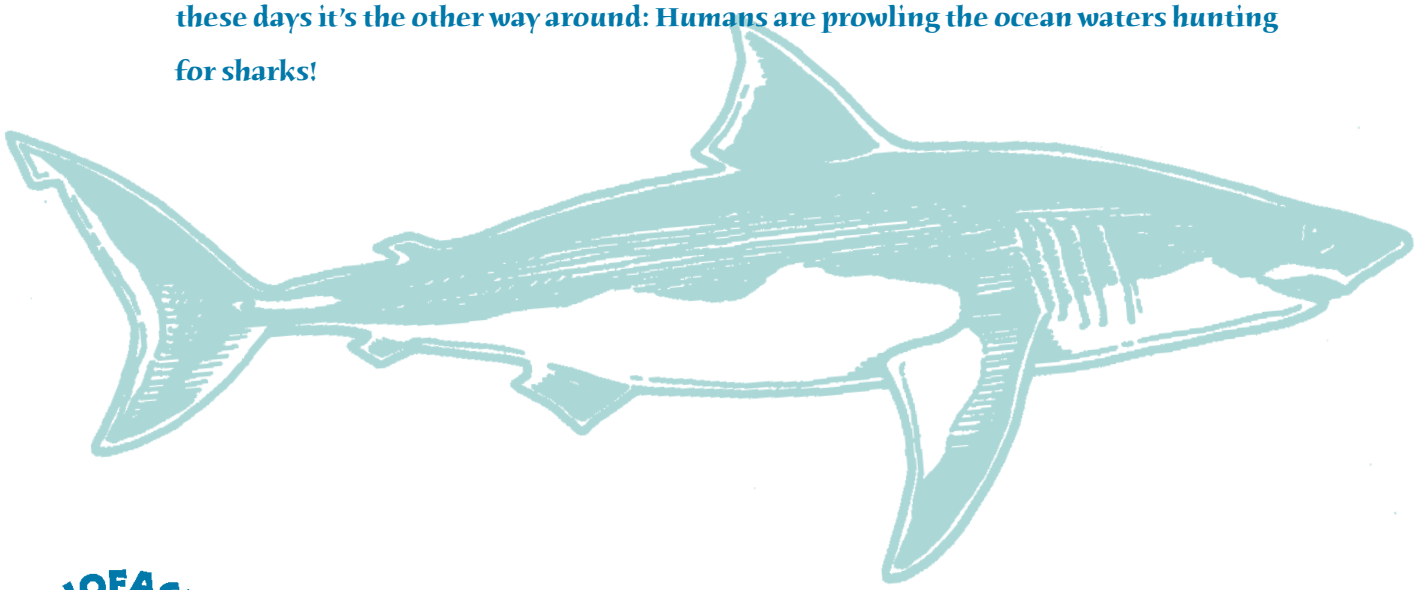
"Despite their fierce image, sharks are among the most vulnerable creatures in the ocean."

–Ocean Conservancy

Background Information

It's a hot summer day at the beach. Ready to cool off, you wade into the ocean and dip under the waves. You swim five, ten, twenty feet. And then it happens. For a split second, you think about sharks. What if a giant killer is lurking in the dark waters beneath you? What if you see a triangular fin heading your way? Your heart thumps and your spine tingles. Even though you know you shouldn't be so afraid, there's no fighting your imagination now. Spooked to the core, you turn in for shore. So much for an ocean swim. You hope the shower feels safe.

If you're like a lot of people, you may find sharks terrifying. But you might be surprised to learn that sharks don't really deserve their horror-movie reputation. They aren't prowling the ocean waters hunting for the next person to attack. In fact, these days it's the other way around: Humans are prowling the ocean waters hunting for sharks!



BIOFACT

Who's really more dangerous? For every person killed by sharks, an estimated 10 million sharks are killed by people.

Fishing for Sharks

Catching Sharks Catches On

The annual capture of sharks has been rising steadily in recent years. That may come as a surprise to those of us who have never seen a shark product, much less a shark. But three activities—recreational (sport) fishing, commercial fishing, and accidental catch—are contributing to the decline of shark populations.

Recreational Fishing: In growing numbers, people on both the Atlantic and Pacific coasts are paying for the thrill of trying to catch a shark. The sharks' tremendous fighting spirit gives people all the excitement they've been seeking in this extreme sport (see "The Magnificent Mako"). White sharks, commonly referred to as "great whites," historically have been considered a prize catch for sport fishers. But the National Marine Fisheries Service has banned targeted fishing of great whites because they have declined so dramatically. They are naturally rare, so they're easily overfished in the few areas where they are known to live.

In terms of numbers, recreational fishing isn't the biggest threat to shark populations. But it does present certain problems. One is that offshore fishers aim for big trophy sharks, such as makos. Makos grow faster than some other sharks and mature early, so large individuals have high reproductive potential. Capturing them means a great loss in terms of their potential offspring. In addition to offshore fishing, a lot of recreational fishing takes place near the shore, which is often a location for shark nurseries. That means that fishers may be taking pregnant females or juvenile sharks that haven't had a chance to reproduce at all. One good option for sport fishers is to practice "catch and release" when fishing for sharks.

Commercial Fishing: Many markets for shark products have expanded in recent years, driving commercial shark fishing to an all-time high. For example, the meat of thresher, porbeagle, and other sharks is now on the menu at many restaurants, replacing more traditional seafood that has become too rare or expensive. Restaurants in California have even been known to try to pass off the tasty meat of mako sharks as swordfish—a popular ocean fish that is depleted in some regions.

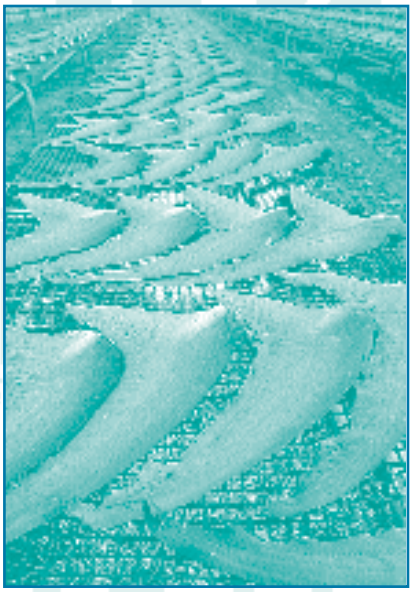
The Magnificent Mako

One of the most sought-after shark species is the shortfin mako. Mako sharks dwell in tropical and warm-temperate seas around the world. In North America, makos live off the coasts of southern California and Baja California as well as in the western Atlantic Ocean, including the Gulf of Mexico. Makos are powerful and fast, and they're known for leaping, thrashing, and attacking boats to resist capture. Fishers even tell stories of makos leaping into boats, jaws gnashing, scaring the people aboard into the water! But ultimately, even makos aren't fierce enough to avoid being killed by people.

shortfin mako

Shark Fins—Past and Future

An expensive bowl of shark-fin soup may not sound like a delicacy to you, but in Asia, it's a traditional dish that has been around for many years. In fact, sharks and shark parts are the basis of numerous foods, as well as health and beauty treatments, that are important in ancient Asian cultures. Hundreds of years ago, when shark products first became popular, shark populations were most likely larger and healthier. At the same time, human populations involved in exploiting these creatures were smaller, which meant that harvesting the sharks wasn't as destructive to the animals' populations.



©Mako Hirose/Seapics.com

But now, with growing human populations and the accompanying increase in demand for shark products, shark-fishing practices are causing serious conservation concerns. Reducing unsustainable shark fishing, while working to decrease the demand for shark products, may offer hope for reestablishing healthy populations in the future. It's important for conservation and cultural groups to work together to protect the diversity of life in the seas while respecting well-established cultural traditions.

Interest in other shark products is spurring commercial shark fishing too. Shark livers are used as a source of lubricants, vitamins, and cosmetics. Shark skin—once a popular material for cowboy boots—is still made into leather products. And powdered shark cartilage, considered by some people to be a powerful cure-all for everything from sore eyes to cancer, sells for as much as $100 per bottle, even though there is no reliable evidence that the powder is effective in fighting disease.

What's more, the market has skyrocketed for one small part of the shark: its fins. In Hong Kong and other places around the world, diners pay up to $90 for a bowl of shark-fin soup. When catching fish for their fins, many fishers will simply slice off the shark's fins and throw the shark back into the water alive. These injured sharks soon drown or die of starvation, infection, or predation.

Accidental catch: Fishers don't always catch sharks on purpose. Many times their nets and hooks accidentally snare sharks, as well as other fish, sea turtles, and marine mammals. When the species that are caught are unwanted, they are called *bycatch*. (Blue sharks, for example, are considered bycatch because their meat has very little commercial value.)

One of the biggest causes of accidental bycatch of sharks is *longline* fishing for tuna and swordfish. Longlines are thin cables or monofilament lines that may stretch as far as 40 miles across ocean waters. They have a float every few hundred feet and a baited hook every few feet. Unfortunately, longlines aren't very discriminating: Approximately 25 percent of all animals caught with longlines are discarded, and of those, up to 75 percent are sharks.

In 1989, about 80 percent of the sharks caught in the northwestern Atlantic as bycatch were killed and dumped back into the ocean. Today, as the value of shark meat and fins has grown, fishers keep more of the sharks they catch. But, of course, that doesn't increase the sharks' survival rates—it just reduces waste. Even worse, many sharks that are caught are immature and have not lived long enough to produce young.

great white shark

"Sharks around the world are facing a bleak future. In order to turn this tide, people will need to not only stop fearing sharks, but care enough to take action on their behalf."

–Sonja Fordham,
Shark Fisheries Specialist,
The Ocean Conservancy

The species that fishers catch and *keep*, even though they aren't the targeted species, are called *incidental catches.* For example, people fishing for tuna keep the makos and thresher sharks that get caught in their longlines or nets because the sharks are just as valuable at market as swordfish and tuna.

As you might have guessed, all these activities spell bad news for sharks. Scientists estimate that some species of coastal sharks in the Atlantic waters of the United States have declined by as much as 80 percent over the last 20 years. These numbers would create concern about any fish population. But in the case of sharks, they're especially troublesome. While sharks may be some of the top predators of the sea, they're not good at bouncing back when their numbers get low. To understand why, it's important to know more about sharks and their life cycles.

Shark Natural History

A Shark's Life

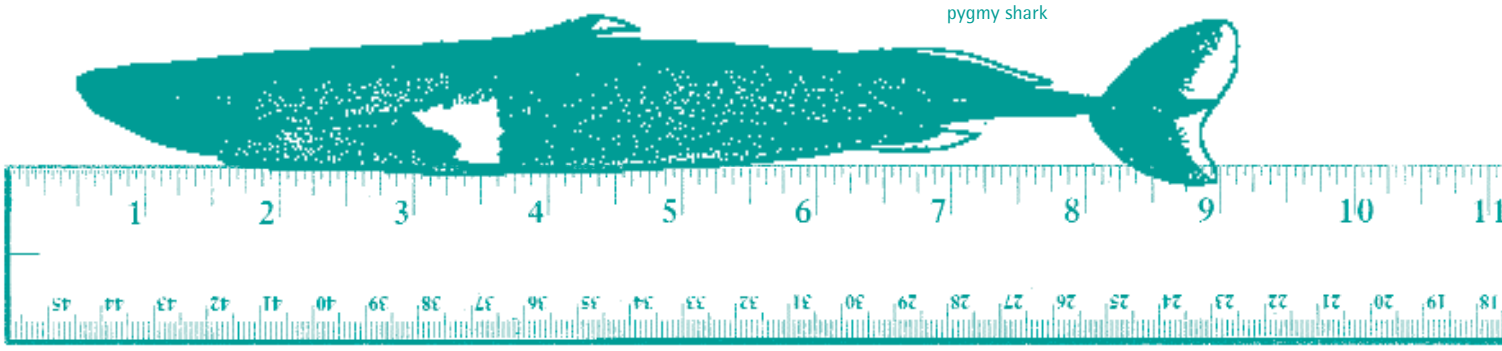
Sharks, along with skates and rays, belong to a group of fish called *elasmobranchs*. Elasmobranchs are distinguished from other fish mainly by their skeletons, which are made of cartilage rather than dense bone.

Most sharks have a few key characteristics in common. They have five or more gill slits on each side, unlike most fish, which have a gill cover, or *operculum.* They have leathery skin covered with tiny, sharp scales. Most sharks have tails that are asymmetrical—the upper lobe extends out over the lower lobe. (Lammid sharks, white sharks, and makos have symmetrical tails.) And sharks don't have swim bladders to keep them buoyant, which means they have to swim to keep from sinking. (*Pelagic* sharks, such as makos, also have to keep swimming in order to breathe, but not all sharks swim constantly. Angel sharks, like other *demersal* species, live at or near the bottom and can rest on the ocean floor.)

Variety of Lifestyles: Beyond those few simple facts, it's hard to generalize about sharks. That's because there are so many species of sharks—nearly 500 by last count—and the variation among those species is tremendous. (See pages 202-203 for examples of different shark species.) Some sharks live in fresh water, some live in coastal areas, and some live only in the deep sea. One of the smallest sharks, the spined pygmy shark, is only 8 to10 inches long; the largest, the whale shark, can grow to be more than 40 feet!

Interestingly, not all sharks reproduce in the same way. Some, including horn sharks and cat sharks, release their fertilized eggs into the sea, leaving them completely unguarded. (The eggs are protected inside tough, leathery egg cases.) Others, such as lemon sharks and hammerheads, retain the fertilized eggs, hatch them internally, and nourish them through placentas until they are old enough to be born. Still others, such as cookie-cutter sharks, retain the fertilized eggs, which hatch internally but receive no nourishment from the mother. Instead they must survive by eating unfertilized eggs and their smaller siblings! Despite these dramatic differences in reproductive strategies, all sharks have relatively long, slow life cycles.

All animal species go through their life cycles at different rates. At one end of the spectrum are insects such as fruit flies that can hatch, mature, reproduce, and die in a matter of days. At the other end are species such as elephants and people that take many years to mature, reproduce, and die. Sharks are more like elephants than insects. Most shark species grow slowly and mature late. In fact, dusky sharks don't reach their breeding age until they are more than 20 years old. Many shark species reproduce only every other year. Some sharks carry their young for two years. And many produce only a small number of young at a time.



Long Life Cycle Is No Longer an Advantage: When species live in unstable environments, it's advantageous for them to have a short life, mature early, and produce many young. This helps populations bounce back quickly when, for natural reasons, many individuals die. Sharks, on the other hand, evolved in a relatively stable environment, so they can invest more of their energy in living longer, fertilizing internally, and producing fewer and larger offspring. One advantage is that their young are born large enough to avoid their few predators and start feeding immediately on the fish, crustaceans, and cephalopods that form the bulk of their diet.

Unfortunately, sharks no longer have a stable, relatively predator-free environment. Overfishing by humans has reduced the numbers of many fish that sharks depend on for survival, making it harder for them to find food. And humans have become the predator that many sharks never had.

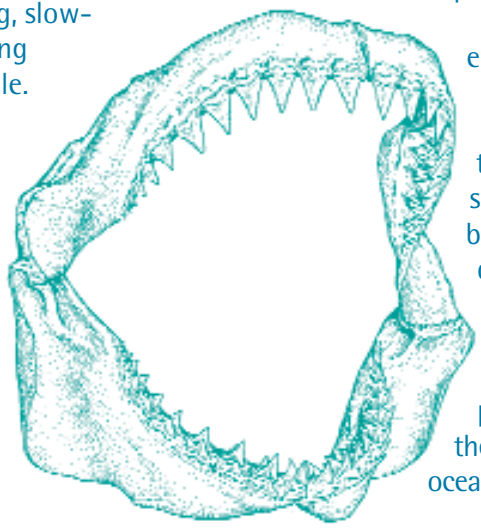
If sharks matured quickly and reproduced more rapidly, they might have a better chance of surviving the impact of these human activities. But sharks, like other species, cannot suddenly change their life cycles. Moreover, even swordfish—which release millions of young at a time—have been rapidly depleted by humans because females are being caught before they are sexually mature. So it's easy to see why late-maturing, slow-growing, small-litter-producing sharks are especially vulnerable. In the late 1990s, scientists estimated that sharks off the Atlantic Coast were being killed twice as quickly as they were reproducing.

What Good Are Sharks?

Many people would agree that sharks are remarkable to observe. Their sleek bodies, sculptured fins, and gaping jaws inspire not just fear, but also awe. Still, their real value is the role they play within their ecosystem.

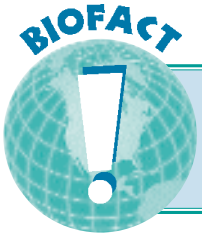
Some sharks, such as basking sharks, feed by opening their mouths wide and straining small fish and invertebrates from the water. Others, such as makos, chase down tuna, swordfish, and other large fish. Great white sharks and tiger sharks seek out larger prey, such as seals and sea lions. But adult sharks have few predators other than humans. For that reason, some are top predators within their ecosystem.

Some sharks eat the same kinds of fish that people do. But when it comes to selecting which individual to catch, sharks and people have different approaches. Sport fishers aim for the biggest, heaviest fish, and commercial fishers often capture fish at random. But scientists believe that sharks tend to catch sick, injured, older, or less agile animals—in other words, those individuals that are less capable of escaping an attack. In this way, sharks may help ensure that the fittest animals survive to reproduce, boosting the overall health of ocean populations.



Scientists are concerned about the effects that shark depletion could have on marine biodiversity—the overall species diversity of the sea. In addition to weeding out less healthy individuals, sharks take advantage of big population booms in their prey populations. In so doing, they keep any one species from becoming dominant and overwhelming other species that share their home.

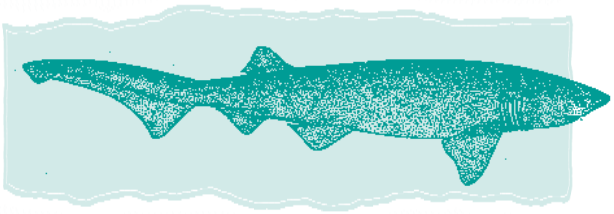
And, of course, sharks themselves are part of the overall diversity of the ocean. If they decline, the richness and variety of the ocean will be diminished too.



Shark's teeth, which are actually modified scales, grow in rows, and sharks can sometimes have as many as five rows of teeth at a time! Rather than growing along with the shark, sets of teeth are replaced with other sets of teeth as the animal matures.

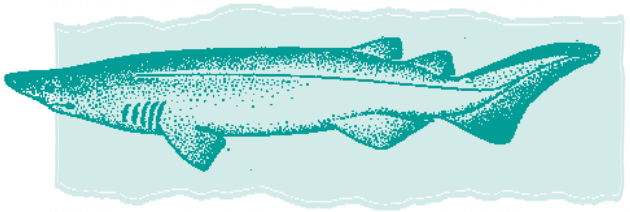
Name That Shark!

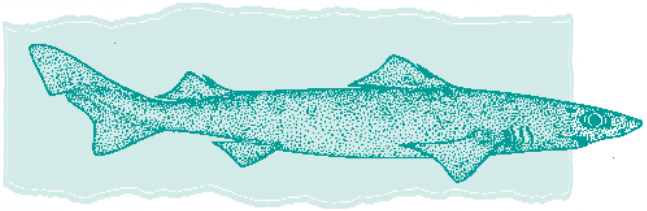
Few people know that there are nearly 500 species of sharks around the world. Check out these pictures to get a glimpse of the incredible diversity of shark species.



Bluntnose Sixgill Shark

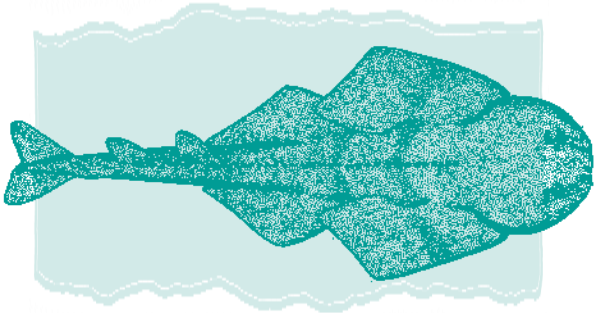
Prickly Shark





Gulper Shark

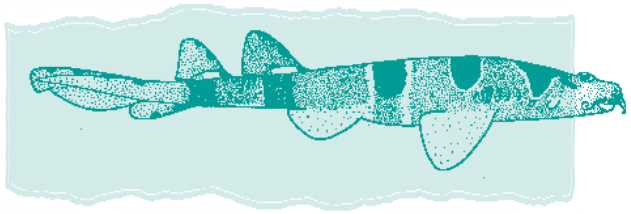
Mandarin Dogfish Shark



Sawback Angelshark

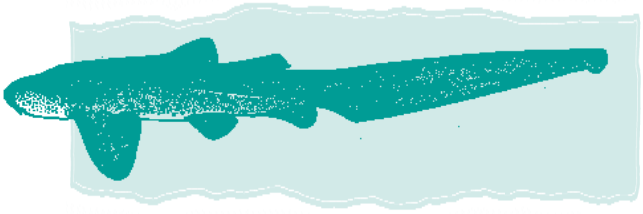
Zebra Bullhead Shark

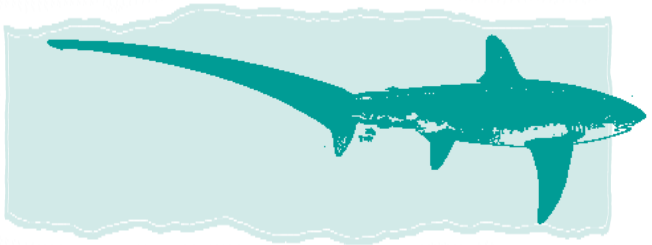
Name That Shark! (Cont'd.)



Northern Wobbegong Shark

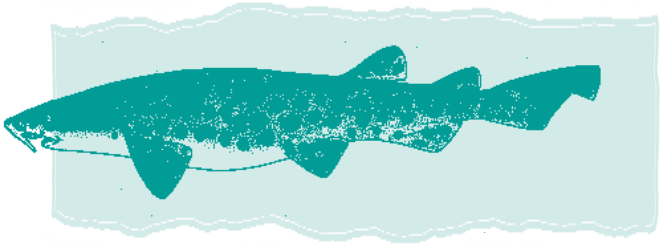
Zebra Shark

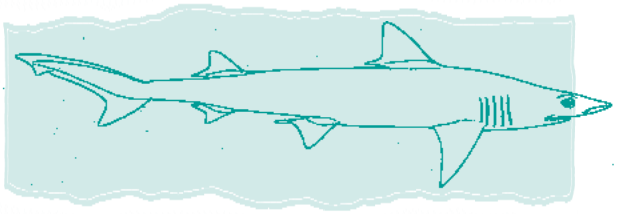




Thresher Shark

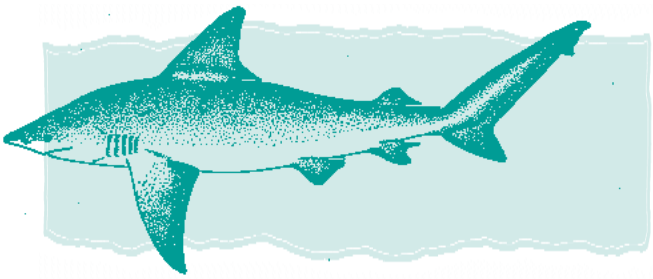
Barbeled Catshark





Hooktooth Shark

Sandbar Shark



Shark Solutions

Laws for Jaws

The U.S. government and some state governments have taken a number of steps to try to protect sharks from overfishing. In 1976, the United States declared exclusive control over fishing within 200 miles of its coastline. The federal government has now made it illegal to kill sharks in the Atlantic and Pacific Oceans just for their fins. It also established shark catch quotas, which set specific annual limits on shark takes in the Atlantic. Concern about shark depletion has led to even greater restrictions on shark fishing since 1997, when the government reduced the quota on some sharks in the Atlantic by 50 percent. In addition to these fishing controls, the establishment of marine protected areas in certain parts of the world is helping to protect shark nurseries and habitat.

All of these laws are good for sharks, but problems remain. After all, the United States is only one of 125 countries actively involved in trading shark products. Not all shark populations enter into international waters, so the United States can protect some species of sharks, but if other countries don't set limits on shark takes, laws that exist in only a few countries will not be enough to keep all shark populations healthy.

Also, shark quotas don't address the number of sharks killed as bycatch and thrown back into the sea. As it is now, the bycatch numbers are very large, and many marine conservationists think they need to be better controlled. (For more about marine legislation, see pages 341-344.)

Changing Views of Sharks

People's attitudes toward sharks vary widely from place to place and from culture to culture. For example, traditional Hawaiian cultures treat all sharks with respect in their religion, mythology, and daily life. By contrast, some Western cultures tend to view sharks as frightening creatures of the deep, that can pose a serious threat to human life. This attitude has done a great deal to fuel shark hunting, while making it very difficult for shark conservation to gain public support.

But there are signs that things are changing. Peter Benchley, the author of *Jaws*, now writes articles and essays explaining his new understanding of the creatures he once portrayed as ruthless man-eaters. He believes people need to respect and protect sharks. And perhaps they are beginning to do just that: New laws for shark conservation suggest that people are coming to recognize the importance of these fascinating fish. Perhaps as we learn more about sharks, we can get past some of our fears. We may still get spooked when we take a swim at an ocean beach, but that doesn't mean we can't recognize the vital role sharks play in the ocean environment and take action to ensure that they survive into the future.

BIOFACT

Scientists believe that ancestors of sharks swam through Earth's seas more than 400 million years ago—about 200 million years before dinosaurs.

"Jaws" movie poster

Courtesy of Universal Studios Licensing LLLP

"What I definitely have become—to the best of my ability—is a shark protector, a shark advocate, a shark appreciator, and above all, a shark respecter. Sharks have an extremely important place in the natural order . . . and we're just beginning to learn how complex and wonderful they are. I know so much more about sharks than I did when I wrote **Jaws** *that I couldn't possibly write the same story today."*

—Peter Benchley, author

1 What Do You Think About Sharks?

SUBJECTS
language arts, social studies, science

SKILLS
interpreting (inferring, identifying cause and effect, reasoning, elaborating), evaluating (critiquing, identifying bias)

FRAMEWORK LINKS
37, 40, 59, 60

VOCABULARY
attitude, fact

TIME
one session

MATERIALS
copies of "A Short Shark Story" (page 211), "Shark Survey" (page 212), and "Shark Meters" (page 213)

CONNECTIONS
For other values-clarification activities, try "Sizing Up Shrimp" (pages 160-165), as well as "The Spice of Life" in Biodiversity Basics *and "Perspectives" in* Wildlife for Sale.

AT A GLANCE

Explore your knowledge of and attitudes toward sharks by reading a short story.

OBJECTIVES

Identify statements that are facts versus those that are attitudes. Explore personal attitudes toward and knowledge of sharks. Describe some of the ways that knowledge and attitudes are related. Name several ways that attitudes about sharks can influence our actions toward them.

Man-eater. Predator. Monster of the deep. Read a popular account of sharks, and you'll likely come across these or similar phrases. In contemporary Western culture, sensational articles and spine-tingling movies such as *Jaws*, *The Deep*, and *Deep Blue Sea* have largely shaped our views of sharks. As a result, most people view sharks with fear and animosity.

But these views of sharks are not universal. Cultures that have long-standing ties to the ocean often view sharks with respect, if not reverence. New research is also helping people to see that sharks are not the indomitable people-killers we make them out to be. In fact, they are much more vulnerable to the actions of humans than we are to them.

In this activity, your students will get a chance to gauge their own knowledge of and attitudes toward sharks. And they'll review their classmates' results to see if there are any connections between what we know about sharks and what we *think* about them.

Before You Begin

Make one copy of "A Short Shark Story," "Shark Survey," and "Shark Meters" for each student.

What to Do

1. Give each student a copy of "A Short Shark Story."

Have the students read the story to themselves or ask for volunteers to read different paragraphs aloud.

2. Identify statements of fact and statements that are personal feelings or attitudes.

Have the students review the statements made by the characters in the story. Then have them: (1) Underline at least three statements that reflect the personal feelings or attitudes of the speakers, and (2) put a circle around at least three statements of fact.

If there is any confusion, ask one of the students to explain the difference between a personal feeling or attitude and a fact. Then have the students share some of the fact statements and attitude statements they selected.

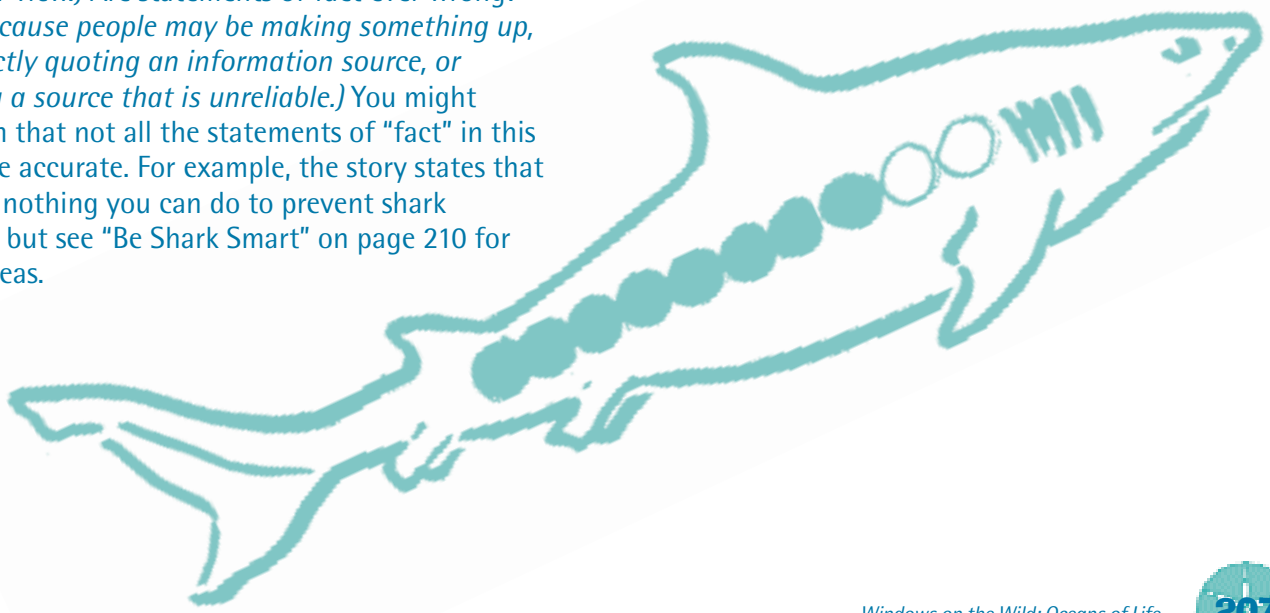
Afterward, ask the students if a person can have wrong feelings or attitudes toward sharks. *(No, because a feeling or attitude is just a personal belief or view.)* Are statements of fact ever wrong? *(Yes, because people may be making something up, incorrectly quoting an information source, or quoting a source that is unreliable.)* You might mention that not all the statements of "fact" in this story are accurate. For example, the story states that there is nothing you can do to prevent shark attacks, but see "Be Shark Smart" on page 210 for some ideas.

3. Hand out the "Shark Survey."

Have the students complete the "Shark Survey." In the first part of the survey, students will record their attitudes toward sharks. You might remind them that there are no wrong answers in this section. The second part of the survey poses questions of fact. There are correct answers to these questions (see page 214), but students should simply answer according to their knowledge and best guesses.

4. Hand out "Shark Meter" pages.

Now tell the students that they're going to tabulate the results of their "Shark Surveys." They should follow the instructions on the handout, filling in as many circles on each of the two sharks as is appropriate. The top shark measures attitudes: The more circles that are filled in, the more positively that student feels about sharks. The bottom shark measures knowledge: The more circles that are filled in, the more that student knows about sharks.



5. Review and discuss results.

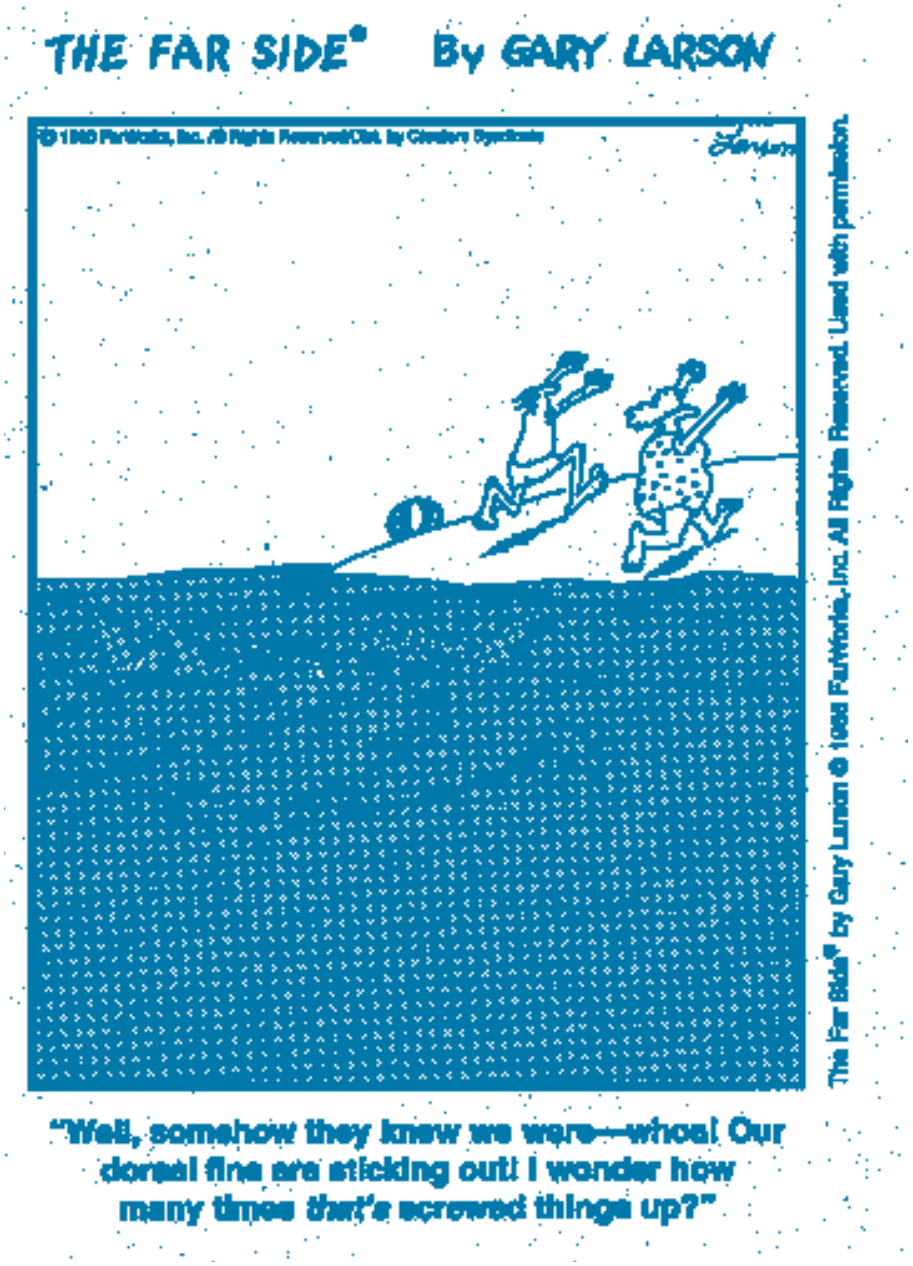
When students have finished calculating their attitudes and knowledge about sharks, encourage them to share their results. You might want to have the students post their "Shark Meters" in the classroom. Or, for a more active approach, have the students line up across the front of the room in five groups: those who scored a 1 or 2 in their attitude measurement, those who scored a 3 or 4, those who scored a 5 or 6, those who scored a 7 or 8, and those who scored a 9 or 10. You should end up with five groups separated just slightly in the order described. Into which category did most of the students fall?

Now ask for a show of hands from all the students: Who got 1 or 2 of the factual questions right? Who got 3 or 4 right? Who got 5 or 6? Who got 7 or 8? Did anyone get 9 or a perfect 10? As you survey the students, encourage everyone to keep an eye on where the hands are going up. Can they detect any relationship between knowledge and attitudes? For example, did people who knew the least about sharks generally have a better attitude or a worse attitude toward sharks than those who knew the most?

Ask some of the students to share examples of where they picked up their knowledge about sharks. Based on the sources mentioned, is this information likely to be reliable? Why or why not?

Finally, ask the group for a show of hands to vote for one or two possible answers to the following: If they had $100 to designate for wildlife conservation, and they could choose to give all of it to protect pandas or half of it to protect pandas and half of it to protect sharks, which would they choose? Tell them to assume that sharks are suffering major population declines (which they are). After students have voted, ask the students to again reflect on any patterns they observed. Did people's attitudes toward sharks correspond with their willingness to help protect them?

Explain to the students that, as this unit continues, they'll be learning more about sharks and the problems they face. It might be interesting to see if anyone's attitude toward sharks changes along the way.



WRAPPING IT UP

Assessment

The students are going to be the teacher! It's time for a test, but the students are going to create their own tests. In the center of a page, have the students write some statements about sharks—either facts or personal attitudes. On both the left side and the right side of the statements there should be blank lines. The lines on the left will be marked as "Fact" or "Attitude." The lines on the right side will be marked "Positive" or "Negative" to show how the student thinks each statement would shape a person's attitude.

Have the students put in the answers they believe are correct in their own tests. For fun, you could use statements from different students' assessments and do a "fun quiz" with the class. Grades won't be necessary, but see how well the statements worked.

Unsatisfactory—Elements of the test are missing, facts and attitudes are not clearly distinguished, and positive/negative responses are not all reasonable.

Satisfactory—Five to seven statements are presented with correctly distinguished facts and attitudes as well as reasonable positive and negative answers.

Excellent—Eight or more statements are clearly written with correct factual and attitudinal responses as well as reasonable positive and negative answers.

Portfolio

In their portfolios, students should include their "Shark Meters," as well as a few sentences explaining how people's attitudes about sharks may be linked to their level of knowledge about sharks. They can also include the tests they wrote for their Assessments.

Writing Idea

Each student can write a short piece that informs community members about sharks and the roles sharks play in marine ecosystems. In their pieces, students should address several common shark myths and provide factual information to help readers better understand how those myths came to be popularized and in what ways the myths may affect people's willingness to protect sharks.

Extensions

- Look for references to sharks in the media. Your students can compile a list of the representations of sharks they found and collect images of sharks in newspapers and magazines.
- Create a shark bulletin board. Have your students post their shark meters so people can compare the results. Or, have the students post any shark articles, poems, photographs, and drawings they find over the course of the unit.
- Show a short film or video about sharks. What views of sharks does this film convey? Did it affect the students' attitudes in any way?
- Have the students do some research to come up with a list of tips for being safe in coastal areas where sharks might be active. (Share the "Be Shark Smart" tips on page 210 with your students.)

BE SHARK SMART!

1 What Do You Think About Sharks?

1. Always swim in a group. Sharks are more likely to attack someone who's alone.

2. Never swim at night or at dusk or dawn. Sharks are most active at those times.

3. Swim in clear water. In murky water, a shark may mistake you for its usual prey.

4. Stay far from places where people are fishing or cleaning fish. Fish blood and guts can attract sharks and put them in a feeding mood.

5. Stay away from places where lots of small fish are leaping from the water. This could be a sign that a shark is chasing them. Also stay away from places where lots of seabirds are diving. That's a signal that small fish are nearby, potentially accompanied by sharks that like to feed on them.

6. Don't stay in the water if you are bleeding. Blood can attract sharks.

7. Don't wear shiny jewelry. Jewelry can look like flashing fish scales.

8. If you see a large shark, don't panic and start splashing around. That can make the shark think you're injured prey—an easy target. Just warn others and calmly leave the water.

9. If a shark ever does attack you, fight back. Hit its eye or gill areas with your fists or feet.

And here's one more tip: Don't worry, swim smart, and have fun!

BIOFACT

Each year lightning kills more than 70 times as many people as sharks do!

A SHORT SHARK STORY

1 What Do You Think About Sharks?

Carlos, Katie, and Katie's twin brother, Nick, stood on the beach and stared out at the blue waters of the Pacific.

"It looks so welcoming today," Katie said.

"No it doesn't. Look at those little waves," Nick said. "The more you look at them, the more they look like hundreds of shark fins popping out of the water."

Carlos shook his head. "You can't think about yesterday, guys, or you'll never get in the water. Do you want to learn the joys of surfing, or don't you?"

Katie nodded, hesitantly. Nick shrugged.

The day before had been a terrifying one at this same beach. A surfer had been lying on his board, waiting to catch the next wave, when a large shark came up and grabbed onto his board. Without even thinking, the surfer whacked the shark on the nose. The shark took a large bite of board and disappeared. The frightened surfer paddled to shore, too scared to even look behind him. Now everyone in Santa Cruz was talking about sharks—surfers, swimmers, you name it. Nick thought it was a pretty lousy time to be visiting California and getting his first surfing lesson.

"Sharks freak me out," Nick said. "I don't know if I can do this."

"Sure you can," Carlos said. "Did you know that you have a better chance of being killed by lightning than by a shark?"

"That may be true," Katie said. "But I can do stuff to avoid being struck by lightning. There's nothing a person can do to avoid being eaten by a shark."

"Except to stay out of the water," Nick said quickly.

"I'll admit it, every surfer I know has thought about sharks at one time or another," Carlos said. "How can you not? Scientists say a surfer lying on a board looks a lot like a seal or sea lion from a shark's perspective. And great white sharks eat lots of seals and sea lions."

"You're making me feel much better, Carlos," Nick said sarcastically, taking a step back from the waves.

"OK, so there is a risk," Carlos said. "But we take risks every day. It's risky to drive a car on a highway. At least out here I can catch a big, high wave and ride it in, with the sun beating on my shoulders and the water sparkling like a sapphire. That's worth a little risk!"

"It does sound pretty great," Katie said. "Should we go for it?"

"I think I'd rather surf in a swimming pool," Nick said.

"It's up to you," Carlos said. "But I can't stand wearing a wet suit without getting wet any longer." He waded into the water. "C'mon, Katie. Let's teach you how to catch a wave!"

"Are you coming, Nick?" Katie asked, turning to her brother.

"I don't think so," he said. "But I'll keep an eye on the two of you, just in case you get into trouble out there."

"You might regret this for the rest of your life, Nick," she said, wading in after Carlos.

"At least I'll have the rest of my life!" Nick answered.

SHARK SURVEY

1 What Do You Think About Sharks?

What Do You Believe?

1. Sharks are scary. . . . . agree/disagree
2. People who swim in oceans where sharks live are crazy. . . . . agree/disagree
3. Sharks are a little frightening, but they're not bad. . . . . agree/disagree
4. All sharks that swim near the shore should be killed. . . . . agree/disagree
5. Some kinds of sharks don't seem scary to me at all. . . . . agree/disagree
6. Sharks are interesting. . . . . agree/disagree
7. The world would be better off if there were no sharks. . . . . agree/disagree
8. Sharks are mean. . . . . agree/disagree
9. I worry about people killing too many sharks. . . . . agree/disagree
10. The ocean is a better place with sharks in it. . . . . agree/disagree

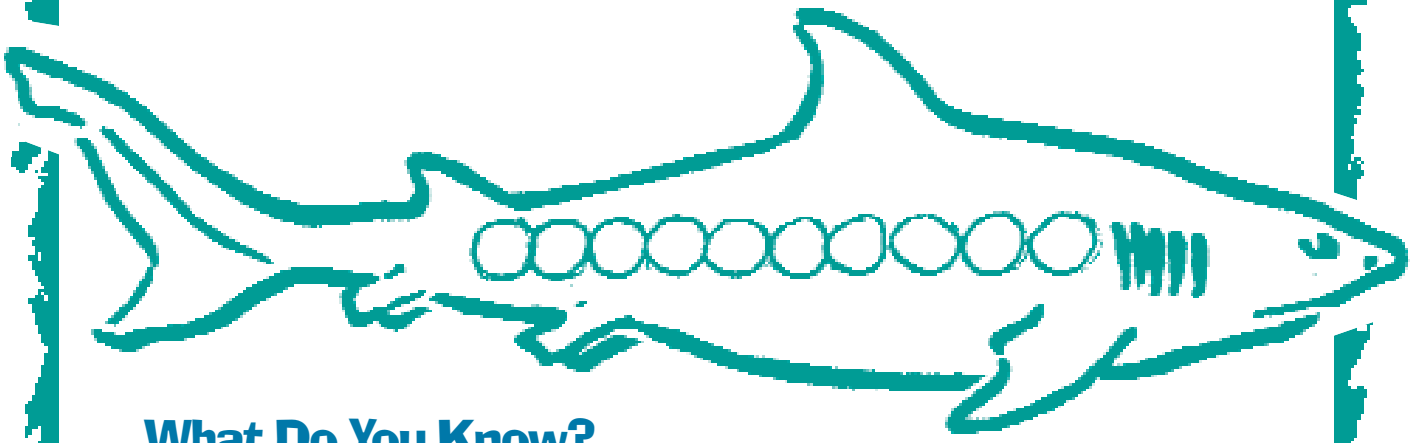
What Do You Know?

1. Sharks are a kind of fish. . . . . true/false
2. Almost all sharks live near the coast where people swim, snorkel, and surf. . . true/false
3. If you see a shark while you're in the water, it will probably attack you. . . . true/false
4. If a shark bites you, you will probably die. . . . . true/false
5. There are fewer than 100 species of sharks in the world. . . . . true/false
6. Some of our medicines are derived from shark products. . . . . true/false
7. Some adult sharks are less than a foot long. . . . . true/false
8. Some people eat sharks. . . . . true/false
9. Because people are taking special precautions, there are fewer shark attacks now than ever before. . . . . true/false
10. Sharks have few natural predators, so their populations are stable. . . . . true/false

What Do You Believe?

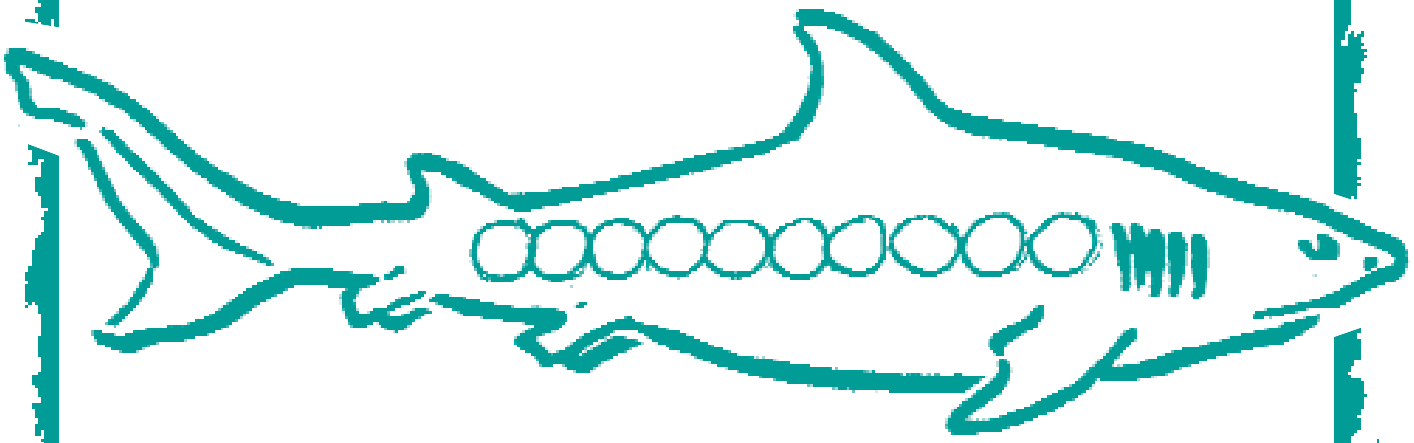
Compare the answers below with those you gave on your survey. Then fill in a dot on the shark meter for every answer you gave that matches the numbered answers here. (For example, if you had four matching answers, fill in four dots in a row, starting at the shark's tail.)

(1) disagree, (2) disagree, (3) agree, (4) disagree, (5) agree,
(6) agree, (7) disagree, (8) disagree, (9) agree, (10) agree.



What Do You Know?

Fill in a dot in the shark for every one of the questions you answered as follows:
(1) true, (2) false, (3) false, (4) false, (5) false, (6) true, (7) true, (8) true, (9) false, (10) false.



ANSWERS TO THE "SHARK SURVEY"

1. **True.** Sharks are a special kind of fish, though, because their skeletons are not made of dense bone. Instead, their skeletons are made of cartilage, like your ears or the end of your nose. So they're called *cartilaginous* fish.

2. **False.** Sharks live in a variety of ocean settings—from coastal areas to the deep ocean.

3. **False.** Sharks rarely attack humans, and when they do it's likely to be a case of mistaken identity: The sharks mistake the person for a sea lion, another marine mammal, or an injured fish. Sharks also may attack divers who bother them in some way.

4. **False.** Scientists think sharks often give people a bump or bite to investigate what they are (or to make them go away if they're bothering the sharks) and will not necessarily continue to attack.

5. **False.** Scientists have identified nearly 500 species of sharks worldwide.

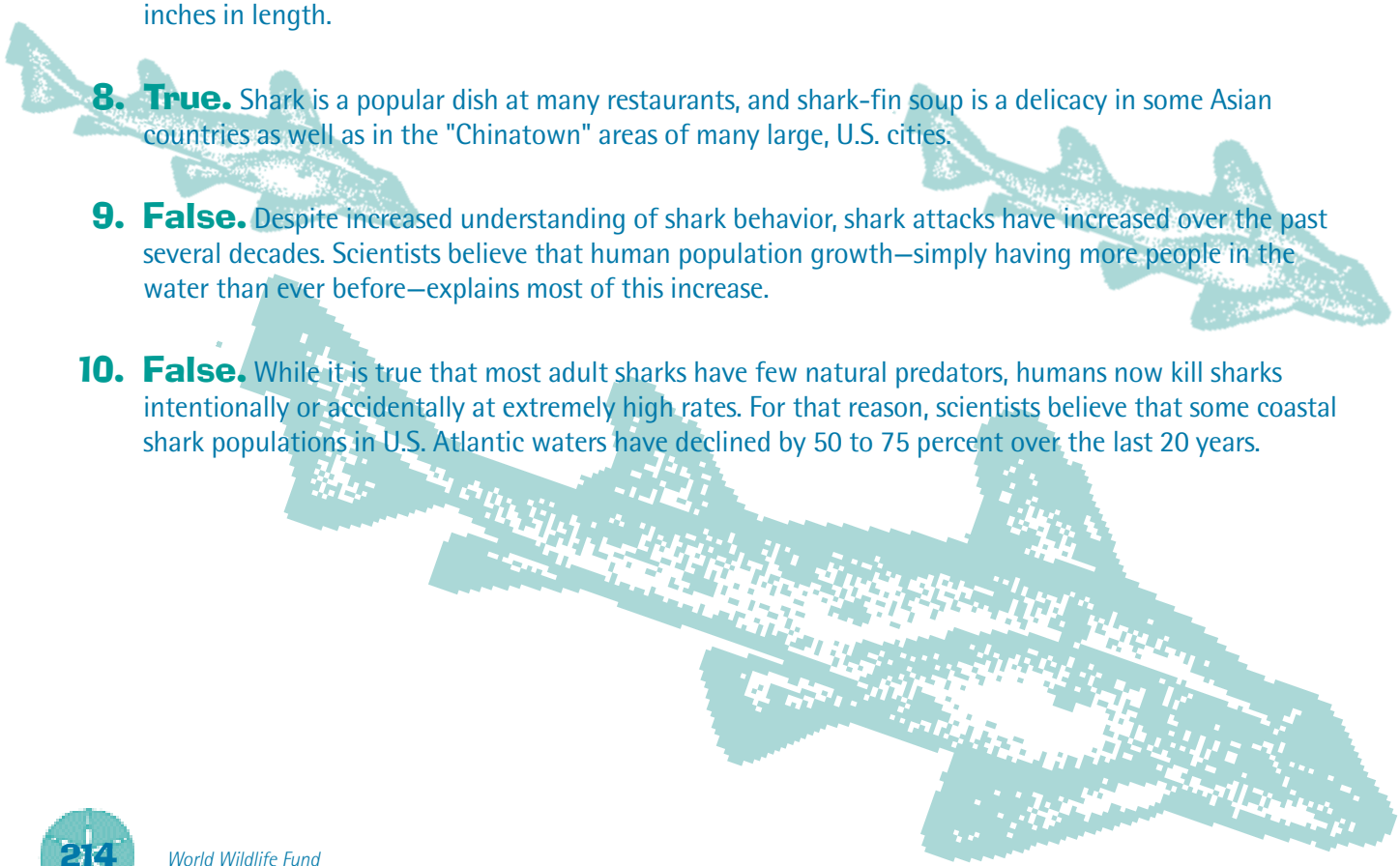
6. **True.** Parts of sharks have been used for everything from artificial skin for burn patients to anticoagulants for people with heart problems.

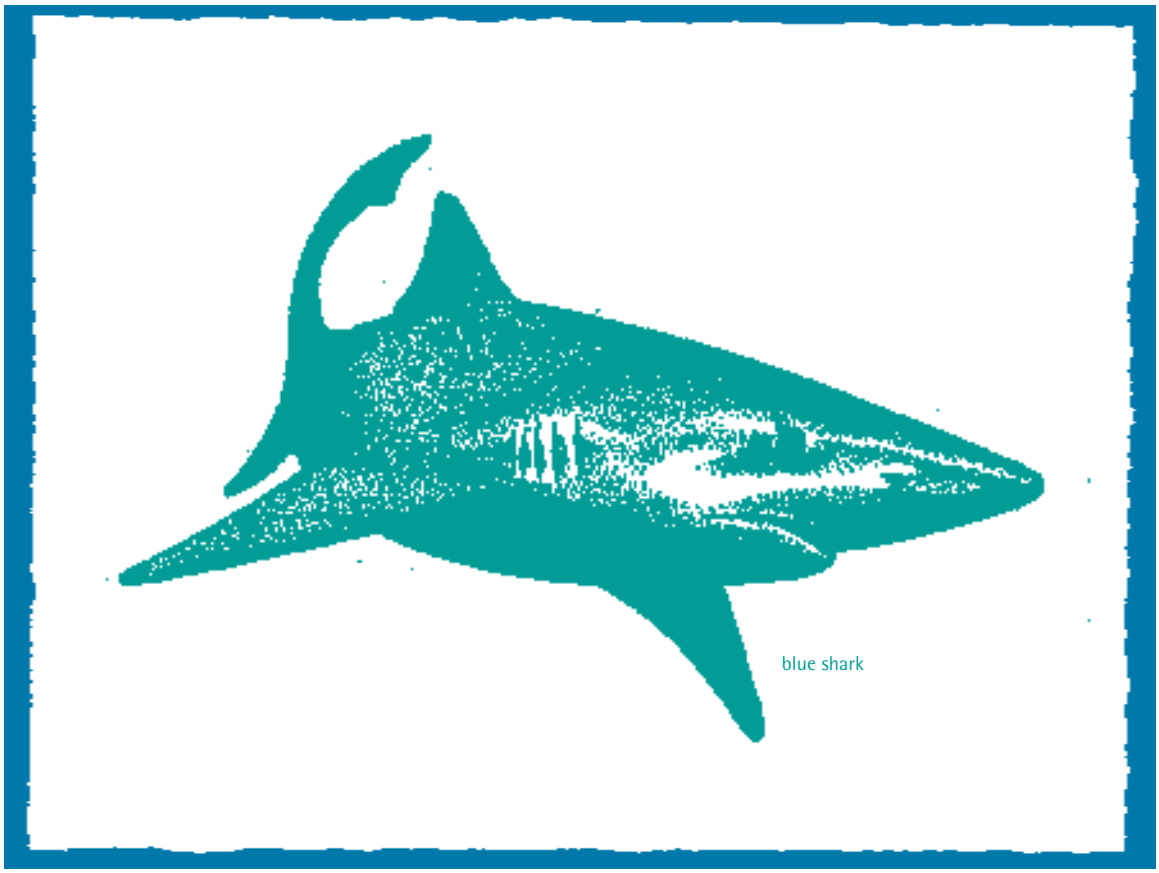
7. **True.** There are many species of small sharks. For example, adult pygmy sharks grow to be only 10 inches in length.

8. **True.** Shark is a popular dish at many restaurants, and shark-fin soup is a delicacy in some Asian countries as well as in the "Chinatown" areas of many large, U.S. cities.

9. **False.** Despite increased understanding of shark behavior, shark attacks have increased over the past several decades. Scientists believe that human population growth—simply having more people in the water than ever before—explains most of this increase.

10. **False.** While it is true that most adult sharks have few natural predators, humans now kill sharks intentionally or accidentally at extremely high rates. For that reason, scientists believe that some coastal shark populations in U.S. Atlantic waters have declined by 50 to 75 percent over the last 20 years.





blue shark

"We now know that the best shark is not a dead shark; that these oft maligned fish play critical roles in preserving balance in the marine ecosystem."

–Mike Hayden, President/CEO,
American Sportfishing Association

2 Where the Wild Sharks Are

SUBJECTS
science, language arts

SKILLS
organizing (classifying, categorizing, arranging), interpreting (translating, relating, reasoning), applying (restructuring, composing)

FRAMEWORK LINKS
1, 1.1, 2, 3, 17.1, 18, 21, 23.1

VOCABULARY
barbels, bathypelagic, **biodiversity,** *bottom trawls,* **coral reefs,** *epipelagic,* **estuaries,** *kelp beds, luminescence, mesopelagic, mollusks, pelagic,* **plankton,** *rays,* **trawl**

TIME
one to two sessions

MATERIALS
copies of "Meet the Sharks" (pages 220-223) and Clues—"Where the Wild Sharks Are" (page 224); large drawing of "Ocean Zones" (page 226); scissors, string, tape, crayons or markers (optional)

CONNECTIONS
Use "Sea for Yourself" (pages 72-81) to get students interested in learning about different marine species as well as the importance and uniqueness of their habitats.

AT A GLANCE
Identify shark species and determine where in the ocean each species lives.

OBJECTIVES
Describe some of the different ocean zones. Describe several species of sharks and the parts of the ocean in which they live.

The vast expanses of water in the oceans seem so much alike. That's why students are often surprised to learn that the ocean has different zones of life, defined primarily by the depth of water and distance from shore, as well as by geographic distribution—from polar to temperate to tropical regions. In this activity, students will learn about some of the different zones in the ocean as they meet a range of shark species and piece together information to determine where each one lives.

Anja G. Burns

Before You Begin

Make one copy of "Meet the Sharks" and "Clues—Where the Wild Sharks Are" for each student or pair of students. Redraw the "Ocean Zones" diagram (from page 226) on a large piece of paper. You can label the ocean zones yourself or leave them blank and have your students label them, using the clues on the handout. Do not put the numbers on your drawing. Students will be asked to place their sharks in the correct zones, but they do not have to have the exact placement as shown on page 226.

What to Do

1. Discuss shark attack scenario.

Begin by describing this scenario to your students:

"A 12-year-old girl is attacked by what witnesses call a 'big shark' in waist-deep water on the Florida coast. After her mother pulls her to safety, the girl receives 72 stitches to her leg and survives."

Ask the students if they think it would be difficult to identify the kind of shark that attacked the girl. Are there many different kinds of sharks? Are they similar or quite different? Explain to your students that sharks vary a lot from one species to the next. In this activity, each student or pair of students will determine the habitat of an assigned shark species and assess whether their species might have been the shark that attacked the girl.

2. Hand out copies of "Meet the Sharks" and "Clues—Where the Wild Sharks Are."

Tell the students that the information on "Meet the Sharks" will introduce them to 25 species of sharks, all of which can be found in North American waters. Can someone define the term species? *(A species is a group of organisms that have a unique set of characteristics [such as body shape and behavior] that distinguish them from other organisms. If they reproduce, individuals within the same species can produce fertile offspring.)* You might explain to the students that there are nearly 500 shark species worldwide. Assign one species to each student. (Some may need to work in pairs or work on two sharks, depending on your class size.) Tell the students that their job is to read the information and clues to determine where their particular shark species lives. Have the students cut out the shark with its description and, if you wish, tape one end of a piece of string to the back of it. They can also color the shark if they'd like.

3. Discuss ocean zones.

While the students are preparing their sharks, hang up the ocean zone diagram. When the students are ready, ask them to think about conditions in the ocean. If they walk into the water right off the beach, what is the ocean like? *(Shallow, cold in winter but warmer in the summer or in the tropics.)* If they were able to keep walking into deeper and deeper water, how would the ocean change? *(It would get darker and colder. Fewer or no plants would be growing on the ocean floor, there would be fewer or no coral reefs, and so on.)* Remind the students that, because of variations in light, temperature, and other conditions, species of fish and marine mammals are usually better suited to one part of the ocean than the other, just as some land animals are suited to different climates, different parts of a forest, and so on.

Discuss the four oceans zones (epipelagic, mesopelagic, bathypelagic, and coastal), explaining the characteristics of each (see page 224). Point out to your students that, while most sharks spend the majority of their time in one particular zone, they do travel throughout various ocean zones especially to feed.

At this point, if you haven't already labeled the ocean zone diagram, ask for volunteers to use clues from the handout to fill in the blanks.

4. Affix sharks to chart.

Now invite the students to come forward and place their sharks in the appropriate zones of the ocean, explaining what clues led them to this conclusion. (Mention that some students may need to wait until other sharks have been placed before they can place their own species accurately.) They can either tape the sharks directly in the zones or tape them nearby using a piece of string to connect them to the proper zone. Also, have the students say whether they think their species of shark could have been responsible for the shark attack described at the beginning of the activity. Why or why not? (See page 226 for appropriate zones.)

You may want to remind the students that, although this diagram will indicate the particular ocean zone each shark species prefers, it doesn't reflect their geographical distribution. For example, blue sharks are found all around the world, but Atlantic angel sharks are found only in the ocean waters from Massachusetts to the Caribbean. Yet both appear in this diagram together.

5. Discuss results.

After students have completed their handouts, discuss the following questions.

- What are some of the reasons that different species of sharks favor particular zones of the ocean? *(Some follow preferred food sources, some are better adapted than others to cold water and dark water, some are too large for shallow water, and so on.)*
- Were you surprised that some of the larger sharks, such as great white sharks and tiger sharks, often venture into coastal areas? Why does this make sense? *(These sharks feed heavily on marine mammals, which are concentrated close to land.)*
- Biodiversity is a word that means the variety of life on Earth—including genes, species, and habitats. What aspects of biodiversity did this activity cover? *(The activity illustrated the great variety of shark species and provided examples of some of the different types of habitats where they live.)*
- Do the students notice any pattern in the distribution of sharks on this diagram? *(Although the diagram is not comprehensive, it does show more sharks in coastal areas than in other parts of the ocean.)* You might take this opportunity to explain to your students that marine biodiversity is not evenly distributed across the oceans. Certain areas—such as coral reefs and other coastal habitats—contain disproportionately more species than other areas. And these areas are often more vulnerable to harm from pollution, destructive fishing practices, and other problems caused by people.

whale shark

BIOFACT

Whale sharks are the largest fish in the sea, reaching lengths of over 40 feet and weights of up to 20 tons.

WRAPPING IT UP

Assessments

Ask students to draw a cross-section (side view) of the ocean floor. They should identify some of the different zones in their diagrams and label what changes there would be between each zone. Have the students name a shark that would live in each zone.

Unsatisfactory—Only one or two zones are identified with differences clearly noted, or several zones are identified but no differences are explained.

Satisfactory—Three zones are identified with differences named. At least one shark is assigned correctly to each zone.

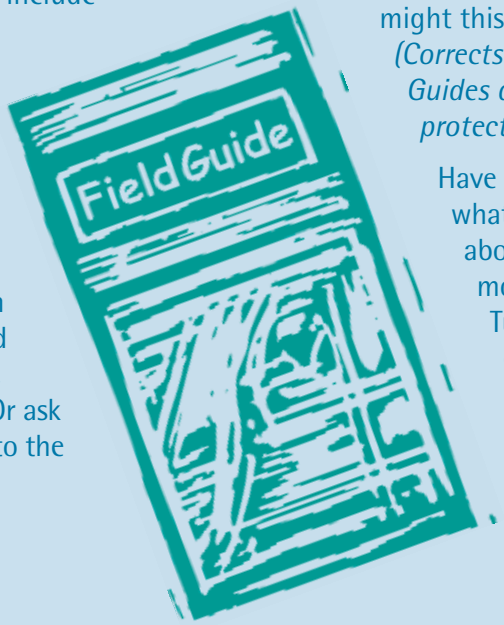
Excellent—Four zones are identified with differences named. At least one shark is assigned correctly to each zone.

Portfolio

If students complete one of the shark mystery challenges (page 227), have them include a short piece on their mystery species in their portfolios. Or, if students pursue research as outlined under the first Extension activity, have them include the reports in their portfolios.

Writing Idea

Have students create field guide entries for each of the species highlighted in the "Meet the Sharks" diagram. Field guide descriptions include information on the species, such as its common and scientific names, length, coloration, habitat, range, and preferred diet. Or ask students to write up their answers to the "Shark Mystery Challenges."



Extensions

- Have each student choose one species of shark and put together a short report on it. The report should describe its preferred food, geographic distribution, method of reproduction, and other interesting aspects of its life and behavior.
- Give each student a copy of "Shark Mystery Challenges" on page 227. Explain to the students that our current understanding of sharks lags well behind our knowledge of many other kinds of animals. Can they guess why? *(For many years, information about sharks was obtained primarily through brief glimpses of live sharks and the study of dead specimens. As diving equipment became more sophisticated, scientist began to slowly accumulate data on shark behavior. Year-round, close-up observations were first possible when people began to keep sharks in captivity. Another boost has come quite recently with the development of advanced scuba equipment, which enables divers to stay underwater for long periods of time. Now scientists are able to observe sharks in their natural environment and tag sharks for long-term monitoring.)* Why might this information be helpful? *(Corrects misconceptions about sharks. Guides decisions about how best to protect sharks over the long term.)*

  Have each of your students investigate what scientists do and do not know about sharks by researching one or more of the mysteries on page 227. Turn to page 228 for help with evaluating their answers.

Note: These pictures are not to scale.

1. Frilled Shark

Frilled sharks are about six feet long and have soft, eel-like bodies. This has led some people to observe that they look more like sea snakes than sharks. Frilled sharks feed on octopuses and bioluminescent squids and are sometimes caught in bottom trawls.

2. Bramble Shark

The bodies of bramble sharks are covered with thornlike spines that help them glide through the water. The large, slow-moving shark will sometimes float motionless, perhaps looking for hidden octopuses and rockfish.

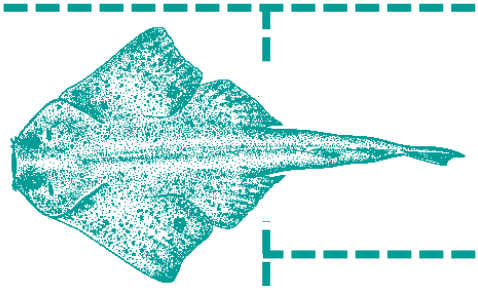
3. Spined Pygmy Shark

The spined pygmy shark is one of the smallest sharks in the world, reaching lengths of only about eight to ten inches. It is blackish-brown on most of its body and has a luminescent underside.

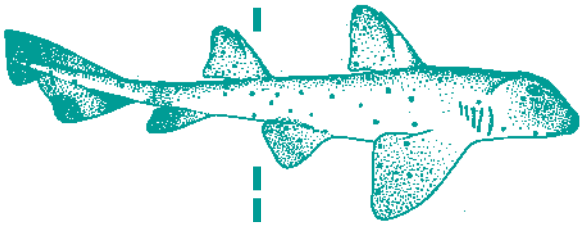
4. Cookie-Cutter Shark

Scientists finally discovered why small, round holes covered the bodies of some tuna, porpoises, whales, and sharks when they observed how the cookie-cutter shark feeds: The shark holds its mouth against the skin of its prey, sucks in a cylinder (or plug) of flesh, tears it off with its sharp teeth, and leaves a hole. These strange sharks emit a greenish glow.

5. Atlantic Angel Shark



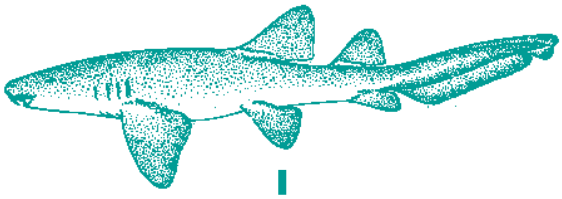
Also known as a sand devil, the Atlantic angel shark looks a lot like a ray. Angel sharks feed on mollusks, skates, flounders, and other creatures. They are found in the same zone as lemon sharks, but tend to burrow under the sand.



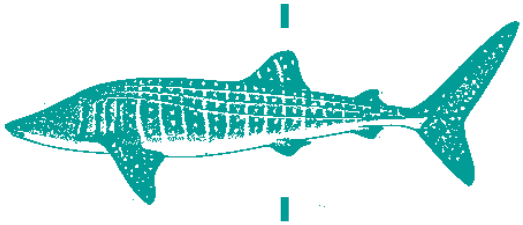
6. Horn Shark

Horn sharks have a short, blunt head with high ridges above the eyes. By day, they often hide in kelp beds, emerging at night to feed on small fish, mollusks, and other creatures.

7. Nurse Shark



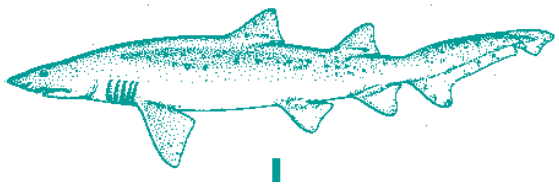
Sluggish and generally docile, nurse sharks often lie on the ocean floor without moving. But watch out! Some divers have made the mistake of touching the quiet sharks, only to receive a sudden, severe bite in response. You can recognize nurse sharks by long fleshy appendages, called barbells that hang below their snouts. These sharks are commonly found in the vicinity of reefs.



8. Whale Shark

Whale sharks are gentle giants that are covered with spots and stripes. They're the largest fish in the world, averaging about 32 feet in length. Certain individuals may reach lengths of more than 40 feet! But whale sharks are very docile, feeding on plankton and small crustaceans on the surface, usually well off shore.

9. Sand Tiger Shark

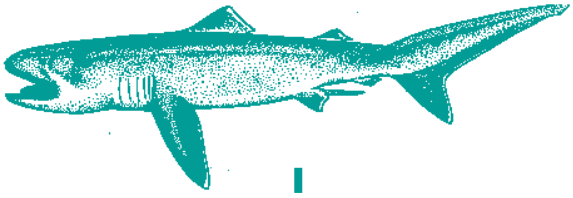


Sand tigers are voracious eaters, consuming a steady diet of fish and squids, and they've even been known to feed on sea lions and other mammals. Nonetheless, these large sharks are essentially gentle and rarely dangerous. Groups of sand tiger sharks often gather around rocky reefs.

10. Goblin Shark

The unusual snout of the goblin shark extends out from its head in a long, flat blade. It is one of the rarest of shark species. Little is known about the goblin shark's feeding habits, but it is thought to spend most of its time swimming at depths of more than 3,500 feet.

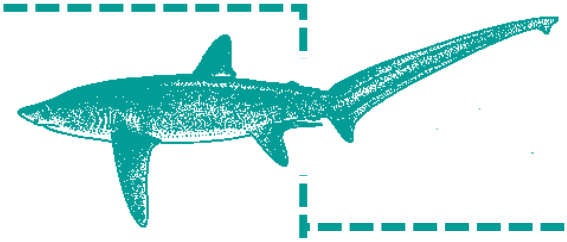
11. Megamouth Shark



In 1976, a U.S. Navy crew stationed off Oahu, Hawaii, found an enormous shark entangled in a large sea anchor about 500 feet below the surface. Apparently the shark had tried to swallow the anchor and died. The shark, new to science, was given the name megamouth shark because of its huge, wide mouth.

12. Bigeye Thresher Shark

Bigeye thresher sharks feed primarily on squids and small tuna, and often get caught in tuna fisheries longlines. Like other thresher sharks, they have extremely long tails, which scientists think they may use to round up or even stun fish.

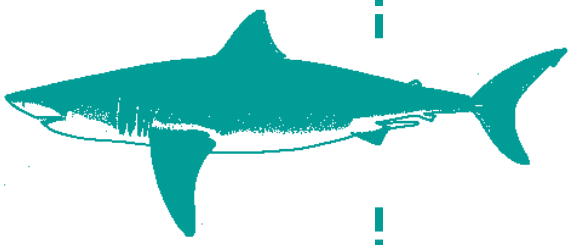


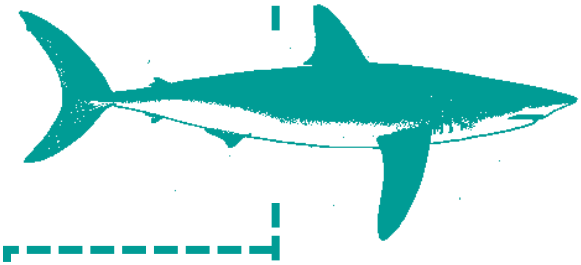
13. Basking Shark

Basking sharks swim with their mouths open, gulping water and plankton and then straining out the water. The second largest species of shark, basking sharks are reported to attain lengths of 40 to 45 feet. In summer, they are often seen basking near the surface of the water.

14. Great White Shark

Few animals cause as much terror as great white sharks. They are strong swimmers, and they prey on seals, sea lions, porpoises, tuna, sea turtles, and other sharks. They often congregate around seal and sea lion rookeries and are responsible for one-third to one-half of all human shark-attack fatalities each year. But that doesn't mean that a lot of people are killed by them: The total number of fatalities internationally from great white shark attacks was only ten for the entire 1990s.



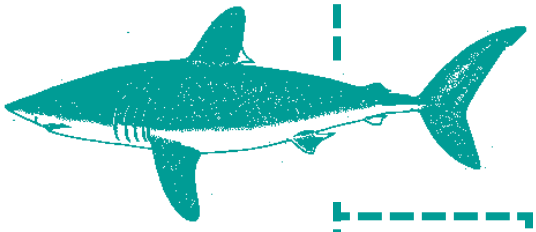


15. Shortfin Mako

The fastest of all sharks, shortfin makos prey on other sharks, swordfish, and tuna. They are among the most beautiful and powerful fish in the sea. But they're probably best known for their fierce antics when caught on a fishhook. They can leap high in the air to try to shake out the hook and, in an attempt to escape, may even attack fishing boats and the people in them.

16. Porbeagle Shark

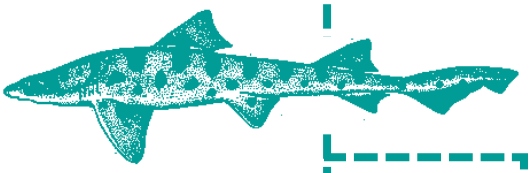
In the nineteenth century, porbeagle sharks were heavily fished for their liver oil, which was used to tan leather. These sharks feed on squids, and fish such as mackerel, cod, and flounder.



17. Brown Cat shark

Only about two to three feet long, the brown cat shark feeds primarily on shrimp and small fish. It has a chocolate brown body and green eyes.

18. Leopard Shark

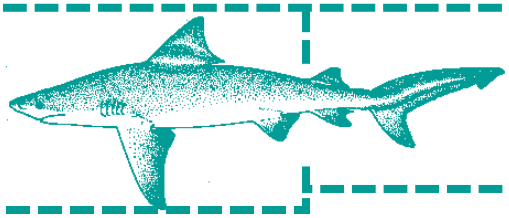


This shark is spotted like a leopard and eats small fish, crabs, sea worms, and other organisms. Leopard sharks are sometimes seen in large schools by divers and kayakers, but they are harmless to humans.

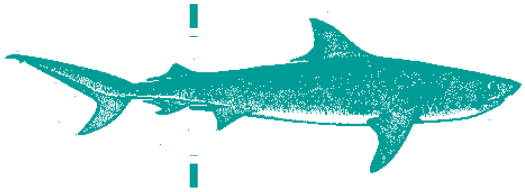
19. Silky Shark

A fast-moving shark with unusually smooth skin, the silky shark feeds on organisms such as squids, mackerel, tuna, and pelagic crabs. Sometimes they swim in the same ocean area as blue sharks.

20. Bull Shark



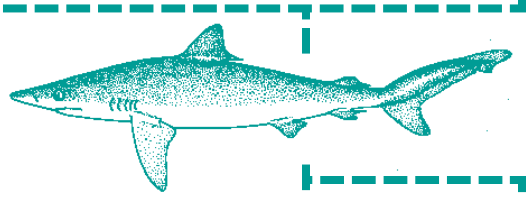
Bull sharks are sizable predators—they can grow to the length of 11 feet. They have been known to attack swimmers in estuaries, rivers, and freshwater creeks that flow directly into the ocean.



21. Tiger Shark

The tiger shark is striped like a tiger and weighs as much as 2,000 pounds. Although they usually feed on marine birds and seals, a variety of items have been found in the stomachs of tiger sharks, including: squids, lobsters, smaller sharks, turtles, canned peas, lumps of coal, the leg of a sheep, and human remains.

22. Night Shark

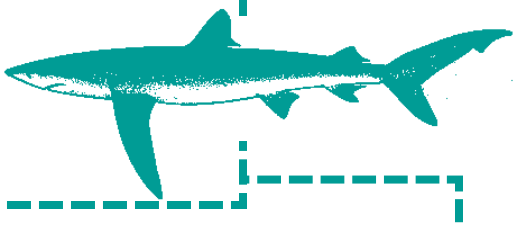


Night sharks search for fish and shrimp with their large, green eyes. They give live birth, and their litters usually range from 12 to 18 pups.

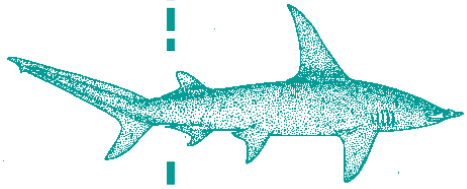
23. Lemon Shark

Lemon sharks are active around docks and estuaries, and they feed on fish, crabs, seabirds, and more. They look somewhat like bull sharks, but they have distinctive yellowish undersides.

24. Blue Shark



One of the widest ranging sharks, blue sharks have been known to swim more than 40 miles a day! Their migrations keep them in cool waters, where they feed largely on schooling fish and squids.



25. Great Hammerhead Shark

You won't have any trouble identifying a hammerhead: Its head is shaped like a wide rectangle with eyes at either end. It is a voracious eater, making a meal of rays, smaller sharks, and other fish. Hammerheads are very common around tropical reefs.

CLUES—WHERE THE WILD SHARKS ARE

1.
The two largest sharks in the world reside in the same ocean zone.

2.
Kelp beds grow just off the coast in many temperate climates.

3.
Sharks with large eyes and/or green eyes tend to live in the deepest parts of the open ocean.

4.
Swordfish, tuna, and squids are often found in the epipelagic zone.

5.
Sharks that dwell in the bathypelagic zone often have luminescence (the ability to glow), which may allow them to communicate and capture prey in the ocean's darkest, deepest waters.

6.
An estuary is a place where freshwater creeks or rivers empty into the sea.

7.
Seals and sea lions tend to congregate on islands and rocky coasts.

8.
Cookie-cutter sharks and green dogfish are found in the same ocean zone.

9.
Bottom trawling is a fishing method in which a large net, or trawl, is dragged along the seafloor bottom to catch shrimp and pelagic fish.

10.
Many coral reefs are found in coastal zones.

11.
Porbeagles and shortfin makos are found in similar habitats.

12.
Leopard sharks and horn sharks live in the same zone, but they're found in different parts of the world.

OCEAN ZONES

Coastal: Located near the shore, and stretching from the ocean's surface to a depth of 650 feet, this sunlit zone is home to a wide variety of marine species—from squid to sea lions.

*__Epipelagic:__ This zone, similar to the coastal zone, is located in the open ocean rather than near the shore. Phytoplankton flourish in the abundant natural light, providing nutrients for a wide array of marine animals.

*__Mesopelagic:__ Extending from about 450 feet to 3,300 feet, light penetrates the upper areas of the zone, but the lower reaches are almost completely dark.

*__Bathypelagic:__ No sunlight touches this region (3,300 feet to about 13,200 feet, not including the sea floor), but bioluminescent animals thrive in the dark waters, producing their own light to lure prey.

*Pelagic means "of the open ocean."

ANSWERS

(1) bathypelagic

(2) bathypelagic

(3) bathypelagic

(4) bathypelagic

(5) coastal

(6) coastal

(7) coastal

(8) epipelagic

(9) coastal

(10) bathypelagic

(11) mesopelagic

(12) bathypelagic

(13) epipelagic

(14) coastal

(15) epipelagic

(16) epipelagic

(17) bathypelagic

(18) coastal

(19) epipelagic

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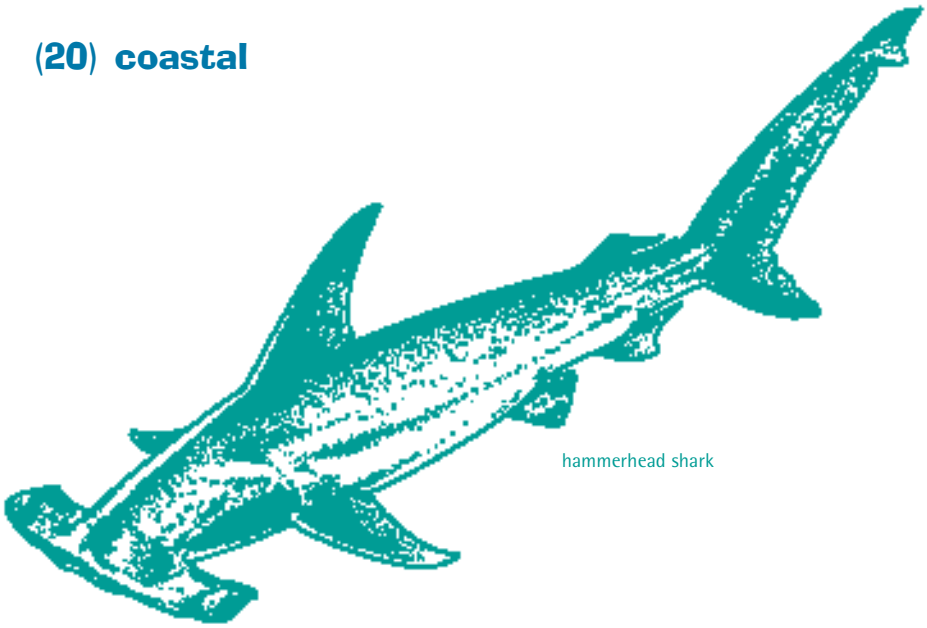
(22) bathypelagic

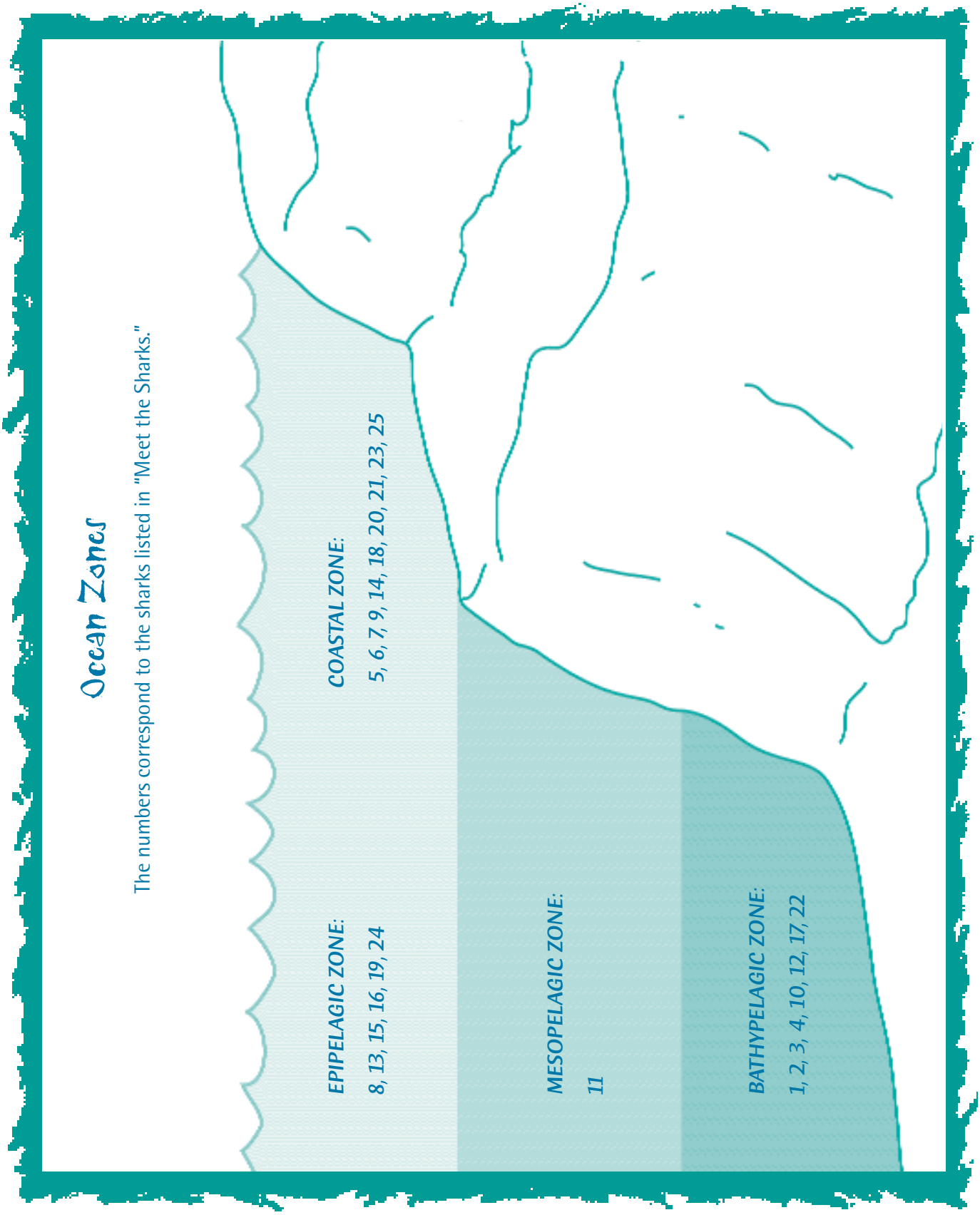
(23) coastal

(24) epipelagic

(25) coastal



hammerhead shark


Ocean Zones
The numbers correspond to the sharks listed in "Meet the Sharks."
COASTAL ZONE:
5, 6, 7, 9, 14, 18, 20, 21, 23, 25
EPIPELAGIC ZONE:
8, 13, 15, 16, 19, 24
MESOPELAGIC ZONE:
11
BATHYPELAGIC ZONE:
1, 2, 3, 4, 10, 12, 17, 22

1.

Your Uncle Hughie is the director of a large aquarium. For years, his visitors have been begging him to display a live great white shark. Now Uncle Hughie has asked you to look into the matter. Do great white sharks survive in captivity? If so, what are their basic living requirements? If not, can you recommend another shark that would be more suitable . . . and still please the public?

2.

You've learned how to scuba dive and can't wait to take a dive off the coast of California. But there's one problem: You're terrified of sharks. You've decided you're willing to buy the best equipment to keep you safe. What kinds of inventions have been designed to help protect people from sharks? Which ones work? How? Is there anything else you can do to reduce your risk of attack?

3.

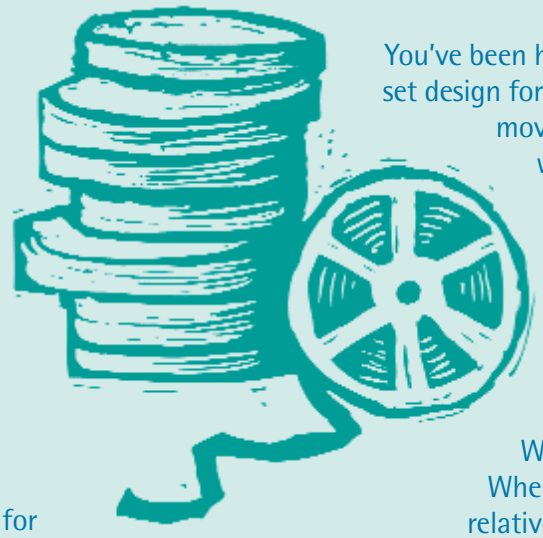
A friend tells you, "Sharks aren't good for anything." You disagree, so you propose a bet. He'll pay you $5 for every benefit sharks provide for people and the planet. How many benefits can you find? What are they? How much money does your friend owe you?

4.

You've learned that a tour boat leader has started "chumming" the waters about three miles from your favorite beach. Chumming means spreading bait, such as animal blood and oil, to attract sharks for viewing and filming. You think this sounds bad. Can you justify your concern? Why or why not?

5.

One day you're walking through a fish market in Southeast Asia, and you come across a shark you can't identify. You buy the shark—not to eat it, but to compare it with pictures you have of sharks in your favorite shark book. After a bit of searching, you tell your travel companions that you think you've found a new species of shark. They think you're crazy. How could you justify your position? How could you find out if you really do have a new species of shark?



6.

You've been hired to help create the set design for a new *Jurassic Park* movie. The producers want to have an ocean scene, but they aren't sure which animals were around during the Jurassic period. Can you find out which sea animals existed at that time? Were sharks present? When did the first shark relatives appear on Earth?

7.

Your mother tells you that she's found a delicious-looking recipe for shark-fin soup, which she hopes to serve at her next dinner party. You think the recipe must be a joke, and you're determined to talk her out of it. What can you find out about shark-fin soup?

ANSWERS TO "SHARK MYSTERY CHALLENGES"

1.

There are about 100 species of sharks on display in aquariums around the world. The sand tiger shark, bull shark, sandbar shark, blacktip reef shark, and whitetip shark are some of the sharks that have adapted most easily to aquarium life. By contrast, the great white shark has never done well in captivity. In general, sharks do well if they have enough space and if scientists know enough about their feeding habits to keep them well fed.

2.

One important thing you can do to lower your risk of a shark attack is to avoid diving, swimming, or snorkeling when sharks are most active—at dusk or dawn. Some wetsuits have been designed to mimic the striped coloration of pilot fish, which sharks don't eat. But these suits don't work: Sharks don't avoid pilot fish because they're striped, but because healthy and strong pilot fish are too hard to catch. More successful suits have been made with tiny interlocking stainless steel rings, which are able to protect a person from a shark's bite. Unfortunately, these suits are very expensive. (For more tips on avoiding shark attacks, see "Be Shark Smart" on page 210.)

3.

Many very large sharks, such as great white sharks and tiger sharks, feed on seals, sea lions, and other marine mammals that eat large amounts of mollusks and other small organisms. The sharks' predation helps keep populations of those mammals from depleting their own prey populations. Smaller sharks provide food for other species. Sharks have also been useful as medicines: In the 1930s, shark liver was used widely as a source of vitamin A, but now vitamin A can be synthesized, so this use is no longer common. Shark corneas have been used successfully as transplants for human corneas. Shark cartilage yields a kind of artificial skin used for victims of burns. Anticoagulants from sharks are used for treatment of cardiac problems. And an extract from shark bile has been shown to be useful in treating acne.

4.

Scientists are still investigating the effects of chumming on sharks and people, but in general people are concerned that chumming makes sharks unnecessarily dependent on people and may put nearby swimmers and divers at risk.

5.

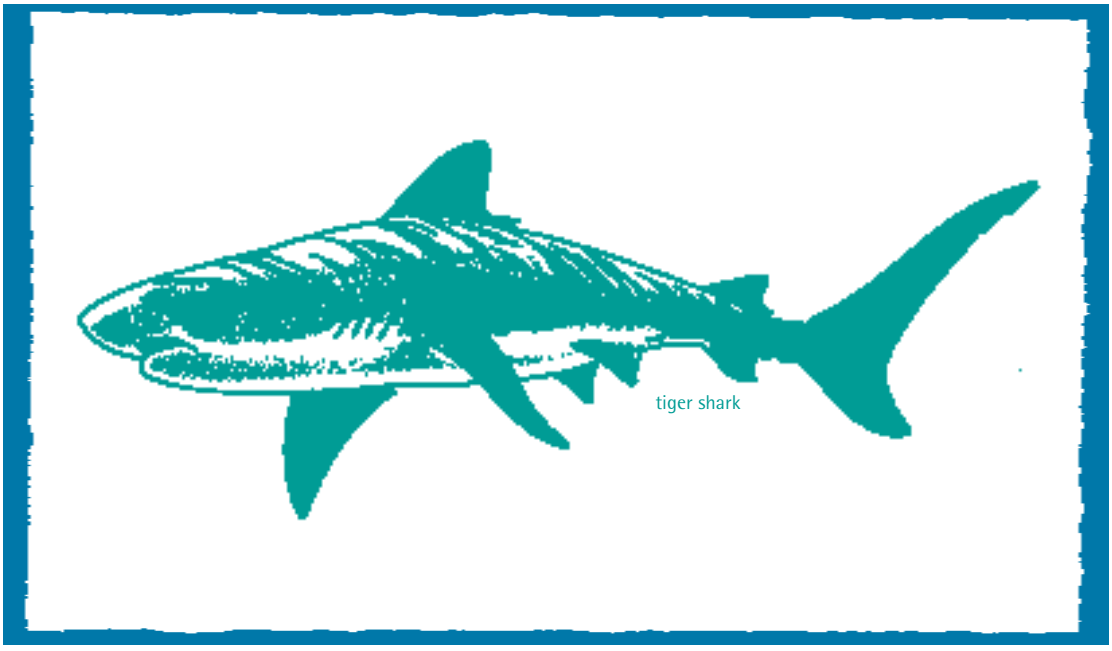
So far, scientists have identified nearly 500 species of sharks. Most scientists believe that we have not yet discovered all the shark species that exist in the world. For example, in a study conducted in 1998 and 1999, scientists discovered 14 potentially new species of sharks at a fish market in the Philippines. So finding a new species of shark at a market isn't as crazy as it may seem. You could consult a shark field guide or an expert to see if your species has previously been recorded.

6.

Sharks were beginning to dominate the sea by the Jurassic period, some 208-155 million years ago. Other animals present in the ocean at that time were turtles, clams, snails, and corals. The first primitive sharks appeared at least 400 million years ago. That means they preceded dinosaurs, trees, mammals, and flying insects!

7.

There are indeed many people who believe that shark-fin soup is a delicacy. Unfortunately, the food spurred a practice called finning—catching a shark, removing its fins, and throwing it back into the water. These sharks die after being finned and, since so little of the shark has been used, the practice is both wasteful and a contributing factor in the decline of sharks worldwide. Shark finning has been banned in U.S. waters, and many shark-fin products worldwide now come from fisheries that make use of the entire fish.



tiger shark

"In all our lives there are milestones, important moments we remember long after. This was one of them. For the brief time of his appearance I drank in every detail of the shark—his eyes, black as night; the magnificent body; the long gills slightly flaring; the wicked white teeth; the pectoral fins like the wings of a large aeroplane; and above all the poise and balance in the water and the feeling conveyed of strength, power, and intelligence."

—Hugh Edwards, naturalist

3 Sharks in Decline

SUBJECTS
mathematics, science

SKILLS
interpreting (drawing conclusions, inferring, defining problems, reasoning, elaborating), applying (predicting, hypothesizing)

FRAMEWORK LINKS
30.1, 40, 47.1, 50, 50.1

VOCABULARY
bycatch, gill nets, longlines

TIME
two sessions, one night for homework

MATERIALS
bandanas or other strips of cloth, three Nerf balls or other soft objects that can be thrown safely, two 12-foot ropes/clothesline, 8 to 12 clothespins, notebook paper, copies of "Fishing Worksheets A and B" (pages 236-237)

CONNECTIONS
"Where the Wild Sharks Are" (pages 216-228) can set the stage for helping students understand how certain fishing methods may affect some shark species more than others, based on where in the ocean the sharks live. For more on fishing methods that can affect shark populations, try "Catch of the Day" (pages 166-175).

AT A GLANCE
Carry out group simulations of common fishing methods and assess why these methods and sharks' reproductive biology are together contributing to a rapid decline in shark populations.

OBJECTIVES
Describe several methods by which sharks are captured. Discuss some of the advantages and disadvantages of each method.

When shark-attack stories make the news day after day, people start to think that sharks are becoming more aggressive or that their populations are growing. However, sharks aren't increasing in numbers or ferocity. In fact, sharks are suffering significant population declines. Scientists estimate that some species of coastal sharks have declined by between 50 and 75 percent in just the last 20 years.

One reason that shark populations have declined so rapidly is that many common fishing methods accidentally capture sharks in addition to the targeted fish. Another reason is that a growing market for shark meat, shark fins, and other shark products has made sharks a direct target of fishers who previously didn't capture sharks, or at least didn't keep the sharks if they were caught. (For more on shark-fishing methods, see pages 197-199.)


sharkskin boots

But these practices might not take such a dramatic toll on sharks if it weren't for some basic aspects of sharks' reproductive biology. Sharks are slow-growing, late-maturing animals that don't reproduce very quickly. And they are extremely susceptible to population declines if large numbers of them are killed.

This activity contains a series of simulations that explore different fishing methods and how they intentionally or unintentionally lead to the capture of sharks. Then the activity highlights why some fishing methods are so disruptive to shark populations, particularly in light of sharks' reproductive biology.

Before You Begin

You should decide in advance whether you want to conduct the trawling simulation with your students. It is part of the Shrimp Case Study on pages 166-175, but can also be done as part of this activity. If you decide not to do it, strike out all references to trawling on the handouts and do not include the trawling chart.

Before beginning any of the simulations, push desks to the sides of the room, leaving a large open space in the middle. Gather the materials for the simulations. Copy Charts A, B, and C from "Fishing Worksheet A" onto the board, and make a copy of "Fishing Worksheets A and B" for each student.

What to Do

1. Discuss fishing.

Ask students if they have any idea how people catch fish in the open ocean. Have a few students share what they know about the topic, then tell them that you're going to conduct a series of classroom exercises to show different fishing methods and their effectiveness in catching targeted species. Write the following list on the board:

a) Hook and line
b) Gill nets and drift gill nets
c) Longlines
d) Trawling (optional)

2. Simulation A: Hook and Line

The hook-and-line fishing method is used by sport fishers as well as by some commercial fishers. In this simulation, some of your students are going to be fishing for yellowfin tuna using a hook and line. The other students are going to be the tuna, sharks, and other sea creatures.

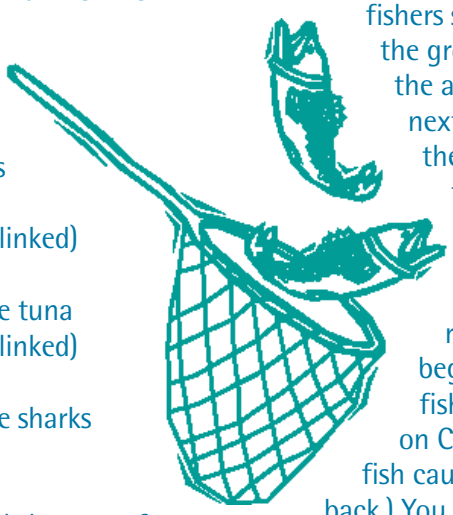
Ask for three volunteers to be fishers. Have the fishers stand aside while you divide the remaining members of the class as follows:

1) 3 to 4 pairs of students (with arms linked) = adult tuna
2) 3 to 4 individual students = juvenile tuna
3) 3 to 4 pairs of students (with arms linked) = adult sharks
4) 3 to 4 individual students = juvenile sharks
5) remaining students = other fish

Tie a bandana or strip of cloth around the arm of every tuna. You need not label the other students, but they should remember what identity they've been assigned.

hook and line

Now present the rules of the game. The fishers will have one minute to "fish" for a tuna from the group. Since it wouldn't be safe to throw a hook and line at their classmates, they'll "fish" by throwing the Nerf ball or other soft object. To make things harder for the fishers, they have to be touching a desk with a part of their body when they throw the ball. None of the fish may run. Any fish the fishers hit is considered "caught," but if it's not an adult tuna, the fishers should "throw" the fish back into the group and toss the ball again. Have the adult tuna that are caught stand next to the fishers who caught them. Whichever fisher has caught the most adult tuna when the minute is over wins the game.



To begin the game, group the fish in the middle of the room. Then tell the fishers to begin. As the fishers catch their fish, record the results on the board on Chart A. (Be sure to count every fish caught, even if the fish is thrown back.) You might want to do another round of fishing if time permits. (To do this, "restock" the waters and select new fishers.)

Afterward, have the students copy the results from the board onto Fishing Worksheet A and analyze the results. How many fish were caught that were not adult tuna? Tell the students that sharks are generally able to survive when they are caught using a hook and line and then thrown back. That being the case, what was the expected total shark mortality in these simulations? *(Answers will vary, but it's unlikely that many would die.)*

3. Simulation B: Gill Nets

Explain to the students that some commercial fishers use gill nets to catch fish in the open ocean. Gill nets allow a fish to fit its head and gill covers, but not its fins or other parts of its body, through the net holes. The gill covers get caught in the net and prevent the fish from wriggling loose. So any fish that are larger at the gills than the holes in the net will get stuck. Once pulled onto the deck of a fishing boat, the fish will quickly die. You might point out that, in addition to being directly targeted by commercial fishers, a lot of sharks are accidentally caught in gill nets by fishers that are targeting tuna.

Some gill nets are fixed in one place and collect fish until they're hauled in. Others are allowed to float through the open water. (These floating gill nets are called drift nets.) Sometimes drift nets get lost; they can float for years gathering fish and other sea creatures in them.

To simulate gill net fishing, select one student to be the fisher. Have that person place the two ropes down on the floor to create three equal-sized "lanes." Then have that person secretly designate one lane to be where the gill net will be. (Be sure the person tells you which lane he or she has selected before the other students start "swimming.")

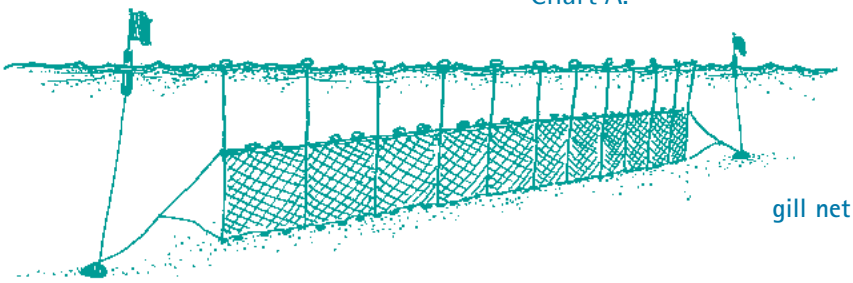
Meanwhile, divide the rest of the students as follows (you need not label them, but they should remember the identity they've been assigned):

1) $^1/_4$ of the students = adult tuna
2) $^1/_4$ of the students = juvenile tuna
3) 1 student = sea turtle
4) 1 student = dolphin
5) 2 to 4 students = small fish
6) $^1/_2$ of remaining students = adult sharks
7) other $^1/_2$ of remaining students = juvenile sharks

Now gather the students at one end of the classroom, and tell them they have to walk to the other end. When they reach the ropes, they should continue down one of the three lanes. Tell them that the fisher has placed a gill net across one of these lanes, but since fish cannot see gill nets, neither can the students. Tell them that they cannot change their lane once they have selected it.

The marine creatures should "swim" from one end of the room to the other, and they should stay in their lanes at the other end of the room. Then have the fisher announce which lane had the gill net, and have him or her count up the catch. All the small fish would have been able to swim through the netting in the gill net. The remaining creatures should be considered caught.

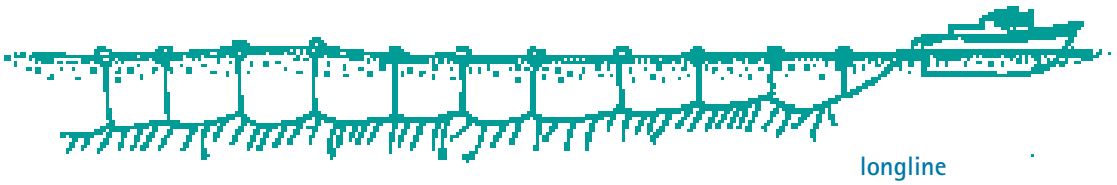
Run through the simulation again if time permits, recording both simulations on Chart B. Have the students copy the figures onto Fishing Worksheet A, Chart B and compare with the results logged on Chart A.



gill net

BIOFACT

In Hong Kong, a bowl of shark-fin soup can sell for as much as $90!

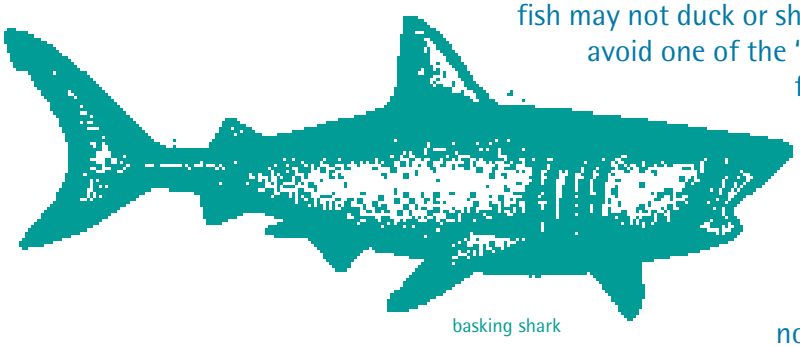


longline

4. Simulation C: Longlines

Explain to the group that longlines are just what they sound like: long, thin cables or monofilament strands that stretch as far as 40 miles across the ocean. (Help your students understand this distance by comparing the distance to a place about 40 miles away from your classroom.) Tell the students that on a longline, there is a float attached to the cable every few hundred feet and a baited hook every few feet. Longlines are often used to capture tuna and billfish such as swordfish. But they also unintentionally catch many sharks.

Choose two people to be longline fishers. Give them one rope, the clothespins, and 10 or more pieces of paper. Then have them go out into the hall and clip the paper on the rope in whatever distribution they want. Tell them that they'll learn how to "fish" with their longline when they get back into the room.



basking shark

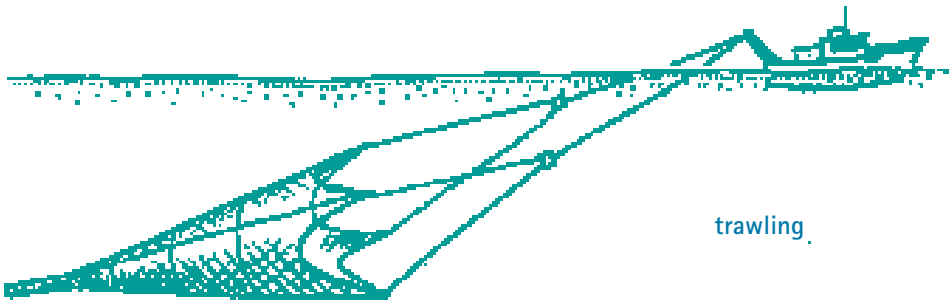
While the fishers are out of the room, divide the group as follows (again you need not label them, but the students need to remember the identity they've been assigned):

1. $^1/_4$ of students = adult tuna
2. $^1/_4$ of students = juvenile tuna
3. 2 students = sea turtles
4. 1 student = dolphin
5. $^1/_2$ of remaining students = adult sharks
6. other $^1/_2$ of remaining students = juvenile sharks

Tell the fish to stand around the room in any configuration they want. The only thing they may not do is stand directly behind another fish. Tell the fish you haven't yet decided which side of the room (front or back) the fishers will start from, so there's no point in bunching up at the back of the class.

Bring the two fishers in and have them stand at the front or back of the room with their rope stretched out across the classroom. Explain that the papers on their longline are meant to represent their baited hooks. They should hold the rope so that the papers pass over the heads of some fish and brush against others. Then have them walk slowly down the length of the classroom, being sure not to shift their longline just to hit a particular fish. The fish may not duck or shift their bodies to avoid one of the "hooks." Every time a fish is brushed by a piece of paper, that student should remove the paper. (In real life, once a hook has caught a fish, no other fish can be caught on it.) Then the fish that are caught should go to the front of the room and identify themselves. Repeat the simulation if time permits.

Discuss the outcome of the fishing, record it on Chart C (with students copying the figures to Fishing Worksheet A, Chart C), and compare the results with those recorded on Charts A and B.



5. Simulation D: Trawling

(See "Catch of the Day" on pages 167-169 of the Shrimp Case Study.)

6. Discuss simulations.

Ask the students if they have any questions about the simulations. In each simulation, were they surprised by how many sharks and other fish were caught, even though they weren't the targeted species? Explain that this unwanted catch is called *bycatch.* Some students may express dismay that fishers are responsible for killing so many marine mammals and fish that they don't use. You might explain that people are working to minimize this bycatch, but that it is difficult and expensive to change common and ingrained practices.

7. Assign homework.

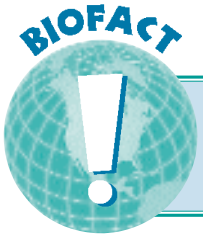
Assign "Fishing Worksheet B" for homework. Use the worksheets as a means of assessing each student's understanding of the concepts (see Assessments). Then return the sheets to the students and set aside a class period to review and discuss the answers. (An answer sheet is provided on page 238.)

8. Discuss status of sharks.

Tell your students that because of current fishing practices, many kinds of sharks are experiencing huge population declines. In fact, scientists estimate that humans kill at least 100 million sharks every year. What are some ways that people could try to reduce this number? *(Set limits on shark catches, set limits on the size of sharks that fishers may catch, reduce consumer demand for shark fins, or change fishing methods.)* Why might these changes be difficult to implement? *(It's hard to rally public concern for sharks; many sharks move from one country's waters to another's, so fishing limits set by one or two countries won't guarantee that sharks are protected; current fishing methods are profitable to the commercial fishing industry, so any changes are likely to be resisted.)*

9. Research shark conservation.

As a wrap-up to the activity, have your students research current efforts in shark conservation. They should search the Web, contact environmental organizations, check the newspaper for articles, and so on. Allow students to share their findings with the rest of the class.



The fish used in England's famous "fish and chips" dish is sometimes from a shark—the dogfish shark.

WRAPPING IT UP

Assessments

For assessment, use "Fishing Worksheet B" as a homework assignment.

Unsatisfactory—Provides incomplete or insufficient answers.

Satisfactory—Adequately answers each question.

Excellent—Provides thoughtful responses to each question.

Portfolio

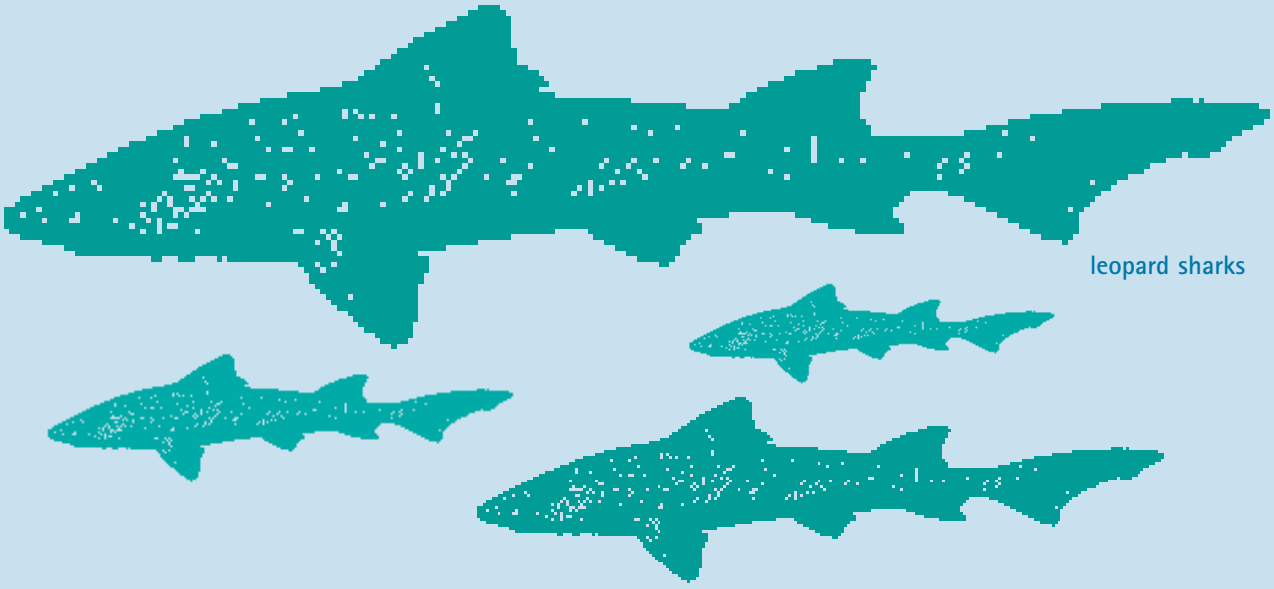
Students should include "Fishing Worksheets A and B" in their portfolios.

Writing Idea

Have students write a letter to the editor of a local newspaper from a fisher's perspective, explaining the pros and cons of the fishing methods explored in this activity. The letter should also discuss the need for further research on new ways to catch fish that cause minimal marine habitat destruction and reduce bycatch.

Extension

Have your students look into the reproductive biology of several shark species. Do sharks reproduce in the same way that other species of fish do? Or are sharks' reproductive habits closer to those of large mammals? Explain.



leopard sharks

FISHING WORKSHEET A

Record the fishing results for each of the following methods.
Circle the types of fish that were ultimately kept.

Chart A: Hook and Line

	Adult tuna	Juvenile tuna	Adult shark	Juvenile shark	Other fish
Round One					
Round Two					

Chart B: Gill Nets

	Adult tuna	Juvenile tuna	Adult shark	Juvenile shark	Sea turtle	Dolphin
Round One						
Round Two						

Chart C: Longlines

	Adult tuna	Juvenile tuna	Adult shark	Juvenile shark	Sea turtle	Dolphin
Round One						
Round Two						

Chart D: Trawling

	Kind of netting	Targeted species	Bycatch
Round One			
Round Two			

FISHING WORKSHEET B

1. Explain what you think might be the *advantages* of each of the following fishing methods.

a. Hook and line

b. Gill nets

c. Longlines

d. Trawling

2. What do you see as the *disadvantages* of each of the following methods?

a. Hook and line

b. Gill nets

c. Longlines

d. Trawling

3. Most sharks reproduce slowly, producing small numbers of young at a time and maturing quite late in life—more like elephants or humans than cockroaches or rabbits. Why might some fishing methods, such as using drift nets and longlines, present particular problems for many shark species, whether they are intentionally or accidentally caught?

4. In recent years, many sharks that were caught accidentally were dumped back into the sea—dead or alive. Now, because of the rising popularity of shark-fin soup, many fishers are cutting off the sharks' fins and then dumping the sharks back into the ocean. What do you think of this practice?

ANSWERS TO "FISHING WORKSHEET B"

Note: Answers will vary according to simulation results.

1. **Advantages of hook and line:** Doesn't require extremely expensive equipment, better able to catch target species. **Advantages of gill nets, longlines, and trawls:** They catch many more fish and require less labor and precision.

2. **Disadvantages of hook and line:** Requires a lot of human labor and is time intensive. **Disadvantages of nets, longlines, and trawls:** They catch species indiscriminately so they accidentally kill many unwanted species, although the size of openings in the nets' mesh and the types of hooks used can help make these methods more selective. In some areas, up to half of the bycatch consists of sharks. Also, gill nets and longlines can get lost at sea and will continue catching and killing fish and other marine creatures. When trawling is done along the ocean floor, it destroys ocean habitat.

3. **Because nets and longlines catch sharks of all ages,** they catch many immature females—females that have never had a chance to reproduce. For example, if a female dusky shark is caught before she's 22 years old, she will not have had the opportunity to produce any offspring. What's more, those sharks that do reach reproductive age do not produce many young at a time, so populations cannot easily bounce back from heavy fishing tolls.

4. **Answers will vary.** Some students may point out that cutting off the fins can give fishers some monetary reward for catching a shark and that it's less wasteful than throwing back a dead shark without using any part of it. Others may think that it's still wasteful to use so little of a shark and may point out that finning only increases the total number of shark deaths and encourages the market in illegal trade. Some students may point to the cruelty of throwing a mortally wounded animal back into the sea to suffer and die.

WWF-Canon/Catherine Holloway

". . . Or can man not only learn how to live in harmony with his fellow men, but also contrive to co-exist amicably with sharks, avoiding unnecessary conflict and recognizing that planet Earth is the home of other species, as well as Homo sapiens, and that these species have an equal claim on the resources of the world."

–Rodney Steel, science journalist

4 Rethinking Sharks

SUBJECTS
language arts, social studies, art

SKILLS
applying (creating, synthesizing, composing), presenting (writing, illustrating)

FRAMEWORK LINKS
5, 37, 41, 42, 58

VOCABULARY
attitudes, **culture,** *nenue, Seri, Tlingit*

TIME
one to two sessions, depending on projects chosen

MATERIALS
copies of "Sharks in Culture" (pages 243-246), lined and unlined paper, pencil, paints, colored paper, scissors, glue, clay, musical instruments, and other items as needed

CONNECTIONS
To further explore cultural connections with biodiversity, use "Salmon People" (on the Web) and "The Culture/Nature Connection" in Biodiversity Basics, *and "A Wild Pharmacy" in* Wildlife for Sale.

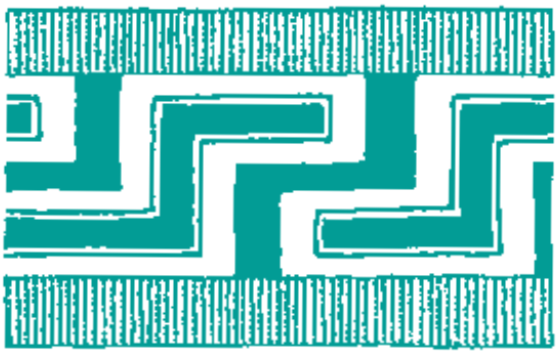
AT A GLANCE
Read a traditional Hawaiian story about sharks and then write a poem, make a poster, draw a comic strip, or create a piece of art that portrays your views toward sharks.

OBJECTIVES
Describe different cultural views of sharks. Articulate your attitude toward sharks.

If you could travel around the world, you'd find signs of sharks everywhere. After all, they don't just inhabit the world's oceans—they also are found in the culture and imaginations of people. For example, sharks play a role in many Hawaiian and Polynesian stories. Sharks decorate the bark paintings of Australian aboriginal peoples and the hats and carved poles of the Haida and Tlingit peoples of Alaska and British Columbia. Pacific Islanders and the Seri Indians of Mexico carve shark sculptures.

Take a close look at those representations and you'll see that negative attitudes toward sharks aren't universal. Far from being the evil villains depicted in most Hollywood movies, sharks are often portrayed in other cultures as powerful guardians, even deities, of the ocean realm.

In this activity, your students will read a Hawaiian story about sharks and look at pictures of shark art from around the world. Then they'll make their own art to portray their perspective on sharks.



Tlingit design

Before You Begin

Make one copy of "Sharks in Culture" for each student. Gather whatever writing or art supplies you'd like to provide for the students' art projects.

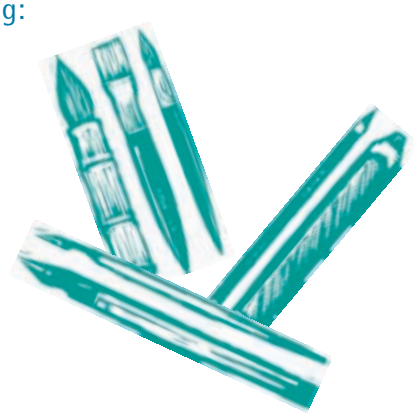
What to Do

1. Hand out copies of "Sharks in Culture."

Have the students look over the handout. Explain that the story and artwork are examples of how sharks are portrayed by people from different cultures around the world. Read "The Shark Guardian," pages 243-244, to the class. Afterward, spend some time discussing the story and the artwork presented. Were the students surprised that the people in the story acted as guardians of sharks? What is the tone of the shark painting? *(Emphasizes the horror of the scene, grotesqueness of the shark.)* What sense of the artists' view of sharks comes through the other shark artwork? *(All three reflect an integration of sharks with the culture—Seri sculpture comes from direct observation of sharks in their habitat, and Australian and Tlingit pieces show spiritual connections to sharks.)* Why might people from different cultures have different attitudes toward and relationships with sharks? *(Answers will vary.)*

2. Assign shark project.

Tell the students that their assignment is to create their own written or artistic representation of their views of sharks. They can model their art piece after one of the examples on their handout (for example, by writing a story about sharks, painting a shark, or carving a shark figurine). Or, they may want to try one of the following:



- Write a poem about sharks, with the word "SHARKS" running down the left side and each line beginning with one of these letters.
- Make a poster for an imaginary movie about sharks. Would the shark be the villain? The hero?
- Draw a comic strip about a superhero who does or does not like sharks.
- Make a shark puppet out of fabric.
- Make a shark piñata.

Whatever format the students choose, their piece should reflect their personal view of sharks.

3. Share results.

Give the students an opportunity to share their art pieces informally or in a class art exhibit. They may want display their pieces in a public space and encourage other people to rethink their attitudes toward sharks.

> *"If there is poetry in my book about the sea, it is not because I deliberately put it there, but because no one could write truthfully about the sea and leave out the poetry."*
> **– Rachel Carson, ecologist**

WRAPPING IT UP

Assessment

Use the poem, poster, comic strip or art piece and have each student write an explanation of how their work reveals their personal attitude toward sharks. Students should also describe the reasoning behind their attitudes.

Unsatisfactory—Explains either attitude or reason (but not both) or fails to explain how the art shows the attitude and reason.

Satisfactory—Describes the attitude and reasons.

Excellent—Relates the reasons with the attitude and reveals how the work includes this.

Portfolio

Include students' poetry and stories in their portfolios. If artwork doesn't fit in the portfolio, have students make a sketch of it or take a photo of it.

Writing Idea

Have students interview neighbors and family members to find out about their perspectives on sharks. Based on these interviews, students should write short "Shark Stories" that explore their community's attitudes toward sharks and highlight how those attitudes might be linked to local culture.

Extensions

- The story you read to the students was about shark guardians. Do the students know any other shark guardians? Have them investigate careers that are devoted to protecting sharks.
- Have the students visit Web sites of organizations working on shark conservation. Then ask them to generate a list of what ordinary citizens can do to help sharks.

THE SHARK GUARDIAN

This is a story of the days when Mary Kawena Pūku'i was a little girl in Ka'ū on Hawai'i. One very rainy day she got to thinking of a certain kind of fish. "I want *nenue* fish," she said.

"Hush, child," her mother answered. "We have none."

"But I am hungry for *nenue* fish!" the little girl repeated and began to cry.

"Stop your crying!" said another woman crossly. "Don't you see we can't go fishing today? Just look out at the pouring rain. No one can get you *nenue* fish. Keep still!"

The little girl went off into a corner and cried softly so that no one should hear, "I do want *nenue* fish! Why can't someone get it for me?"

Her aunt came in out of the rain. It was Kawena's merry young aunt who was always ready for adventure. "What is the matter with the child?" she was asking. "The skies are shedding tears enough, Kawena. Why do you add more?"

"I want *nenue* fish," the little girl whispered.

"Then you shall have some. The rain is growing less. We will go to my uncle."

In a moment the little girl had put on her raincoat, and the two were walking through the lessening rain. It was fun to be out with this merry aunt, fun to slip on wet rock and shake the drops from dripping bushes.

At last they reached the uncle's cave. "Aloha!" the old man called. "What brings you two this rainy morning?"

"The grandchild is hungry for *nenue* fish," Kawena's aunt replied.

"And *nenue* fish she shall have," said the old man. Net in hand, he climbed the rocks above his cave home. Kawena and her aunt watched him as he stood looking out over the bay. He stood there like a man of wood until the little girl grew tired watching. The rain had stopped and sunlight touched the silent figure. Why didn't he do something? Why didn't he get her fish? Why did he stand there so long—so long?

Suddenly he moved. With quick leaps he made his way to the beach and waded out. Kawena and her aunt hurried after him and saw him draw his net about some fish and lift them from the water. Just as the girl and woman reached the beach the old man held up a fish. "The first for you, old one," he said and threw the fish into the bay. A shark rose from the water to seize it. "These for the grandchild," the old man added. He was still speaking to the shark as he gave four fish to Kawena.

blue shark

The little girl took her fish, but her wondering eyes were following the shark as he swam away.

"That is our guardian," the uncle said. He too was watching the shark until it disappeared.

"Tell her about our guardian," said the aunt. "Kawena ought to know that story."

The uncle led them back to his cave. There, dry and comfortable, they sat looking down at the beach and the bay. "It was from those rocks that I first saw him." The uncle began, his eyes on rocks below.

"One day, many years ago, I found my older brother lying on the sand. For a moment I thought that he was dead. Then he opened his eyes and saw me. 'Bring *'awa* and bananas,' he whispered. I stood looking at him, not understanding his strange words. After a bit he opened his eyes again and saw me still beside him. '*'Awa* and bananas!' he repeated. 'Get them quickly.'

"As I started away I saw him pull himself to his feet, holding onto a rock. He looked out over the bay and called, 'Wait, O my guardian! The boy has gone for food.' Then he sank back upon the sand. I looked out into the bay, but saw no one.

"I got *'awa* drink and ripe bananas and brought them to my brother. He pulled himself weakly to his feet once more and moved out onto those rocks, motioning me to bring the food. He called again and his voice was stronger. 'O my guardian, come! Here is *'awa* drink! Here are bananas! Come and eat.'

"Suddenly a large shark appeared just below the rocks on which we stood. As my brother raised the wooden bowl of *'awa*, the great fish opened his mouth. Carefully my brother poured the drink into that open mouth till all was gone. Then he peeled the bananas one by one and tossed them to the shark, until the great fish was satisfied. 'I thank you, O my guardian!' Brother said. 'Today you saved my life. Come here when you are hungry.' The shark turned and swam away.

"While my brother rested on the sand he told me his adventure. His canoe had been caught in a squall and overturned. He was blinded by rain and waves and could not find the canoe. It must have drifted away. The waves broke over him and he thought the end had come.

"Then he felt himself on something firm. 'A rock!' he thought, and clung to it. Suddenly he felt himself moving through the waves and knew that he was riding on the back of a great shark and clinging to his fin. He was frightened, but kept his hold.

"The storm passed on, and my brother saw the beach. The shark swam into shallow water, and Brother stumbled up the sand. It was there I found him.

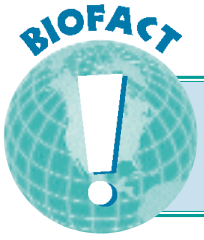
"He never forgot that shark. Often I have seen him standing on the rocks above this cave with *'awa* and bananas ready. Sometimes he called. Sometimes he waited quietly until the shark saw him and came. Sometimes the shark drove a small school of fish into the bay as you saw just now. My brother caught some and shared them with the shark.

"The time came when my brother was very sick. Before he died he beckoned to me. 'My guardian,' he whispered. 'You must give food to the one that saved my life.'

"I have not forgotten, and the shark does not forget. I feed him *'awa* and bananas, and he sometimes drives fish into my net. Today he wanted *nenue* fish and put the thought of them into your mind. Always remember our guardian, Kawena."

Kawena Pūku'i is a woman now, but she has never forgotten the shark guardian.

Told by Mary Kawena Pūku'i



Remoras are fish that hitch rides on the backs of sharks and other fish and eat tiny shellfish that accumulate on the sharks' fins and gills.

1) "Watson and the Shark" by John Singleton Copley, 1778.

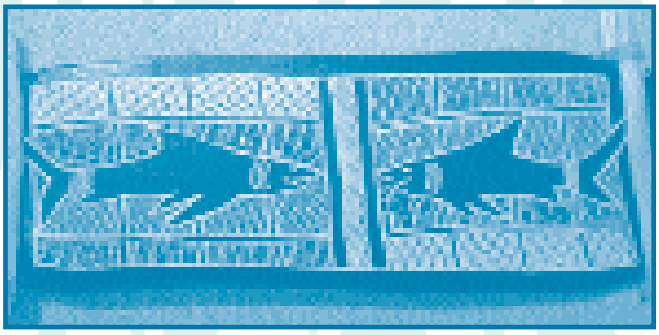
In 1749, a 14-year-old orphan was swimming in the harbor in Havana, Cuba, when he was attacked by a shark. This painting by American painter John Singleton Copley depicts the orphan's shipmates' desperate attempts to rescue him.

Watson and the Shark, Ferdinand Lammot Belin Fund, ©2002 Board of Trustees, National Gallery of Art, Washington, 1778.

Al Abrams

2) Seri Indian ironwood carvings of sharks.

The Seri Indians live on the coast of the Sea of Cortez in Sonora, Mexico, where they hunt and fish for much of their food. Some Seris carve these sculptures to depict the animals they see in their region.



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3) Australian bark painting with shark on it.

Australia's aboriginal people have been making bark paintings for thousands of years. They grind colored rocks to make paint and use eucalyptus bark as the canvas. The scenes on the bark paintings reflect the spiritual "dream time" stories of the aboriginal peoples.

4) Tlingit carved pole.

Creatures from the natural world are depicted on most of the traditional poles of the Tlingit people of the Northwest Coast of North America. The animals on these poles are totem animals who help shape the lives of the families connected to them.

U.S. Forest Service

Shark Resources

Here are additional resources to help you design and enhance your Sharks Case Study. Keep in mind that this resource list includes some of the materials we have found or used; however, there are many other resources available on sharks. For a list of general marine biodiversity resources, see the Resources section on pages 360-369.

Organizations

American Elasmobranch Society is a nonprofit science organization that conducts research on sharks, skates, rays, and chimaeras, and promotes public awareness of natural resources. **www.flmnh.ufl.edu/fish**

Mote Marine Laboratory's Center for Shark Research is an international center for research, scientific collaboration, consulting, education, and public information on sharks and their relatives (skates and rays). Their Web site includes shark facts and statistics. **www.mote.org**

Curriculum Resources, Books, and Web Sites

The Bridge—Ocean Sciences Education Teacher Resource Center is a growing collection of online marine education resources. Use the Search feature, or under "Ocean Sciences Topics," click on "Biology," then "Sharks." Sea Grant Marine Advisory Services, Virginia Institute of Marine Science College of William and Mary, Gloucester Point, VA 23062. **www.vims.edu/bridge**

Great White Sharks (Adult) by Richard Ellis and John E. McCosker centers on one of the most feared ocean creatures. Extensively illustrated, the book is the first-published compilation of information and research about great whites. (HarperCollins, 1991). $35.95

NOVA Online: Shark Attack! is an "online adventure" resource on the biology of sharks, their distribution, and the people who interact with them. **www.pbs.org/wgbh/nova/sharks**

The Shark Almanac (Adult) by Thomas Allen tries to dispel myths of sharks as man-eaters and delves into the unknown world of these marine creatures. The book provides recent scientific research as well as updates on continuing shark conservation efforts. (Lyons & Burford Publishers, 1999). $35.00

Shark Research Program of the Florida Museum of Natural History provides links relating to various aspects of sharks. Viewers can visit an image gallery featuring a range of species or click on "Education" for a discussion of shark natural history. **www.flmnh.ufl.edu/fish/sharks/sharks.html**

Sharks (Elementary) by Niki Walker and Bobbie Kalman is a general shark resource for children. Complemented by color photographs, the book outlines various species of sharks, from tiny cookie-cutters to giant makos. (Crabtree Publishing Group, 1997). $19.96

Sharks! (Elementary) by Irene Trimble and Mike Maydak, a work of the "Know-It-All" series, is a die-cut book featuring shark species, their diet, and physical abilities. (McClanahan Book Company, 1999). $2.79

Sharks in Question: The Smithsonian Answer Book (Adult) by Victor G. Springer and Joy P. Gold addresses commonly asked questions about sharks in the first half of the book. The second half covers the biology of various shark species and the reasons behind attacks on humans. (Smithsonian Institution Press, 1989). $24.95

To Culture or Not to Culture

OVERVIEW
Aquaculture, like any other industry, has its costs and benefits, as well as its proponents and opponents. Students will discuss some of the pros and cons related to aquaculture. As a class, the students will discuss the hypothetical case studies provided. In cooperative learning groups, students will engage in an aquaculture debate in the style of a town meeting.

OBJECTIVES
Students will:
Describe impediments to aquaculture development.
Describe the pros and cons of an aquaculture industry in their community.
Describe the position of several community groups regarding aquaculture development.

GRADE LEVEL:
6 -12

SUBJECTS
Science
Social studies
Environmental studies

VOCABULARY
aquaculture, carnivorous, herbivorous, mangrove, sustainability

TIME
2 class session

MATERIALS
Copies of student handouts Two Florida Communities and Aquaculture Pros and Cons

NATIONAL SCIENCE STANDARDS
This activity supports the following National Academy of Science science education standards.
Grades 5-8:
Unifying Concepts and Processes—Systems, order and organization
Standard C: Life Science—Populations and ecosystems
Standard E: Science and Technology—Understandings about science and technology
Standard F: Science in Personal and Social Perspectives—Populations, resources, and environments
Standard F: Science in Personal and Social Perspectives—Risks and benefits
Standard F: Science in Personal and Social Perspectives—Science and technology in society

Grades 9-12:

Unifying Concepts and Processes—Systems, order and organization
Standard F: Science in Personal and Social Perspectives—Natural resources
Standard F: Science in Personal and Social Perspectives—Environmental quality
Standard F: Science in Personal and Social Perspectives—Science and technology in local, national, and global challenges

NATIONAL SOCIAL STUDIES STANDARDS
This activity supports the following National Council for the Social Studies standards.
Middle Grades:
Standard I: Culture—a, d
Standard III: People, Places, & Environments—k
Standard IV: Individual Development & Identity—h
Standard V: Individuals, Groups, & Institutions—g
Standard VII: Production, Distribution, & Consumption—f
Standard VIII: Science, Technology, & Society—b, d, e
Standard IX: Global Connections—d
Standard X: Civic Ideals & Practices—c, d, g

High School:
Standard I: Culture—a
Standard III: People, Places, & Environments—k
Standard IV: Individual Development & Identity—h
Standard VII: Production, Distribution, & Consumption—f
Standard VIII: Science, Technology, & Society—d, f
Standard IX: Global Connections—d
Standard X: Civic Ideals & Practices—c, d

BACKGROUND
Aquaculture—the production of aquatic organisms for human use—is an increasingly important source of seafood. Many believe that it can help fill the gap between the growing demand for seafood and what can be caught in the wild. It can also provide jobs and rejuvenate the seafood processing industry in some places.

Aquaculture exists in almost every country in the world, but the US produces relatively little. Even though national policy is aimed at encouraging aquaculture initiatives, there are still many barriers to starting new aquaculture ventures including:

Economics
Starting a new aquaculture venture is expensive, it requires a large initial capital investment, and it may be quite some time before entrepreneurs begin to see a profit. Banks may be skeptical about loaning large sums of money to small aquaculture entrepreneurs. As a result, new aquaculture enterprises often favor large businesses over smaller, community operations.

Siting issues
Not every body of water can serve as a site for an aquaculture facility and many species are farmed inland in human-made ponds or raceways. Very specific requirements must be met. For example, to raise Pacific White shrimp, pond water must remain near 75-85 degrees for three to four months while the shrimp grow to full size. For salmon or other finfish grown in net-pens in the ocean, you must have very strong tides to disperse the wasted produced from the finfish or you risk polluting the surrounding waters. For oysters, mussels and other mollusks, you must have nutrient-rich water. Culturing mollusks and aquatic plants usually has minimal negative environmental consequences.

Aquaculture operations in the ocean and on the coast are always at the mercy of Mother Nature. Storms and other oceanographic and meteorological conditions can wreak havoc on one's fish, mollusk, or shrimp farm. A specific threat related to farmed bivalves is a tiny organism called fecal coliform bacteria which can enter the water via sewage, particularly during times of flooding. Because these bacteria can contaminate the bivalves and threaten the health of consumers, mollusks must be grown in clean waters. In spite of all these hazards, excellent environments for aquaculture operations across the U.S. do exist.

Environmental issues
Aquaculture production of some species and in some areas is being done in a way that minimizes environmental impact. Several conservation organizations such as Monterey Bay Aquarium, Environmental Defense, and Blue Ocean Institute publish seafood cards that rate farmed catfish and tilapia, for example, "green" (the best designation). But many people are concerned that some forms of aquaculture can create more problems than they alleviate. On fish farms, species such as shrimp and salmon are fed high-protein pellets which include high percentages of fishmeal and fish oil made from small wild fish such as anchovies. There is a range of scientific opinion about exact conversion ratios, but fisheries experts agree that raising carnivorous species currently consumes more fish than it produces, putting pressure on wild fish populations.

To make way for modern aquaculture operations, farm fields may be flooded for catfish ponds, shrimp farms may be adjacent to sensitive coastal forests, and waters in coastal areas may be fenced to raise "crops" of salmon, mollusks, and seaweed.

Dead fish, uneaten food, and excrement wash directly into waterways from many modern aquaculture operations. And the antibiotics, vaccines, and chemicals that many farmers use to fight disease get flushed away, too, with unknown effects on wild fish and their habitat. The U.S. Environmental Protection Agency recently established national standards to control the effluent from aquaculture operations.

Fish farms often raise fish that aren't native to the area. Farmed fish are usually stocked in cages when disease-free. They often catch diseases that are naturally occurring in the water and on wild fish, and then amplify the disease or parasite due to high stocking densities. Now the disease can become a much larger threat to wild fish that swim by the net-pens. When farmed fish escape, they can become established in the wild, and

compete with or prey on native fish. Up to 50% of salmon caught in certain rivers in Norway are of farmed origin, and on average they estimate that 1/4 of all salmon in the wild are of farmed origin (not just escapees, but also offspring of escapees).

Opposition
Among the biggest barriers to starting new aquaculture ventures in the U.S. is a lack of appropriate areas for mariculture or culture of species along the coast combined with local public opposition. Although there are many people who support and encourage a growing aquaculture industry, there are others who oppose growth in this industry if it does not appear sustainable.

A long-term goal of the aquaculture industry and government proponents is to help offset the annual $8 billion seafood trade deficit (as of 2005). For example, the US is the largest importer of farmed shrimp, and currently, over 70% of the seafood that Americans consume is imported, and at least 40% of our seafood imports are aquaculture products. Success with aquaculture in the United States requires high rate and high yield production systems that are both environmentally and economically sustainable and yield a high quality product.

BEFORE YOU BEGIN
1. Make copies of the Two Florida Communities handout for each student.
2. If desired, make copies of the Aquaculture Pros and Cons handout for each student.

WHAT TO DO
Before the Activity
1. Prior to class, have the students read the Two Florida Communities handout.

The Activity
1. As a class or in cooperative learning groups, review the Two Florida Communities handout describing the hypothetical case study about Gull Island and Tern Island. Develop a possible pros and cons list for aquaculture or use the Aquaculture Pros and Cons handout provided.

2. Engage the class in a discussion about the case study. How and why did the two communities reach such different conclusions about the issue of shrimp farming?

3. Introduce the idea of a town meeting or debate in which various members of the community come together to reach a consensus on an issue or proposal which will affect their community. Explain that the class will conduct their own town meeting to decide whether to permit the establishment of an aquaculture venture in their own community.

4. Have the class set the parameters of the aquaculture site that is being proposed:
    a. Will the company be culturing finfish, shellfish, or sea vegetables? Will it be a carnivorous or herbivorous species? What species?

b. Will the site be warmwater, coldwater or marine? A river, estuary, shorefront, land-based, or deepwater?
c. Is the area already used by others? By whom?

5. In the aquaculture debate, groups of students will role play a position on aquaculture and defend it in a town meeting. Select about six roles from this list, or create roles appropriate to your community: commercial fisherperson, tourist bureau representative, homeowner, vacationer, local/state politician, small-scale aquaculture entrepreneur (local), large-scale aquaculture entrepreneur (international), scientist, or conservation group representative.

   Before the debate, stress the professionalism and decorum which ought to take place in a town meeting. Establish a set of guidelines based on mutual respect so that the debate does not degenerate into a shouting match. You may need to stress that the point of a debate is to adopt the position of the group and defend that position. The position may or may not reflect the students' own opinions. Therefore, students ought not to feel personally attacked and have the advantage of learning how to argue positions other than their own. Students should gain an understanding of the complexity of community issues.

6. Break the class up into as many groups as there are roles. Assign (or let the groups choose) a different role for each cooperative learning group. You may want to provide a "blurb" describing each group's general position on aquaculture. However, be careful not to pigeonhole groups into black and white categories. There are advantages to letting the students struggle with defining the roles of these groups themselves, rather than providing them with a predetermined script. Encourage groups to approach this as a real-life scenario.

   Give students time (20-30 minutes) to prepare their case. They can use the Two Florida Communities handout and the Aquaculture Pros and Cons as reference materials to help build their arguments. Case statements can include stipulations such as: "I support aquaculture in the community if x, y, and z are included."

7. Give each group three minutes to present their case. After all groups have spoken, any group may "counter" or challenge another group's argument. Be sure to give the challenger a time limit (one or two minutes) and give the challenged group an opportunity to respond. Limit challenges and responses to one per group.

8. After the debate is over, individuals will be asked to vote on whether or not they want to start an aquaculture venture in their community and what, if any, stipulations they'd enforce. Write the final decision on the board or overhead and, as a group, list the reasons and/or stipulations for the decision.

ASSESSMENT
Ask students to write an essay describing their personal opinion regarding the class vote and explain their reasoning.

EXTENSIONS
- Survey/Questionnaire: Ask students to create a survey/questionnaire to determine how members of the community would feel (or do feel) about having an aquaculture facility in their community. Have them survey family, friends, and members of the community and share their results with the class. Students may also choose to tape a personal interview with someone who has an interesting point of view.

- Marine Issues: Divide students into groups and have each group monitor one local marine issue or controversy involving fisheries and/or aquaculture.

CREDIT
Adapted with permission from "To Culture or Not to Culture: The Controversy Continues" in the *Maine Aquaculture Curriculum Guide* by the Maine Aquaculture Innovation Center, www.maineaquaculture.org.

TWO FLORIDA COMMUNITIES

Two island communities in Florida were approached by shrimp farming entrepreneurs. One community said yes while the other community said no. Why?

A few years ago both Gull Island and Tern Island were approached by separate companies wishing to establish shrimp farming operations on their islands. The majority of the year-round residents on Gull Island and Tern Island make their living as fishermen and wild shrimpers. While the residents of Tern Island fiercely rejected the proposal for shrimp farming ponds on their island near the coast, the residents of Gull Island grappled with the proposal for some time and eventually decided to accept it and try shrimp farming, hoping to supplement their traditional fishing income. What prompted these two similar communities to have such different responses to shrimp farming on their islands? Let's take a look at these two different approaches.

Tern Island

In 2003, a representative from Shrimp Servers Inc. submitted a proposal for a 10-year lease of 100 acres of coastal lands on Tern Island. The residents of Tern Island were first introduced to the proposal at a public hearing. No attempt was made to introduce the idea to Tern Island's residents prior to the hearing, and the people of Tern Island were not pleased about being left in the dark.

The proposed 100-acre lease area was near coastal mangrove forests, which were important breeding and feeding grounds for the fish and wild shrimp that the residents depended on for their income. The fishing community was concerned about not having access to the coast near those 100 acres but, more importantly, they worried about the effect the shrimp ponds would have on the nearby waters and mangrove forests. They feared contamination of the water from the shrimp food and waste, antibiotics used in the ponds, chemicals used in the shrimp foods, and diseases spread by the farmed shrimp. Another fear was that escaped shrimp could mix with wild shrimp and negatively affect the local native shrimp species. Many of these fears were valid, while others were not. Contamination problems have arisen in some shrimp pond operations due to poor management. Producers using better management practices and following U.S. regulations would have a very low risk of contamination.

The effect of aquaculture on the local economy was another issue for the residents of Tern Island. While Shrimp Servers Inc. promised economic gain, residents feared that the big corporation would bring workers from off-island. Residents researched the job total and determined that there would be a total of only three to five jobs available, which might not make up for the money lost from the 100 acres of land leased to Shrimp Servers Inc.

Another issue was tourism. Tourists and summer residents alike are attracted by the beauty of the island. In the summer, the size of the island swells from 1,200 to 6,000. Islanders feared the shrimp ponds would be an eyesore that would compromise the natural beauty of the island, deter tourists, and reduce the property value of their homes. Due to community opposition, Shrimp Servers Inc. withdrew its proposal.

Gull Island

Soon after the Tern Island aquaculture fiasco, Gull Island was approached with a different shrimp farming proposition. Initially, a representative of Shrimp Lovers Ltd. came to the island to speak with members of the Gull Island Fisherman's Coop. Members of the community were invited to several informative discussions to decide whether they were interested in exploring shrimp farming as an option. Although there was a great deal of negative aquaculture propaganda floating around the community, there was little in the way of concrete information. Keeping an open mind, the Gull Island Fisherman's Coop thoroughly researched shrimp farming, and visited other shrimp farms in Florida and Texas.

A number of the shrimp farms that Gull Island residents visited were well run operations employing former and current fishermen. The farms used better management practices including fully recirculating water systems and bacteria capable of digesting shrimp wastes rather than traditional water discharge shrimp culture systems. As a result the effluent did not flow into oceans or rivers and affect local fish populations. The farms avoided problems with contamination and disease by ensuring that the shrimp were not stressed by overcrowding, which minimized their use of antibiotics and other chemicals. They followed U.S. laws regarding antibiotic and chemical use, only using those that had been reviewed and approved by the Food and Drug Administration's Center for Veterinary Medicine. Shrimp farmers frequently commented that if the shrimp ponds were to contaminate the waters in any way, their stocks would be the first ones to suffer.

Although the Gull Island fishing community was sufficiently convinced about the merits of aquaculture to continue exploring shrimp farming as an option, there was still opposition from members of the community. Some residents remained concerned about the potential environmental problems associated with aquaculture. Other residents felt that the shrimp farms would bring competition and have a negative economic affect on the wild shrimpers. Still others were concerned with the aesthetic value of their coastline and the affect that shrimp farms could have on the property value of their homes. Much of this opposition came from summer residents and tourists.

Ultimately, there was greater support for shrimp farming than there was opposition to it. Shrimp Lovers Ltd. Offered to help set up any member of the community who wanted to get involved in shrimp farming, so a mutually beneficial partnership was established. Gull Island began shrimp farming very conservatively, with two ponds on 25 acres. They invested in a "zero-discharge" system that used settling ponds and employed bacteria to digest the shrimp wastes, and purposefully stocked shrimp in low densities to avoid problems associated with overcrowding. As a result of their caution, no antibiotics were necessary and the shrimp and the surrounding habitat were healthy.

Aquaculture: Pros and Cons

Arguments in favor of aquaculture:

1. Can create jobs in community
2. Can increase revenue on city, state and national level
3. Can reduce seafood trade deficit
4. Can help feed a growing U.S. and world population
5. Can encourage local investment
6. Can increase scientific knowledge and technology
7. Can place more emphasis on protecting coastal waters from pollution, especially in the case of mollusk and seaweed culture.
8. May reduce fishing pressure on certain wild stocks if that species can be produced through aquaculture rather than fished.

Arguments against aquaculture:

1. Can conflict with other users of water bodies such as lobstermen, fishermen or migrating fish
2. Can put excess pressure on wild stocks that are used to create high protein feed pellets
3. Can amplify and transfer disease and parasites to wild fish populations
4. Can pollute water systems with excess nutrients (fish feed & wastes), chemicals and antibiotics
5. Can compromise native gene pools if farmed fish and native species interbreed
6. Can threaten livelihood of fishermen
7. Can be an unpredictable enterprise for small local communities due to its susceptibility to severe weather, predators, disease, and global competition
8. Can compromise the aesthetic beauty of coastline